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中國二疊紀植物化石之新屬

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周贊衡節譯

西歷一千八百六十九年夏、李希霍芬氏曾在奉天本溪湖煤田、採集植物化石數種、經植物學家邢克氏研究後定名爲羊齒類之 Taeniopteris 及蘇鐵類之 Pterophyllum、此二屬均爲二疊紀化石、（見李氏中國篇第四卷第二一一頁）其蘇鐵類一屬保存雖不完整、但頗有詳細研究之價値、考當時邢氏定名 Pterophyllum Carbonicum 時、亦因其保存不甚完整、不能確定其種屬、故曾與 Noeggerathia 及 Cordaites 相比較、民國五年冬、著者在唐山煤鑛廢石堆中、檢得新種植物化石一、當時曾與邢氏之蘇鐵化石圖形比較、頗相類似、次年春在湖南耒河一帶、研究無烟煤田時、又採集同樣化石甚夥、且常與大羽羊齒類化石(Gigantopteris nicotianaefolia Schenk) 同層發見、著者未赴湖南調查以前、在北京地質調查所之標本中、亦見有同樣化石、係丁文江氏在河南採集者、惜民國八年該項標本運往瑞典時、輪船中途遇險、盡遭沉沒、現在所研究之標本、均爲那林氏採自山西陽曲縣之新材料、經著者詳細研究後、始知邢氏之所謂蘇鐵類化石 (Pterophyllum carbonicum)、並不屬於上述三者中之任一屬、乃爲一新屬、今定名爲丁其亞屬 (TingiaNov. Gen.) 蓋於地質調查所長丁文江氏表示一種敬意也、屬此者共有二種、即 Tingia carbonica n. comb. 及 T. crassinervis n. sp. 是也、此種植物枝粗而分腹背兩面、葉似羽狀複葉、但有大小兩種、各成二行在枝之上、面二行者、葉面甚小、且與其枝成銳角、其在枝之下面者、葉大而成平面、有楔形、倒卵形、或長橢圓形之分葉之二緣、均完全、惟至頂端分成圓形裂片、葉脈數枝一入葉底、即各分二枝、經葉面全部而達裂片中、今將二種枝葉形態、約略分述於後、

一　Tingia carbonica n. comb.

枝分腹背兩面、在印痕上約有三至八公釐寬葉之外形、似羽狀複葉、有大小兩種、各成二行、其在枝之下面二行者大舖張成平面形、在枝上作四十至六十度角、葉長有達十公分者、葉底寬闊、葉尖分成三五裂片、作楔形或三角形、在枝之上面二行者、葉較小、均與枝成銳角而向上端、葉尖亦分成三角形之裂片、葉脈甚細、入葉底時、即分爲二、直達葉尖、每裂片中、約有二或三以上之葉脈、參看附圖第一版、即知其葉之形態大小變率甚大、此種化石產山西陽曲縣陳家峪附近、在最高煤層之上、約一百五十公尺、在大羽羊齒 (Gigantopteris nicotianaefolia) 化石層之下、約七十公尺、至在唐山及河南發見者、其層次未明、若在湖南耒河一帶發見者、則常與大羽羊齒同屬一層、

二　*Tingia crassinervis* n. sp.

此爲新種植物化石、其葉序葉形等、均與上述者相似、葉亦有大小二種、各成二行、位於枝之上下兩面、惟其葉較前者長且寬、枝甚粗、在印痕上竟有十公釐寬、葉之長者有十公分、葉底闊、葉尖分成不規則之裂片、長約二公釐、葉脈亦較粗、入葉底時、其數約有八、均分岐直達葉尖之裂片中、附圖第二版第一圖所示、尙爲其一部、兩端均未保存、長已達二十七公分、其最闊處爲十三公分、葉近枝之上端者、長約九公分、由此而下漸短、其最短者、僅七公分、第二及第三圖所示者、其枝葉均較第一圖爲小、產地亦在陳家峪附近、但發見地點、其層次較前者稍高耳、

結論

本屬植物化石、其葉之外形、酷與 *Noeggerathia* Stenrb. 及 *Plagiozamites* Zeill. 之羽狀複葉相似、惟大葉二行

之外、尙有小葉二行、始知爲帶葉之枝、而非羽狀複葉、其較小之葉二行、非精細研究、不易察看、在 Noeggerathia 及 Plagiozamites 二屬中、其葉尖分裂較深、每裂片中、有多數葉脈、且葉之平行兩緣、生無數細齒、或竟細若毛髮、齒各有脈、若在丁其亞屬、則葉長而狹、常排列成四行、葉之平行兩緣、完全無齒、此其極大異點也、至其異狀之葉、則又於植物生理學上、頗有興趣、設葉因光線之反動力而變形、則葉之大者、其位置當在枝之下面、如是可得最適宜之光線作用、證之現今高等植物之有異狀葉者皆然、但考丁其亞屬生大葉之枝面、稍向內凹、則又似與一種永產植物、大葉浮水面、小葉沉水中者極相似、但今尙難直接證明、姑依上說、與陸地植物之有異狀葉者相比擬焉、其餘理論當詳載古生物誌山西古生界植物篇中、

湖北宜昌興山秭歸巴東等縣地質鑛產

謝家榮
趙亞曾

一、緒言

民國十三年十月、榮等繼續調查湖北全省地質。本屆範圍、爲鄂西宜昌興山巴東施南等十二縣。劉君季辰、因病未能出發、乃由地質調查所另派趙君亞曾、共同調查。於十月二十一日由漢口搭輪至宜昌、二十六日開始調查、先自宜昌北行經黃家場羅惹坪等處、該處地層完備、化石豐富、故研究稍詳。預定計劃、本擬東至遠安、更繞道北行經通城河後坪殿家坪等處、而達興山、乃因後坪一帶、匪氛極熾、旅行不便、不得已改由霧渡河沿川漢路赴興山、復自興山而秭歸巴東。是時適北京政變、全國騷然、川鄂之間、軍事佈置、尤形嚴重、榮等本定由巴東赴施南、再由施南取道北大路返宜昌。至是因種種障礙、無法進行、不得已遂搭民船返宜昌。計前後調查約一月有半、茲將觀察所得、縷述如左。

二、地形

本區域當川鄂交界、宿以崇山峻嶺著稱、其地形爲一少年至中年時代之侵蝕高原、據氣壓計約測、其高度約在一千至一千五百公尺左右。山脈大致成南北向、而稍偏向東。宜昌方面之河流、以黃柏河爲巨幹、自界嶺埡發源、始向東南、繼爲西南、薈合衆川至宜昌入江、流域所經、深入山地、川漢鐵路、即利用其平緩之坡面而築焉。興山秭歸巴東方面之河流、以香溪吡溪及龍河爲最大、南流入江。香溪與黃柏河之分水嶺、在界嶺埡、照氣壓計測算、約高距宜昌八百公尺、至於山巔之高度、當在一千至一千五百公尺之間。以上皆大江以北之河流也。至於江南諸河、以萬石河紗鎮溪爲最重要、不在本屆調查範圍之內、故略焉。

上述各河之位置、俱依構造為轉移、故經流方向、皆約略與地層走向相平行、分水之界、大致與背斜軸相合、因之其生成時代、當在背斜層掀起之後、換言之、即地質學上所謂後成河者是也。惟長江則獨能穿越此叢山峻嶺之背斜層、絲毫不因構造之阻碍、而變其自東而西之經流方向、此則談鄂西地形者、所當重視者也。關於宜昌附近長江發育之歷史、北大教授李四光先生、曾有所討論、載中國地質學會誌第三卷第三四期。仝人此次調查、於江北各山、曾經研究、沿江地質、則因從水路順流而下、未及致察、對於李氏結論、未能有所貢獻、深為遺憾。惟最近在施南等處、觀察地文上之變化、似與長江發育歷史頗有關係、以非本篇範圍之內、故不贅、當俟作施南報告時詳論之。

就岩石種類與地形之關係言、片麻岩片岩及花崗岩質地堅固、不易剝蝕、故呈雄偉之山形、位於宜昌大背斜層之中部、而為黃柏香溪二水之分水嶺焉。震旦系之石灰岩、富於矽質、剝蝕亦難、成層既厚、且具有垂直之節理、一經風化、即成孤立之危岩絕壁、往往高達四百公尺、頂底則尖削如筍、風景至為美觀。沿黃柏河上流、及興山兩河口等處、絕壁深溝、皆此岩所組成。奧陶紀石灰岩下部富於砂質、成二三公尺之厚層、其質性與震旦系灰岩相似、故有時亦成絕壁、惟遠不如震旦系之雄偉。在興山東北黃家台一帶、奧陶紀灰岩與震旦系灰岩幾成連續之絕壁、惟中有二百餘公尺厚之寒武紀頁岩、以為之界、故尚易辨別。至奧陶紀灰岩之上部、則含矽既少、成層亦薄、頂部更富泥質、山形頓呈平緩之狀。志留紀頁岩、質弱易蝕、類成低山、如羅惹坪廣大平緩之山形、即其例也。惟其頂部及上中部之硬頁岩及砂岩、往往成峭壁。巫山石灰岩層厚質堅、夙以成絕壁著稱、但無垂直之節理、故不成孤峯、此其與震旦系相異者也。中生代之巴東系在巴東附近之露頭、最為完備、山高約七八

百公尺。其中岩質甚雜、有堅密之灰岩、有鬆弱之頁岩、所呈地形、因之亦不一律、但層次較薄、故未見有成峭壁者。香溪含煤系質性鬆弱、受蝕後俱成低山、在香溪谷中、觀察最明、該處西爲歸州系、東爲大冶石灰岩、俱成高山、而煤系位於二者之間、獨成低窪之山形。歸州系中之岩石、更爲複雜、其中砂岩礫岩、有時質地堅密、亦成峭壁、惟大致俱呈平緩之山坡、山之高度、平均在一千公尺左右。

此外鄂西地形上當注意之事實、即沿江一帶偉麗絕倫之峽、與波濤洶險之灘、我國自古以來、載諸詩人吟咏、文家筆記者、不勝枚舉。考峽之生成、俱河流侵蝕之力、而尤與其岩質有關。在宜昌巴東間、經過峽甚多、其大者爲巴峽、在巴東之西、地層屬巫山石灰岩、長數十里、上與四川巫山縣之巫峽相連、爲各峽中之最長者。至香溪之東、有米倉峽、長不及數里、而兩岸絕壁高聳、形勢雄偉、江水中流、宛如小溪、風景之美、殆無倫比、其地質亦屬巫山灰岩。米倉峽之下三十里、爲牛肝馬肺峽、地質屬震旦系灰岩、雄偉不逮米倉。再下至南陀宜昌間、爲宜昌峽、長約三十里、兩岸俱奧陶紀灰岩、傾斜甚平、山勢亦低、江面至此亦略寬、故雄偉更不逮牛肝馬肺。以上所述、共有五峽、然我國詩人之所謂三峽者、乃以牛肝馬肺與米倉合而爲一稱中峽、巫山巴山爲上峽、而宜昌爲下峽也。大抵峽俱發育於岩質堅韌之地層內、如巫山石灰岩之質密層厚者、最易成奇偉之峽、震旦系及奧陶紀灰岩次之、若其他岩層、則未見有峽也。至於灘與地質之關係、則適相反。灘者、乃江中爲碎石所阻塞、水流不暢、因而湍急成波濤洶湧之狀、舟行至此、頗爲危險、上行之舟、尤以須逆浪而行、難於抵抗、故非雇多數民夫拉縴不可。攷灘之生成、大抵因附近岩質鬆疏、風化之後、崩解成塊、乃從小溪流入江中、日積月累、遂致壅塞水流、而成兇險之灘、故灘之位置、往往在一小溪之口、如洩灘叱灘新灘等是也。石灰岩中、雖偶有灘、而灘俱不大。最易

成灘之地層、爲歸州系巴東系新灘頁岩及片岩片麻岩等、蓋此項地層、大致爲頁岩砂岩等所組成、質地鬆疏、易受侵蝕、且各層強弱之度不等、如強者位於弱者之上、而弱者先受江水之冲刷、則上部之強者、亦將因虛懸而終至崩解。凡此條件、皆合於灘之生成、故無怪灘之多也。若石灰岩則質既堅密、而各層強弱之度、又不甚懸殊、故岩石崩解之機會少、而灘亦不易成矣。巴東宜昌之間、所歷灘無數。巴東以西有娘娘灘將軍灘青竹標、巴東以東、有橫梁灘洩灘、俱在巴東系地層範圍之內。各灘皆兇險、而尤以洩灘爲最。嘗在該處見一運貨之船、雇拉縴夫二百餘人、各竭力從事、而船爲湍浪所撞、竟不能動一步、歷數小時而仍未能上、後以用力過猛、斷一縴索、由此可見洩灘之險惡矣。秭歸附近、灘甚多、如叱灘坳灘碎石灘俱在歸州系地層之內、而皆不甚大。香溪東之新灘、險惡僅亞於洩灘、係在新灘頁岩範圍之內。自新灘以下、遂入片岩及片麻岩區域、灘雖多而不甚險、如崆岭灘獺洞灘無義灘等、皆面積不廣、水流雖急、而普通運貨之船、有數人拉縴、即能措置裕如矣。

三、地層系統

前震旦系

片麻岩結晶片岩及花崗岩系

此次路線所經、穿過太古界岩層者有二。自南沱至崆岭灘一帶、太古界岩石性質較爲整齊。南沱黃陵廟一段、概爲白色花崗岩。及至三斗坪以西、則花崗岩內之角閃石漸呈有定向之排列、而成片麻岩、但其外觀仍與花崗岩相似也。崆岭灘一節、則岩石忽變爲結晶片岩、以角閃及雲母片岩爲主。關於本路線岩石之分佈、李仲揆教授論之頗詳、茲不重贅。

自宜昌縣霧渡河以東起至興山縣兩河口附近止、亦爲此次路線所經太古界地層分佈之地。此帶岩石變質甚深較爲複雜、且岩石性質因地變更、彼此關係頗難斷定。大致言之、亦可別爲三類、分述之如下。

(一)片麻岩　分佈最廣、種類亦多。有呈粗粒或細粒結晶之別。片麻岩石理以在界牌埡及楊家小廟一段爲最發達。自楊家小廟至霧渡河一節、則逐漸變爲花崗岩。

(二)結晶片岩　最普通者爲雲母片岩及角閃片岩兩種。每與片麻岩相雜出。片狀石理之傾斜頗急、走向東北西南、與大江者同。在堆積於路旁之石塊中、每見有含渾圓砂粒之片麻狀岩石、極似成於水成岩。

(三)花崗岩　路線所經、大塊之花崗岩似不多見。霧渡河以東、震旦系之下、悉爲一灰白色花崗岩。內含石英長石雲母等礦物、結晶粗細不等。兩河口東北於南沱冰磧層之下、亦見有含紅色長石之斑狀花崗岩、結晶頗粗。

以上三類岩石之分佈及其相互之關係、因旅行忽促、未及詳考。大致言之、則花崗岩皆係後來侵入者。至於片岩之成因、就其與片麻岩互相雜出頗似水成岩之逐層變更、及其包含之渾圓砂粒、極似造成砂岩之質料觀之、似至少界牌埡以西之片岩及片麻岩爲古代砂質岩變質而成。然此僅係片面之理想、非待精密研究後、未可據爲定論者也。此外尚有各種之侵入岩脈、如輝綠岩斑岩偉晶花崗岩等等、種類繁多、茲不具述。

古生界前之不整合

太古界變質岩之上、即直接覆以層叠清楚之南沱系、二者成不整合之接觸。其交接處在崆嶺灘附近大江北岸、露出頗清。傾斜甚急之變質岩上、呈一平整之侵蝕面、直接蓋以南沱系之基底礫岩層。愈上卵石愈小、漸變

爲粗砂岩。礫岩中之卵石均爲石英或花崗岩等所成。形狀圓滑、概皆屑小、顯然來自下面之變質岩系。由此觀之二者之關係絕非侵入之接觸、乃太古界岩層經過侵蝕之後、始有古生界岩層之停積。至於因侵蝕而欠缺之岩層有多少、以在宜昌一帶古生界以前之地層尚未有詳細之攷察頗難斷定、但其時期似極久遠、則可斷言云。

古生代

古生代岩層在三峽一帶極爲完全、除泥盆紀外餘皆有海洋式停積之代表。其分類如下（英文第一九頁第一圖）

震旦紀
- 南沱系……八——八〇公尺
- 燈影石灰岩……六〇〇——六五〇公尺

寒武奧陶紀
- 石牌頁岩……三五——二〇〇公尺
- 宜昌石灰岩……一一〇〇公尺
- 艾家山層……約一〇〇公尺

志留紀
- 新灘頁岩
  - 龍馬頁岩……四〇〇公尺
  - 羅惹坪系……六〇公尺
  - 紗帽山系……三二五公尺

巫山石灰岩｛陽新石灰岩……………五〇〇公尺
　　　　　｛大冶石灰岩……………一三〇〇公尺

震旦紀

南沱系

南沱系在南沱附近最爲完全。據李四光教授計算、總厚約八十餘公尺。與太古界變質岩成不整合之接觸。底部有基底礫岩層、中部概爲紅色粗砂岩上部爲冰磧層。冰磧層之形狀極易辨認。全層皆爲一種極軟之黃綠色泥質物、內含大小不一排列無定之石塊。保存完全者上刻有無定向之條痕。蓋當最古之時、該處氣候嚴寒、常年冰結、冰挾石移、因劃爲種種溝紋、一如現在之冰川也。大多冰磧石塊、皆爲花崗岩等所作成、但其中亦間見有成於石灰岩者。關於此點頗耐尋味。吾人知在宜昌一帶、冰磧層或直接即覆蓋於太古界變質岩之上、或中間隔以一粗砂岩層。無論何處均未見有石灰岩層介其間。則灰岩石塊之存在非來自遠方、即代表本地侵削之結果。若然、是冰磧層未作成以先、他處或本地總有一石灰岩系之存在也。

據此次調查結果、南沱層愈北愈薄。例如在興山縣兩河口附近、冰磧層之厚度只有八公尺。雖其下部與太古界變質岩接觸之處不得見、但不可見者亦只在二三尺之間、其間絕無厚砂岩層似可斷言。至於更北是否並冰磧層而亦無之、則以足跡未至須俟諸後日解決之。

燈影石灰岩

維理士氏調查沿江地質時、統名南沱系以上新灘頁岩以下之石灰岩系（中間實夾有一頁岩層）曰雞心嶺石灰岩、而以之屬於寒武奧陶紀。其後野田氏雖將維理士之地質圖加以改正、並名其下部之石灰岩系曰牛肝石灰岩、但其時代仍未能確定。本年春李四光教授等始由其地層上之關係及藻類化石 Collenia cylindrica Grabau 之存在、斷定其與北京附近之南口系相當。其時代因得證明確屬於葛利普博士所改正之震旦紀。

此次調查路線所經、穿過燈影石灰岩者凡四次。一、馬廻坪至霧渡河。二、兩河口至黃家台。三、牛肝峽之東端。四、燈影峽。凡此四處、燈影石灰岩之厚度及性質均大致相同、惟在牛肝峽內薄層石灰岩似較他處者爲厚而且清晰耳。

燈影石灰岩之下部、似與南沱冰礦層成不整一之接觸。岩石以薄板狀石灰岩及灰質板岩爲主。層叠分明狀如叠板平常暗灰至黑色間呈灰紫色。黑色板狀石灰岩內含扁圓狀之凝結物頗多最爲特別。本部岩層與上面厚層石灰岩之劃分頗難。其層叠每逐漸加厚、漸趨入於厚層石灰岩中。故其岩石性質雖稍有不同、但似亦無劃分之必要。厚度未得詳細測定、約在一百公尺以上。

燈影石灰岩之上部概爲層叠不淸之石灰岩。內含矽質頗多、性脆、間含燧石薄層。以鎚擊之、多破碎成帶尖稜之石塊、以手擦之、頗粗澀觸人之肌膚。平常淺灰色、但久經風雨之侵蝕、堆積於河谷內之石塊、則概呈白色。以其層叠不淸也、故多成懸崖絕壁、峭立千尺、上覆以尖銳之峰尖。遠觀孤峯特立青色蔚然者皆是也。因此、其化

石雖不易搜尋、其形狀實易於辨認。共厚約五百五十公尺。

寒武與陶紀

石牌頁岩

威理士等調查時以行程過促無暇詳究、誤以本層露出於宜昌峽者爲新灘頁岩。其後野田氏始改正之、而名之曰下部粘板岩層、但彼對於其地質上之時代亦無供獻。李四光教授等因在石牌以東之天河板下採集有三葉虫 Redlichia 頗多因命名之曰石牌頁岩、並斷定其與山東之饅首頁岩相當同屬於下寒武紀。據云、該處岩層共厚約二百公尺。

按此次調查結果、石牌頁岩愈北亦愈薄。如在馬廻坪共厚只有三十五公尺。經長時之搜尋、亦未得有化石之痕迹。全體均爲黃綠色頁岩所作成、僅在附近河谷內見有豆狀石灰岩一小塊。下與燈影石灰岩交接之處常被土掩、但二者之走向傾斜均完全如一、並無不整合之迹。總之、即令二者中間有一間斷、其關係亦非可目睹而只可意會、一如中國北部饅頭頁岩之於震旦系也。

在大背斜之西翼、如興山縣之黃家台本層較馬廻坪者大厚、但亦只有一百六十公尺、仍較石牌者稍薄。下部爲深灰色頁岩、概破碎成碎片散佈於山坡。中部爲黃綠色頁岩、內含頗硬之砂質薄層。頁岩內有時雲母薄片頗多灼灼發光。上部概爲砂質頁岩、每與宜昌石灰岩同成峭壁。過此時恰遇天雨採集爲艱、雖費二時之時間、只得有不能確實鑑定之腕足類化石一種 Eoorthis。

在黃家台石牌頁岩下與燈影石灰岩及上與宜昌石灰岩之關係示如第二圖、(見英文第二七頁)其岩層次

序如下。

1 燈影石灰岩、層理不淸概成峭壁、

2 灰色頁岩易於破裂成碎片、

3 黃綠色頁岩內含砂質薄層、上部則概爲砂質頁岩、

4 珊瑚(Archaeocyathinæ)海藻(Girvanella)及豆狀(Pisolitic)石灰岩之互層……一四公尺

5 綠色頁岩……一〇公尺

6 薄層石灰岩、上部含珊瑚及海藻頗多……四二公尺

7 薄層石灰岩……七八公尺

8 綠色頁岩……四公尺

9 薄層石灰岩　以上未測

以上諸層2至3爲石牌頁岩4至9屬宜昌石灰岩

宜昌石灰岩與石牌頁岩之關係

日人野田勢次郎測量湖北地質圖時、在興山縣後坪附近、於平善壩石灰岩(即宜昌石灰岩)之底層採、有數塊極破碎之珊瑚、經矢部長克博士之鑑定、謂其與撒丁尼亞(Sardinia)下寒武紀內者幾完全相同、因推想至少平善壩石灰岩之下部應隸屬下寒武紀。珊瑚名稱爲Coscinocyathus cf. cancellatus Bornemann、但彼同時又以海藻化石Girvanella sinensis Yabe代表奧陶紀。本年春、北大調查團在宜昌石灰岩之底部採集有保

存完全之珊瑚甚夥、並尋見多量之海藻 Girvanella sinensis 與珊瑚同生於一層。是矢部長克之謂珊瑚代表寒武紀、海藻代表奧陶紀者、顯然由於化石層位置之不詳。

本層內所產之珊瑚種類甚多、屬亦各異但皆屬於古盃珊瑚科 (Archæocyathinæ)。最普通者厥爲一種 Spirocyathus 暫名之曰 Spirocathus hupehensis Chao (sp. nov.)。按屬於古盃珊瑚科之珊瑚分佈甚廣、如撒丁尼亞、蘇格蘭、美國拉布拉多(Labrador)之明幹島(Mingan Island)紐約尼瓦打(Nevada)、西伯利亞、印度、及澳大利亞等處。世人均以其時代屬於寒武紀或下寒武紀。但就近來之研究、產於明幹島之古盃珊瑚層實非寒武紀而爲下奧陶紀(見葛利普中國北部奧陶紀化石)、直隸臨楡產之古盃珊瑚亦屬奧陶紀。且凡在上述之產古盃珊瑚之區、其岩層之次序、似均未有詳細之研究。寒武紀三葉虫抑與古盃珊瑚同生於一層、或上下相隔成不整一之接觸、亦無記載。故古盃珊瑚之是否只限於寒武紀頗有疑義。作者此次調查即特別注重此點、但結果則宜昌石灰岩下與石牌頁岩之關係如何、仍難斷定。古盃珊瑚及海藻 Girvanella 並不限於一層、實則與豆狀石灰岩及薄層石灰岩相間、中間並夾有綠色頁岩一薄層。石灰岩中復含有三葉虫之碎片頗夥。石牌頁岩既確屬於下寒武紀、今若以珊瑚層歸之於下奧陶紀、則其間應有一大間斷、其大甚至包有上及中寒武紀之全部。但珊瑚層與石牌頁岩接觸之處毫無侵蝕之迹、且珊瑚石灰岩與薄層石灰岩相間並中夾頁岩及豆狀石灰岩、一若完全整合然。珊瑚石灰岩與薄層石灰岩內復時夾有三葉虫之碎片。若以珊瑚石灰岩等歸之於下寒武紀、則與所見事實不符者亦不少。吾人知在中國北部中及上寒武紀地層皆爲數百公尺之石灰岩所作成、內含三葉虫極富、有時層叠幾均爲其介殼所作成。在安南雲南一帶、情形亦大致相同。宜昌既

居安南及中國北部之中、自亦屬印度太平洋區。如無上及中寒武系則已、有則其情形亦必與前者大致相似。但本年春、北大躬與調查者凡十人、竟於珊瑚層之上未採有其他之化石。作者二人自宜昌至興山路上曾穿過本層者凡二次、亦未見有三葉虫之痕迹。所經岩層固有時爲土所掩、或因他故不及逐層推敲、然其情形如與山東及安南者相髣髴、似亦不至不見其零星碎片。此以珊瑚層屬於下寒武紀之極難解釋者也。

總之石牌頁岩上面侵蝕證據之欠缺、珊瑚層內與其上面薄層灰岩內三葉虫碎片之存在、以及宜昌石灰岩之巨大厚度等、似均代表石牌頁岩與宜昌石灰岩之中間並無間斷而爲一連續的沉積。至於珊瑚層以上三葉虫之欠缺或由於攷察之未詳、或由於宜昌石灰岩代表一特別之海相、其中不適宜於三葉虫之生存、或由於珊瑚層之上有一間斷、中部及上部寒武系完全缺掉。三者何者爲是何者爲非、則非現時所可解決、而須待將來詳細之研究。但無論如何、宜昌石灰岩之下部或僅其珊瑚層似應仍屬寒武紀也。

宜昌石灰岩

野田氏名之曰平善壩石灰岩、謂其厚只有四〇〇公尺。李四光教授改名之曰宜昌石灰岩、推算其總厚約在一二五〇至一六八〇公尺之間。此次自黃家台至黃粮坪路上測算之結果亦厚約一一〇〇公尺。則宜昌石灰岩之厚、必在一千公尺以上似無問題。

宜昌石灰岩之底部爲薄層灰岩與珊瑚灰岩相間已如上述。珊瑚之多有數層全爲彼等之骨骼所作成、一若近代之珊瑚礁然。其分佈頗廣、凡宜昌石灰岩之底層無處無之。珊瑚層以上薄層石灰岩與厚層者相間、間含燧石結核。於其中部曾見有類似海藻之圓形物 Cryptozoa、除此之外、中部及下部尚未得有其他之化石。經

拗曲作用挾於厚層石灰岩中間之薄層者常皺成種種之小彎曲。上部概爲層叠較厚之石灰岩。在距艾家山層約五六公尺之處有一頗富之化石層(loc. 831)。在羅惹坪以西所採集者含有下列諸種。

Batostomella antiqua Yabe

Orthis (seral species)

Eccyliopteris sp.

Proterocameroceras matheui Grabau

Proterocameroceras matheui 之産生概受風化作用暴露於岩面。其環形凸起完全蝕去、更蒙以霉斑、外觀之一如黑色之棍條、及在實驗室內刻去其附着之岩石、始克現原來之面目。P. matheui 首先發現於直隸開平之下奧陶系、其後東南大學徐君更得之於南京附近之崙山石灰岩。在羅惹坪所採集者似與直隸者稍有不同、但與產於崙山者則完全如一。據葛利普博士大略之鑑定、謂暫時無妨視之與直隸產者相同、詳細鑑定俟之後日。其餘如腕足類 Orthis 之介殼猶爲衆多、常排列成層。但石質堅硬、採集較難耳。此層分佈極廣、艾家山層之下無處無之、如羅惹坪奇草壩黃猻坪及建陽坪等處。本年春李四光教授等在南津關所尋覓之化石層即此層也。

在建陽坪之東本層與艾家山層之關係及其岩層之次序如下，

1 青灰色石灰岩、含 Eccyliopteris

2 薄層狀青灰色石灰岩、含 Proterocameroceras 極多……………………………………一四公尺

3 薄層狀青灰色石灰岩、無化石…………四公尺

4 灰綠色灰質頁岩、稍夾薄石灰岩層、含 Triplecia poloi 及其他之化石…………二〇公尺

5 薄層狀灰色泥質石灰岩、呈結核狀構造、間夾黃灰色頁岩及細密狀灰紫色純灰岩、後者含三葉虫甚多、泥質灰岩內產寶塔石尤富…………三四公尺

以上1至3為宜昌石灰岩、4至5為艾家山層。

宜昌石灰岩雖厚但抵抗侵蝕之力似遠不逮燈影石灰岩及巫山石灰岩、故所作成之山嶺概較後二者為低。又以石牌頁岩過薄、對於山形上無若何之影響也。故遠觀之一若與燈影石灰岩同成一系然。然其層疊之清晰、下接以石牌頁岩所作成多少之緩坡、亦易於與峭壁直立層疊不清之燈影石灰岩區分也。

艾家山層

昔威理士等自秦入川沿大甯河長江而下時、曾於彼等所謂雞心嶺石灰岩之上新灘頁岩之下、見有一黃綠頁岩及薄層灰岩系。以其地層位置及岩石性質皆介居二者之間、且在徐家壩首先發現多量之化石、因名之曰徐家壩過渡層。據 Weller 鑑定化石之結果、時代屬於上部中奧陶紀。

野田勢次郎調查湖北時、誤以本層歸之於新灘頁岩、即彼所謂之上粘板岩系也。但新灘頁岩與本層之岩石性質及所含之化石皆迥然不同、二者不但不可以歸之於一系、而其間復有一所謂不整一者在焉。

前者西人某曾在新灘東北六七里之艾家山一帶、採有化石極多、轉贈於調查所、並附有一簡略之切面圖。此等化石顯然與威理士等所採集者同來於一層。當時葛利普博士以三峽一帶地質之調查尚屬幼稚、且艾家

山化石之多、保存之美、頗應得標準地 (type locality) 之美稱、因特名之曰艾家山層以誌不忘。本年春李四光教授等更在該處測有較詳之切面、採有多量之化石、於是艾家山層之名乃充滿於調查所與北大地質系而威理士首先命名之徐家壩層反落選矣。

此次調查曾稍事考察本層者有三處、卽羅惹坪之西、黃猴坪之北及建陽坪之東。凡此三處其情形皆大致相同、厚薄似亦相等。

建陽坪之切面已如上述、在羅惹坪岩層之次序如下。(參閱英文第三二頁第三圖)

1 青灰色石灰岩、內含 Orthis, Eccyliopteris。

2 青灰色石灰岩內含 Orthis 甚多。

3 青灰色石灰岩、在距艾家山層五六公尺之處含化石頗多、如 Proterocameroceras 及 Batostomella 等

(以上屬宜昌石灰岩)。

4 黃綠色灰質頁岩中夾灰岩薄層、含化石極富如 Triplecia, Cycloceras 等。

5 黃綠色灰岩間夾黃綠色灰質頁岩、含大小不一之 Orthoceras chinense 極多、(以上屬艾家山層)。

6 龍馬筆石頁岩。

就上二切面觀之、艾家山層大致可分爲二部。上部以石灰岩爲主、厚約二十至三十公尺、層薄、含泥質甚多、並時夾頁岩薄層。色平常黃綠、間呈紫色。在分鄉塲至羅惹坪之路上、曾見有一種青紫色細緻石灰岩夾於含寶塔石灰岩層中、其上滿充以三葉虫之介殼、其多無異於產於山東之九龍系者、當時頗以爲奇、及測建陽坪

切面時、於寶塔石石灰岩之內又見之、三葉蟲之多及岩石之性質一與前者同。但在此二處其岩石皆過於緻密堅硬、無法擊碎、又以行程急促、覓人爲難、致使大好化石、失之交臂殊可惜也。除此之外、土質灰岩內含寶塔石 Orthoceras chinense Foord 極多、小由數寸大至數尺者到處均有。間亦有 Discoceras eurasiaticus Frech 及 Cyrtoceras 等、但爲數無多、祇在黃家塲之南、珠寶山之下採有數塊。由黃家塲至羅惹坪之大路大致與寶塔石石灰岩與龍馬頁岩接觸處相符、故鋪路之石板上、圓角狀之寶塔石觸目皆是、天然之剖面極爲美觀、其中以在分鄉塲街道者爲尤悅目。自此以西漸歸絕迹。及至黃糧坪之東北、鋪路之石板上寶塔石又出現。故欲知艾家山層之有無、一觀其鋪路之石板即可大概想知矣。

下部以頁岩爲主、厚約二十至三十公尺。岩石爲黃綠色泥質薄層石灰岩及黃綠色灰質頁岩之互層。含化石極富、保存亦極完全、單個之介殼每散漫於山坡、其中尤以 Triplecia 爲最夥。在羅惹坪之西採有下列諸化石 (loc. 830)。

Triplecia poloi (Martelli)

Orthis calligramma Dalm.

Clitambonites giraldii Martelli

Clitambonites chinensis Weller

Dalmanella cf. testudinaria Dalm.

Dalmanella (several species)

Eccyliopteris sinensis Erech

Cyrtoceras sp.

Endoceras sp.

Vaginoceras sp.

Cycloceras sp.

Orthoceras sp.

在建陽坪之東本層時被土掩、未作詳細之採集、僅得有下列數種化石。

Clitambonites giraldii martelli

Orthis sp.

Cycloceras sp.

Endoceras sp.

Orthoceras sp.

艾家山層之時代屬於中奧陶紀之上部與中國北部之馬家溝石灰岩（即珠角石石灰岩）爲同時之堆積、但代表二隔絕之生物羣。本層之分佈頗廣、意人 Martelli 首先述之於陝西之秦嶺、維理士等更見之於大寧河之徐家壩等處、去年在鄂省東南部大販石灰岩上部所尋覓之化石層即此層也。

志留紀前之不整一

凡志留紀頁岩之底部。皆爲一黑色薄頁岩層、內含筆石頗多、下與艾家山層接觸之處似不見有侵蝕之痕迹、一若完全整合然。但就鑑定化石之結果、則其間應有一大間斷、其欠缺之時間包有上奧陶紀之全部。此等形式之間斷、乃爲中國所常見者、亦無足怪也。

志留紀

新灘頁岩

維理氏等統名巫山石灰岩以下徐家壩過渡層以上之頁岩砂岩系曰新灘頁岩。彼等在新灘頁岩內並未得有化石、其採集於東官口者顯然來自巫山石灰岩之底層而非來自頁岩內。以其位置恰居奧陶紀及石炭紀之間也、彼等因推想其時代大致爲志留泥盆紀。

自調查所遷移視線於中國南部後、大江一帶之志留紀地層乃驟放光明。李四光教授等於新灘頁岩之底部發現一筆石層(龍馬頁岩)。劉謝兩君於調查鄂省東南之陽新及西北之京山時、更在與新灘頁岩位置相當之富池口頁岩內尋得一極富之三葉虫 Coronocephalus 層。王竹泉君復發現本化石層於江西。雖由地層上之次序觀之、鄂省東南之富池口頁岩與江西西北之崖山下頁岩應與新灘頁岩爲同時之堆積、但總缺化石上之證據。且三葉虫層之上尚有數百公尺未得有化石、則此部抑同屬於志留紀或代表大陸式泥盆紀停積之一部頗難斷定。此次調查將此問題完全解決。在東湖縣北八十里羅惹坪附近、於新灘頁岩之上部、不只尋見三葉虫 Coronocephalus 更發現在中國尚未發現之化石多種。

志留紀岩層之性質既因地不同、化石復隨處而異、故此處之命名礙難應用之於他處。欲救其弊、則莫若名全

系爲新灘頁岩、但關於某一區之詳細層序則無妨應用本地之地名以代表之。例如在羅惹坪一帶、新灘頁岩可爲三層、下爲龍馬頁岩中爲羅惹坪系、上爲紗帽山層。在建陽坪一帶則亦有下面之龍馬頁岩而無羅惹坪系。

此次路線所經新灘頁岩出露之處、一爲背斜層東翼之黃家塲分鄉塲羅惹坪等處、一爲西翼之黃狠坪建陽坪新灘等處。茲分述之如下。

在羅惹坪一帶

新灘頁岩之出露於黃家塲者只有其下部、上部似均被侵蝕剷去。其上即直接覆以鄂中紅砂岩系之基底礫岩層成不整合之接觸。自黃家塲北行、新灘頁岩漸完全、及至羅惹坪乃臻於極盛。羅惹坪位居新灘頁岩之中、東臨巫山石灰岩之高山、西望宜昌石灰岩之峻嶺、中間擴爲一大低谷。於其東北五六里之紗帽山曾作一切面、下起艾家山層上至巫山石灰岩、其岩層詳細之次序示如柱形圖(見英文第三十五頁第四圖)分述之如下。

1 黑色板狀頁岩、緊接寶塔石石灰岩者爲數寸厚之黃色頁岩不含化石、再上色較黑、至中上部色最黑含筆石化石亦最富、再上爲黃白色頁岩。共厚……七公尺

2 綠色薄頁岩、易破裂成薄片散布於山坡、顏色有時深綠有時黃綠至黃色、無化石。……三五〇公尺

3 綠色頁岩。成厚層狀、與上下頁岩之界限皆不分明似遞嬗漸入於無化石之頁岩中、含化石雖不甚富、但種類則頗多(loc. 824.)……一二公尺

4 黃綠色薄頁岩、易於破碎成碎片、無化石。……一五公尺

5 黃綠色厚層輭頁岩含化石頗多 (loc. 825)。……一公尺

6 黃色薄頁岩、無化石。……二五公尺

7 薄層石灰岩與黃色頁岩之互層。化石以 Halysites 及 Favosites 爲主 (loc. 826 A)。……一〇公尺

8 黃色頁岩內含灰岩石塊、產化石頗多、如珊瑚及 Pentamerus 等 (loc. 826 B)。……一〇公尺

9 黃色頁岩內夾灰質層、化石以單體珊瑚及單個之腕足類爲最多 (loc. 826 C)。……一四公尺

10 黃色頁岩、間含砂質及灰質頁岩、化石甚少。……二四公尺

11 灰色純石灰岩、含 Pentamerus 頗多 (loc. 827 A)。……四公尺

12 黃色頁岩、富灰質結核、常爲珊瑚虫所造成、含化石頗多 (loc. 827 B)。……三五公尺

13 黃色薄頁岩、易於破裂成碎片、無化石。……一五公尺

14 灰綠色頁岩、無化石。……二〇公尺

15 綠色砂質頁岩、內含三葉虫及腕足類等化石 (loc. 827 C)。……三公尺

16 薄層綠色輭頁岩、無化石。……二四公尺

17 灰綠色砂質頁岩內含化石之碎片 (loc. 827 D)。……一〇公尺

18 灰色頁岩及砂質頁岩之互層、多成峭壁、無化石。……一七〇公尺

19 灰或白色硬砂岩、組成陡壁。厚約……三〇公尺

20 黃綠色輭頁岩、……………………………………………………………………二〇公尺

在羅惹坪東約十里之五龍觀下、本系又露出、該處岩層之次序示如剖面圖(第五圖)。

1 黃綠色軟頁岩

2 黃綠色厚層頁岩一薄層、內含 Encrinurus rex Grabau 等化石顯然與紗帽山剖面中之5相當。

3 黃綠色軟頁岩、無化石。

4 薄層石灰岩及頁岩之互層、內夾 Halysites 及 Favosites 頗多。……………………二公尺

5 黃色灰質頁岩含化石頗少、產於本層之 Pentamerus 概皆體積細小、大不過產自上層者三分之一。……
……………………………………………………………………二〇公尺

6 灰色珊瑚石灰岩一薄層、間含腕足類化石、……………………………………一公尺

7 黃色灰質頁岩、內含 Pentamerus 極多、常排列成層、其被水冲出於地面者、到處皆是。…………四五公尺

8 灰色純灰岩一層。……………………………………………………………四公尺

9 綠色硬頁岩、有無化石未詳細攷察。

本剖面內之4至8顯然與紗帽山剖面中之7至11相當。至於以上是否亦有化石層如紗帽山、則以時間急促未容詳攷。

總上觀之、就其岩之性質及化石之分佈、本處新灘頁岩可分之爲三部。

下部　龍馬頁岩。　本層所含岩層相當紗帽山剖面中之1至6、共厚約四百公尺。底層爲一厚僅七公尺之

黑色頁岩、含筆石頗多。其上漸變為一極厚之綠色頁岩、當新鮮時如露出於河谷之兩旁者、本頁岩呈厚層狀深綠色。當久經風雨之侵削、則概呈黃綠色破裂成碎片散布於山坡。上部四十公尺以內有化石層二、與不含化石之頁岩界線不分明。於其下化石層內、亦見有筆石之存在。因此種種、故其厚雖達四百公尺、而實與底部之黑色頁岩同代表一筆石層、即龍馬筆石頁岩是也。

中部　羅惹坪系。　本系概為薄層石灰岩與灰質頁岩及黃綠色頁岩所作成、共厚約六十二公尺。含化石甚富、以珊瑚為主。本系相當紗帽山剖面中之7至10。

上部　紗帽山層。　下部概為綠色頁岩、內夾砂質層、含有化石。中部砂質漸多、時組成陡坡。上部有石英質砂質一層、厚約三十公尺。上與巫山灰岩接觸之處、為一黃色軟頁岩。本層共厚約三百三十公尺、與紗帽山剖面中之11至20相當。

新灘頁岩內之化石

龍馬頁岩　自珠寶山至羅惹坪之大路恰與艾家山層及龍馬頁岩交接處相符、故路旁之黑色頁岩內無處不有筆石之痕迹。但頁岩受風化較甚、作成筆石之炭質物多為破毀、頗難得完美者。

在珠寶山之下黃家場之西及分鄉場村邊所採集之化石、據孫雲鑄君之鑑定、含有下列諸種。

Lingula.sp

Climacograptus cf. tornguisti E. & W.

Climacograptus hsiehi Sun

Climacograptus chaoi Sun

Petalograptus palmeus S. S. (Barrande)

Petalograptus sp. nov.

Monograptus sp. nov.

Glyptograptus serratus var. nov.

於羅惹坪西北之紗帽山剖面中、在距黑色頁岩約三百五十公尺之處、有一薄黃綠色頁岩、層厚僅二公尺、即剖面中之3 (loc. 824)。內含化石頗多、以圓球狀之 Favosites nucleolatus 爲最多。在岩層之侵蝕面上、復見有黃色之筆石化石積聚於一處、頗爲美觀。據葛利普博士大致之鑑定、含有下列諸種。

筆石　Monograptus marri perm.

Monograptus sp

Climacograptus cf. scalaris His.

Cephalograptus cometa

珊瑚　Enterolasma sp.

Favosites nucleolatus Grabau

Heliolites interstinctus var. Yangtzeensis Grabau

腕足　Stropheodenta ? sp.

頭足　Dawsonoceras sp.

三葉虫　Encrinurus (Coronocephalus) rex Grabau

Proetus latilimbatus Grabau

Bronteus cf. partschi Barr.

海百合　Crinoidal stems (coiled)

本層上十五公尺之處、復有一化石層、厚只一公尺、即剖面中之5 (loc. 825)。岩石顏色較前者稍黃、層疊亦較厚。二者相距雖祇有十五公尺、而所含之化石、除一二種散見於各層者外、頗有不同之處。而尤奇者即其中之種類、頗有帶奧陶紀之彩色者。本層化石以三葉虫爲主、腕足類化石雖亦常見、但多保存不全頗難命名、葛利普博士暫先鑑定者有下列數種。

珊瑚　Enterolasma sp.

三葉虫　Coronocephalus rex Grabau

Harpes veneulosa Curd var. sinensis Grabau

Illænus asaphoides Grabau

Acidaspis octospinosa Grabau

腕足　Dalmanella testudinaria Dalm.

Triplecia cf. grayiæ Davidson

本化石層以上再經二十五公尺之無化石黃色輭頁岩、即入於下述之羅惹坪富化石系。

羅惹坪系　本系內之化石種類既繁多、保存復完美。單個之珊瑚及介殼滾落於山坡者比比皆是。就其岩石性質及化石之分佈、本系似又可分為三部。下為薄層石灰岩與頁岩之互層厚十公尺即剖面中之7。化石以複體珊瑚 Halysites Favosites 及 Heliolites 為最多、而尤以鏈珊瑚 Halysites 為最特別。故可簡稱之為鏈珊瑚層。中部為夾灰質凝結物之黃色頁岩厚十公尺即剖面中之8。化石以單體珊瑚 Pselophyllum zaphrentiforme 為最多、且上下均無之、故名之曰 Pselophyllum 層。其餘如 Palæocyclus, Platyphyllum, Glassia, Trochonema 等亦極衆多、而為本層之標準化石。上部為三十公尺之黃色頁岩、間含砂質及灰質層。化石以圓柱狀之 Cystiphyllum 及 Microplasma 為最特別、下二層內均未見之。因名之為 Cystiphyllum 層。複體珊瑚雖中上兩層亦有之、但為數極有限、即上面之紗帽山層似亦有其踪跡也。形狀奇異之 Pentamerus borealis (俗名鷹子嘴) 尚未見之於下部、中上二層則極普遍。總此三層內之化石、經葛利普博士鑑定者、有下列諸種。

珊瑚　Palæocyclus fletscheri E. & H.

Pselophyllum zaphrentiforme Grabau

Cyathophyllum chaoi Grabau

Platyphyllum minor Grabau

Cystiphyllum cf. placidum Barr.

Microplasma poilon Grabau

Halysites cf. cratus Eth.

Halysites hupehensis Grabau

Favosites gotlandicus Lam.

Favosites tachlowitzensis Barr.

Favosites tachlowitzensis var. lentiforme Grabau

Heliolites bohemicus Wentzel

Heliolites megastomus

Heliolites interstinctus var. yangtzeensis Grabau

Heliolites decipiens M'coy.

腕足 Pentamerus borealis Eichwald

Conchidium tenuiplicatus Grabau

Glassia obovata Sow. var. magna Grabau

Strinoklandinia transversa Grabau

腹足 Trochonema depressa Grabau

葉腮 Orthonota antelonga Grabau

頭足 Orthoceras sp.

海百合　Crinoidal stems (straight)

在羅惹坪東五龍觀之剖面中、4至8之化石層顯然與紗帽山剖面中羅惹坪系相當、惟所含化石之多寡大相懸殊。在後者單體珊瑚及腕足類Glassia obovata var. magna成千累萬、極爲繁多但在前者則單體珊瑚較少、腕足類 Glassia obovata var. magna 只得一個、而 Pentamerus borealis 乃取二者之位而代之。在4層中 Halysites 及 Favosites 頗多、一與紗帽山剖面內同。本層之上漸有 Pentamerus borealis 出現、惟其體積極爲細小。及至上部之黃色頁岩內、長至數寸之 Pentamerus 乃達於極盛。Pselophyllum zaphrentiforme Gr. 爲數不多只限於中部。Cystiphyllum cf. placidum 亦爲上部所特有、情形與紗帽山同。總其各部之化石、約有下列諸種。

珊瑚　Pselophyllum zaphrentiforme Gr.

Cystiphyllum cf. placidum Barr.

Halysites cf. cratus Eth.

Halysites hupehensis Gr.

Favosites gotlandicus Lam.

Favosites tachlowitzensis Barr.

Heliolites interstinctus Linné

Heliolites bohemicus Wentzel

腕足 Pentamerus borealis Eich.

Pentamerus. cf. esthonus Eich.

Pentamerus (Conchidium) tenuiplicatus Gr.

Dalmanella elegantula Dalm.

Glassia obovata var. magna Gr.

紗帽山層　羅惹坪系頂層純灰岩之上、卽緊接以厚約三十五公尺之黃綠色頁岩、內含化石雖不甚富、但其種類多與上述之珊瑚層內者不相同、而反與起先之三葉虫層中者多相似。此種事實似代表當珊瑚生物羣將沒之時、原先之三葉虫 Encrinurus 生物羣復又侵來、故本生物羣跨有前二者之攙合的彩色也。據葛氏大略之鑑定、本層含有下列諸種 (loc. 827 A, B)。

珊瑚 Enterolasma sp.

腕足 Pentamerus borealis Eich.

Conchidium tenuiplicatus Gr.

三葉虫 Encrinurus rex Gr.

本層三十五公尺以上復有一綠色砂質頁岩層、厚三公尺、卽剖面中之15 (loc. 327 C)。所含化石尤與龍馬頁岩內之三葉虫層內者相似、其種類如下。

珊瑚 Enterolasma sp.

腕足 Dalmanella sp.

Stropheodenta shörnsdenensis Kayser

Nucleospira pisiformis Hall

Retzia cf Rh. borealis var. sinensis Kayser

三葉虫 Encrinurus rex Gr.

Proetus latilimbatus Gr.

自此更上二十四公尺、有厚約十公尺之灰綠色砂質頁岩一層、即剖面中之17 (loc. 827 D)。內含化石之碎片、頗難得能確實鑑定者。

自此以上二百餘公尺其岩石性質與下面化石層絲毫無別。徒以行程急促未曾詳細攷查、但就其形狀觀之其中極似有化石之存在也。

在黃狼坪建陽坪及新灘一帶

凡此三處新灘頁岩之岩石性質均大致相同。底部為黑色頁岩、厚只數公尺、內含筆石化石。中部為黃綠色或綠色頁岩、易於破裂成碎片。愈上砂質愈多、漸變為砂質頁岩及砂岩。在黃粮坪因斷層而上部被覆、未得考查。在建陽坪及新灘、則上部砂岩層厚約百公尺、其上更有白色石英狀硬砂岩一層、居巫山石灰岩之下、厚約五十公尺。在黑色頁岩之上尚未發現化石、惟其確無羅惹坪之富珊瑚化石層則可斷言。三葉虫 Encrinurus 屬似可存在、其未得尋見者想係考察之未詳耳。

時代及比較

凡在羅惹坪新灘頁岩內發現之化石、不與歐洲下志留紀內者屬同種即與之極相近、故新灘頁岩之屬下志留紀毫無疑義。

昔李希霍芬調查中國地質時曾於秦隴川交界處之高昌壩附近、見有志留紀岩層露出頗全。據李氏之研究及近來葛利普博士之改證、該處岩層可分為三段。上為趙店層、岩石以綠色頁岩為主、常夾灰質結核塊、化石以腕足類為最多、有 Strophomena Schlörnsüenensis Kayser, Nucleospira pisiformis Hall 等。中為前水（譯音）石灰岩、岩石概為泥質石灰岩、含珊瑚化石極富、有 Favosites, Heliolites, Halysites, Cystiphyllum, Platyphyllum 等。下為黃柏峪（譯音）系、為紅色石灰岩與頁岩所作成、含化石不富、多為腕足類。就上述化石之分佈情形觀之、則該處剖面中之趙店層及前水石灰岩恰與吾等之紗帽山層及羅惹坪系相當。二地遠隔千百里而化石竟多屬同種、此化石之可貴而業地質者之極力搜尋也。高昌壩剖面中黃柏峪系與羅惹坪剖面中龍馬頁岩內之化石雖截然不同、但二者實仍代表同時之堆積。其化石所以不同之故、乃由於二者屬於不同式之堆積。黃栢峪系之岩石概為石灰岩及頁岩、則其作成應在海水較深之處。龍馬頁岩則概為黑色及綠色頁岩、並富含筆石化石、故其形狀實代表一古三角洲式之停積。海水較深之區筆石化石不能保存、造成三角洲之地其餘生物鮮能存在、此二系內化石之所以不同也。與龍馬頁岩屬同式而且同時之堆積厥為雲南永昌府南之施甸筆石層。二者既均有黑色頁岩、復同屬於歐洲之 Monograptus sedgiwicki 級、惟在施甸黑色頁岩為較厚耳。若然、則當時鄂西雲貴一帶豈皆為濱海三角洲堆積之區、西北行漸趨入於海洋之域乎。

據王竹泉君、江西之崖山頁岩厚達二千餘公尺、三葉虫之產生約在其頂下三百公尺之處、則該三葉虫層似非吾等龍馬頁岩上部之三葉虫層、而實爲紗帽山層內之下部者。又鄂東富池口頁岩內之三葉虫層產於其中下部、就其位置而言、似與崖山頁岩內者非同層、而大致與龍馬頁岩上部之三葉虫層相當。然此不過片面之理想、精確之比較尚須俟之他日之詳細調查也。

凡羅惹坪系之富化石層在鄂省東南及黃猄坪建陽坪新灘一帶均未見之、則當時海浸顯係由高昌壩沿現在的黃陵背斜之東翼浸來、形成一狹長之海灣。此等事實乃地史上所常見亦無足怪也。

石炭紀前之不整一

巫山石灰岩下與新灘頁岩交接之處、在羅惹坪爲一種黃色輭頁岩。在建陽坪及新灘一帶則爲一頗厚之石英岩、其間更似有一極薄炭質層中隔、據本地人云間夾有煤層。在上述諸處、二者之接觸線概爲土掩、無法考察、惟其岩層之走向及傾斜、皆完全如一。但據化石上之證據、其間實有一大間斷、因間斷而欠缺之時間包有下石炭紀之大部泥盆紀及上中志留紀之全部、幾與中國北部石炭紀以前之間斷相抗衡、亦云偉矣。

石炭紀至二疊紀

巫山石灰岩

威理士等統名新灘頁岩以上巴東系或香溪煤系以下之厚灰岩系曰巫山石灰岩。彼等在本層內所採集之化石既有限、而來自何部復不明、據蓋爾載氏(Girty)之鑑定、謂全部應皆隸上石炭紀。其後野田氏改名之曰米倉石灰岩、更分之爲三部。下曰兵書石灰岩、中曰硅質石灰岩、上曰寶劍石灰岩。但彼對於各層之時代仍未

能確定。

野田氏之寶劍石灰岩及硅質石灰岩實屬一系、岩層性質逐漸變更、並無劃分之界限。巫山石灰岩之下部卽野田氏所謂兵書石灰岩者、則與上部截然不同、全體多成厚層狀、富含燧石結核。據吾等觀察所及、此等性質到處如一、故巫山石灰岩可分爲二部如下。

- 巫山石灰岩
  - 下部—陽新石灰岩
    - 下部……石炭紀
    - 上部……下至中二疊紀
  - 上部—大冶石灰岩……上二疊紀

此次路線所經巫山石灰岩出露之地凡五處、一分鄉塲至羅惹坪之東、二黃猴坪之西、三大峽口至建陽坪、四官渡口至巫山峽、五米倉峽。此五處之內、黃猴坪至興山路上、巫山石灰岩之下部恰因斷層而被覆、不適宜於研究。米倉峽之剖面、曾經北大同人詳細考查、亦無須重敍於此。本報告所述者只有其餘之三處。

羅惹坪

陽新石灰岩　野田氏宜昌地質圖、黃家塲至羅惹坪以東一帶、只畫有新灘頁岩。但據此次調查、則新灘頁岩之上實尙有頗厚之燧石石灰岩、卽上所謂陽新石灰岩者是也。本地只見其下部、至於上部存在與否、則以足跡未至、不敢確定。本處岩石性質一與他處同、色灰、層厚、含燧石結核頗多、間排列成層。東與當陽遠安中隔之高山、卽爲本層所作成。在羅惹坪東十五里之土地岩、於散佈於山顚之石塊內、採有下列二化石。

Fusulinella sp.

Lonsdaleia chinensis Girty

石灰岩之底部、間含不連續厚薄不等之煤層、現有人用土法開採、但其絕無經濟上之價值可斷言。

吾等知在大背斜之西翼、如香溪一帶、巫山石灰岩之上莫不有上二疊紀之含煤系。在宜昌西十五里南津關一帶、宜昌石灰岩之上卽直接覆以紅砂岩系之基底礫岩層。凡所謂艾家山層、新灘頁岩、巫山石灰岩者均付缺如。及至宜昌北五十里之黃家場、則艾家山層及新灘頁岩又復現。至分鄉場甚至巫山石灰岩之下部卽陽新石灰岩又現出。由此知南津關一帶岩層之欠缺、並非由於原來之未停積、實原於大背斜隆起之後、該處至少有一極強之大河系（古揚子江）將其上部岩層完全削去。由此推想、地層旣愈北愈全、則遠安一帶未嘗不可有大冶石灰岩及香溪含煤系之可能。若然則遠安其亦有煤系如香溪乎。但自遠安之北至襄陽一帶古漢水之侵蝕力似亦甚偉大。則上述之陽新石灰岩之產於羅惹坪一帶者、再往北去或復被侵蝕殆盡、亦未可知。總之、遠安襄陽一帶非本次調查範圍、將來赴西北時不難解決之。

大峽口至建陽坪

大峽口居香溪水之西岸、其東有支流自兩河口建陽坪等處來會、亦即川漢鐵路所經之地也。此河穿過黃陵大背斜之西翼、爲觀察地層次序測勘厚度最便之地。沿河之北岸巫山石灰岩之次序示如第六圖。（英文第四十八頁）據測算之結果、巫山石灰岩共厚一八〇〇公尺。

陽新燧石石灰岩　據本年春李四光教授等在米倉峽所採集之化石、來自燧石石灰岩之最上層者屬於中二疊紀。但採自下部墜落於山根之石塊中者則屬下石炭紀之最上部。作者在野外調查時、即特別注重此點、

思有以劃分之。結果、雖未得有一確實之分界線或不整一、而下部之二百公尺以內則似均屬棲霞山層、上部之三百公尺則確屬二疊紀。

本系位於新灘頁岩內石英質砂岩之上、全部厚五百一十公尺、均爲含燧石之青色石灰岩所作成。上下兩部概皆呈厚層狀、燧石多成結核、散見於各層中。在其中部約距底部二百公尺以上之處、有一節層疊頗薄含燧石甚多、概排列成層。此節之露出於北岸者靠近河坡之處、恰爲土掩、無法研究。其露出於河之對岸者、則薄層灰岩之下似有一極軟之層、經風雨之侵蝕腐爛而成一溝。至於其是否代表上下兩部之不整一線、抑爲一煤層、或即平常之灰岩層、以河流中隔、無法渡越、不敢一定。

在其下部散佈於山根之石塊中、曾見有黑色頁岩之碎片、內含化石。就其位置而言、此種頁岩顯然來自距底部一百公尺以上及二百公尺以下之灰岩內。其岩石性質、似代表燧石石灰岩之下部、亦有不規則之煤層夾於中也。

本系以概成絕壁、採集化石誠非易事。然如有適宜之沿層理之露頭、或在其墜落之石塊中、採集亦誠易易。

在建陽坪之西、陽新石灰岩之最底層採有下列數種化石。

Fusulinella sp.

Syringopora sp.

Michelinia favositoides Girty

在羅惹坪土地岩所採集者、顯然即來自本層也。

在下部之散見於山坡之黑色頁岩中、亦得有腕足類一種。

Productus grandicostatus sp. nov.

凡上面所述之化石、均來自陽新石灰岩之下部。

在距底部約二百二十公尺之處、於滾落之石塊中曾採有 (loc. 836)

Neoschwagerina sp.

Amplexus sp

Productus sp. aff. P. palliatus (Kayser)

Productus cf. punctatus Martin

於距頂部約百餘公尺之石塊中、亦曾採有有孔虫類之化石。但自此以上、則岩層之內似確無有孔虫類介殼之存在。

於本系之頂層內、在廟坪村東、曾得有下列三化石。

Oldhamina cf. depeciens Konink

Productus gratiosus Waagon

Reticularlua waagoni Lo'czy

大冶石灰岩　位居陽新石灰岩之上、其岩石性質之驟變、及化石截然之不同、頗似中間有一不整合。在興山以東大峽口對岸及萬古寺等處、本系與香溪煤系成直接但不整一之接觸。此外大槪爲香溪水所切隔香溪

煤系出露於河西而本系則見於河東焉。本系所成之山高約七八百公尺、其西面山坡之斜度適與地層傾角相合。卽地形上所稱之 Hogback。北自興山南達香溪、此類地形幾整齊如一、變更甚少、亦頗堪注意者也。

本系共厚約一千三百公尺。上部爲層叠清楚之青色純灰岩、多成峭壁。下面層叠漸薄、間夾灰質頁岩之薄層、多呈拗彎之薄板狀。下部頁岩愈多、層叠亦愈薄、遠觀之一若均爲硬頁岩然。但本系下面之陽新石灰岩則層叠甚厚、含燧石頗多、二者劃分之線極爲明瞭。二者本彼此上下相接、而其岩石之性質竟相差若是、殊可異也。

在大冶石灰岩之下部、距陽新石灰岩約三十公尺之處（露出於廟坪之北山坡上）有灰黑色頁岩一薄層、厚僅數寸、中含葉腮類化石。惟所含不多、且層叠過薄、頗難得完美者。經葛氏之鑑定、謂屬新種、名稱爲

Pseudomonotis chaoi Grabau

官渡口至巫山峽

威理士等三峽地質圖上、在楠木園畫有新灘頁岩、於楠木園之滿西、畫以奥陶紀宜昌石灰岩（即威氏雞心嶺石灰岩之上部。）在 Research in China 中。彼更作有一由巫山縣至官渡口之剖面圖。作者此次親至該地、始知威氏等之地質圖及剖面圖完全錯誤。在楠木園並無新灘頁岩、彼等所謂新灘頁岩者實即大冶石灰岩下部之薄層灰岩及頁岩層、楠木園以西、彼等所謂奥陶紀石灰岩者、實即大冶石灰岩之一部。蓋巴東至巫峽地層本均走向東西、傾斜北向、但受種種局部的小摺曲之影響、頗顯複雜。自官渡口至楠木園一節、地質構造爲一小背斜、此背斜層之軸約在火燄石附近、故下面之陽新石灰岩只在後者至楠木園一節露出一小部分、而除此以外均爲大冶石灰岩也。

陽新石灰岩　陽新石灰岩之露出於本地者、只有其上部、其分佈區域、亦僅限於火磣石至楠木園一節、出露於火磣石者、燧石特別衆多、概排列成層、火磣石之名即原於此。於其頂部、在楠木園曾採有下列諸化石。

Lyttonia richthofeni (Kayser)

Productus gratiosus Waagen

Productus cf. cora d'Orb.

Productus yangtzeensis Chao sp. nov.

Productus abichi Waagen

Marginifera lopingensis (Kayser)

Martinia sp.

Pseudomonotis kazanensis Golookinsky

Aviculopecten sp.

Naticopsis klurensis Waagen

Entalis sp.

在江之南岸距頂部約百餘公尺之處、石灰岩中夾有煤層、現有人開採。於其附近之石塊中、曾見有有孔虫類化石。

大冶石灰岩　本系由官渡口至火磣石一節露出頗全。楠木園以西大江略與岩層之走向平行、作者雖至冷

水溪即返、但由其走向推之、似即西經巫峽至巫山縣、江之兩岸不致有老於巫山石灰岩之地層露出也。岩石性質與見於大峽口至建陽坪者同。惟該化石層則以時間迫急、未得窺探。

時代及比較

凡在羅惹坪及建陽坪陽新石灰岩底部所採集之化石、皆產於南京附近棲霞山石灰岩內。故二者代表同時之停積、毫無問題。據佛萊士(Frech)鑑定李希霍芬在棲霞山所採集之珊瑚化石之結果、謂其時代應屬於下石炭紀之最上部 (Viséen)。但彼只標出化石之名稱、既無圖說、復無描述、頗與人以難信之機會。惟在未有詳細研究棲霞山化石以先、吾人仍不得不從佛萊士之議而視之為下石炭紀也。

在廟坪及楠木園於陽新石灰岩頂部所採集之化石、按其地層之位置及化石之種類、皆與米倉峽內小新灘者同、最主要者如 Oldhamina, Lyttonia, Productus gratiosus, Marginifera lopingensis 等。其時期與印度之 Middle Productus limestone 及浙江之長興石灰岩相當。按印度 Productus limestone 之時代、久為討論之的。瓦岡氏(Waagen)雖將其研究化石之結果、滙為印度古生物誌五大卷 (Palaeontologia Indica, Productus limestone Fossils of Salt Range)、但對於其地質之時代、僅表示其大概屬於二疊紀。其後俄國古生物專家產迴都夫(Tschernyschew)研究烏拉山及天門之上石炭紀化石後 (Obercarbonischen Brachiopoden des Ural- und des Timan)、以印度與俄國所產者常有同種、因視印度之 Middle Productus limestone 與俄國之 Uralian 級相當、而同屬於上石炭紀。但近來學者概公認 Lower Productus limestone 為石炭二疊或上石炭紀、Middle Productus limestone 及 Upper Productus limestone 則屬二疊紀、更進而有視 Lyttonia 為中二疊紀之標準化

石之趨勢。據此、則陽新石灰岩頂部之屬中二疊紀毫無疑義。其採自距底部二百二十公尺石塊中之化石（在建陽坪大峽口剖面 Loc. 836）雖未經確實之鑑定、但確帶有下二疊紀之彩色。由此觀之、陽新燧石石灰岩之上三百公尺皆爲二疊紀。此三百公尺內頂部之一百公尺屬於中二疊紀、下面之二百公尺似屬於下二疊紀。

據上面所述化石之證據、陽新石灰岩之下部既屬下石炭紀、而上部復屬二疊紀、則其間應有一大間斷（平行不整一）其大甚至包有中及上石炭紀之全部。但在野外之觀察、二者竟岩石性質如一、毫無劃分之界限、殊可異也。然同時吾人尙須一顧另一面之觀察、即佛萊士之鑑定是也。按下石炭紀之產於中國北部者有甘肅新疆等處、產於南部者有雲貴湖南等地。凡此諸處、均有其標準化石之 Productus giganteus 或 Dibunophyllum 代表之。但在長江流域之棲霞石灰岩內、則無論何處均無此二化石。其解釋非棲霞石灰岩代表一特殊生物羣、卽其時代並非下石炭紀。如佛萊士鑑定棲霞化石之結果不可靠、而此珊瑚石灰岩實屬於上石炭或二疊石炭紀、則恰與吾人野外之觀察相符、即陽新石灰岩代表二疊石炭紀至中二疊紀時之連續的沉積。總之、上面所述純屬意測、在未詳細研究棲霞山珊瑚之先、吾人只好從佛萊士之鑑定、而承認陽新石灰岩中間有一大平行不整一在焉。

陽新石灰岩之分佈在大江一帶極爲普遍、如鄂東陽新大冶一帶之陽新石灰岩、安徽之葉山冲湖州及江蘇之棲霞山石灰岩。但其厚度則愈東愈薄、其上部屬二疊紀之岩層漸歸無有。例如在陽新共厚只有四百公尺、上部之一部變爲一煤系（炭山灣煤系）及至南京則厚度只餘百公尺左右、其上部之屬二疊紀者竟完全

缺掉。由此知當時海水係由西部浸來、及停積棲霞石灰岩（即陽新石灰岩下部之屬於石炭紀者）之後、乃漸向西退。東部突出海面之時、西部尚正在沉積之際、此西部岩層之恆較東部爲厚而且完全也。

中生界

維理士及勃拉克維德調查三峽地質時、統名巫山石灰岩以上之地層曰歸州系。彼等所採集之動物化石、經蓋爾戴氏之研究、謂其屬於二疊紀。但蓋氏曾聲明因化石保存不全及爲數無幾之故、如將來能有豐富之採集、其時代亦未可以不較二疊紀爲新。威勃兩氏未來中國以前、崩波來氏 (Pumpelly) 及李希霍芬亦曾在歸州附近採集有植物化石多種。紐卜瑞 (Newberry) 以之屬於上三疊紀之最上部 (Rhaetic)、申克 (Schenk) 則歸之於侏羅紀。其後經懷底氏 (White) 詳細之研究、始確定其屬於上三疊紀。因此、威理士等以含動物及植物化石層之關係如何既不可知、而統稱彼等所謂之歸州系之地質年代爲二疊中生代。

當威理士等調查宜昌地質時、適有奧本能氏 (E. C. Abendanon) 亦由川入鄂考察地質。奧氏所述之巫山石灰岩以後之地層之次序（六至九參見湖北地質礦產專刊第一號第八頁）、較威氏者稍詳、但奧氏並未採得化石、故每層之年代仍未能決定。

野田勢次郎當測勘湖北全省地質圖時、進而分巫山石灰岩以後之地層爲三系。

一洩灘雜色頁岩層……………………一〇〇公尺

二香溪含炭砂岩層……………………五〇〇公尺

三興山赭色砂岩層……………………未測出

猛觀之野田氏之分類似極詳盡、而詳考之實錯誤叢生。彼對於所謂洩灘頁岩者只見其一部、對於香溪系包有時代不同之地層過多、至於與山與香溪兩系之在何層劃分、竟令人百思而莫得一解。故其香溪以西之地質圖幾全無可取者、乃當然之結果耳。

本年春、李四光教授趙亞曾及北大學生等來宜調查地質、以時間急促、對於中生界地層未得詳究。但歸州系與香溪含煤系之關係及二者之時期均大略決定、亦未嘗不無小補也（參見地質彙報第五期下卷葛利普歸州系內之白堊紀化石。）

三峽間之中生代地層既向無精細之研究、故作者卽特別注重此點、因得對於前人之觀察多所發明。就其地層之次序及化石之證據、巫山石灰岩以後之地層實可分爲三段如左。

一巴東系		三疊紀
二香溪系	下含煤系	上三疊紀
	上含煤系	下侏羅紀
三歸州系		白堊紀

三疊紀前之不整一

巴東系與下面巫山石灰岩之接觸關係、在巴東縣城南山及縣西三十里官渡口等地觀察甚明、並均未見有削蝕之跡、或傾斜之不同。然岩石之忽由一厚純石灰岩變爲一紫色頁岩系、似代表當時停積之情形起變更、及證以本系之分佈而言愈信。自三峽以東下迄大江下游一帶、向未發見與巴東系同式之岩層。溯江而上至秭歸西四五里之沙鎭市、巴東系之紫色頁岩漸出現。及至巴東縣沿江一帶、本系岩層竟厚至八百公尺、幷中

間夾有頗厚之灰岩層。再西至四川之廣元縣、李希霍芬曾見有一厚雜色石灰岩系、不整合的覆於皺曲之新灘頁岩之上。李氏所見者顯然與本系屬同層、由此可見巴東系愈西愈厚而灰質亦愈多。其解釋爲當巫山石灰岩停積之後、海水退出經過若干時期、海水復從西南浸來、但未達鄂中一帶即行終止、故深海之區如巴東之西南等處能造成頗厚之灰岩及頁岩而宜昌以東以至大江下游一帶、則向來無巴東系之堆積也。由此可證明巴東之下或有一平行不整一在焉。

巴東系

日人野田勢次郎以本系中一部分之雜色頁岩及薄層石灰岩名爲洩灘雜色頁岩系、以出露於秭歸縣西洩灘得名。此次在秭歸巴東境內對於本系考察甚詳、在巴東對河山上曾採得化石多種、並探至其下與巫山石灰岩接觸之處。始知本系岩質甚雜、全層厚約八百公尺。野田氏所指抑僅爲其一部、或更含有香溪系之底部、頗難證明。蓋以野田氏圖上、香溪東岸之洩灘系大部皆係香溪煤系、其所指之香溪含炭砂岩層出露於香溪以西者、大部屬歸州系、其中並不含煤也。且出露於洩灘之雜色頁岩系僅有一小部、而復傾斜過急、無法研究。因此種種、洩灘系之名已不適用。以其出露於巴東者爲最完備也、特名之曰巴東系、以示巴東之地位恰適宜於研究巴東系之意焉。

巴東系之分佈頗易於研究。在香溪一帶不占重要之位置已如上述。但自秭歸縣西十餘里之沙鎭市、西經洩灘巴東至官渡口沿江之北岸、幾全爲巴東系所作成、蓋以大江略與秭歸以西之背斜層之軸平行故也、由白塔市至巴東一節、巴東系之露頭最爲完整、由巴東至官渡口一帶、則皺成若干之小摺曲。故江之南北紅光滿

目頗爲美觀。

(一)巴東縣剖面

本系岩石大部爲紫色頁岩、中夾綠色頁岩之薄層。在中部有一頗厚之灰色薄層灰岩及灰質頁岩系、在頂部亦有一薄灰色石灰岩及頁岩層、其上即直接覆以香溪系之基底粗砂岩。化石之產生僅限於石灰岩內、頁岩中向未見有化石。在巴東縣城對河山上、自上而下之剖面示如第七圖(英文第五五頁)

1 大冶石灰岩

2 紫色頁岩中夾綠色頁岩及灰質砂岩之薄層。下與巫山石灰岩接觸之處、爲黃綠色薄頁岩、厚僅數公尺。此部分佈於大江兩岸準確厚度未詳。但在大江北岸山坡所測者厚約一百八十公尺、若假定河床所掩者厚五十公尺、則得總厚……二三〇公尺

3 灰色石灰岩、質純層略厚、間成結晶狀、中夾質鬆而受蝕甚深之灰質岩石、及綠色灰質頁岩薄層。共厚……一六〇公尺

4 堅密質黃灰色石灰岩一薄層、厚只一尺。但其分佈則頗廣、如白塔市巴東及由巴東至官渡口之路上均有之。中含化石頗多、而種類則頗少、化石之產生、多在受風化之表面上呈種種之橫切面、以錘擊之概沿無定向而破碎、極難得完美者。

5 綠色頁岩泥灰岩及純石灰岩之互層。厚……一五〇公尺

6 紫色頁岩、稍夾綠色灰質頁岩之薄層。……二五〇公尺

7 本層在此處之露頭多爲石塊所掩。在外面露出者只有石灰岩一層、厚約二十公尺。其下與紫色頁岩是否隔以他種岩石抑直接接觸、及其上與香溪系之基底砂岩有何關係均無法探知以是不得不由他處之層序比較之。

8 灰色及黃色之不純質砂岩、於下部含煤一層、夾於頁岩中、此層當屬下述之香溪系。

以上自2至7皆屬巴東系、總厚約八百公尺。其中部所含之化石幾全爲腕足類 Spiriferina 及數種保存不完之葉腮類。

(二)洩灘剖面

在秭歸縣西二十五里洩灘村下之溝中、本系上部露出極明、自下而上之層次如左。

1 紫色頁岩中夾綠色頁岩及砂質頁岩之薄層、底部未露出能觀察者約厚、……一七〇公尺

2 綠色頁岩。……七公尺

3 薄層灰色石灰岩、間含頁岩薄層。……二九公尺

4 綠色頁岩、每含砂質及灰質之結核物。……二一公尺

5 至8 香溪含煤系。

如巴東系已停積之後香溪系未作成之先、秭歸巴東間一帶並未受若何之侵創、則本剖面中之2至4似與巴東對岸之6相當、1與5相當。惟洩灘附近地質之構造爲一緊密之背斜層、且地臨大江觀察不便、故紫色頁岩以下之地層未得詳究。

又自洩灘至石門道中、在江之北岸於香溪含煤系之下、常見有薄層灰色純灰岩、有時與黃綠色頁岩相間爲層、顯然與洩灘剖面2至3相當於石灰岩中曾得有孔虫類化石頗似屬於Textularidae、及腕足類之剖面。惟以石質堅靱、未得完美者。

時代及比較

總上觀之、巴東系雖厚達八百公尺、但所含之生物羣似極缺乏、且向無標準化石之發現、故其年代究屬何時、頗有可討論之價値。

關於化石方面　凡維理士等所採集及作者所携歸之化石、非過於破碎、即屬新種、其所代表之屬、古生中生兩代皆可有之。蓋爾戴氏之謂其屬於二叠紀者、純以Dielasma之殼內有二齒板(dental plates)。按Dielasma之鑑定、在腕足類中極爲困難、且其生活時期、下起泥盆紀、上達中生代、即令有完美者、古生物家尙每難恃之以定地層之年代、何況維氏所採集者、過於破碎、不足以供鑑定之用乎。即蓋爾戴氏亦謂帶齒板之Dielasma不祇限於古生代、中生代內亦時有之。其餘如Aviculopecten ? richthofeni Girty及海百合莖等、更無論矣。故蓋氏之說、似無充足之證據。作者在巴東對岸所採集之化石、以Spiriferina爲最多、且最完備、不幸彼等皆屬新種、然其形狀適與二叠紀內者不同、反與喜馬拉雅山三叠紀內者較相近。至於葉腮類之化石、對於中生代之關係、較前者尤爲明瞭。其保存雖不全、古生代內常見之屬(Genus)無一似之者。是巴東系內之動物羣較帶有三叠紀之彩色也。雖然、三叠紀內之標準化石、如菊石(Ammonites)等、何以經幾次之搜尋、並未見有絲毫之踪跡、頗與人以難自信之機會、於是不得不由地層方面之觀察以證實之。

關於地層方向　大冶石灰岩（巫山石灰岩之上部）在三峽一帶共厚不下一三〇〇公尺、直接覆於含 Lyttonia 生物羣之燧石石灰岩之上、僅在其底部數十公尺以內發現有 Gastrioceras 等。其餘二疊紀內常見之化石、如 Oldhamina, Lyttonia, Productus 等竟完全絕迹。又在印度 Salt Range 之 Productus limestone 中、Oldhamina 等產於其頂部。後之學者每視該層為上或中二疊紀。由此觀之、是我人歸大冶石灰岩全部為上二疊紀、已覺何以上二疊系之在中國竟有如此之厚、且其生物羣何以如此之特別、今若更歸厚八〇〇公尺成不整一接觸之巴東系仍為上二疊紀、恐愈將趨入迷途、百思而莫得一解矣。

總上兩方面觀之、巴東系之屬於三疊紀似無問題。至於其屬於三疊紀之何部、則以化石之證據不全、分佈之區域不知、須俟之後日解決之。

香溪系與巴東系之關係

在香溪一帶、巫山石灰岩之上有時似直接即覆以香溪含煤系、如大峽口之對岸、有時似隔以一薄紫色頁岩層、如白馬灘之河谷。自沙鎮市至巴東縣一帶、則香溪含煤系之下概為一頗厚之紫色頁岩及灰岩系、即上所謂巴東系者也。香溪西距沙鎮市只不過二十餘里、而在前者巴東系或完全欠缺、或只有數公尺、在後者則巴東系厚至數百公尺。在如此短距離之內、岩層厚薄竟差至數百公尺、其解釋自非一簡單之前進覆蔽（transgressive overlap）所能包容。而巴東系在香溪之驟然減薄、甚至完全欠缺、至少大部由於後來之侵削。此侵削最烈之區、又恰與香溪谷即黃陵背斜層之西翼相符。此等事實似代表當巴東系停積之後、黃陵背斜即開始上昇、當時因有黃陵背斜所作成之高山中隔、故背斜以西諸水均向西流、於是將香溪一帶之巴東系完全或

大部蝕去。至於沙鎭市巴東一帶之巴東系岩層、則以距黃陵背斜較遠、未受若何之上昇、因得保存。經此侵削期之後、香溪含煤系方堆積於該地。由此觀之、香溪系與巴東系之間、至少在香溪一帶應有一大間斷在焉。

香溪煤系

香溪煤系以出露於香溪水得名。在興山秭歸巴東三縣內分佈頗廣、凡歸州系之下巫山石灰岩之上如响灘市香溪窰灣溪一帶（在黃陵背斜之西翼即歸州向斜之東翼）或巴東系之上如登子石洩灘石門牛口鎭巴東一帶（在歸州向斜之西翼卽巴東背斜之北翼）莫不有之。經詳細之研究、按其岩層之次序及化石之不同、香溪系可分爲上下二含煤系中間隔以一頗厚之砂岩礫岩層。在香溪一帶、二煤系多無連續之剖面、欲究其關係頗費搜尋、只在鹽拐子之南及大峽口之對岸、二煤系中間之礫岩砂岩層約略可辨。在秭歸縣西一帶、其關係最爲分明。如在登子石、下煤系之基底砂岩層與二系中間之砂岩礫岩層、因抵抗侵蝕之力較強、均作成隆起之山脊、二煤系之石質較輭、槪成溝渠。一脊一溝之地形、上下二煤系之關係、極易於辨認。在洩灘（參見英文五七頁第八圖）雖只有基底砂岩及中間砂岩礫岩層露出、但二者之上均有一煤系、可由其上均有煤窰以爲證也。在石門、二煤系之關係尤爲清晰、不過此處下含煤系之含煤頁岩竟薄至兩三公尺、本地所採之煤均來自上含煤系、爲他處所罕見耳。其岩層次序如左（參見英文第六〇頁第十圖）

1 綠色頁岩及石灰岩、下部沒於大江中（巴東系）

2 灰色軟質粗砂岩……………………二四公尺

3 黑色及灰色頁岩……………………三公尺

(2至3 香溪下含煤系)

4 白色石英質砂岩及礫岩……三〇公尺

5 綠色砂岩、中夾黑色頁岩及煤層、在下部之黑色頁岩內、採有 Cyrena 及植物化石、(香溪上含煤系)……一〇〇公尺

6 暗色砂岩(歸州系)

下含煤系　下含煤系之厚度似因地不同、平常約在五六十公尺之間。下與巴東系相接之處爲一灰色粗砂岩質頗鬆軟、厚約三十公尺左右。上部槪爲黃綠色頁岩砂質頁岩黑色頁岩及薄層砂岩之互層。在香溪一帶、此部含煤層頗多、並有保存完美之植物化石多種、惟多淹沒於香溪中。在游家河附近香溪之北岸、本系之上部露出頗完、其岩層之次序如左(英文第五十九頁第九圖)。

1 砂岩、底部沒於香溪中。

2 黃綠色砂質頁岩、頂上有砂岩一薄層。……二公尺

3 深灰色頁岩、間含砂質薄層。……二・八公尺

4 灰色砂岩、內含植物化石 Podosamites 頗多。……一公尺

5 灰綠色頁岩、頂上含煤一層。……二・三公尺

6 灰綠色頁岩、內含砂質薄層、植物化石極爲豐富、葉脈之清晰一如今日者。……一・四公尺

7 厚層砂質頁岩、上部含煤一層。……二・三公尺

8 薄層灰色砂岩上部土掩。

下煤系內含煤頁岩之次序所知者只有此十餘公尺。底部之1是否即基底砂岩層、頂上之8是否卽中間之砂岩及礫岩層、頗難斷定。惟在大峽口之對岸、下煤系岩層之次序雖無法攷查、但砂礫岩層之距巫山石灰岩只不過四五十公尺則可斷言。在登子石、含煤頁岩似亦頗薄。是含煤頁岩之最大厚度、在香溪一帶亦不過二三十公尺也。

砂岩礫岩層　嚴格論之、本層實爲一粗砂岩、質堅色白、時帶淡綠色、呈石英岩狀。在登子石其上部爲一灰色之輭砂岩、共厚約二十五至三十公尺。所含卵石概見於中部。其分佈情形毫無規則、有時積聚於一處作成極顯著之礫岩、如露於石門者是。平常則概聚爲多少不同形狀無定之扁豆體、旁出不遠即歸絕迹、或代以含卵石稀少之砂岩。更有時砂岩之內含卵石甚少、猛觀之一若全層均爲砂岩然。卵石之質料幾全爲黑色燧石所作成、顯然係來自陽新石灰岩內之燧石核、間亦有爲白色石英所作成者。大小頗均勻、普通長約半寸至一寸、形狀圓滑、毫無尖稜、與現在河谷者絲毫無二。凡煤田內堆積於山坡河谷之大塊礫岩、幾全來於本層也。

總上述事實、本層顯然代表一河流式之停積、其卵石均曾經長時之冲刷。即當下煤系停積之後、有一部分巫山石灰岩突出地面（似卽現在之黃陵背斜）、經河流之侵削、殘蝕殆盡、甚至將其下部之陽新石灰岩亦侵蝕若干。石灰岩性質較輭、未達香溪一帶卽歸消磨無餘、燧石較硬、因得獨存、此所以礫岩之內幾全爲燧石之卵石也。由此觀之、上下兩煤系之間其亦有一所謂不整一者乎。

上含煤系　本系共厚約二百公尺左右。下與下含煤系接觸處隔以一厚砂岩礫岩層、上與歸州系交接處亦

隔有一厚粗砂岩層。全體岩石以綠色砂岩爲主、內夾綠色頁岩及黑色頁岩之薄層。於其上部曾見有煤苗兩層。在香溪一帶、以其恒高出水面也、故開採者尙不少。於其下部之黑色頁岩內、曾採有淡水葉腮類 Cyrena 及保存不甚完全之植物化石。此奇異之淡水葉腮類雖爲數無多、其分佈則頗廣、如在登子石沙鎮市之對岸及石門等處皆見之。

時代及比較

下含煤系內含植物化石極爲衆多、且最爲完美。崩波來及李希霍芬兩氏所採集者、顯然大部來自此層。近來經懷底氏之研究、時代確屬於上三疊紀之最上部、即 Rhaetic、惟崩李兩氏採集化石時、對於岩層之次序均未作詳細之研究、則其中之一二種或者來自上含煤系亦未可知。此次在游家河附近第六層內（見剖面九圖）所採集之化石、經周贊衡君大略之鑑定、含有下列諸種。

Podozamites lanceolatus (Lindl. & Hutt.) Schimp.

Pterophyllum sp.

Dictyophyllum nilssoni (Brongn.) Göpp.

Cladophlebis sp.

Taeniopteris tenuinervis Brauns.

Sphenozamites sp.

上含煤系內之化石多產於下部之黑色頁岩內。在登子石沙鎮市之對岸及石門所採集之化石共含有下列

諸種。

Podozamites lanceolatus (Lindl. & Hutt.) Schimp.

Pterophyllum aequale (Brongn.) Nath.

Phoenicopsis sp.

Taeniopteris tenuinervis Brauns.

Dictyophyllum nilssoni (Brongn.) Göpp.

Cladophlebis cf. denticulata (Brongn.)

Sphenopteris sp.

本系化石雖與下煤系同種者尚屬不少、惟其確有其自己之特種、不見於下煤系。最特別者厥爲一種葉肢類之小介、似屬於 Cyrena 、凡上煤系露出之處莫不有之。下含煤系既屬三疊紀之最上部、上含煤系復與之隔以一頗厚之礫岩層、是後者定較上三疊紀爲新。因此種種、上含煤系之時代似非上三疊紀所仍可包括。又下白堊紀在歐美含煤層雖極普遍、在中國則發現尚少、且其所含之 Cyrena 迥與歸州系內者不同、是上含煤系之時代亦不似屬於下白堊紀。因此、葛利普博士及作者暫時歸之於下侏羅紀即 Lias 但將來化石詳細研究後、其時代亦未嘗不可以仍屬上三疊紀或較 Lias 爲稍新也。

香溪系在中國南部分佈頗廣、鄂省東南部之蒲圻煤系江西之萍鄉煤系均是也。惟在他處尚未有詳細之研究、不過就前人鑑定植物化石之結果、似亦可分爲上下二煤系一屬 Rhaetic 一屬 Lias 之如香溪也。

歸州系

歸州系以秭歸興山境內最爲發達。由鹽拐子至秭歸路上、露頭尤爲完備。全系厚度據大略測算結果、約三千五百公尺左右、較前人所推算者大厚。野田氏所謂之興山紅砂岩系及香溪含煤砂岩系之上部、卽均隸屬本系也。

本系下與香溪上含煤系交接處爲一粗砂岩層、厚約三十公尺左右。在其附近、間見有含燧石卵石之石塊。此種礫岩內之卵石概皆屑小、其膠粘物又爲一種灰黃色之鬆輭砂質物、故似與香溪系中間之礫岩不同。且其雖爲滾落之石塊、但其位置遠在香溪系礫岩層之上。因此、其來源似非由於香溪系內中間之礫岩而來自上述之歸州系之基底砂岩層。惟在調查時、經數次之搜尋、竟在該層內未見有卵石之痕迹殊可異也。總之、如香溪上含煤系之時代確爲下侏羅紀如上所述、則歸州系與上含煤系之間應有一不整一、而此粗砂岩層似卽代表侵刷之結果焉。

就岩石之性質、歸州似可分爲四部。其下部二百公尺以內、概爲黃綠色頁岩及砂岩之互層。下與香溪含煤系交接處爲一厚粗砂岩層。

此上一千三百公尺皆爲紫色頁岩及綠色或黃綠色砂岩之互層。頁岩與砂岩層之厚薄大致無甚差異、極爲齊整、卽薄砂岩與薄頁岩成互層、厚砂岩與厚頁岩成互層。遠觀之一紫一綠一起一落之山形、極爲美觀。

再上一千公尺岩石雖仍爲紫色頁岩及綠色或黃綠色砂岩、但層次簡單全爲二三極厚之頁岩及砂岩層所作成。前者較後者爲尤厚、故所成之山形遠不若前者之複雜美觀、而概成圓滑之山頭隔以寬廣之低谷。

最上部約一千公尺、爲薄層紫色硬頁岩與綠色砂岩及灰綠色砂岩之互層。砂岩之內、有時含紫色頁岩之碎片、其長軸概與層面平行、且常積聚於一處。以其層薄也、故常成種種彎曲之狀、其層疊之薄及砂岩內紫色頁岩片之存在、頗易於與前者區分。

自鹽拐子之南至秭歸縣之北、歸州系之次序示如剖面圖（英文第六四頁第十二圖）。

1 黃綠色頁岩及砂岩、含化石頗多。……二〇〇公尺

2 黃綠色頁岩及紫色頁岩、內夾砂岩薄層、頂上有砂岩一層、厚十四公尺。……九〇公尺

3 黃色頁岩中夾砂質層、下有紫色頁岩一層、厚十四公尺、內含灰質凝結物頗多、幾全爲淡水葉腮類 *Cyrena hupehensis* Gr. 作成。……六五公尺

4 黃色砂岩。……五〇公尺

5 紫色頁岩及黃色頁岩之互層。……一七〇公尺

6 黃綠色砂岩。……五〇公尺

7 黃綠色頁岩。……五〇公尺

8 黃色砂岩、間呈頁岩狀。……六〇公尺

9 紫色頁岩中夾綠色頁岩薄層。……四五公尺

10 黃色砂岩、中有紫色頁岩一薄層。……一三〇公尺

11 紫色砂質頁岩。……八〇公尺

12 紫色頁岩及黃色砂岩之互層。……一〇〇公尺

13 紫色頁岩、中夾砂質層。……六五公尺

14 淺綠色砂岩。……五〇公尺

15 紫色頁岩、中夾白色砂岩一層。……八〇公尺

16 紫色頁岩內含灰質塊狀物、上帶有介殼之碎片。……八五公尺

17 黃色軟質粗砂岩。……一〇〇公尺

18 紫色頁岩。……一四〇公尺

19 黃色砂岩。……一三〇公尺

20 雜色頁岩、中夾砂岩一層。……三八〇公尺

21 綠色砂岩。……一一〇公尺

22 紫色硬頁岩及綠色砂岩之互層。……一〇〇公尺弱

本系內之化石層、概限於其中下兩部。在大峽口之北、於散佈在底部之黃綠色砂岩石塊中、曾採有下列數種。

Unio cremeri Frech

Unio chaoi Gr.

Unio johan-bömi Frech

Cyrena kweichowensis Gr.

在巴東縣石門附近、散見於江邊之砂岩石塊中、亦採有下列二種。

Unio cremeri Frech

Unio chaoi Gr.

Mycetopus mengyinensis Gr.

在大峽口之南一二里之一小水溝中、有一黃綠色頁岩層露出於溝岸上。其中葉腮類之小介極爲衆多、且頗色鮮黃、甚爲美觀。本化石雖未經詳細之研究、但似與葛氏在地質彙報第五期中所鑑定者皆不相同。

Cyrena hsiangchinsis Chao (sp. nov.)

Cyrena kweichowensis Gr.

在鹽拐子之西南山坡上、於距底部約六十公尺之綠色頁岩內、亦採有二種。

Cyrena hsingshanensis Chao (sp. nov.)

於距底部約百公尺之處、有一紫色頁岩內夾灰質塊狀物、幾全爲淡水介殼所作成。

Cyrena hupehensis Gr.

在大峽口北三十里香溪西岸之平玉口村邊、有一綠色頁岩層露出、內含極小之介殼頗多、並採有不能確實鑑定之植物化石數種。

Cyrena hsiehi Chao (sp. nov.)

凡此化石雖均屬新種、而其形狀則與英國瓦爾登(Wealden)層所產者極相似、故其時代屬於大陸式之下

白堊紀。Mycetopus mengyinensis Gr. 首先發現於山東之蒙陰系、今更得之於歸州系二者當代表同時之停積。由此觀之、是歸州系之下部一千五百公尺之內確屬於下白堊紀。惟再上一千公尺之岩石性質與下面者無絲毫之差異、則其時代自亦相差無幾。頂部之一千公尺岩石性質雖大致仍與下面者相同、但確有其自已之特色、其時代抑仍屬下白堊紀或較新則以證據不足未敢臆斷、惟仍屬於白堊紀則似可斷言也。

第三紀

紅砂岩系

此次調查經過本岩層分佈之區域過少、只在宜昌至黃家場一節、曾貫穿其底部一次。本系下與古生界地層成不整合之接觸。交接處爲一厚礫岩層、約百公尺左右。卵石頗大、概爲燧石石灰岩及花崗岩等所作成。自小溪塔至珠寶山一節露出頗完、沿河兩旁每成絕壁。礫岩層之上爲紅色及白色粗砂岩、內夾礫岩層。

本層確實之年代不詳。惟本系岩層均曾受變動影響向東傾斜、則其造成必在最後變動時期之先。今若假定中國南部最後變動之時期與喜馬拉雅山者屬同時、即在中新與漸新世之間、則本層造成之年代當在第三紀之初期。

四、構造

此次調查範圍僅宜昌秭歸興山巴東四縣、面積既狹、對於鄂西地質構造、遂不能多所供獻。就調查區域內論之、則地質構造極爲簡單、約言之、即宜昌秭歸間爲一背斜層、秭歸與沙鎮溪間爲一向斜層、而巴東附近、則又成爲一背斜層是也。斷層甚少、僅在興山東北黃狼坪附近見之、係一斜交斷層、致使一部分之大冶石灰岩、與

新灘頁岩相接觸、其關係觀地質圖自明、茲不詳述。至於其他不重要之小斷層、當不能免、然非詳細測繪不能知、非茲忽促調查之所能覺察也。總之、本區域內之構造、以縐綯爲主、而斷裂實不重要、茲將上述各縐綯分論如左。

（一）黃陵背斜層　宜昌秭歸間之重要構造、爲一大背斜層、茲名之曰黃陵背斜層、軸向東北北至西南南、軸斜向西南、中部爲震旦紀以前之片麻岩片岩及花崗岩、兩翼爲水成岩層、其時代自古生界以至中生界。西翼地層、顯露最爲完備、自震旦系起、迄白堊紀止、無一或缺。東翼地層之在宜昌附近者、因有東湖砂岩層之掩覆、故奧陶紀灰岩以上之地層、皆缺焉未露。但宜昌以北七十里黃家塲羅惹坪等處、東湖砂岩既未及掩覆、奧陶紀灰岩以上之地層、如新灘頁岩巫山石灰岩等、遂一一出露。自此向東、爲遠安縣、聞遠屬產烟煤、依其礦地之位置推測之、或更有香溪含煤系之露頭、亦未可知也。由此觀之、東西兩翼之露頭、在沿江雖有詳略之分、而實際則發育極爲均勻。但東翼未必有歸州系、即有、恐亦不如在歸州附近之完備、此則將來調查時當注意而證實之者也。東西兩翼地層之傾角頗不同、東翼之傾角極緩、至多不過二十度、小時僅四五度、西翼可達五十餘度、至少亦在二十度以上、換言之、即成一不對稱式之背斜層。兩翼傾角之緩急既不同如是、因之露頭面積、亦隨而大異。東翼傾角既緩、故露頭所佔之面積、遂極廣、不特此也、地層又常因成局部縐綯之故、而露頭更廣、如宜昌石牌間之奧陶紀灰岩、佔地達五六十里之多、即一則因傾角極緩、二則有多數之微小縐綯、有以致之也。西翼地層則不然、傾角既急、露頭遂狹、自崆嶺灘至香溪間不過三十餘里之距離、而數千公尺之地層、自震旦系至香溪煤系止、已完全顯露而無遺矣。

(二)秭歸向斜層　自香溪至沙鎭溪間歸州系地層成一向斜層構造秭歸縣城適居其中心故名之曰秭歸向斜層其軸向爲北三十度西秭歸縣西之勺溪一部分與此軸向相平行此處東西兩翼之傾角約略相等自四十度至六十度故爲一對稱式之向斜層其傾向殊不易知因東西兩翼之在江南岸者頗有連接之勢而其北端就香溪煤系之分佈觀之亦有包圍而成爲一盆地構造之趨向故實際上秭歸向斜層或係一大盆層但野地調查尙未普遍故是否爲一盆層構造現尙不能決也

(三)巴東背斜層　自秭歸西行數里地層走向漸自南北而轉爲東西自此經洩灘石門而至巴東縣地層仍保持其東西之走向而組成一背斜層構造大江之位置約略當於軸向之位置故江北岸之地層俱向北斜江南岸則向南斜傾角甚大有約近垂直或七十度者平均則約四十五度左右惟煤系及一部分之巴東系因受局部縐縐之故有時現極緩之傾角約觀大致則巴東背斜層乃極緊密而約略成對稱式者也

五、礦產

在調查範圍內礦產甚少興山東南建陽坪五指山有鉛礦昔開今停此次旅行怱促未及往查最重要者爲香溪洩灘及巴東等處之煤礦茲分區述之如左

(一)香溪煤田　北自興山之响灘市南迄秭歸之香溪窰灣爲本煤田分佈之地自响灘至興山縣地層走向自西南西而轉向東南東成半圓弧形自興山經大峽口至香溪其走向約略與香溪水平行即大致爲南北向惟在大峽口以北斜向略偏北以南迄香溪則略偏南以是知其走向有自東北北而轉向西北北之勢响灘市及興山以東之煤田僅供本地居民日用所需無礦業可言在興山之煤系中部隆起成一緊密之背斜層中有

大冶灰岩及巴東系之露出、致使煤系露頭、劃分爲東西二部、此種構造、分佈極狹、故地質圖上未能表示、傾斜甚急、分佈較狹、於開採頗不便利、且因受動力變質之影響、煤質俱變爲無烟煤。自大峽口東北之上下凸起、迄香溪止、爲本煤田分佈最廣、開採最盛之區。自香溪越江而南、煤系露頭、復見於窰灣袁家冲等處、其走向仍南北。總計本煤田之延長、自响灘起至袁家冲止、約有百餘里之遙、爲宜昌大背斜層之西翼、彙歸大向斜層之東翼、至於响灘以北、袁家冲以南、煤系究終止於何地、以未曾窮探、不能妄測。照地質構造上之關係推論之、則响灘一端之煤系、似有向西北延長之勢、窰灣一端之煤系、則或有向西南延長繞彙歸向斜層之南端、而與洩灘巴東之煤系相接、此香溪煤田分佈上及構造上之大概情形也。煤系全部、厚約二百五十公尺、其岩石層序、及與上下地層之關係、已述於前地層節中、茲不復贅。本煤系中所含之煤層、爲數甚多、據正大公司經理向必堪君所述各煤礦之位置厚薄等、列表如左。

煤層名稱	厚度	距離約數(尺)	附記
沙煤	四寸至三尺		此二層之位置俱在半山在一礫岩層之上
		二十尺	
野雞班	在游河家厚五尺		
		三十五尺	
紅灰	不定最厚五尺		
		二十尺	
馬尾師	不定		
		五尺許	
三脉	六七寸		煤質甚佳
		十二尺	
正脉	七寸		煤質最佳
		十五尺	
大炭	數寸至四五尺		火力不足
		十五尺	
小鐵炭	不定		
		十五尺	
油碁子	五尺		成層最穩亦最厚爲香溪煤田之主要煤層
		一百二十尺	
大碁子	五尺		
		百餘尺	
臭碁子			在河面以下開者甚少

煤系	上煤系	下煤系

據向君云、以上各煤層、在香溪一帶、俱經開採、惟層厚及各層間之距離、變遷甚著、上表所列、僅其大概、未可認爲確數也。且各層之名稱位置、皆僅憑本地礦工歷年之經驗而定、是否可靠、或其中頗有雷同重複、調查者因未下井親測、未敢妄斷、但礦工經驗、亦頗有可信之處、故特依向君所述、列爲前表、以備一班之參考。又據向君云、在河邊所開煤窿、僅能及紅灰而止、野鷄班及沙煤二層、皆須在半山開採。據余等實地考察、野鷄班以上之煤層、皆在礫岩之上、乃知河邊礦窿之不能及野鷄班者、因有礫岩爲之阻耳。職是之故、紅灰以上之煤層、特假定爲上煤系、以下者則屬下煤系。(參閱前地層節)

自大峽口至香溪間、現有正式採礦公司七家、其礦區皆互相銜接、沿煤系露頭四十五里間、已無復有隙地可尋。茲列各公司之名稱地點及產額約數等如左表。

公司	地點	產額約數
天生公司	興山上下凸及秭歸向家店	開辦不久尚未產煤
豐明公司	興山潘家灣及秭歸晷日嶺	月產五六百噸
歸興公司	興山游家河及秭歸萬古寺	仝上
志成公司	秭歸賈家店	月產二百餘噸
元合公司	秭歸西覓灘紫雲宮	仝上

正大公司	秭歸雞拐上扇子岩	月產六百噸
桂元公司	秭歸黃羊畔	尚未產煤

江南之窰灣溪、現有大興公司開採、袁家冲亦有一公司、其名未詳、俱未正式產煤。總計本煤田現在產額、每月約二千噸左右、若加以响灘興山等處未曾註册之小礦合計之、至多亦不過三千噸、倘各公司俱能產煤、則全區或能達月產五千噸之數。

本煤田所產之煤、俱屬烟煤、專供航行長江上游小火輪之用、在宜昌及沙市等處之售價、大塊每噸在二十四元以上、末子每噸十四元。各公司自置民船、由礦地直接運至宜昌。船分大小二種、大者可裝煤自五十噸至八十噸、小者祗裝二噸左右。航路常年通行、惟在秋冬水淺之時、約需二日到宜昌、夏季水漲時、則半日可達、每噸運費約需六七元。開採成本、每噸自四五串至二十串、平均約十串文左右、合銀洋五六元、總計成本每噸十三四元、若以售價二十四元計、則每噸可獲純利十元、其利之薄、可以見矣。

(二)洩灘巴東煤田　洩灘巴東一帶之地質構造、為一約成東西軸向之緊密式的背斜層。在洩灘附近、沿江兩岸之山坡上、俱有煤系、位於歸州系之下、巴東系之上。煤層甚薄、據云不及一尺。在洩灘附近、所採者以下煤系為主、亦有採上煤系者、向西十五里至石門、則下煤系極薄、所採者大部屬上煤系。本煤田之煤質為半無煙煤、多末子而少大塊、層數厚度、俱不逮香溪煤田之富厚、蓋此處背斜層構造、極為緊密、因動力變質之影響、遂使煤質變為無烟煤、且減少其層厚也。本地人以煤屑和黃土製成三寸長一寸許寬之煤磚、以供居家之用。此

項煤磚之售價、在本地每萬二十六串文、在宜昌五六十串文。經營礦業者、俱係本地鄉民、規模甚小、大多數未經正式註册、近聞亦有組織公司者。至於每月產額、以礦塲四散、調查非易、以意度之、每月亦不過二千餘噸耳。自石門經牛口而至巴東縣江北岸山上之煤系露頭、連續不斷、俱有本地人開採。至於江南岸則因背斜層逐漸開展、巴東系及其下之大冶石灰岩、逐漸露出、故背斜層南翼之煤系、已出我人調查範圍之內矣。在巴東對河山上、有煤窰六七處、專供本城居家之用。

欲比較煤田之優劣、於煤質之外、尤當知其礦量之多寡。此次調查、既未詳細測量、而煤層厚度、亦僅憑礦商口述、難以盡信、故欲精計礦量、萬分困難、茲姑約略計算如左。

煤田	分區	長度（公尺）	厚度（公尺）	礦量（噸）
香溪煤田	香溪至大峽口	二〇、〇〇〇	四・〇	三一、二〇〇、〇〇〇
仝上	江南窰灣一帶	一〇、〇〇〇	三・〇	一一、七〇〇、〇〇〇
仝上	大峽口至興山	二〇、〇〇〇	一・〇	七、八〇〇、〇〇〇
洩灘巴東煤田	洩灘至巴東	二五、〇〇〇	〇・五	四、八七五、〇〇〇
共計				五五、五七五、〇〇〇

以上計算、係以煤之比重爲一・三、沿斜向之深度爲三百公尺。照現在土法開採之技能言、此項深度、已不易採到、故上述之數、乃目前可以利用之礦量、若用新法開採、則三百公尺以下之煤、亦當計入、如是則全區礦量、

或可達一萬萬噸左右。前項計算法最不可靠之處、係煤層厚度據向君所述、香溪一帶、煤有十一層之多、總厚可達三十尺、即約十公尺左右、似嫌過多。茲爲穩慎計、假定其平均厚度爲四公尺。窰灣興山等處、雖與香溪相接、據云煤層較薄、巴東煤田則更薄、故煤系面積、雖分佈甚廣、而儲量則遠不如香溪一帶之豐富、至論煤質、亦以香溪爲最優、興山窰灣等處次之、而洩灘巴東爲最劣。茲列正大公司所採煤樣之化驗如左。

水分	揮發物	固定炭	灰分	灰色	焦性	發熱量	硫黃
一·七八	二八·〇二	五八·二〇	一二·〇〇	淺櫻	團結	七五四〇加路里	〇·一三八

揚子江流域巫山以下之地質構造及地文史

葉良輔 謝家榮 著

引言

自前清同治三年（即西歷一八六三年）、美國崩派萊氏、調查長江流域地質以來、繼而起者踵相接註一。其研究較詳者、當推李希霍芬氏、與東京地學協會之調查隊、惟疑而莫決有待於詳察者亦正多也。

中國地質調查所實行調查長江流域地質、則自民國七年始。蓋至是一變曩時局部觀察之舊習、而爲全省地質調查之計畫矣。省各設調查員二人、定以二十四個月至三十個月爲實地觀察之時期。江蘇由劉君季辰趙君汝鈞擔任、始於民國七年、成於民國十二年。安徽由葉君良輔李君捷擔任、始於十二年冬。湖北亦於是年、由謝君家榮劉君季辰趙君亞曾調查之、均猶未竣事也。王竹泉君曾於民國七年調查江西吉安安福永新諸地、又十三年春調查江西西北武寗瑞昌德安修水銅鼓宜豐等縣。北京大學李四光先生、亦於十三年春率領該校地質科學生赴宜昌一帶實習、頗有所獲。同時本所葛利普博士率其學生孫雲鑄趙亞曾田奇㻪諸君、研究採自野外之化石標本、由是揚子流域之地質史遂得而論定焉。江蘇地質大體調查完畢、已編圖報刊行於世。其餘諸省未蕆事者暫編簡報、擇要分刊於地質彙報及地質會誌等、其地史材料、率已見於葛利普氏之中國地史學。

註一 (1)一八六三至一八六四年有崩派萊氏之調查(2)一八六八至一八七二年有李希霍芬氏之調查(3)一八七二至一八八〇年有洛采氏之調查(4)一九〇三至一九〇四年有維理士等之調查與阿本特那 (E. C. Abendanon) 之調查(5)一九〇九至一九一一年有石井八萬次郎與杉本氏之調查(6)一九一三至一九一四年有野田氏之調查(7)民國六年即西歷一九一七年則有本所丁文江先生之調查

地質系統比較表

各地地質之詳細層序、或已列印註一、或即將發表、故不具論。茲爲便於比較計、列表如左、并略附說明於後。

第四紀	冲積層		冲積層	冲積層	冲積層	冲積層	冲積層 黃土 ?	
上新統				紅土	紅土	宜南層 120	玄武岩 120 雨花台層 140	
不整合								
中新統？	東湖系 1700		應城紅色石礫岩	紅色砂礫岩(輝綠岩)	紅色砂礫岩	新山層夾輝綠岩 300	赤山層 60 紅色砂礫岩 550	
不整合								
白堊紀	歸州系 3000+			斑岩 250 靈鄉砂礫岩 50			斑岩 120	
侏羅紀	香溪含煤系 { 上部 / 下部			蒲圻煤系 600	侏羅紀煤系	侏羅紀煤系 200	鐘山層 1800	
三疊紀	巴東系 800							
上中二疊紀	巫山石灰岩 1700	上部	大冶石灰岩 600	大冶石灰岩 500	北山石灰岩 900	石鹽灰岩 400	揚子層	上石灰岩 120–250m
		中部	北間頁岩 100	炭山灣煤系 100	老虎山煤系 180	宜運煤系100± 孤峯灰岩0–100±		煤系 60–80m
不連續 下石炭紀 不連續		下部	陽新石灰岩 100	陽新石灰岩 400	鑒山石灰岩 250	叶山冲灰岩0–75		下石灰岩 80–120m
志留紀	羅惹坪系900 龍馬頁岩 30		富池砂頁岩 1300	富池砂頁岩 1000	墳山砂岩層 2500	銅官層 800+	界嶺層 700	
奧陶紀	艾家山系200 宜昌石灰岩1700		京山石灰岩 400 平壩石灰岩1500	大阪石灰岩	烏石門石灰岩 450	陳家岑灰岩 2200+	崙山層	
寒武紀	石牌頁岩200		金家店頁岩 ?					

	宜昌巴東間 (李四光趙亞曾謝家榮)	鄂北 (謝家榮劉季辰)	湖北東南部 (謝家榮劉季辰)	江西西北部 (王竹泉)	安徽南部 (葉良輔李捷王竹泉)	江蘇南部 (劉季辰趙汝鈞)
震旦紀	燈影石灰岩 520 陡山沱頁岩灰岩 198 南沱冰磧層 83 800			上樵山層 1700	大洪嶺層 6000+	
不整合						
元古界	崆嶺片岩 美人沱片麻岩	千枚岩系 (輝長岩侵入體)			滁州片岩	陶山片岩片麻岩
太古界	黃陵花崗岩	片麻岩 (花崗岩)			灌陽山片麻岩	

表中厚度、均以公尺計算。

所謂安徽南部之大洪嶺系、可分上下二部。上部爲紫綠色頁岩與砂岩、下部爲灰色頁岩。砂岩時呈片理、頁岩則一部變爲千枚岩狀。李希霍芬氏假定其下部之千枚岩、爲寒武紀以前之地層、而隸其上部於下古生界。按葉李兩君之觀察、上下兩部、逐漸變遷、實無界線可分。凡軟弱地層與強固地層相接時、兩者褶曲狀態、固不必同一程度、而其構造之顯有出入、又未必即爲不整合之證也。

自經比較記述與採集標本以後、已知江西之上樵山層即當安徽之大洪嶺系。前者整合於烏石門灰岩之下、而烏石門灰岩上部確有奧陶紀化石、其下部復獲一三葉蟲、似屬寒武紀、故似以大洪嶺系與樵山層歸諸震旦紀爲當。比較表第三行所稱之千枚岩、亦或即震旦層之一部、惟其地無更古之岩層、故其關係尚未詳。

長江流域例有兩種產煤地層、一屬石炭二疊紀、一屬侏羅紀。實則下石炭紀灰岩之底部亦時產烟煤、成晶片形而爲湖北東南部之重要產煤地層。煤系之較新者純屬二疊紀、西向宜昌逐漸以薄削。在宜昌附近之巫山石灰岩中、惟上部底層、略有頁岩而已。二疊紀煤系下往往有石灰岩、屬於中二疊紀、即安徽之竹塘石

灰岩孤峯石灰岩與湖北之巫山石灰岩中部是也。惟二疊紀之燧石灰岩、與下石炭紀之燧石灰岩形態殊相似、非得化石不足以證明之、故湖北北部與東南部之陽新石灰岩、疑有一部當於巫山灰岩之中部者。

註一　王竹泉　江西吉安安福永新一帶煤田地質（地質彙報第二號）
謝家榮劉季辰　湖北東南部地層系統（地質會誌第三卷九十一頁）
葉良輔李捷　安徽宣城涇縣煤田地質（地質彙報第六號）
劉季辰趙汝鈞　江蘇地質誌（地質專報第四號）
葛利普　中國地史學（中國地質調查所出版）
謝家榮趙亞曾　湖北羅惹坪志留紀層之研究（地質會誌第四卷第一期）
仝上　湖北與山秭歸間中生界地層考（仝上）

地質構造

太古及元古界區域

巫山以下、長江流域有元古界與太古界地層露頭凡四區。(1)宜昌以上之黃陵廟、(2)河南之桐柏山脈與安徽之淮陽山脈、(3)沿津浦路滁州附近、(4)江蘇之海州。（見附圖第一版）(1)(2)兩區是否相連、未敢斷定、蓋漢水上游尚未調查也。(2)(3)兩區之間為合肥平原、其地祇有第三紀紅砂岩層之小山、故關係不明。(3)(4)兩區之間為洪澤湖流域。就構造大致而言、最後三區其初似連續不斷者。

岩石為片麻岩片岩與千枚岩、間有石英岩夾入其中。片理方向與岩層走向、均甚明晰。宜昌以上之峽谷中、片理方向及層向為北偏東、與南偏西。至漢水以東、蘄水安陸之間則改為西北與東南。入安徽境之太湖縣、忽折

而爲東北。直至江蘇之海州、猶未變其方向。

古生界與中生界區域

太古界與元古界區域之南、爲古生界與中生界區域、其地質構造、似較複雜。就大體論、尤以褶曲爲最要。本篇爲記述構造概要計、於褶曲詳情、姑不具論。

附圖第一版中之褶軸線、祇限於古生界與中生界地層之構造。新生界地層、雖亦微受褶曲、而非同一之褶曲作用、故缺而勿載、以免紛亂。

湖北西部　建始縣附近、褶軸方向爲東北偏東、與西南偏西、更東北則變爲北偏東與南偏西。來鳳咸豐恩施一帶、褶軸趨向北北東與南南西、更東北行、折爲東北偏東。五峯鶴峯一帶以及鶴峯縣以北淸江沿岸、褶軸方向爲東偏南與西偏北。

漢水以東長江以北　自襄陽達蘄水、褶軸方向爲西北偏西與東南偏東、經湖北東界以達安徽、長江沿岸地層層向東北與西南。以古生界與太古元古界兩區域褶曲方向之變遷相比較、可知其變遷隨處平行。再以漢水東西之層向傾向合而言之、則漢水流域似屬於內斜層、惜爲新生地層所掩蔽、未能窺其究竟耳。

湖北東南部與江西北部　大冶陽新一帶、火成岩侵入體較多、地層構造亦較複雜、然褶軸方向大致尙明瞭。自蒲圻至武穴之間、褶軸由西南偏西與東北偏東、變爲東偏北與西偏南。江西西北由修水至德安、褶曲大致由東偏北與南偏西、而變爲東偏南與西偏北。湖北東南部與西南部之間、盡爲湖沼、其構造爲新地層所埋沒、茲就兩區相距最近兩端之構造揣測之、自西至東、褶軸方向由西偏北與東偏南、而改爲西南偏西與東北偏

東、大致成弧形、與洞庭湖之北長江之曲線相符合。

長江以南九江以下　安徽東流秋浦之地層層向、東偏北與西偏南。更南、褶軸方向由東偏南與西偏北、改爲東北偏東。由蕪湖經南京至丹徒、沿江褶曲大致初趨東北偏東與西南偏西、既而東偏北與西偏南。自丹徒至常州、層向西北與東南。

褶曲結論

綜觀各節所序地層層向、不無散漫之憾、第於長江流域之地質構造、已頗能詳其梗概。褶軸方向雖變換無常、而亦至有規則。惟實地所見尙極紛紜、尤以湖北東南與安徽南部爲最。蓋地層種類既多、性質不均、加以火成岩出沒無定、褶曲結果殊難一致也。自震旦層至歸州系、褶曲皆整合、故褶曲時代、可斷爲後於白堊紀。茲爲便於說明計、暫定其時代爲第三紀初期、詳俟後論可也。

桐柏淮陽忽由西北折而東北、造成所謂霍山弧（註一）者、早知爲構造弱線、而爲安徽地震之震源矣。其突然如斯屈折者、不獨山脈之趨向爲然、即地層層向與片理方向亦莫不然。並與其附近之古生界及中生界地層之褶曲、亦若相符合。其所以致是之由、舉之得二說焉。(一)此平行屈折構造、由白堊紀後褶曲作用所產生。蓋自太古以迄白堊紀之地層、可以受同一之褶曲、而太古元古層之變質狀態、固不必發生於此時也。(二)桐柏淮陽山脈之褶曲早產生於震旦紀以前之褶曲作用、即本區域內自太古界以後、直至中生代以前、惟一之褶曲作用耳。當奧陶紀與志留紀之世、拗面作用疊起、江北地盤上昇（註二）、其南緣即爲桐柏淮陽山。其昇起之邊緣、適與原有之屈折構造線相合、其後無甚變易。或謂昇起之邊緣、初則形狀不一、其後屢受侵蝕、遂成屈折弧形、

與原有構造曲線一致。於是中部古生界以後諸岩層、次第沉積其旁、褶曲時、仍以原有曲線爲模型、而爲今日平行折屈之構造也。兩說均可通、第以前說爲近是。蓋若準今日之地形圖而示古時海陸分佈之情狀 註三、知二疊紀之末、中國中部有陸地可名曰戈壁、西部有陸地可名曰西藏、東南亦有陸地可名曰格塞西。設第三紀褶曲初起時、在中國中南兩部之三陸地、果大致位置如此、則大陸間之大內斜層受褶曲時、其褶曲方向、當大受鄰近陸地壓迫力之支配、轉言之、其褶軸方向、可延長於兩陸之間也。桐柏淮陽適當戈壁大陸之南緣、其霍山弧之發生、或因其抵抗力屈服於其餘兩大陸及揚子大內斜層之褶曲力所致也。

註一　丁文江 Geology of the Yangtze Estuary below Wuhu, pp. 28–39, 1919, Shanghai

註二　詳見本篇地文史

註三　葛利普　中國地史學第一册附圖第五　又維理士 Research in China, Vol. II, pl. 6.

地文史

古生界

大凡地文史愈古、而事蹟愈略、蓋前紀之地形、往往爲後紀之侵蝕作用所毀滅也。茲爲按次記述、計揚子流域之地文史、暫以古生界爲始。

考之各種岩層、與其內古生物之分佈、可知寒武紀之初、格塞西古陸地之北有東北西南向之大內斜層、其後日沈於海洋中 註一。桐柏淮陽山脉之南北地層、初無分別。及至奧陶紀、南北地層中之古生物已略有不同、蓋其時桐淮陸地、已漸上昇、即非盡露水面、而其高度、已足使兩界生物分佈有差 註二。至志留紀長江諸省變爲

淺海、桐淮山脈、適當一陸地之南緣註三。泥盆紀之地層、沿江各地尙未發見、殆其時全部幾成陸地耳。及至下石炭紀、又入於海註四。自上石炭紀至下二疊紀、又自中二疊紀至三疊紀、長江諸省之海陸變遷、正與由泥盆紀至下石炭紀所經過者同註五。二疊紀之海水、漸向西退、而爲淺海、終至三疊紀、乃成陸地。

桐柏淮陽山脉、既自志留紀時、即爲古陸之邊緣、其附近構造與地形、自當注意。在湖北東北部、地多第三紀層之小山、其東南部之黃石港富池口一帶、與太古界區域最近之岩石、屬二疊紀。安徽潛山縣之南、太古界區域與二疊紀區域之間、有地爲紅土層、寬約三十華里。至滁州西南、太古界區域與和縣含山巢縣等之平行山脊相鄰近、其山脊均爲二疊紀灰岩、傾向西北。和縣之北與巢縣東北一帶、有層向斷層相繼崛起、沿斷層帶有溫泉數處。至滁州、下石炭紀之灰岩直覆于元古界片岩上。或謂其地既爲古陸地之邊緣、則海水內侵、岩石沉澱時、不免有交覆之現象。當地層昇降褶曲之際、多所挫折、恐亦難免。惟其時果有斷層與斷崖、當已爲後世之侵蝕作用所毀壞、與沉積物所掩沒無餘耳。

中生界

二疊紀與三疊紀之交、長江流域、在新灘以下、已露出海面。海水向西南退、故三疊紀層中、海相岩石已大減少。侏羅白堊紀殆全屬陸相岩石、故揚子江流域在中生界、大都悉成陸地。惟其中時有宏大盆地、陸相岩石沈積甚厚。

始新統與漸新統前期

自白堊紀之末至第三紀之前半期、褶曲作用大盛。今日長江諸省之山河大勢、早成於此時矣。長江兩岸之山、

有爲外斜層者、有爲內斜層者、又有爲單斜層者、總之均可列入褶曲山脈一類。即桐柏淮陽山脈之大折曲、亦未始非此時所造成、已於前節論及之矣。

漢水至少自襄陽以下、長江自宜昌以下、其河谷大致與褶軸相平行、從兩水發育之歷史言、與所謂後成河（Subsequent）之定義未合。按其流道、俱似灌輸於折曲之內斜層盆地內而微向東傾斜、以注於海者、故可稱爲縱順流河（Longitudinal consequent river）。究其極、兩水之道、未嘗處處與地層層向平行、而全居於內斜層之中、蓋兩水生成以後、所經歷史既久、變遷頻繁、其稍有出入也宜已。

宜昌以西有黃陵外斜層、長江橫貫之而成曲折峽谷(Entrenched Meandering Gorges)。設以現在之侵蝕輪迴爲準、維理士稱之爲先成河 註六、固當矣。然即以再生河（Rejuvenatedriver）名之、要亦無不可者。當黃陵外斜層褶曲時、必生斜坡、水順坡東下、得開黃陵宜昌間之大江。其後源頭侵蝕既壯、乃強納外斜層西翼之水、以成今日之長江上游、固可信也。考之褶曲以前之歷史、未有能言有大河自西東下者。設以上層遺留河(Superimposed river）稱之、事實與定義又未相符。故長江當始於褶曲變動以後者無疑。

漸新統後期與中新統前期

湖北西南之褶曲山脈、高出海面自一千七百至二千公尺。五峯鶴峯一帶、山頂之天際線、一望如平湖、殆即褶曲區域、曾經削平作用後、復昇起之明證。謝劉二君稱此發育期爲鄂西期、故此期之侵蝕輪迴、可謂之鄂西紀。從長江一帶地文史之次序言、此削平作用、當完成於漸新統後期或中新統前期。侵蝕作用因褶曲所發生之高下而起、至漸達於似平面而止、此之謂削平作用、蓋亦理之所當然也、(見第二版又第三版第一圖)江蘇南

部、與安徽南部、尚未見似平面之遺跡、惟劉君因蘇南諸山、大都高度相若、疑爲削平作用所致。吾等亦未信鄂西期之似平面獨發育於鄂西一隅。在鄂西以外諸地固不必如此完整、但必經過同一階級第爲後紀侵蝕作用所磨滅耳。

鄂西紀之末、長江已達老年期、蜿蜒於似平面之上、而無偉大侵蝕之力矣。(按代維斯 W. M. Davis 所創作之 Peneplain 一字似平原之意也。蓋 Pene 一字由拉丁文中之 Paene (almost) 而來、即近似之謂也。據蔣生氏 D. W. Johnson 之意應改作 Peneplane 蓋平原之義與所指之事實不符近今美國地學家然其說而用之者甚多、故作者譯爲似平面。然 Peneplanation 一字、自以譯成削平作用爲當。)

中新統後期與上新統

湖北西南部山嶺之間、往往有盆地、其中有微受傾斜之紅砂岩、及礫岩層。盆地之地位、高自五百公尺至一千公尺、最大者長六十里、寬三里。鶴峯縣東南之太平鎮、施南來鳳兩縣城所在之地、最顯著。謝劉二君稱之爲山原期。(見三版第二圖、又第四版及第五版第一圖)。由是可知削平作用完成以後、地盤又上昇、重經侵蝕、間有河谷達壯年期者、即今之盆地是也。谷中復沉積砂子礫石、即今之紅砂岩也。據此類推長江諸省之地形發育期、得處處比較之。安徽江南之南陵宣城一帶、爲紅土礫石之丘陵地(註七)、本層處於曾經傾斜之紅砂岩上、(葉李二君名祁山層)而不整合。其砂岩即與宜昌以東所屢見之新紅砂岩相當。在此丘陵地之內、往往有數多之高山、與孤立之小丘、均爲志留紀砂岩、蓋即侵蝕之餘物耳。試去其四周之紅色層而想像之、其爲侵蝕已達壯年期之地面無疑。先有此而後有祁山層與紅土礫石層之沉積、則自與鄂省西南之山原相當。至於地位

高下之不同、又自有故矣（見後）。

故山原紀之時間、可括下列諸事蹟、(1)似平面區域之上昇、河道復活。(2)壯年期之河谷成立。(3)河積層沉澱於壯年期之河谷中。(4)新積成之地層受微弱之地殼變動而微有傾斜與斷裂。(5)侵蝕更進而有較新之砂土沉澱。

第四紀

山原期之後、即爲峽谷猛進之時期、據謝劉二君之觀察、山原紀之盆地、近爲曲屈之峽谷所經流、宜昌以上之三峽、亦正與之相當（附圖第五版第二圖又第六版第一圖）。

查江蘇南部、無深谷焉。而安徽南部、長江流域與徽州盆地之間、其分水嶺之兩坡、則有曲屈之峽谷（附圖第六版第二圖）。至徽州盆地之東南界、則有新安江之曲屈峽谷、亦即錢塘江上游之一。

峽谷式之地形、常見於宜昌以上、而不見於宜昌以下之長江左近者、似爲地盤昇降不同所致。峽谷大都成於地盤上昇、侵蝕猛進之區域。長江西南部地盤上昇、而其東南部、正受下降之拗面作用、所經之構造作用既背道而馳、則其地形之不齊也亦宜耳。

宜昌以下、長江兩岸之大小湖沼、或生或滅、不可勝數。察其地位、與地質構造、無絲毫關係、亦非盡爲河流改道所成者。故謂爲長江曾經淹沒、河水退走之殘跡、似無不可。拗面下降之日、即長江陷沒之時、因果相證、事或有之。是時、長江自宜昌以下、或同時隨江蘇海岸而沉陷（註八）、蓋江蘇南部幾全受下降之拗面作用、更無所謂峽谷之地形明矣。

拗面下降、及地面浸陷、似較紅土礫石層之沉積時期稍新、按安慶貴池一帶、沿江兩岸之湖沼、均伏於紅土層小丘與梯地之間、可知湖水盤据之先、紅土已受多少之侵蝕矣。

江蘇大江南北有玄武岩之平錐山 註九。茲當討論者、厥爲玄武岩在地質系統中之層位與海岸沉陷之先後是也。按玄武岩露頭、既相聚一處、其屬於同一之岩流、已無疑問 註十。直接其下之雨花台石子等、又位於已經傾斜之赤砂岩之上、而蘇皖贛鄂諸省之赤砂岩層、均屬相當、亦無疑問。故江蘇之雨花台層、就地史岩石比較之、當與皖贛之紅土層相當、所差異者、卽黃色而已 註十一。玄武岩以上之地層、在江蘇南部、未曾發見、惟在江北之靈岩山安特山與董常君、曾一度見之。安特生名之爲黃土、董君稱之爲壚土、名稱既異、土質亦別、究屬何物、尙宜詳察焉。

中國北方之黃土、愈南而其量愈減、山東已極不多得 註十二。然由北而南、在安徽與江蘇之北部、或尙有其遺跡。若謂長江流域亦有黃土者、終覺懷疑。余(葉良輔)見丁文江先生所作之地質圖、註十三 在安徽東南郎溪縣(舊縣建平)之北部、塡爲黃土層、其南部爲大通礫岩層(與新紅土層及雨花台層相當)、故本年春季與李捷君調查及此、特由郎溪赴江蘇高湻之東壩、察其究竟。據作者所見、郎溪四周、宣南層(卽新紅土層 註十四)極爲發育、由南而北、紅色漸變爲黃色。其土色之變遷、似爲紅土水化所致 註十五。此種變遷、在皖南沿江一帶、紅土層之上部、處處得見之。再證諸農作物之生產情形、郎溪南北、亦頗相似。蓋本層之土性、遠不若冲積層之富於生產力也。劉季辰君調查江蘇幾遍、尙未能確證黃土之所在。黃君所得之壚土標本、察之亦似與北方之黃土有別。

故吾等以爲靈岩山之壚土直覆於玄武岩層之上者、仍屬新紅土層之一部。玄武岩流之噴發、不過山原紀中之分期而已正當河積層堆積之秋、忽有玄武岩流入其中其後一體下降、沉浸水中而一部遂起水化之現象耳。

最近代中、湖北西部仍繼續上昇、而峽谷亦繼續進行。長江下流則由下降而稍變爲上昇、於是浸陷之區、水勢漸退、餘殘之水、即成湖沼。

今日之長江蜿延曲屈、變遷尚頗自由、然不過隨水量泥量增減而異。若其河岸、頗有界限、非岩石層之山坡、即紅土之梯地、故今日之河谷發育期、與其前紀發育期之有不同者、最近長江下流地盤有上昇之勢使然耳。故即在水漲期間、惟湖沼與紅土間之山谷低地尚有江水侵入、而紅土丘則已高出於河床、約二十公尺、（附圖第七版又第八版）故其頂部極少淹沒。

茲將以上所論述之地文歷史總括之而列表於後、以便比較。

長江下游地文史比較表

時代	地動現象	鄂西
第四紀	各部上昇惟上昇程度不等	地盤直向上昇河流向下侵割而成峽谷－三峽期
上新統－中新統後期	地盤逐漸上昇西部高於東部地動或進或止東部下降	中年河谷造成赭色岩沉積－山原期
中新統前期－漸新統後期		鄂西期之似平面成立
漸新統－始新統前期	造山運動褶曲斷層火山噴發	陸
三疊紀	造陸運動	淺海－陸
上中二疊紀	造陸運動	海
下二疊紀上石炭紀	造陸運動	陸
下石炭紀	造陸運動	海
泥盆紀	造陸運動	陸
志留紀	造陸運動	淺海
奧陶紀	造陸運動	海
寒武紀	造陸運動	海

鄂東贛北皖南	江蘇南部	長江	桐柏淮陽
初地盤下降沿江之地沉陷後地盤微昇昇高之度不一沿江之地水退成湖沼	仝右	宜昌以下之長江初則沉陷其後水退沿江有湖沼侵蝕復活現在壯年侵蝕期宜昌以上之長江因地盤上昇逐漸向下侵削而成幼年期之河谷	侵蝕進行至壯年期
1 壯年侵蝕地面之造成—宜南期 2 赭色岩沉積輝緣岩噴發 3 赭色岩受侵蝕 4 紅土沉積	1 中年侵蝕地面之造成 2 赭色層之沉積 3 雨花台石子之沉積與玄武岩噴發	長江侵蝕復活而成壯年期之河谷	再上昇被侵蝕
仝右	仝右	晚年河	晚年侵蝕期
陸（斑岩噴發）	陸（斑岩噴發）	長江順流河成立	桐柏淮陽山折曲成立
陸	陸	淺海 陸	陸
海	海	海	陸
陸	陸	陸	陸
海	海	海	陸地邊緣
陸	陸	陸	陸
淺海	淺海	淺海	陸地邊緣
海	海	海	逐漸上昇
海	海	海	海

註一 葛利普 中國地史學上部第二十三頁

註二 仝上第二四二頁

註三 仝上第一一六頁

註四 仝上第二二〇頁

註五 仝上附圖第四版

註六　維理士 Research in China, Vol. 1., pt. 1., p. 338.

註七　葉良輔李捷　安徽涇縣宣城煤田地質見地質彙報第六期一九二四年

註八　丁文江　仝前著第五十七至四十八頁

又　劉季辰趙汝鈞　前著第二十五至二十六頁

註九　劉季辰趙汝鈞　江蘇地質誌第十五頁見地質專報甲種第四號

註十　安特生　中國北部之新生界第十八—十九頁見地質專報甲種第三號

註十一　仝上第十五及二十一頁

註十二　譚錫疇與作者之通告

註十三　丁文江　前著附圖第一版

註十四　葉良輔李捷　前著

註十五　G. P. Merrill:-Rock weathering pp. 243-44

褶曲時代及地文史之比較

揚子江大內斜層中之褶軸方向、既可受其隣近古陸地之支配、而古陸自身、亦可被同一褶曲力稍變其形態、然則該褶曲時代究屬何期。再前節所載之地文史、具按時代而分述、其時代之何由判定、尚待詳論。凡所謂地形也、大都爲構造之現象、地史問題與構造問題、原可相提並論、故褶曲時代與地文史時代、可合論於後。

長江流域之地層、下自下寒武紀起、上迄下白堊紀止、皆整合褶曲。換言之、褶曲時代、當起自白堊紀之末葉、或

竟全屬於白堊紀以後。按二疊三疊紀之交、長江流域似有拗面作用、鄂東與長江下游、地面因之隆起、三疊紀之海水向西南退卻、故高起之地、無三疊紀岩石、湖北之歸州盆地、四川之赤色盆地、皆同時有其胚胎而容納侏羅白堊紀之岩石者也。然無論如何、二疊三疊紀間之地殼變動決非顯著之褶曲作用也。不然、侏羅白堊紀層之下、當有極明確之不整合層、第在巫山以下長江流域中迄未見之。

褶曲時代之終了、似遠在東湖系積成之先（宜昌附近之東湖系係由礫岩與紅砂岩所成、與安徽之祁山層、江蘇之赭色層赤山砂岩層相當）。東湖系所存在之小谷與低地、爲先經削平作用之地面、再經上昇與侵蝕而成者、乃本區域內地史之一端、尤爲確無可疑者也。惜東湖系中迄今未獲化石、然其自成一組而較新於歸州系已由近今調查者所確定註一。稽諸舊藉、復得左證。蓋維理士氏等、在秦嶺之陽、漢水上流、曾見古生層與中生層、一例變質、惟石泉砂岩則否註二、其假定屬於侏羅紀之石泉砂岩、應與今之東湖系相當、（其時維理士氏祇知歸州系之屬於三疊紀、不知其一部份已屬於白堊紀也）其生成當在變質作用之後。變質爲果、褶曲爲因、故東湖砂岩之生於褶曲作用以後、尤可信矣。

褶曲告終之後、東湖系沉積之前、尙有鄂西期似平面之告成、與陸地昇起及侵蝕等事蹟亦應需其相當之時間也。

研究長江流域地質者以維理士與阿本特那（E. C. Abendanon）之著爲較詳。維理士之結論如左、

據我輩觀察所及、長江諸省之褶曲時代、當後於歸州系之最上層、即在三疊紀以後是也。因石炭紀以上之地層、均互相整合故耳。雖然、此非最後之結論、蓋我輩觀察未周、且與李希霍芬氏在四川廣元縣所見者適

相反。按廣元在更西四百公里之地。李氏於二疊中生界層之下、見一顯著之不整合層、我輩所見相當層位之露頭甚多、所括地面亦廣、然皆一致整合者 註三。

今知維理士氏之歸州系、實括三疊侏羅下白堊紀等地層、故其所言與褶曲時代之最低限度、相差甚遠。夫李氏 註四 與洛川氏 註五 之顯不整合層、尙有可疑之點。試將李希霍芬氏之著 註六 與我輩最近之觀察相較。凡志留紀層（h）二疊石炭紀之燧石灰岩層（f）、二疊紀含煤系（e）、二疊紀薄層狀灰岩（A）等地層之在四川北部者、與其在長江中游以下者同一完備。既有構造上之不整合、而無地層之缺失、則殊難解。故李氏之不整合層、或爲斷層接觸之結果。況廣元以北、正斷裂繁多之區也。

茲復摘譯阿本特那氏之著述於後、以見其結論之大概 註七。

余嘗見四川盆地之外斜層、走向北北東與南南西、而在盆地北東兩部、則折爲東北、東北東、與東等方向。其所以然者、余意謂赤色盆地猛力被迫於走向東西之崑崙秦嶺等舊山脉所致、故盆地邊部之褶軸方向、與其內部者不一致（五八八頁）。

四川赤色盆地之褶曲時代、後於歸州層（五八九頁）。

巴東外斜層原走向東西、旋變爲南北、而向東北凸曲……出軌之故、由於南沱外斜層之強固所致……。

可知(1)南沱外斜層抵力之量、設其附近果有大斷層存在、尙無如此之抵力、(2)南沱外斜層之生存必在赤色盆地褶曲之先。

據此以觀、長江流域已有兩種時期之褶曲。南沱外斜層、屬於第一期、與崑崙秦嶺之褶曲造成同一時期、即所

謂海西寗期是也。巴東外斜層、屬於第二期、即所謂希馬拉亞期者是也註八。

參閱各家著作、乃知歐西地理學家與地質學家之曾經研究亞洲中部與中國西南部之山系者、輒以爲崑崙秦嶺山脈走向爲西東、而希馬拉亞期山脉之在中國者走向南北、一若山系走向、與其造成時代、有連帶關係者。此種關係似非必然、蓋在一定區域與一定時期內之褶曲作用、其所施之側壓力自有一定方向、然同時如有隣近古陸地之抵抗、與其他局部之影響、則同一時期之褶曲、可有多種方向之褶軸註九。設如大內斜層之周圍、有古陸地數區、則內斜層中之岩石遇褶曲時、可隨其附近古陸之邊緣而走向是也。試以亞洲大陸構造圖註十、與亞洲古地理圖註十一而參攷之、更覺此說之可通矣。

故南沱以東一帶、或已於二疊三疊之交、因拗面作用而上昇、但其時不必已成爲外斜層也。阿木特那曾證明南沱區域在上石炭紀以前與歸州紀之末葉曾兩次變爲陸地、第其根據註十二、與近今之觀察、又未能符合。

綜上所述、則長江流域、至少在中游以下、實無所謂海西寗期之褶曲、凡所有古生代與中生代地層、祇經過一期白堊紀以後之褶曲而已。其時代或稍先於希馬拉亞期、或竟屬於希馬拉亞期、容再申論於後。茲以長江流域之最近構造史、與希馬拉亞山脉之最近構造史、未能直接比較、故將於長江接近之地、而於第三紀之地史已較稱明確者、以求可以比較之法焉。

由浦口沿津浦鐵路而北、其初於淮河以南、見壯年期之地面。其中一部份爲中等高度之小山地、其餘則爲冲積平原、而小山區域之地層與構造、均極複雜。及至蚌埠與利國驛之間、其地面之侵蝕程度更高、故山崗甚低、惟宿蕭兩縣之山、高度較著、地面較廣而已。自銅山縣至利國驛、鐵道所經之地、實爲一平面、然其地尙有傾斜

頗大之石灰岩、相繼出露。由是可知該地實有一大部份已達似平面之程度、惟大都爲冲積土所埋沒、此外之孤山羣崗、不過侵蝕作用之餘物耳。該地面、範圍甚廣、西南達河南之信陽、與皖北之合肥、東迄江蘇之東海濱。該平面復由利國驛向北伸長、至山東境內、分岐而爲山谷與山嶺間之低地、例如泗水、沂水、新泰、蒙陰、汶河諸谷、是其著焉者 註十三 也。

凡諸削平地面與本節所論之關鍵、即在其削平時代之後於始新統也。蓋始新統以後所產生之斷崖、與始新統地層之褶曲、均已一致削平 註十四。山東所產含三趾馬之紅土層(屬漸新統初期)、江蘇浦鎮宿遷一帶與安徽合肥附近之浦口砂岩赤山砂岩及雨花台層、均係隨後沉積於似平面之上者。

劉君季辰自經調查湖北以後、即謂浦口砂岩與赤山層與東湖系爲同時之地層。南京附近之雨花台層與沿江之紅土可以相當、已於前節言之。再進而比較沿江之紅土與山東之三趾馬紅土、則覺兩者之石質、與生存狀態、頗有類同之點、似亦可以相當也。惟山東實無與東湖系相當之地層。凡此新生地層在長江以北、既皆生存於壯年期至晚年期侵蝕之地面、則該地面、應與江南之山原期地面相當、而新於鄂西削平期也無疑。

綜前所述而得之結論、則謂長江諸省之褶曲時代、或發創於白堊紀之末期、但其重要工程、係成於第三紀之前期、即始新統或進而及於漸新統之一部也。故其時代、略新於希馬拉亞期。先褶曲、而後有鄂西期似平面之完成。同時在山東一帶、無顯著之褶曲、而有和緩之拗面作用、因此白堊紀末期之地層與始新統地層、有推移叠進之跡 註十五。其後長江一帶地盤復昇、而一部份受侵蝕之分割、正與北省之斷層與侵蝕同時並進。復次大江南北一致受紅砂岩層局部之遮覆、既而因第三紀末葉之地動而生傾斜與斷層。最後乃有紅土之堆積。

其餘之構造史、與地文史均隸於洪積統矣。自上新統之末、以迄洪積統、拗面作用頗盛。今日亞東地面之高下、該拗面作用有以成之、此乃經驗之談也、註十六。以長江地史證之、亦相符合。

夫維理士氏所定山西直隸之地文期、後經安特生氏改定、而作者 註十七 應用于北京西山者、又戴普拉氏 註十八 及白潑氏 註十九 所舉之雲南地文期、近而至於美國蒙古旅行隊所定之蒙古地文期 註二十、應如何與長江流域之地文期相當、作者未敢妄作比較。但事實種類與其先後之次序、各區域頗有相同之處、以寬泛之時期作階段而比較之、似無不可相當者、但地動作用與侵蝕作用之進止及因地動而生之高下、各區不能一例、其未能有確實相當之比較亦可斷言者。他日調查地域漸廣、材料日富、其相互之關係、自易明瞭也。

註一　李四光　長江峽谷之地質見中國地質會誌三卷第三八二頁至　頁

謝家榮趙亞曾　宜昌興山等四縣地質見中國地質調查所彙報第七期十三頁至八十四頁昔維理士氏阿本特那氏野田氏等均以宜昌附近之砂岩與歸州系相提並論見 Res. in China, Vol. I pt. I p. 286. Abendanon, Struct. Geol. of the Middle Yangtze Gorges, Jour. Geol. Chicago, Vol. XVI. p 606, 1908 又野田氏支那地學調查報告第二卷所附湖北東北部地質圖

註二　維理士　仝前著第三百頁

註三　仝前　二九五頁

註四　仝前　六〇三頁

註五　Loczy:-Reise des Sze'cheny, Vlo. 1, profil 11. & p 685

註六　China: Vol. II. pp. 598—603

註七　Abendanon: 仝前著

註八　J. W. Gregory: The Alps of Chinese Tibet & their Geog. Relations. Geog. Jour., London, 1913. 並其中所舉之參考書

註九　翁文灝先生亦曾有是說見中國山脈考載中國科學社之科學第九卷第十期

註十　維理士　仝前著第二卷附圖第八

註十一　A. W. Grabau: Palaeog. Maps of Asia 中國地質調查所出版一九二五年

註十二　Abendanon: 仝前著第一一一六一二頁

註十三　參考中國百萬分之一地質圖南京衢輝幅(地質調查所將出版)

註十四　譚錫疇　山東中生界及舊第三紀地層載地質彙報第五號第二冊英文一二七—一三五頁間之插圖

註十五　仝上

註十六　維理士　仝前著第二卷第九六—九八頁又 J. Deprat: Sur l'importance des mouvements epirogeniques recents dans l'Asie sudorientale. Comptes Rendus, t. 152, p 1527, 1911

註十七　葉良輔　北京西山地質誌第六五—七七頁地質專報甲種第一號

註十八　J. Deprat: Étude Géologi que du Yunnan oriental. Mem. du Serv. Geol. de l'Induchine, vol. 1. Fas. 1. pp. 350-351. 1912

註十九 Records Geol. Surv. India, Vol XLIV, pt. 2 pp. 116-122, 1914

註二十 Berkey & Morris; The Peneplains of Mongolia, Novit. No. 130, Am. Mus. Nat. Hist. N. Y

洞角獸類化石

步林著
周贊衡譯

一千九百二十二年、在中國三趾馬動物羣中發見一種奇異骸骨、維曼氏曾命名為丁氏麒麟(Chilinotherium tingi Wiman)。嗣經著者詳細研究之結果、認為一種洞角獸類化石、其種名為 Urmiatherium intermedium (Schlosser)與波斯馬拉格 (Maragha) 地方發見之 Urmiatherium polaki Rodler 甚有關係。且與從前在中國發見之假牛類化石 (Pseudobos intermedius Schlosser)、亦屬同樣

標本之大部、為無數不完整之頭蓋骨。間或亦有與下顎骨相連續且其牙齒仍保存者。其中有碎塊一、其大小與馬拉格標本相若。

其頭蓋骨之構造、最足使人注意者、厥惟一公共大角基。其位置自鼻骨後端起、幾達上腦後骨之上邊。而其顱頂骨則縮小成狹長條片、如現代之牛類然(見原文一一一頁插圖一)。但此種大角基在現代洞角類中、甚屬罕見。因將該化石及馬拉格之 Urmiatherium polaki Rodler、均歸入四角鹿科 (Sivatheriinae) 中。蓋此為惟一之偶蹄類、生有同樣大角基者也。

頭蓋骨之基礎、呈一種奇異形態。雖有幾個屬雌性或幼動物者、其下腦後骨之形狀仍屬平常(見原文一一二頁插圖二)。而其大部下腦後骨均甚粗厚、且下面及後面互相成鈍角或垂直。此種發育之程度、或與其角之發育有關係焉。

牙齒異常之高(見原文一一二頁一表)、下齒之形狀及其大小均酷似假牛類化石。著者之所以將丁氏麒麟改名為 Urmiatherium intermedium 者、以其與波斯之 Urmiatherium polaki Rodler 甚相似故也。雖其大小、及

其他不重要部分稍異、但塊狀角基、與下腦後骨之發達、以及上腦後骨之形狀、均甚相似也。

本屬 Genus Urmiatherium 與他屬之關係、現尚不明白。其頭蓋骨雖略似 Criotherium argalioides Schlosser 而角之形狀、及其在頭蓋骨上之位置均異。惟其牙齒甚相似、故此二屬或不無關係。若與 Bubalis 及 Connochaetes 二者比較、亦有同等相似之處。

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CONTENTS

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1925.

TINGIA, A NEW GENUS OF FOSSIL PLANTS FROM THE PERMIAN OF CHINA.

Preliminary note.

By T. G. HALLE.

(With one text-figure and two plates)

In June 1869 v. RICHTHOFEN collected a small number of fossil plants in the coal-bearing deposits at pönn-hsi-hu (本溪湖) in Shengking. The fossils were described by SCHENK (v. RICHTHOFEN: China, vol. 4, p. 211), who remarked that the flora was mainly characterized by a *Taeniopteris* and a *Pterophyllum*, both, according to him, exclusively Permian types.

The form referred to *Pterophyllum* has proved to be of considerable interest, though it was represented by only one rather fragmentary specimen. It was described by SCHENK (l.c., p.214; pl.44, figs.4,5) as a new species, *P. carbonicum*. (In the explanation of SCHENK's plate 44 the name is given as *P. carbonarium*.) The preservation of the type-specimen left much to be desired, and SCHENK was evidently far from sure that it was really a *Pterophyllum*. He compares the plant also with the genus *Noeggerathia* and concludes his description by saying that the preservation was not sufficiently good to permit him to decide whether the specimen represents a pinnate frond or a branch.

Later on SCHENK seems to have re-examined the material and arrived at a different opinion, for in the copy of his work which he presented to the late Prof. A. G. NATHORST and which is kept in the palaeobotanical department of the State Museum of Natural History at Stockholm, there is a pencil note in SCHENK's own hand substituting *Cordaites sp.* for *Pterophyllum carbonicum*. I find that ZEILLER[1] has already mentioned a similar correction in the copy received by him from SCHENK.

Better specimens, which it has now been possible to identify with this form, were later obtained from different localities in the Permian of China. This new material, and finally a re-examination of the type-specimen in Berlin, has convinced me that SCHENK's critical attitude towards his own deter-

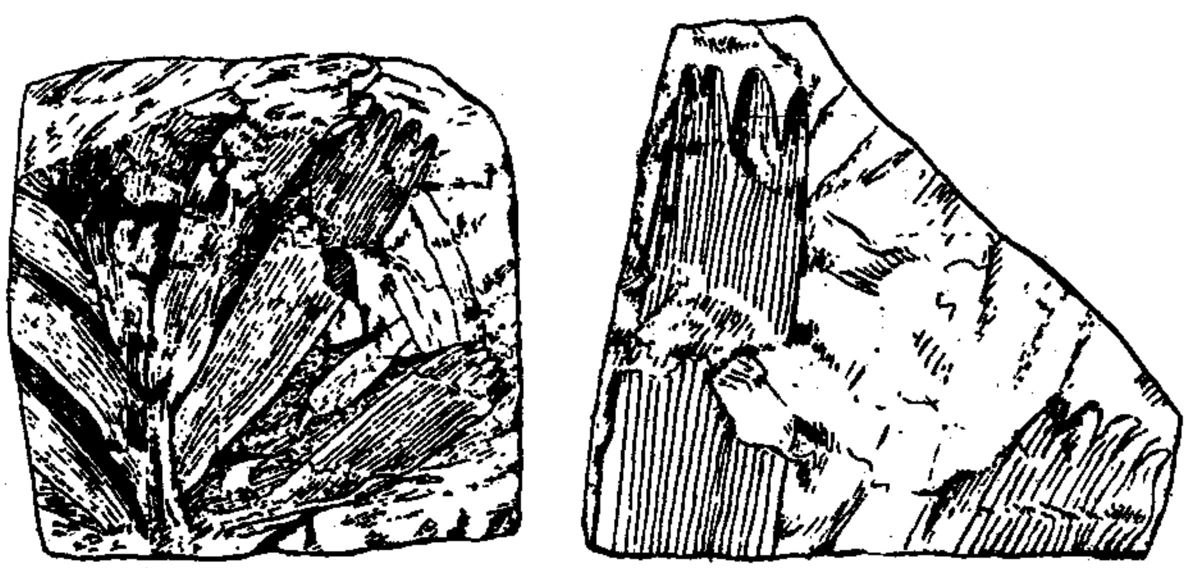
1. R. ZEILLER. Note sur la flore houillère du Chansi. Annales des Mines, 1901, p.25.

mination was justified. *Pterophyllum carbonicum,* however, belongs neither to *Cordaites* nor to *Noeggerathia,* but is a distinct generic type which, in the light of our present knowledge, seems to be characteristic of the Permian of eastern Asia.

I have named this new genus *Tingia* in honour of Dr. V. K. TING, Honorary Director of the Geological Survey of China, who has done so much to further the study of palaeobotany in China, not least through organizing the splendid field work carried out by the geologists of the survey. Dr. TING has a special connection with the present genus, since he had collected some of the first specimens of it that were examined by the author.

The history of the material which finally led to the institution of the new genus is rather interesting and will be briefly told. In December 1916 I found on the dumps of the Tong-shan mine in Chihli a single specimen of a fossil plant which at first sight strongly recalled *Pterophyllum carbonicum* but had pinnae with the apex dissected into lobes. On a close examination of SCHENK's figure of the type-specimen it was found that in the lowermost pinna to the right there is in the drawing a slight indication of what might be similar apical lobes. This feature is very indistinct, however, and appeared more probably to be accidental or due to incorrect drawing. A short time afterwards I had an opportunity of examining, at the Geological Survey in Peking, a collection of Palaeozoic plants which had been made in Honan by Dr. V.K. TING. Among this material were a couple of specimens which greatly resembled the one from Tong-shan, except that the pinnae were longer. While the author was travelling in Hunan with Mr. T.C. CHOW in the spring of 1917 for the purpose of studying the fossil plants of the anthracite field of that province, we found specimens evidently identical with the Tong-shan plant in at least two localities on the Lei-ho (耒河), in both cases associated with *Gigantopteris nicotianaefolia* SCHENK. The same new type of plant had thus been recognized in a very short time among material from no less than three different provinces, and it was evident that it represented a peculiar type widely distributed in the Upper Palaeozoic of China. Unfortunately all specimens of the plant collected before 1919 were lost in September that year through the wreck of the steamer "Peking" while they were being conveyed to Stockholm for further examination.

Up to that time nothing definite was known of the relation of the new form to SCHENK's *Pterophyllum carbonicum*, except the general resemblance in habit which was noted in the case of the first specimen found at Tong-shan. As SCHENK's type-specimen had been repeatedly examined by him, it did not seem probable that it would throw any additional light on the question. All the material having been lost, a comparison of the new form with SCHENK's specimen was not possible, but during a visit to Berlin in January 1922 the author made a careful examination of the type. It was found that the slight indication of apical lobes in SCHENK's figure was correct, while his description was wrong. The pinnae are not entire as stated by him but distinctly lobed or dentate at the truncate apex. Through the kind assistance of Professor W. GOTHAN I was able to obtain photographs of the type in natural size and twice enlarged. These photographs which had to be somewhat retouched will be published, together with a more extensive account of the new genus, in a memoir on the Upper Palaeozoic flora near Tai-yuan fu now under preparation for the Palaeontologia Sinica. Drawings of these photographs are shown in text-fig. 1.



A B

Fig. 1. SCHENK's type specimen of *Pterophyllum carbonicum* (RICHTHOFEN: China, Vol. 4. pl. 44. fig. 4).
A. Natural size. B. Upper parts of two leaves, showing apical lobes, in twice the natural size.

While the type-specimen clearly showed that *Pterophyllum carbonicum* must be removed from that genus, it did not give sufficient information on the morphology of the species or its relation to some other genera. A short time after the examination of the type-specimen in Berlin, however, the author had the great pleasure to receive new material of the type first recognized at the Tong-shan colliery. These new specimens, which had been collected in the coal-bearing deposits east of Tai-yuan-fu by Dr. E. NORIN, were obviously identical also with SCHENK's type-specimen of *Pterophyllum carbonicum* and made it possible to gain a better idea of this species than before. Because of the fragmentary nature of the type-specimen, which is only just sufficiently well preserved to prove the identity with the new specimens, the description given below of *Tingia carbonica* is based chiefly on the latter.

In the new collection made by Dr. NORIN there were also several specimens of another somewhat similar species which should evidently be referred to the same genus. This species, which will also be described below, is important because it shows more clearly than *Tingia carbonica* the morphological nature of the specimens included in the new genus. A diagnosis of the genus and descriptions of the two species known at present will be given below.

TINGIA NOV. GEN.

Dorsiventral, frond-like anisophyllous shoots with thick axis. Leaves apparently arranged in four rows, two on the upper and two on the lower side of the axis. Leaves of the two rows on one (the upper?) side smaller, directed forward at narrow angles to the axis, those of the other two rows (on the lower side?) larger, spread out in one plane and forming a more open angle to the axis; each lateral half of the shoot thus provided with two rows of dissimilar leaves. Leaves of the larger (normal) type varying from broadly cuneate-obovate to oblong or linear, with entire lateral margins but more or less deeply lobed at the apex. Several veins entering each leaf, dichotomizing mostly in the lower part of the leaf, all branches continuing to the apex.

At present the genus comprises only two species, *Tingia carbonica*

(SCHENK) *n. comb.* (=*Pterophyllum carbonicum* SCHENK, the genotype) and *Tingia crassinervis n. sp.* The general characters and relationship of the genus will be discussed after the description of the species.

TINGIA CARBONICA (SCHENK) N. COMB.

Pl. 1, figs. 1-4.

Pterophyllum carbonicum SCHENK 1883, in v. RICHTHOFEN: China, Vol. 4, p. 214; Pl. 44, figs. 4, 5.

Shoot dorsiventral, frond-like, anisophyllous, with rather thick axis (3-8 mm. broad on the impression). Leaves apparently arranged in four rows, two on the upper, two on the lower side of the rachis. Leaves of the two rows on one (the lower?) side large, spread out in one plane, forming an angle of (30) 40 60° to the axis, varying on the same shoot in ascending order from short cuneate-obovate to oblong-linear, attaining a maximum length of almost 10 cm., their base broad, somewhat oblique. Apex of these leaves somewhat truncate, dissected through sharp, narrow incisions into a varying number (mostly 3-5) of irregular, narrow, triangular to linear, obtuse lobes which may attain a maximum length of 8-10 mm. and are often once more dissected at the apex; leaves of the other (upper?) side, smaller, directed towards the top of the shoot, less markedly truncate, with shorter triangular lobes. Veins fine, bifurcating mostly in the lower part of the leaf, two or more branches entering into each of the larger lobes.

The photographs in pl. 1 give a general idea of the great variation in regard to the shape and size of the leaves in this species. It is difficult to imagine, for instance, that the specimens in fig. 3 and fig. 4 can both belong to the same species. The leaves vary, however, within rather wide limits even in one and the same specimen, the general rule being that they grow longer and narrower towards the top of the shoot. While there is a great difference, for instance, between the leaves in the lower part of fig. 3 and in the upper part of fig. 1, a greater resemblance is found if the top of fig. 3 is compared with the base of fig. 1. There is a similar resemblance between the uppermost leaves of the specimen in fig 1 (not shown in the figure) and the basal ones of fig. 2, and also between the top of the specimen in fig. 2 and the large specimen in fig. 4. Thus all the specimens figured in pl. 1 are doubtless specifically identical.

The marked and regular variation in size and shape of the leaves in the same vertical rows, according to their position on the shoot, seems to indicate that the shoots were rather short, of limited growth, and were possibly shed entire.

The disposition of the leaves is not so well shown in this species as in *Tingia crassinervis* and will be more fully discussed in connexion with the latter species. In the figures only the two vertical rows of larger leaves, suggesting pinnae of a compound frond, are seen, but after removing a part of the matrix which bears the impression of the axis, it was found that other somewhat smaller leaves, apparently also in two vertical rows, occur on the other side of the axis.

The present specimens were found by Dr. NORIN east of Tai-yuan-fu, near the village Chen-chia-yü, in the fine section exposed in the Shih-ho-tse valley. The plant-bearing bed from which they are derived belongs to the "Lower Shih-ho-tse Series" of Dr. NORIN and has the number 16 in his general tabular section of the Upper Palaeozoic east of Tai-yuan-fu[1]. It is about 150 m. above the highest coal-bearing level and 70 m. below the oldest horizon (bed 20) on which *Gigantopteris nicotianaefolia* has been noted with certainty; it is possible, however, that the latter species begins much lower down (in bed 18), or less than 20 m. above the horizon with *Tingia carbonica*.—The horizon of the specimen first collected at Lor g-shan is unknown: all other specimens collected at the same time on the dump indicated a level corresponding to the lowermost part of the Shih-ho-tse series or even to the Yueh-men-kou Series of Dr. NORIN (l.c.).—In Hunan as remarked above, the species was found associated with *Gigantopteris nicotianaefolia.*

TINGIA CRASSINERVIS N. SP.

Pl. 2, figs. 1-3.

Shoot dorsiventral, frond-like, anisophyllous, with very thick axis (attaining a breadth on the impression of 10 mm.). Leaves apparently arranged in four rows, two on each side of the axis. Leaves of the two rows on one

1 E. NORIN, The late Palaeozoic and early Mesozoic sediments of Central Shansi. Bull. Geol. Surv. China. No. 4. 1922. Pl. 3.

(the lower?) side large, spread out in one plane, and forming an angle of 40-60° to the axis, varying in ascending order from short cuneate-obovate to oblong-oblanceolate, attaining a length of 10 cm.; their base broad, oblique, decurrent; apex of these leaves broadly obtuse or rounded, dissected into a varying number of irregular lobes. Lobes varying from short semicircular, only 1-2 mm. long, to oblong with a length of 5-7 mm, apex of the longer lobes often dissected into two short secondary lobes. Veins numbering 6-8 at the base of the leaf, very thick, bifurcating twice or thrice, the first time very near the base, generally two or more branches passing out into each lobe.

The shoots of this species attain a larger size than those of *Tingia carbonica*. The largest specimen, a part of which is shown in pl. 2, fig. 1, is broken off at both ends; the preserved portion is 25 cm. long with a greatest breadth of 13 cm. The larger leaves, which measure 9 cm. in length at the top of the specimen, diminish downwards, but even at the lower end they are nearly 7 cm. long. In the specimen in pl. 2, fig. 2, which is also broken off both above and below, the leaves are considerably shorter, or a little over 4 cm. at the upper end and a little less than 3 cm. at the lower. In all specimens except a few fragments representing the uppermost part of the shoot, the leaves diminish in a similar way in length, though not in breadth, downwards; and it is evident that the specimens with short and broad leaves, such as the one in fig. 2, represent the basal parts of shoots. A comparison between the specimens in figs. 1 and 2 suggests that the missing basal part of the former must have been of considerable length and that the shoots generally attained very large dimensions. The regular variation in the size of the leaves according to their place on the shoot, and the fact that no case of branching has been observed, seem to indicate that the ultimate lateral shoots were sharply set off, of limited growth and rather frond-like, and were probably shed entire.

The two rows of smaller leaves are more or less distinctly seen in all the figures in pl. 2. In the largest specimen the matrix bearing the impression of the axis has been removed at the lower end, and fragmentary impressions of two smaller leaves are shown on a deeper level. These smaller leaves appear, on the impression, to be directed towards the top of the shoot, and almost parallel with the axis, though it is possible that they were not adpressed but formed an angle to the plane of the larger leaves. In the specimen in fiig. 2 traces of apparently adpressed smaller leaves are found close to the axis, but their shape is not shown. All four rows of leaves are more or less distinctly present in the small fragment in fig. 3.

This specimen evidently represents the basal part of a shoot, to judge from the thickness of the axis and the broad leaves shown in the rows on the right. The corresponding leaves to the left have been slightly deformed and displaced through pressure so that they appear to be directed more upwards than in their natural state. The rows of smaller leaves close to the axis, however, are yet more adpressed and differ from the rows of lateral leaves not only in size but in direction. In this case the smaller leaves are about half the length of the larger ones, and more or less the same proportion seems to prevail also in the other specimens.

The specimens were found in the same locality, near Chen-chia-yü, as *T. carbonica,* but on a higher horizon, Dr. NORIN's plant-bearing bed 20, belonging to the Upper Shih-ho-tse series.

In the material of *Tingia carbonica* which I examined somewhat superficially in China in 1916-17, and which was afterwards lost, only the larger leaves on one side of the shoot were observed, and there was no reason then to doubt that the specimens represented pinnate fronds. In most specimens of the present material of both species, too, the smaller leaves on the other side of the axis are invisible if not exposed through special preparation. Both *Tingia carbonica* and *T. crassinervis*, therefore, generally show a certain resemblance in habit to pinnate fronds referred to the genera *Noeggerathia* STERNB. and *Plagiozamites* ZEILL. From *Noeggerathia* or at least its geno-tope, *N. foliosa* STERNB., *Tingia* differs through the shape of the leaves, which are longer and narrower and taper less to the base than the leaflets of *Noeggerathia*. From both genera it is easily distinguished through the deep apical lobes each of which receives more than one vein. Both in *Noeggerathia* and *Plagiozamites* the margin of the leaflets is finely dentate or fimbriate, but the teeth are generally small, always narrow, rather hair-like or spine-like and receive only one vein each. Moreover, the venation of *Plagiozamites* and of *Noeggerathia* with dissected margin is more radiating, so that some veins run out into the lateral margins, even in the lower half of the leaflets or almost at the base, whereas in *Tingia* the veins are more nearly parallel and only the truncate or rounded apex of the leaf dissected. The short leaves in the lower part of the *Tingia*-shoot and the basal pinnae of *Plagiozamites* are less different in this respect; and fragmentary specimens may sometimes be difficult to distinguish if the arrangement of the leaves or leaflets is not seen.

While the specimens of *Noeggerathia* and *Plagiozamites* have generally been held to be pinnate fronds, the arrangement of the leaves in four rows proves that *Tingia* represents leaf-bearing shoots. At the same time the *Tingia*-shoots have a very frond-like appearance, and the great resemblance to *Noeggerathia* and *Plagiozamites* suggests that the specimens referred to these genera, too, may actually be shoots rather than fronds. SEWARD[1] has already expressed the view that the segments of *Noeggerathia* are single leaves while ZEILLER[2] held both *Noeggerathia* and *Plagiozamites* to be compound fronds. As reasons for his opinion ZEILLER mentioned that in *Plagiozamites Planchardi* the segments diminish in size downwards, that they are directed more upwards in the upper part of the specimens, and finally that in some cases there seems to be a terminal segment. The first two features, however, are found just as well developed in *Tingia* and, indeed, are frequently seen in ultimate shoots with limited growth. Regarding the occurrence of a terminal segment, it should be remarked that the uppermost leaf, at the suppression of the growing point in a shoot with limited growth, often may be directed upwards and appear as a direct continuation of the axis; it is therefore very difficult to make out the real structure in specimens preserved as impressions. The oblique attachment of the supposed pinnae in *Noeggerathia* and *Plagiozamites* rather suggests that they are of the nature of leaves, and the fructifications assigned to *Noeggerathia* would also be easier of interpretation on the assumption that the specimens represent shoots. While

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1 A. C. SEWARD, Fossil Plants, vol. 2, 1910, p. 430–31.

2 R. ZEILLER, Notes sur la flore des couches permiennes de Trienbach (Alsace). Bull. Soc. Géol. France, 3 sér. t.22, 1894, p.176.

the morphological nature of *Tingia* has no direct bearing on the question, it seems to strengthen SEWARD's interpretation of *Noeggerathia*, which should then be extended to the very similar genus *Plagiozamites*.

The marked anisophyllous development of the *Tingia*-shoots is very interesting and may be interpreted in different ways. If it represents a modification due to reaction to light, it would be natural to assume that the two rows of smaller leaves are placed on the upper side of the shoot, as in this way the best possible utilization of the light would be secured. In recent higher plants with a comparable form of anisophylly a similar arrangement is the rule; and the above diagnoses and descriptions have been formulated according to this interpretation. It is worthy of note, however, that the side showing the large leaves seems to have been slightly concave instead of convex, as would be more natural if it faced upwards. The possibility must therefore be taken into account that the orientation of the shoots might be the reverse to what has here been supposed. It might be suggested that the shoots were floating on the surface of the water and the smaller leaves on the lower side reduced on account of submersion. It is noticeable that the thick axis of the shoot, expecially in *T. crassinervis*, has caused only a very flat impression in the matrix, suggesting that it was of a very soft texture or perhaps hollow, as would be natural in a water-plant. There is no direct evidence, however, that *Tingia* grew in this way, and for the present it seems more natural to assume that the small leaves were on the upper, the larger on the lower side.

Finally it may be mentioned that a specimen of a form of *Tingia* from the neighbourhood of Tai-yuan-fu seems to be identical with *Noeggerathia acuminifissa* KRASSER[1], which should thus be transferred to the new genus. This specimen is of interest as the smaller leaves seem to be divided down to the base into three narrow, linear segments, thus suggesting a form of heterophylly well known in recent water-plants. This material will be described and more fully discussed in a later publication on the Upper Palaeozoic flora of Shansi.

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1 F. KRASSER, Die von W.A. Obrutschew in China und Centralasien 1893–94 gesammelten fossilen Pflanzen, Denkschr. Mat. Nat. Class. K. Akad. d. Wissensch. Wien, Bd. 70, 1900, p.3, pl.1, figs. 3a–7.

EXPLANATION OF PLATES.

EXPLANATION OF PLATES.

All figures are in natural size.

PLATE 1.

Tingia carbonica (SCHENK) *n. comb.*

All the specimens are from the Shih-ho-tse valley, near the village Chen-chia-yü, east of Tai-yuan-fu (Plant-bearing bed 16 in Dr. NORIN's section).

PLATE 2.

Tingia crassinervis n. sp.

All the specimens are from tne Shih-ho-tse valley, near the village Chen-chia-yü, east of Tai-yuan-fu (Plant-bearing bed 20 in Dr. NORIN's section).

1

2

4

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1

2

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GEOLOGY OF I CHANG, HSING SHAN TZE KUEI & PA TUNG DISTRICTS, W. HUPEH.

By C. Y. Hsieh & Y. T. Chao

(with 4 plates & 13 figures)

INTRODUCTION

This report is based upon a reconnaissance survey carried on during the autumn of 1924 in the western parts of Hupeh including the districts I Chang, Hsing Shan, Tze Kuei and Pa Tung. According to our original plan, the field of observation was to be extended much further toward the north and south covering also Yuan An, I Tu, Chang Yang, Sze Nan etc, but the political disturbance of Peking which broke out in October and the consequent movements of troops in many of the western parts of Hupeh have made travelling in the country exceedingly difficult, if not really dangerous, and eventually we had to entirely modify our plan and to cover only the four districts named above.

We left Hankow on Oct. 21 on the steamer "Tung Hu" and arrived at I Chang on Oct. 24 from there our field work began. The route of travel more or less followed the projected line of the Szechuan Hankow Railway which was also the route partly taken by Mr. S. Noda of the Japanese Geographical Society many years ago. Starting from I Chang, we proceeded northward and after arriving at Lo Jo Ping, a very interesting place for its remarkable Silurian fossils, we turned westward leading toward a most mountainous district, the northern part of the Huangling anticline. After a hard journey of two weeks, we arrived eventually at Hsing Shan Hsien and from there we followed the Hsiang Chi valley down to the Yangtze at Tze Kuei. From the latter district we proceeded again up the river as far as the boundary line between Szechuan and Hupeh. On the return we took a boat down the river and arrived at I Chang on the 28th of November. The entire trip lasted about one month and a half in which the actual working days comprised, however, not more than five weeks, the rest having been unavoidably wasted due to incidental delays and to rain.

The writers are greatly indebted to Dr. W. H. Wong and Prof. A. W. Grabau for their valuable suggestions and criticisms. To Prof. Grabau we are also indebted for his determination of the Silurian fossils, his preliminary report is published here as an appendix of this paper. Acknowledgement is also due to Mr. T. C. Chow for his identification of the Jurassic plant fossils.

PHYSIOGRAPHY

The region to be described in the following pages is that mountainous district of Western Hupeh lying south of Lat. 31° 15' on both sides of the Meridian of 111° E. and extending southward as far as the bank of the Yangtze River. Physiographically speaking this region is a young to maturely dissected plateau, its elevation, according to our barometric determination, ranges approximately from one thousand to one thousand and five hundred meters. The mountain system generally runs from north to south, with a slight inclination toward the east, which is precisely in accordance with the geological structure of the region.

Among the numerous tributaries of the Yangtze, the Huang Pai Ho of I Chang may be mentioned first. It originates in a great mountainous district in the north and debouches into Yangtze southeast of I Chang, following a course at first from northwest to southeast and then from northeast to southwest. A part of the projected Sze-chuan Hankow Railway line is laid down in the valley of this river. Other tributaries, of which the Hsiang Chi, the Chih Chi and the Lung Ho are most prominent, flow also in an approximate north-south course, being more or less parallel to the strike of the rocks across which the streams are running. The three streams just mentioned all lie on the western side of the Huangling anticline and have their water debouching respectively at Hsiang Chi, Tze Kuei and Pa Tung. The watershed between two of the most prominent tributaries, the Huang Pai Ho and the Hsiang Chi is to be found in the neighbourhood of Chieh Pai Ya; its altitude attains about one thousand meters. There are of course many other tributaries on the south side of the Yangtze, but they are outside of our area.

The geology of the region may be briefly summarized as comprising a great anticline, the Huangling anticline already mentioned, in the center of which lie the Pre-Sinian schist and gneisses with granitic intrusions and on its two limbs, a thick sequence of sedimentary rocks ranging in age from Sinian to Tertiary.

A few remarks will now be made on the relations between the lithologic characters and the topographic forms, by which these different formations as herein encountered are beautifully exhibited and which can be easily recognized and distinguished in the field. The oldest rocks are gneiss and granite, and being hard and compact, they are but slightly eroded and therefore maintian generally a conspicuous elevation. The Sinian limestone on account of its high content of silica offers also a great resistence to erosion. As the limestone is thickly bedded and has well-developed vertical cleavages, erosion will often result in lofty peaks of pinnacle shape measuring sometimes not less than four or five hundred meters in altitude, and thus presenting a very picturesque landscape. Along the upper part of Huang Pai Ho and in the vicinity of Liang Ho Kou, magnificent canyons and impassable cliffs are to a large extent developed in this formation. Almost the same topographic forms but to a far less degree are found in the lower part of the Ordovician limestone which because of its siliceous and compact nature is also a rock well suited for cliff-forming. Consequently, there is not infrequently to be seen in the field a very characteristic topography composed of two cliffs separated by a gentler slope; the former are the limestones of the Sinian and Ordovician age respectively while the slope between is formed in the Cambrian shale which has a thickness of only two hundred meters. The upper part of the Ordovician limestone, consisting mainly of thin bedded and argillaceous limestone and with very little silica gives, on the contrary, a much gentler and milder topography. Perhaps the softest rocks are to be seen in the Silurian shales which, as a rule, offer little resistence to erosion and consequently form a very open topography with gentle slope and comparatively low elevation. The topography of the Lo Jo Ping valley may be cited as the best example. In the upper and upper middle parts of the Silurian shale, there are however, frequently found ledges of quartzitic sandstone and sandy shale which in most cases may exhibit cliffs of moderate scale.

The Wushan limestone, famous for its impassable cliffs and marvellous canyons can easily be distinguished in the field from the cliffs of the Sinian limestone by the absence in the former of vertical cleavages and therefore lesser development of the characteristic "pinnacle topography". The topography of the Mesozoic sediments show as a rule a gentle slope and rather open valley, but attains generally a very conspicuous elevation as can be seen in the hills between Hsiang Chi and Tze Kuei. The Hsiang Chi coal bearing series which occupies only a subordinate part among the Mesozoic sediments, presents on the other hand, a topography of low elevation. Lying between high ranges of the Kweichow series and the Tayeh limestone, this rock forms at Hsiang Chi Valley a long and narrow depression of most contrasting aspect.

As has already been stated the river systems of this region are developed more or less in accordance with the underlying geological structures. In other words these streams are consequent rivers. To this general rule, the Yangtze River forms perhaps the only exception, for which a different and somewhat complicated history has to be looked for. Every one who ever visits the gorge district of Yangtze will be impressed by the fact that from I Chang to Pa Tung, this mighty river has developed its course chiefly perpendicular to the strike of the rock and has cut right across the heart of a huge anticline, with such an energetic force as is expressed by a series of precipitous canyons, the beautiful scenery of which has long been noted.

In a recent article on the geology of the gorge district, Prof. J. S. Lee(1) has advanced a theory for the interpretation of the gorge development laying special emphasize on the existence of a Yaotze conglomerate near the village Sin Tan. It is to our regret that our study should have been confined to the north of the River, and that we were unable to make observations at Sin Tan or its neighbourhood, so that we are not in a position to make any further contributions with solution of this question. More recently, Mr. C. C Liu and the senior author, during their travel in southwestern Hupeh discovered a Post-Cretaceous Peneplain which has been found to be so characteristic and widespread, that it will certainly throw much light on the physiography in Central China in general and the development of the Yangtze River in particular. For lack of space here, this subject will not be taken up; a complete account will howerer be given in a forthcoming report on the geology of Southwestern Hupeh.

(1) J. S. Lee: Geology of the Gorge District of the Yangtze (From I Chang to Tzekuei) with Special reference to the development of the Gorges. Bull. Geol. Soc. of China Vol. 3, No. 3-4, pp. 351-391.

Other topographic features in the area concerned and which deserve special mentioning here are the deep precipitous gorges or "Hsia" and the dangerous foaming rapids or "Tan", both of them having long been noted, especially through the writings of our ancient poets and literatis since they constitute one of the finest scenic feature of China. The formation of deep gorges is evidently to be attributed to river erosion, but the localization or distribution of the same is a question of entirely different nature, and to the minds of geologists, this is chiefly determined by the physical nature of the rocks through which the river has so effectively penetrated.

Between I Chang and Pa tung, there are several gorges; among them three are most noted. These are usually called upper, middle, and lower gorges respectively. The upper or Wushan gorge begins at Wushan Hsien, Szechuan Province and ends 30 lis W. of Pa Tung constituting the longest and also the most magnificent gorge among the three. The rocks here are composed mainly of limestone of Carboniferous to Permian age; it is from this locality that the name of Wushan limestone was derived by Bailey Willis. The middle gorge lies east of Hsiang Chi; practically it can be separated into two parts the upper or Mi Tsan gorge and the lower or Niu Kan Ma Fei gorge; between them lies an open area of about 30 lis. The Mi Tsan gorge is considered the most splendid on account of its narrow and precipitious nature. It is cut in the Wushan limestons while the Niu Kan Ma Fei gorge, a gorge of less magnificence than the other, is formed in an area of Sinian limestone. Further downward between Nan Tou and I Chang, we have the lower or I Chang gorge which has a length of about 30 lis and exhibits cliffs far less precipitous than the other two. It is cut in the gently inclined Ordovician limestone. Thus the important gorges are all located in areas ef compact and thickly bedded limestone and not in other rocks such as shale or sandstone.

The location of the rapids, on the other hand, is chiefly restricted to the areas of soft shale and sandstone or more generally where shale and sandstone occur in alternation. The formation of a rapid may be roughly described as brought about in the following manner: pebbles and boulders, derived from the erosion of the mountain blocks, are carried down to the Yangtze either by the tributaries or by sliding down some nearby cliffs and ravines. At the outlet of a tributary or under some other favorable conditions, these pebbles and boulders are gradually accumulated and eventually the deposit becomes so thick and extensive that it checks the currents and thus plays the rôle of a partial dam narrowing the channel. The result is that a rushing current is formed in the narrowed part of the channel. With the energetic force of the current and its destructive effect on the rocky floor, the rapid forms a most serious impediment, sometimes even a grave danger, to the navigation especially to the boat which goes up the River; in that case men sometimes to the number of several hundred must be hired in order to overcome the current and to keep the boat moving by pulling.

The most favorable condition for the formation of a rapid is first of all that the geological formations should be of such a soft and easily destructed nature as to yield a sufficient amount of pebbles and boulders. Secondly, there must be a ravine or a tributary located nearby which affords the pathway to the pebbles. Consequently most of the prominent rapids such as Yeh Tan, Chih Tan and Sin Tan are usually found near the outlet of their respective streams. A formation of soft and hard rocks alternately interbedded such as the shales and sandstones commonly seen in the Patung and the Kweichow series is especially favorable for the development of rapids. In a formation of such nature, the soft layer is likely to be eroded away first and the overlying hard rock, though sufficient resistant to stand out for a time, will eventually be destroyed in its turn by the undermining action of the current, thus causing the accumulation of pebbles and consequently affording more opportunity for the formation of a rapid.

In the gorge district of the Yangtze, practically all the important rapids seem to be located in the area where sandstones and shales of the Patung series, Kweichow series, Sintan shale and also the Pre-Sinian gneiss and schist are exposed. We have not seen, however, any important rapides in the limestone area, though such cases may not be entirely lacking. The explanation of such particular distribution is probably to be found in the relations which we have just briefly discussed in the foregoing paragraphs.

Between Pa Tung and I Chang we have encountered a great number of rapids, which may now be briefly described. West of Pa Tung city there are Niang Niang Tan, Chiang Chun Tan, Tsin Chu Piao and east of it Heng

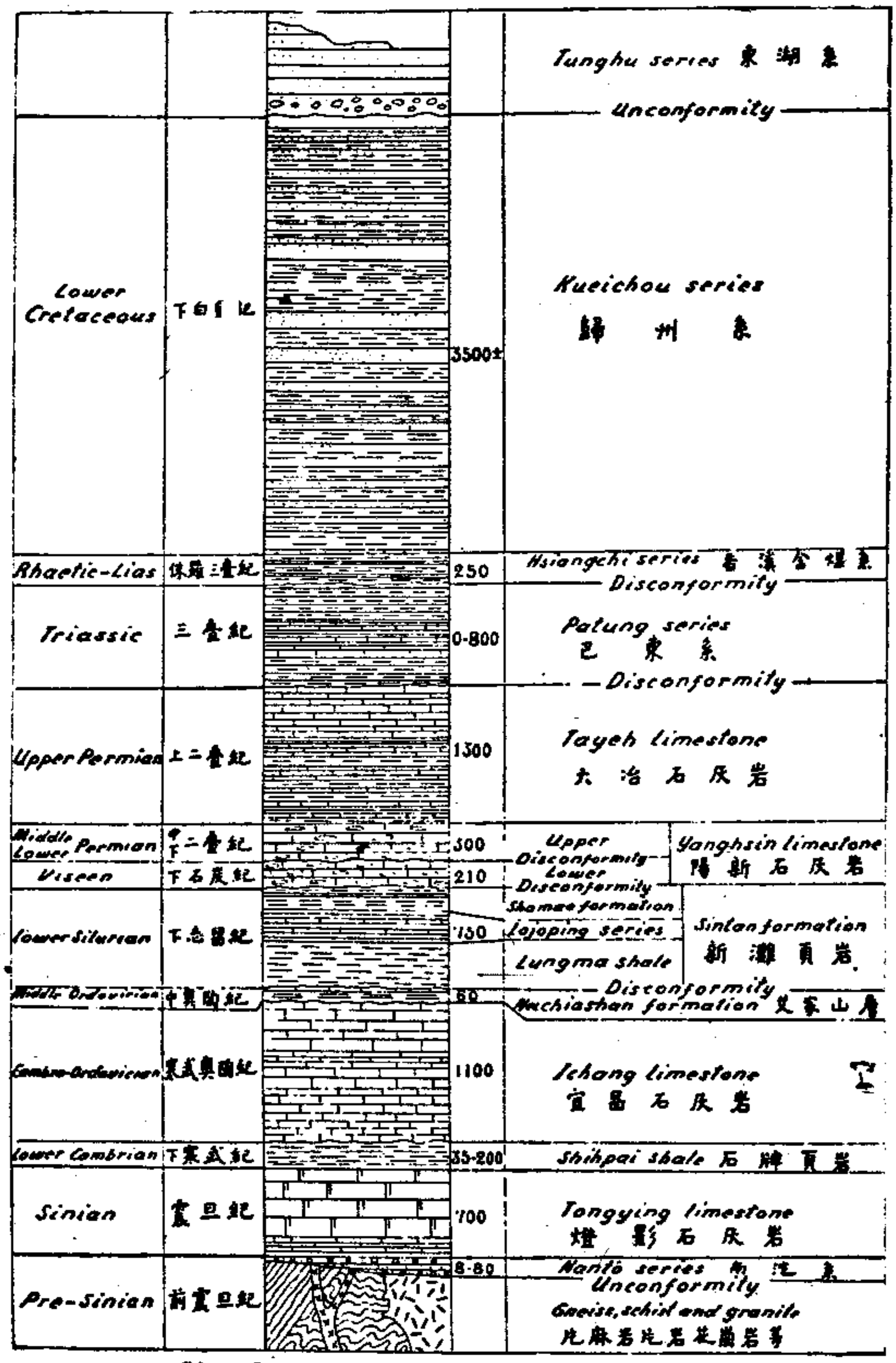


Fig. 1. Generalized section of Ichang district.
宜昌秭歸與山巴東地質柱形圖

Liang Tan and Yeh Tan all being located in the area of the Patung series. The last named Yeh Tan is especially famous for its foaming current and has long been considered by the native boatman as a dangerous spot. Once we have seen at this place a cargo boat going up the River. Not less than two hundred laborers were required, all of them working hard, using their utmost strength in order to pull up the boat, but without success. Dragging and hauling went on for a long time until one of the two ropes was broken and the boat would have been entirely swept away except for the other rope which remained intact. This particular case which we have personally witnessed shows how serious an impediment to transportation the rapids constitute in the gorge district.

In the neighbourhood of Tze Kuei, there is again a series of rapids such as Chih Tan, Ao Tan, Siu Shih Tan etc., all located in the area of the Kweichow formation. East of Tze Kuei, the River cuts into a vast area of thick-bedded and compact limestone to form the middle gorge and along this part we have observed practically no rapids. They reappeared 30 li eastward at the locality Sin Tan from which the Sintan shale of Willis was named. This is the Sintan rapid, its dashing current and foaming character being considered as only next to Yeh Tah. From Sin Tan downward we were again in a vast area of limestone and no rapids were found until the River enters the gneiss and schist of Pre-Sinian age; thus east of the Niu Kan Ma Fei gorge, there are several rapids called Kung Ling Tan, Ta Tung Tan, Wu I Tan etc., all of them developed in the gneiss & schist region. These rapids, though considerable in number, are of far less prominence when compared with those already described. They affect the transportation in the gorge to a slight extent only and will usually require only a few men to pull the boat when going up the River.

STRATIGRAPHY

The classification of the different formations in the I Chang district mainly follows the nomenclature of Prof. J. S. Lee[1] who has contributed so much to the elucidation of the geology of the district concerned. In some cases,

(1) J. S. Lee, Op. cit.

however, new names are proposed for those formations which are not exposed within the area of his traverse. In descending order, the different formations, as embodied in this paper are as follows:—

XI	Tunghu series		Tertiary
		Unconformity	
X	Kweichow series		Cretaceous
		Disconformity	
IX	Hsiangchi series	Upper coal series	Lias
		Lower coal series	Rhaetic
		Disconformity	
VIII	Patung series		Triassic
		Disconformity	
VII	Wushan limestone	Tayeh limestone	Upper Permian
		Yanghsiu limestone	Upper Permian Disconformity Lower Viséen
		Disconformity	
VI	Sintan formation	Shaomao formation Lojoping series Lungma shale	Lower Silurian
		Disconformity	
V	Neichiashan formation		Middle Ordovician
IV	Ichang limesione		Cambrian? to Ordovician
III	Shipai shale		Lower Cambrian
II	Tongying limestone Nantou Series		Sinian
		Unconformity	
I	Granite, gneiss, schist		Pre-Sinian

I. Pre-Sinian.

We crossed the Pre-Sinian crystalline rocks twice in the field, once along the Yangtze river from Nan Tou to Kun lin Tan, the other along the projected Chuanhan railway from Wu Tu Ho to Liang Ho Kou. The rocks exposed along the former route have been carefully described by Prof. J. S. Lee and thus need not be noted here. Along the latter route, the pre-Sinian rocks cover even a larger area, but during our reconnaissance in the field we had not enough time for a detailed examination and hence we can give only a very brief account of them here.

From Wu Tu Ho to Liang Ho Kou, the crystalline rocks have the same general characters as those along the Yangtze valley but their distribution appears to be more irregular and complex. Under the magnificent Sinian system at Wu Tu Ho, the same light greyish granite of a rather coarse texture is again met with but its area seems to be rather limited. From here westward, passing through different intermediate gradations, the granite becomes rapidly changed to a typical gneiss with conspicuous banded structure and lenticular bodies of red feldspars and dark minerals. This gneiss covers a wide area along our route. It first appears mid-way between Wu Tu Ho and Yang Chia Hsiao Miao and thence extends for a long distance westward until in the vicinity of Chieh Pai Ya it is replaced by the crystalline schist. The prevailing type of the latter is a kind of hornblende schist but mica schist is also frequently met with. From here westward to Liang Ho Kou, however, schist is not the sole type of crystalline rocks along the line of our route, but gneiss also occurs in alternation. Among the fallen blocks lying beside the road gneissoid rocks with mosaic of round sand grains were frequently observed. A little west of Liang Ho Kou, a porphyritic granite with phenocrysts of red feldspars appears immediately below the magnificent Sinian system.

All along the route, minor igneous intrusions are scattered here and there the most common of which are doleritic dykes.

The genetic order of the three types of rocks has been fully discussed by Prof. Lee, and our observations coincide to a large extent with his conclusion. Thus the alternation of the schist and gneiss west of Chieh Pai Ya resembles strongly the variation in composition of sedimentary rocks. The round sand grains included within the gneissoid rocks form another indisputable fact of a sedimentary origin. The intrusion of the granite at a later date must certainly be responsible for the production of the gneiss at the contact.

The age of these old sedimentary crystalline rocks is not quite clear at present. But it seems rather safe to regard them as Post-Taishan and Pre-Sinian.

II. Sinian System.

Above the Pre-Sinian metamorphic rocks lies unconformably the well stratified Sinian formation. The contact between them can best be seen on the northern bank of the Yangtze river a little distance below the entrance of the Niukan gorge. Here the highly inclined crystalline schist presents a fairly level plane which is barely followed by the basal conglomerate of the Nantou series. Going upwards, the pebbles gradually decrease in size and the rock is transformed to a coarse sandstone. The pebbles are almost entirely made up of quartz and granite, apparently derived from the old metamorphic series. The contact of the Sinian limestone with the overlying Shipai shale has not yet been actually seen in the field, though it is highly probable that there exists a disconformity.

Prof. Lee classified the Sinian rocks under three district formations, the Nantou series, the Toushantou series and the Tongying limestone. The latter two formations, however, though they differ to some extent in lithological characters, have no well-defined boundaries and it is sometimes extremely difficult to distinguish one from the other; hence we propose to unite them into one formation, and the name Tongying limestone is here used to include all the Sinian rocks above the Nantou tillite.

Nantou series: The Nantou series is typically developed in the vicinity of Nan Tou village. It lies unconformably above the Pre-Sinian crystalline rocks and is followed probably disconformably by the Tongying limestone. Its basal layer as exposed along the Yangtze valley is a thin basal conglomerate and its top bed is characterized by the famous glacial tillite, the remaining part being entirely made up by red and white coarse sandstones.

The tillite is very characteristic and can be easily recognized in the field. It is a greenish clay-rock containing subangular and variously arranged boulders of different dimensions. Upon the best preserved of them are seen numerous striae in various directions which have apparently resulted from the polishing and scratching during the movement of the ice. Among the different kinds of rock the boulders of siliceous limestones are particularly to be noted. Since we know that in the I Chang district the tillite either lies directly upon the Pre-Sinian crystalline rocks or is separated from them by a series of coarse sandstones and there is nowhere to be seen a limestone formation intervening between them, it appears that the limestone boulders either represent the residual erosion products of a former limestone bed or what is most probable, are derived from a remote source. Further systematic survey of the northwestern part of Hupeh will certainly settle this problem. In any case however, there must have been an extensive erosion before the deposition of the Tongying limestone and consequently a disconformity is infered below it.

According to the measurement of Prof. Lee in the village Nan Tou, the total thickness of the Nantou series is about 80 m. and the thickness of the tillite alone is 35 m. On the western limb of the Huangling anticline, the Nantou tillite is again well exposed with probably the same thickness along the northern bank of the Yangtze river a little distance below the entrance of the lower Niukan gorge. At Liang Ho Kou about 100 li north of Kun Lin Tan, the Nantou series was seen to consist only of 8 m. of tillite which is followed directly by the slaty limestone. Although the actual contact between the tillite and the underlying granite is not observable, yet the 2 or 3 feet of covered interval leaves no doubt as to the absence of the thick Nantou sandstone. This shows that the Nantou series becomes gradually thinner and thinner towards the north and may completely wedge out still farther in that direction.

Tongying limestone: We crossed the Tongying limestone four times in the field: 1 from Ma Hui Ping to Wu Tu Ho, 2 from Liang Ho Kou to Huang Chia Tai, 3 in the Tongying gorge, and 4 in the lower part of the Niukan gorge. In all these places it holds its normal characters and retains probably the same thickness.

The lower part of the Tongying limestone is composed of dark slaty limestones and sometimes purple calcareous slates. They are well stratified and present the appearance of a pile of boards. In one of the slaty limestones in the lower part of the formation discoid nodules, already noted by Blackwelder,(1) were frequently met with. These thin bedded slates and limestones become more calcareous upwards and finally change into the massive siliceous limestone without marked line of demarkation. And thus although the lithological characters differ somewhat between the upper and lower division, no attempt was made to separate them as distinct formations.

(1) Willis & Blackwelder: Research in China Vol. 1, Pt. I, pp. 269.

The upper part or the upper three-fourth of the Tongying limestone is all composed of not well stratified massive limestones. They are brittle and siliceous, sometimes carrying thin bands of flint They are commonly light greyish in color but the fallen blocks lying upon the river-beds are usually weathered to a whitish tint. On account of their massive character, they usually form vertical cliffs thousands of feet in heignt. The imperfect stratification and the cliff-forming habit are characters which can be easily recognized even at a distance.

The total thickness of the Tongying limestone as exposed along the route from Ma Hui Ping to Wu Tu Ho was estimated at 600 to 650 m.

Although we found no fossils in this mighty limestone series, yet its Sinian age has been fully proved by Prof. Lee and others who found a *Redlichia* fauna in the overlying Shipai shale and several well-preserved specimens of *Collenia* in the lower part of the Tongying limestone at different localities along the Yangtze river, the latter being the index fossil of the Sinian system in China.

III. Shipai Shale.

This Lower Cambrian shale escaped altogether the keen observation of Willis and Blackwelder. They really saw it within the Ichang gorge, but they erroneusely regarded it as equivalent to the Sintan shale. In mapping Hupeh, Noda justifiably corrected the observation of Willis and Blackwelder, but he again offered no contribution as to its stratigraphic position. Later studies by the University party under the direction of Prof. J. S. Lee assisted by Y. T. Chao have shown for the first time that it is to be correlated with the Manto shale of Shantung, by the finding of *Redlichia chinensis* Walcott in it. According to the measurements of Prof. Lee, the Shipai shale is about 200 m. thick at its type locality, *i.e.* Shipai Chi.

Besides the two exposures within the Ichang gorge and the Niukan gorge along the Yangtze river which have been carefully described by Prof. Lee, we further crossed this shale twice along our route leading from I Chang through Wu Tu Ho to Hsing Shan Hsien.

On the eastern limb of the Huangling anticline at Ma Hui Ping, about 80 li north of I Chang, the thickness of the Shipai shale is reduced to only 35 m. It consists entirely of yellowish green easily fissile shales. Only upon the valley bottom in the neighbourhood, did we see a small piece ot pisolitic limestone the original source of which is still rather doubtful.

On the western limb of the Huangling anticline at Huang Chia Tai about 100 li further west, the Shipai shale is again exposed. Here it appears to be much thicker, amounting to about 160 m., but is still thinner than that at Shipai Chi. The lower part is composed of greyish shales usually weathered to thin flakes which are scattered upon the slope. The middle part consists of greenish yellow shale carrying frequent intercalations of hard calcareous layers. The upper part is mainly made up of yellowish and greenish sandy shales, which torm cliffs. The shaly layers are sometimes micaceous. So far no other fossils except an unidentifiable *Eoorthis* were found in this formation.

The considerable reduction of the Shipai shale towards the north as well as the absence of any recognizable limestone intercalations which are so extensively developed at Shipai Chi suggests that the Shipai shale marks a transgression of the Lower Cambrian sea from the south to the north. If such is the case, a complete thinning out of the Shipai shale further north and its extensive development towards the south may be predicted.

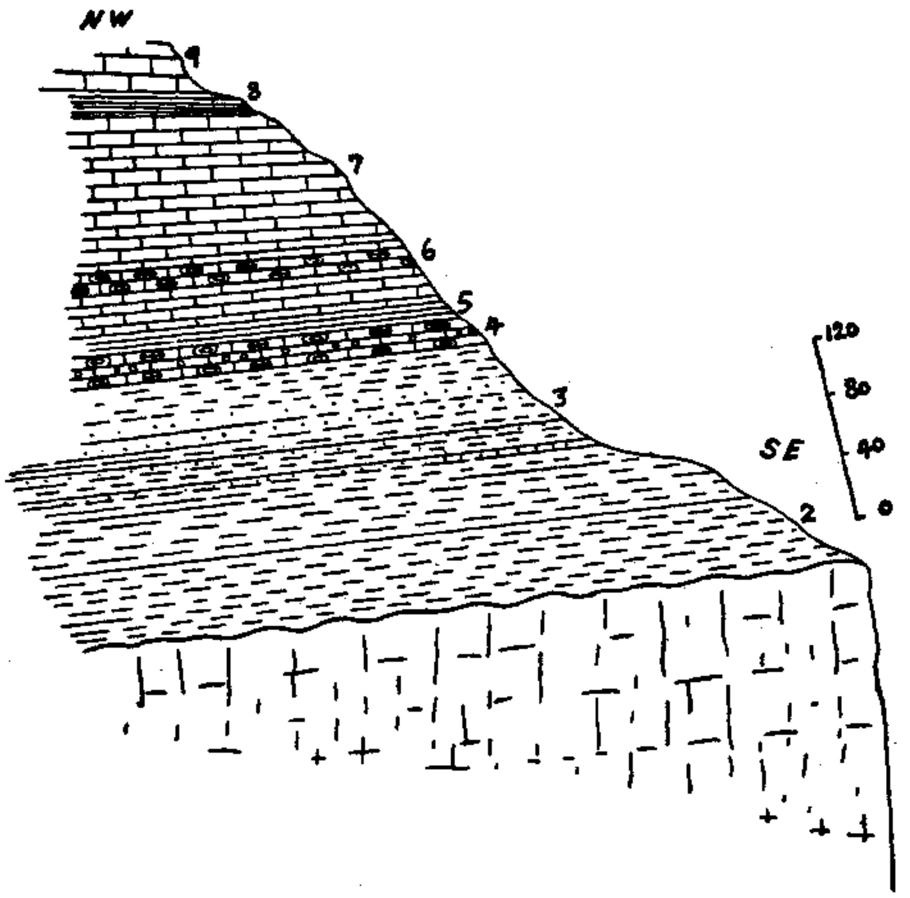
IV. Ichang Limestone.

This limestone forms apparently a large part of the Kisinling limestone of Willis and Blackwelder and is essentially equivalent to the Pingshanpa limestone of Noda. Prof. Lee estimated its thickness at from 1250 to 1680 m. According to our measurement from Huang Chia Tai to Huang Lang Ping, it is about 1100 m. Hence, the Ichang limestone must be well above 1000 m.

The contact of the Ichang limestone with the subjacent Shipai shale exhibits alternating beds of coral and Girvanella limestone, greenish shale, pisolitic limestone and thin bedded limestone (fig. 2). The corals and Girvanella are extremely abundant and some of the limestone layers are entirely made up by them. Above tnis basal division lies a mighty sequence of massive and thin bedded limestones in alternation Small black flint nodules are sometimes present in them. The weak layers between the massive limestones are frequently twisted into a series of minor folds. Towards the upper part, the limestone becomes more massive.

Although the Ichang limestone is of an enormous thickness, yet its resistance to the agency of weathering seems to have been less than that of the

Tongying and the Wushan limestones, and consequently the hills made up by it are commonly less rugged and more moderate than the latter two formations. Since the Shipai shale is too thin to influence the topography to any marked degree, it generally constitutes the same range with the Tongying limestone. It can be, however, easily distinguished from the latter by its marked stratification and the more or less gentle slope formed by the Shipai shale below the limestone.



第二圖 黃家台剖面圖

Fig. 2 Section at Huang Chia Tai showing relation between Shipai Shale and Ichang limestone.

1. 燈影石灰岩 Tongyin limestone 2-3 石牌頁岩 Shipai shale; 2. Grey easily fissile shale, 3. Yellowish green shale with thin beds of sandy shale, becoming sandy in the upper part. 4-9 宜昌石灰岩 Ichang lime tone: 4. Archaeocyathinae limestone alternated with pisolitic limestone, 5. Green shale, 6. Thin bedded limestone with a bed of Archaeocyathinae limestone in the upper part, 7. Thin bedded limestone 8. Green shale 9. Thin bedded limestone.

Fossils from the Ichang limestone and their bearing to its age: The fossiliferous beds so far discovered in the Ichang limestone are all confined to its top and basal layers, no fossils whatsoever having yet been obtained from the middle part except a Cryptozoa-like limestone which was found midway between Lien Shan Po and Ma Hui Ping.

The upper fossiliferous zone occurs only 4 meters below the top of the Ichang limestone. The rock is a kind of pure grey limestone sometimes crystalline. The upper bed is characterized by *Proterocameroceras*, the middle by *Orthis*, and the lower by *Eccyliopteris*. The total thickness of this fossiliferous limestone seems to be no less than 50 m.

This fossiliferous zone is of a rather wide distribution in the Gorge district, having been found at Lo Jo Ping, Chi Tsao Pa, Huang Lang Ping and Kien Yang Ping and indeed in every place where the upper bed of the Ichang limestone is exposed. The fossiliferous layer discovered by Prof. Lee at Nan Tsin Kuan represents essentially this bed, or at least a part of it. A little west of Lo Jo Ping, we obtained the following species of fossils from it:

Batostomella antiqua Yabe
Proterocameroceras matheui Grabau
Orthis (several species)
Eccyliopteris sp.

Proterocameroceras matheui stands out mostly in relief upon the weathered surface of the limestone. The annulations around its outer shell are almost entirely destroyed in the weathered specimens but can be clearly seen by etching them out in the laboratory. The species was first described by Prof. Grabau from the Lower Ordovician of North Chihli and more recently was again found by Mr. Weimann Hsu in the Lunshan limestone of the Nanking hills. It is the specimen from the latter locality with which our shell completely agrees. Associated with *P. matheui* is *Batostomella antiqua* Yabe.

The orthoid shells occur abundantly in a compact semicrystalline limestone a few meters below the *Proterocameroceras* bed. But the limestone is too dense to yield good specimens.

The age represented by this meager fauna is Lower Ordovician.

At the very base of the Ichang limestone, there are 14 m. of alternating beds of coral and pisolitic limestones; 40 m. higher up, another thin coral limestone also occurs. The coral limestone is almost entirely made up of the remains of Archæocyathinæ and Girvanella, cemented by an argillaceous lime-mud in which fragments of trilobites are frequently observed. Free checks and segments of trilobites were also frequently met with in the thin limestone intercalations, but so far no identifiable specimens were secured.

The Archæocyathinæ and Girvanella occur, as a rule, in the same bed of limestone, but they are distinctly distributed into two different layers. Most commonly the Girvanella abounds in the lower, while the Archæocythinæ occur in the upper part.

The Girvanella belongs to a species widely distributed in south China. It was first described by Yabe from the Lunshan limestone of Kiangsu who introduced the name *Girvanella sinensis.* In mapping Hupeh, Noda also obtained it from an oolitic limestone at Liu Chia Ho, Hsing Shan Hsien. Its geological age was regarded, at that time, as Ordovician.

The corals collected include perhaps several genera all of which belong to the family of Archæocyathinæ. Tho most common species among them is a kind of *Spirocyathus*, provisionally named as *Spirocyathus hupehensis* Chao. (sp. nov.). The species is characterized by its cylindrical form, numerous dissepiments and strongly thickened septa which are, as a rule very regular in the middle part of the intervallum but become greatly perforated and irregular towards the walls particularly the outer one where they become warped and broken into an imbricating nets-work. In form our species is not unlike *Spirocyathus atlanticus* Billings but can be easily distinguished from the latter by the more regular septa.

Then arises the question, what is the age of the Archæocyathinæ limestone or the lower part of the Ichang limestone. Yabe assigned an Ordovician age to *Girvanella sinensis* but he at the same time identified the corals collected by Noda as *Coscinocyathus* cf. *cancellatus* Bornemann of the Lower Cambrian of Sardinia. Now we are quite confident that Noda's collection was derived from the same Archæocyathinæ limestone at the base of the Ichang limestone and we are equally confident that the Girvanella obtained from the oolitic limestone at Liu Chia Ho by Noda is also derived from this bed. The conflicting conclusion arrived at by Dr. Yabe is then due to an inadequate knowledge of the stratigraphic position of the fossils concerned.

It has been well known that Archæocyathinæ have a world-wide distribution. They have been reported from Scotland, Sardinia, India, Australia, Siberia, and several parts of N. America. In these places, they are all referred to the Lower Cambrian or the ***Olenellus*** zone. It is to be noted that the limestone at Mingan Island in which ***Archæocyathus minganensis*** occurs, has been recently proved to be of Ordovician(1) instead of Upper Cambrian as has been held by some, and that ***Archaeocyathus chihliense*** Grabau also comes from the Lower Ordovician of Chihli. Moreover, in most of these places if not all, very little is known about the detailed succession of the Archæocyathinæ limestone with the overlying and underlying rocks. And Prof. Grabau is now inclined to believe that more detailed study of the stratigraphy of the above-mentioned places may prove that the Archæocyathinæ limestone all belong to the Lower Ordovician instead of Lower Cambrian from which they are separated by a profound disconformity. But our field observations seem to afford little support to his view.

In Sardinia and Australia, the Lower Cambrian is immediately followed by the Archæocyathinæ limestone. In Hupeh, the Archæocyathinæ limestone also occurs directly above the Lower Cambrian shale which carries a ***Redlichia*** fauna. The genera represented by our Chinese Archæocyathinæ seem to be essentially the same as those of Sardinia and Australia. Further careful study may show that some of them are closely related if not specifically identical. Thus both on a stratigraphic and faunal ground, the reef limestone in Hupeh is to be correlated with that of Sardinia and Australia.

The contact between the Archæocyathinæ limestone and the Shipai shale as revealed in the section at Huang Çhia Tai (fig. 2) shows not the slightest trace of disconformity or hiatus. Moreover, intercalated with the Archæocyathinæ limestone are still several thin layers of greenish shales and pisolitic limestones which differ in no way lithologically from those of the Shipai shale. Fragments of trilobites are frequently observed in the lime-matrix of the Archæocyathinæ limestone and are sometimes very abundant in the thin bedded limestones intercalated within the Archæocyathinæ limestone.

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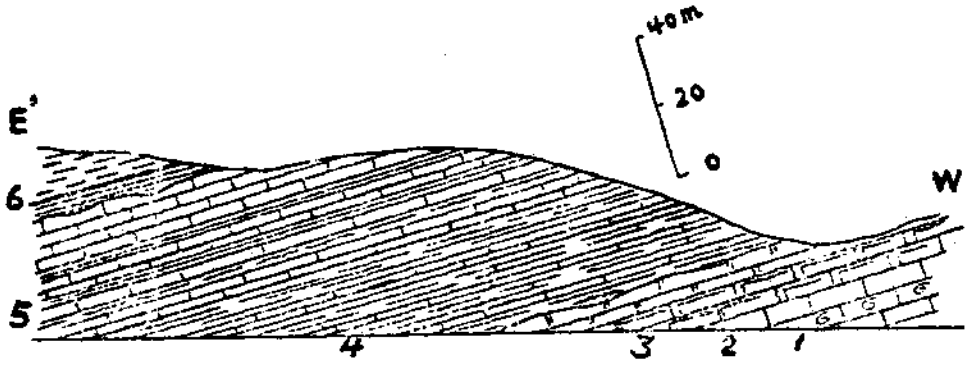
(1) Grabau A. W: Ordovician Fossils of North China; Pal. Sinica, Ser. B, Vol 1 Fas. 1, pp. 15.

The absence of any evidence of erosion, the continuity of the lithological characters and the presence of abundant fragments of trilobites suggest that the lower part of the Ichang limestone or at least the Archæocyathinæ limestone still belongs to Cambrian. The enormous thickness of the Ichang limestone also favors this suggestion. The only objection to it is the lack of any fossil evidence above the Archæocyathinæ bed. We know, in N. China, Yunnan and India, the Middle and Upper Cambrian is characterized by a wonderful number of trilobites and here moreover the extensive Archæocyathinæ fauna of Ichang is absent. If the Ichang limestone really represents a continuous deposit during Cambro-Ordovician time, trilobite remains will certainly be present somewhere in the lower part above the Archæocyathinæ zone. But the fact that in spite of repeatedly careful searching in the field, nothing has been obtained from it is worthy to be noted. This however, can be explained either by our present inadequate knowledge about the faunal succession of the Ichang limestone or by the presence of a disconformity not far above the Archæocyathinæ limestone. At any rate, we must consider this question as unsettled and its final solution has to wait for further detailed examination of our field geologists.

V. Neichiashan Formation.

The Neichiashan formation lies concordantly above the Ichang limestone and is followed directly by the graptolite shale of the Sintan formation. Its thickness was estimated at about 100 meters.

The whole formation is composed principally of an alternation of greenish calcareous shales and slabby earthy limestones. In the upper part, limestones are the dominent type of rocks while towards the lower part shales are prevalent. At the very top of the formation just below the Graptolite shale there is a thin limestone several meters thick which particularly abounds in *Orthoceras chinense* Foord. Not far below the top of the formation, there is also frequently seen a thin layer of purple dense calcilutyte which is closely crowded with remains of trilobites. They are, however, mostly represented by free cheeks, segments and occasionally pygidium, glabella being exceedingly rare if not entirely absent. In about the middle part *Triplecia poloi* which was more recently made a new genus *Yangtzeella* by Kolarova and other characteristic species occur in great numbers in the shaly intercalations.



第三圖　羅惹坪西艾家山層剖面圖

Fig. 3. Section of the Neichiashan formation, W. of Lo Jo Ping

1-3 宜昌石灰岩Ichang limestone: 1. *Eccyliopteris* bed, 2 *Orthis* bed, 3. *Proterocameroceras* bed. 4-5 艾家山層 Neichiashan formation: 4. Yellowish green earthy limestone and calcarious shales in alternation with abundant *Yangtzeella* & others, 5. Yellowish green earthy limestone with thin intercalations of yellowish shale, upper bed abounds in *Orthoceras chinense*. 6. 龍馬頁岩 Lungma shale.

The road leading from Huang Chia Chang through Fen Hsiang Chang to Lo Jo Ping coincides approximately with the contact between the Neichiashan formation and the Sintan shale. On account of the thin bedded character of the former, the limestones are extensively used for paving the road. On these stone pavements, particularly on those in the street of Fen Hsiang Chang, horn-shaped *Orthoceras* occur in great numbers and their sections present even a more attractive sight to travellers. These are well known to the local people as Pagoda stones. On the western limb of the Huangling anticline, the same condition occur as Huang Lang Ping is reached. Hence the approach of any occurrence of Neichiashan formation in the vicinity of a certain place is almost infallibly announced by the stone pavements on the way.

The Neichiashan formation is rather uniform and persistent in western Hupeh and whereever it occurs it contains the same species of fossils.

(1) Kolarova: The generic status of Triplecia poloi; Bull. Geol. Soc. of China, Vol 4, No. 3-4.

The collections made at Chu Pao Shan, Lo Jo Ping and elsewhere along the road leading from the former to the latter include the following species:

Orthoceras chinense Foord
Discoceras eurasiaticum Frech
Cyrtoceras sp.
Orthoceras sp.
Cycloceras sp.
Vaginoceras sp.
Endocers sp
Orthis calligramma Dalm.
Dalmanella cf. *testudinaria* Dalm.
Dalmanella (several species)
Clitambonites giraldii Martelli
Yangtzeella poloi (Martelli)
Eccyliopteris sinensis Frech
Asaphus sp.

As discussed by previous authors, the Neichiashan formation is late Middle or early Upper Ordovician in age. It is equivalent essentially to the Machiakou limestone or the Actinoceras limestone of North China but belongs to a different faunal province.

The Neichiashan formation is widely distributed in Central China. It was first found in Tsinglingshan in Southern Shensi whence Martelli described most of the brachiopods in the list above given. Willis and Blackwelder again found it at Hsu Chia Pa in the upper reaches of the Tañing Ho. The fossiliferous bed discovered in the Tafan(1) limestone in Southeastern Hupeh also belongs here. Further systematic survey of S. China will certainly find it in many other places.

VI Sintan Shale

Above the Neichiashan formation without any evidence of erosion or discordance of dip comes the Sintan shale. A disconformity, however, is inferred between them and is evident, since the former belongs to late Middle Ordovician and the latter to Lower Silurian.

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(1) C. Y. Hsieh Stratigraphy of S. E. Hupeh, Bull. Geol. Soc. of China Vol.III, No. 2, p. 91.

Having failed to find any reliable fossils in the Sintan shale, Willis and Blackwelder assigned it a Siluro-Devonian age on account of its intermediate position between the Ordovician Hsuchiapa transition zone and the Carboniferous Wushan limestone. During recent years, our knowledge on the Silurian stratigraphy of Central China has been greatly improved. In 1923 Messrs C. C. Liu and C. Y. Hsieh(1) found an *Encrinurus* bed in the middle part of their Fuchi shale in Southeastern Hupeh. The same bed was also found by Mr. C. C. Wang in Kiangsi. In 1924 Prof. J. S. Lee, Y. T. Chao and others discovered a Graptolite zone at the base of the Sintan shale in its type locality, Sin Tan. In mapping the I Chang district, we even discovered several far more richly fossiliferous beds in about the upper part of the Sintan shale at Lo Jo Ping which yield a fauna of about 50 species. Since the lithological characters and accordingly the faunas of the Sintan shale differ from place to place, it seems desirable to describe the occurrence separately.

In Lo Jo Ping and its vicinity.

On the eastern limb of the Huangling anticline the Sintan shale is completely eroded away or else it is buried under the Tunghu series at the entrance of the Ichang gorge. From I Chang northward, it first appears at Chu Pao Shan a little south of Huang Chia Chang about 40 li north of Tung Hu Hsien (Ichang), but there again only the lower part is preserved and it is unconformably overlaid by the basal conglomerate of the Tunghu sandstone series. Still farther north, higher beds appear in succession until at Lo Jo Ping where the whole sequence is completely exposed. Lo Jo Ping is situated about 70 li north of Tung Hu Hsien. To the east, rises the magnificent Wushan limestone crowned with whitish peaks; to the west, the Ichang limestone constitutes a mighty group of high hills; while between the two the Sintan shale is depressed into a broad valley. At Sha Mao Shan 5 or 6 li north of Lo Jo Ping, the Sintan shale is beautifully exposed (fig. 4). Along this section its thickness was estimated at 780 meters.

Both from its lithological character and fossil contents, the Sintan shale as revealed in this section allows of a three-fold subdivision. In ascending order, they are:

(1) C. Y. Hsieh. Op. Cit.

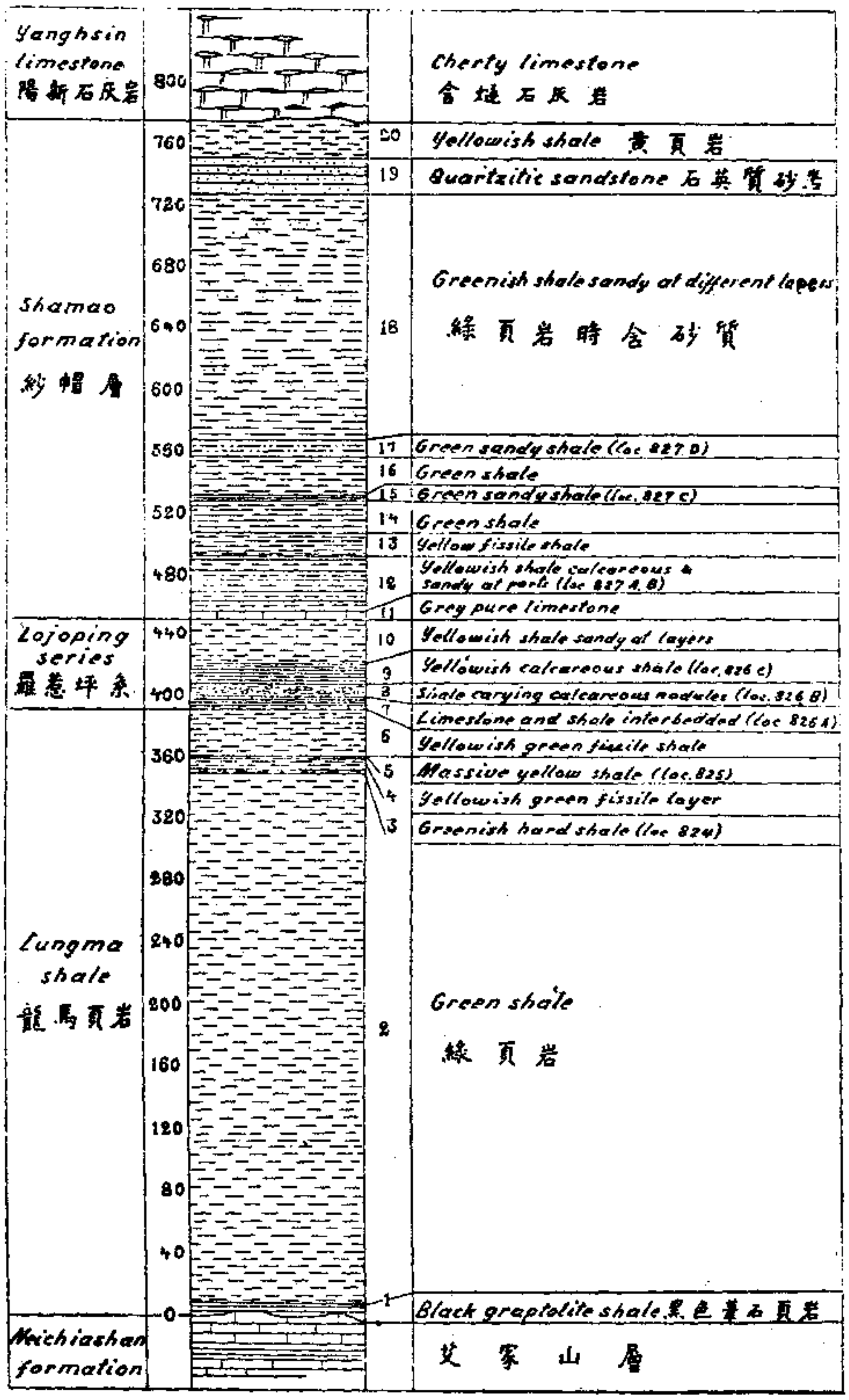

Fig. 4. Columnar section of the lower Silurian at Lojoping, 70 li W. of Ich'ang.
羅惹坪下志留系之柱形圖

Lungma shale: This is a shale series about 400 meters thick. The basal layer is a black Graptolite shale only 7 meters in thickness. Its contact with the underlying Orthoceras limestone can barely be seen in the Sha Mao Shan section. Above the Orthoceras limestone without any indication of erosion interval is a yellowish unfossiliferous shale, only a few inches thick. A little higher up, the shale becomes gradually dark-colored and Graptolites begin to make their appearance. In the upper middle part of these 7 meters of Graptolite shale, the color becomes blackest and the Graptolites are also most abundant. Still upwards in the sequence, the black color gradually fades away and the black shale changes insensibly into deep g reen shale, and at the same time the Graptolites disappear. Despite the slight thickness of this black shale, it is as yet very persistent in distribution. It has been found along the slopes of the hill Chu Pao Shan, Huang Chia Chang and indeed all along the road leading from the latter place through Fen Hsiang Chang to Lo Jo Ping.

Above the black shale at the base is a shale series about 390 meters thick. When the shales are fresh such as those exposed on the vertical banks of river valleys, they appear to be massive and olive green. But wnen they are long subject to the agency of weathering, they are of a light color and are usually crumbled to thin flakes scattered here and there upon the slopes. In the upper 40 meters of this green shale series, there are two thin intercalations of massive yellowish green shale carrying a Trilobite and Graptolite fauna. These two fossiliferous beds, however, change insensibly into the ordinary green shales and no boundary whatever can be drawn between them.

The absence of any boundaries in lithological character between the different members of this formation and the occurrence of Graptolites even in its upper part suggest that all these shales are to be classified under the same formation *i. e.* Lungma shale.

Lojoping series: This division consists of alternating beds of calcareous shales, sandy shales and thin limestones. It is separated from the highest fossiliferous bed of the Lungma shale by 25 meters of unfossiliferous yellowish green shale. The basal member of the series is an alternating bed of thin limestones and shales carrying calcareous nodules, and the rest is composed mainly of yellowish shales, sandy shales and calcareous shales with a bed of grey pure limestone 4 meters thick at top. Fossils are present practically in every layer. The total thickness is estimated at 62 meters.

Shamao formation: This constituts the upper 320 meters of the Sintan shale. The lower and middle part of the series is composed principally of greenish shales and sandy shales. The upper part comprises mostly sandy layers and sandstones forming prominent bluffs. The uppermost layer is a bed of greenish yellow soft shale which is capped by the cliff-forming Wushan limestone.

Fossils from the Lungma shale. The fossiliferous layers are mainly confined to the base and upper part of the formation, no fossils whatever having yet been found in the middle 350 meters of the green shale above the basal Graptolite zone.

In the black shale at the base of the formation, Grapolites are present pratically in every layer. The richest bed, however, seems to be confined to its middle part where the shale is also the blackest. The most abundant species belong to *Diplograptidæ*. A species of *Lingula*, though not abundant, was also detected at several places. In lithological character and stratigraphic position, this black shale corresponds undoubtedly to that exposed at Sin Tan. But so far we found only an imperfect specimen of ***Monograptus*** which is so abundant in Sin Tan(1) is a noteworthy fact.

The three lots of fossils collected at Chu Pao Shan, Huang Chia Chang and Fen Hsiang Chang combined yield the following species according to the preliminary determination of Mr. Y. C. Sun:

Lingula sp.
Petalograptus palmeus (Barrande)
Orthograptus vesiculosus Nicholson var. *sinensis* Sun.
Climacograptus hsiehi Sun
Monograptus crenularis Lapworth
Mesograptus chaoi Sun
Diplograptus sp.

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(1) Lee J. S. Geol. of the Gorge District etc.; Bull. Geol. Soc. China Vol. III, No. 3-4, pp. 308

In the upper part of the formation, two other fossiliferous beds also occur. The lower bed is about 357 meters above the base. It is a kind of greenish hard shale only 2 meters thick. Its boundaries with the underlying and overlying shales are not distinguiable and the fossiliferous shale passes insensibly into the unfossiliferous ones. Fossils seem not be abundant, but whenever they occur they mostly differ specifically. The most characteristic and common species is the sub-sphærically shaped *Favosites nucleolatus* Grabau which often appears as small round balls scattered upon the surface of the slopes. Upon the weathered surface of a small piece of green shale, beautifully preserved Graptolities of a bright brownish color are also rather abundant. According to the preliminary identification of Prof. Grabau, the fossils collected from this bed comprise the following species (Loc. 824):

Graptozoa

Monograptus marri Pern.
Monograptus sp.
Climacograptus cf. *scalaris* His.
Cephalograptus cometa (Geinitz)

Anthozoa

Enterolasma sp.
Favosites nucleolatus Grabau
Heliolites interstinctus var. *yangtzeensis* Grabau?

Brachiopoda

Glassia obovata Sow.
Stropheodenta? sp.

Cephalopoda.

Dawsonoceras sp.

Trilobita

Encrinurus (Coronocephalus) rex Grabau
Proetus latilimbatus Grabau
Bronteus cf. *partschi* Barr.

Crinoidea

Crinoidal stems (coiled)

The upper fossiliferous bed is separated from the lower by 15 meters of yellowish green shale and is 25 meters below the top of the Lungma formation. It is a massive yellow shale only 1 meter thick and has, like the lower bed, no well defined boundaries. Although the two fossiliferous beds are only 15 meters apart, yet the faunas have very few elements in common. Moreover, some of the species have a distinct Ordovician affinity. The following is a list of species supplied by Prof. Grabau (Loc. 825):

Anthozoa

Enterolasma sp.

Trilobita

Encrinurus (Coronocephalus) rex Grabau
Harpes veneulosa Cord var. *sinensis* Grabau
Illaenus asaphoides Grabau

Acidaspis octospinosa Grabau

Brachiopoda

Dalmanella testudinaria Dalm.
Triplecia cf. *grayiæ* Davidson

Fossils from the Lojoping series: The Lojoping series yields fossils in every layer. They occur not only in well-preserved condition but also as result of weathering, scattered in great numbers as individuals upon the slopes. The predominent type of fossils are corals represented both by compound and simple forms.

Although the Lojoping series is fossiliferous throughout, yet every bed has its peculiar species which is not known both above and below. On a palæontological point of view, it is divided conveniently into three fossiliferous zones as follows:

Upper-*Cystiphyllum* bed:	Grey pure limestone....................	4m.
	Yellowish shale sandy and calcareous at horizons..........................	24m.
	Yellowish shale (826 C)................	14m.
Middle-*Pselophyllum* bed:	Yellowish shale carrying calcareous concretions (826 B)............	10m.
Lower-*Halysites* bed:	Yellowish shale and thin limestones intercalated (S26 A)................	10m.

The lowest fossiliferous zone or the *Halysites* bed is characterized by the great abundance of compound corals such as *Halysites*, *Favosites* and *Heliolites*. In the *Pselophyllum* bed, the compound corals gradually decrease in number, while the horn-shaped corals ***Pselophyllum zaphrentiforme*** Gr., cylindrical ***Plat yphyllum,*** disc-like ***Palæocyclus,*** single shells of ***Glassia obovata*** var. ***magna*** Gr. and ***Trochonema depressa*** Gr. and others occur in great abundance. The characteristic ***Pentamerus borealis*** Eichw. locally known as Ying Tze Tsuai or "beak of eagle" also makes its appearrance and survives even to the very beginning of the Shamao formation. In the ***Cystiphyllum*** bed, fossils seem to be confined mainly to its lower part. Among the many species collected the genera ***Cystiphyllum, Strinklandinia*** and ***Conchidium*** may be particularly noted. In this bed, the remarkable ***Pentamerus borealis,*** also occurs in large numbers but the horn-shaped ***Pselophyllum***, coiled ***Trochonema*** and smooth shelled ***Glassia*** which are so abundant in the ***Pselophyllum*** bed disappear completely.

All the fossils collected from these beds, when combined, yield the following species according to the determination of Prof. A. W. Grabau:

Anthozoa

Palaeocyclus fletcheri E. & H.
Pselophyllum zaphrentiforme Graban
Cyathophyllum chaoi Grabau
Platyphyllum minor Grabau
Cystiphyllum cf. ***placidum*** Barr.
Microplasma poilou Grabau
Halysites cf. ***cratus*** Eth.
Halysites hupehensis Grabau
Favosites gotlandicus Lam.
Favosites tachlowitzensis Barr.
Favosites tachlowitzensis Barr. var. ***lentiformis*** Grabau
Heliohtes bohemicus Wentzel
Heliolites megastomus
Heliolites interstinctus var. ***yangtzeensis*** Grabau
Heliolites decipiens M'Coy.

Brachiopoda

Pentamerus borealis Eichwald
Conchidium tenuiplicatus Grabau
Glassia obovata Sow. var. ***magna*** Grabau

Strincklandinia transversa Grabau

Stropheodonta sp.

Gastropoda

Trochonema depressa Grabau

Pelecypoda

Orthonota antelonga Grabau

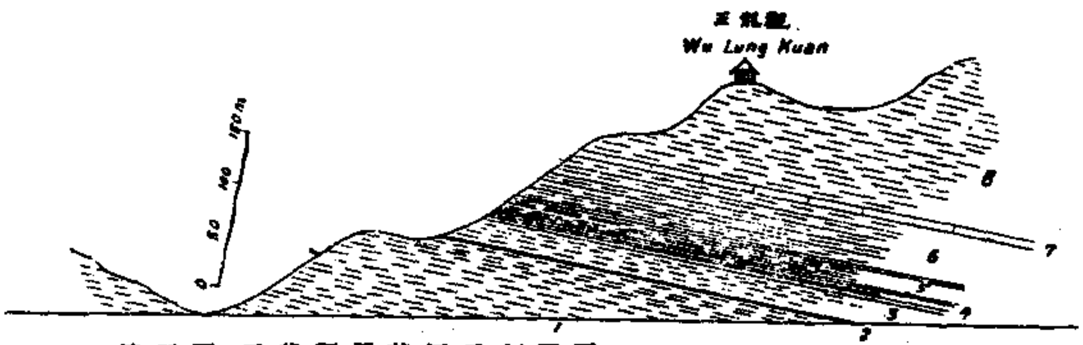
Cephalopoda

Orthoceras sp.

Crinoidea

Crinoidal stems (straight)

At Wu Lung Kuan about 8 li southeast of Lo Jo Ping, another section was taken and collections were made (fig. 5). Here the Lojoping series has



第五圖 五龍觀羅惹坪系剖面圖

Fig. 5. Section of the Lojoping series at Wu Lung Kuan, Lo Jo Ping, 70 li N. of I Chang.

1–3 Lungma shale: 1 yellowish green shale, 2 massive yellowish shale with *Encrinurus*, 3 yellowish green shale. 4–7 Lojoping series: 4 thin limestones and shales carrying calcareous nodules, full of *Halysites*, *Favosites* etc., 5 yellowish calcareous shale with a layer of coral limestone at top, full of small *Pentamerus*, 6 yellowish calcareous shale with very abundant large *Pentamerous*, the latter often arranged into layers, 7 grey dense limestone with remains of brachiopoda. 8. Yellowish shale (Shamao formation).

apparently the same succession as that at Sha Mao Shan. The fossils collected, however, though in large measure still corresponding to those collected at the latter locality, differ markedly in relative numbers. Thus at Sha Mao Shan the simple coral *Pselophyllum* and the small brachiopod *Glassia* occur in great abundance, but at Wu Lung Kuan they are extremely rare, their place being taken by *Pentamerus borealis*. This characteristic species appears immediately above the basal *Halysites* bed, but there the shells remain always small, not exceeding one inch in height. Higher up in the sequence, the shells gradually increase in size until in the upper part of the series they attain a height of more than two inches. As in the section at Sha Mao Shan, the lower part (Loc. 826') is characterized by ***Halysites***, *Favosites*, and *Heliolites*, the upper part (Loc. 826'') by ***Cystiphyllum*** and others. The following is a combined list of the species collected from these beds supplied by Prof. Grabau:

Anthozoa

Palaeocyclus fletcheri E. & H.
Pselophyllum zaphrentiforme Grabau
Cystiphyllum cf. *placidum* Barr.
Halysites cf. *cratus* Eth.
Halysites hupehensis Grabau
Favosites gotlandicus Lam.
Favosites tachlowitzensis Barr.
Heliolites interstinctus Linné
Heliolites bohemicus Wentzel

Brachiopoda

Pentamerus borealis Eichwald
Pentamerus cf. *esthonus* Eichwald
Conchidium tenuiplicatus Grabau
Dalmanella elegantula (Dalm.)
Glassia obovata Dav. var. *magna* Grabau

Fossils from the Shamao formation: Two lots of fossils were collected from the lower part of the Shamao formation. An analysis of the fauna from these two beds has led to interesting results. Some elements of the fauna at the base of the formation such as *Pentamerus* and *Conchidium* are still survivors of the underlying Lojoping series, while others such as *Coronocephalus* and *Proetus* are apparently new invaders from the old Silurian sea at the end of the Lungma epoch. In the higher beds the fauna becomes quite pure; the relic forms of the Lojoping sea become extinct and some new elements which have never been known to occur in the lower beds begin to appear. This seems to suggest that at the end of the Lojoping epoch, a part of the old *Coronocephalus* fauna together with some new elements again invaded in, resulting in the mingling of fauna at the base of the Shamao formation.

In the greenish shales above the top limestone of the Lojoping series a small collection was made which comprises the following species (Loc. 827 A, B):

Anthozoa

Enterolasma sp.

Brachiopoda

Pentamerus borealis Eichwald
Conchidium tenuiplicatus Grabau

Trilobita

Encrinurus (Coronocephalus) rex Grabau

After 35 meters of unfossiliferous yellowish and greenish shale, another collection was made from a greenish sandy shale (Loc. 827 C.) about 74 meters above the base of the Shamao formation. The following is a list of the species supplied by Prof. Grabau:

Anthozoa

Enterolasma sp.

Brachiopoda

Dalmanella sp.
Stropheodonta shönnsüenensis (Kayser)
Nucleospira pisiformis Hall
Retzia sp. (cf. *Rhynchonella borealis* var. *sinensis* Kayser)

Trilobita

Encrinurus (Coronocephalus) rex Grabau
Proetus latilimbatus Grabau

24 meters higher up, fossils were also detected in a dark green sandy shale, but so far no identifiable specimens were obtained. From this bed upwards, no attempt was made to look for fossils, though it is not doubted that they may be expected in any of the upper layers.

In Huang Lang Ping and Kieu Yang Ping.

Huang Lang Ping and Kieu Yang Ping are both located on the western limb of the Huanglin anticline. The Sintan shale exposed in these two localities has essentially the same characters as that at Sin Tan but is markedly different from that at Lo Jo Ping by the absence of those richly fossiliferous limestones and shales in the middle part of the formation.

The black shale at the base of the Lungma shale is again exposed a little north of Huang Lang Ping. At Kieu Yang Ping, it is mostly covered by debris but the blackish color of the soil near the top of the Neichiashan formation is conspicuous enough to warrant its presence. So far as can be determined at Huang Lang Ping, its thickness, lithological character and relation with the overlying green shales seem to differ in no way from that at Lo Jo Ping as previously described.

Overlying the black shale is a thick series of green shales which constitute the lower half of the Sintan formation. Higher up in the sequence, instead of a limestone and shale series with animal remains, comes a division of barren shales and sandy layers. At Huang Lang Ping, the middle part of Sintan shale is in fault contact with the Tayeh limestone, its upper part being concealed. At Kieu Yang Ping, the upper part is mainly composed of sandstones with shaly intercalations upon which lies a thick bed of whitish quartzite which is finally followed disconformably by the cliff-forming Wushan limestone.

No fossils whatever have as yet been found in the beds above the basal Graptolite shale. Although the *Coronocephalus* horizons may possibly be found somewhere in the middle part of the formation when that is more carefully examined in future, yet the complete absence here of the rich fauna of the Lojoping series seems to be unquestionable. The marked change in lithological character and the complete absence of the rich fauna within no great distance suggest that the Lojoping sea was probably mainly confined to that part of the geosyncline now forming the eastern limb of the Huanglin anticline.

Age and correlation

Von Richthofen[1] described a Silurian section at Kiau Tschang Pa in the southern foothills of Tsingling Shan in the border region between northern Szechuan, southwestern Shensi and southern Kansu, with which our section at Lo Jo Ping is to be compared. The succession there is more complete and the rocks are mainly limestones with shaly intercalations. The upper series

1. Richthofen von. China, Vol. II, pp. 597-600.

or the Chaotien limestone as revised by Prof. Grabau[1] contains many species of brachiopods among which ***Strophomena shönnsüenensis*** Kayser and ***Nucleospira pisiformis*** Hall are worthy of special mention. The middle series or the Chienshui limestone abounds in corals both compound and simple among which, ***Heliolites interstinctus*** Linné, ***H. depeciens*** M'Coy, and the characteristic genera ***Halysites, Platyphyllum*** and ***Cystiphyllum*** may be noted. The lower series or the Huangpayi formation contains several species of brachipods and corals but no Graptolites. The presence of ***Strophomena shönnsüenensis*** and ***Nucleospira pisiformis*** in the Shamao formation and the great abundance of the corals ***Halysites, Favosites, Heliolites (H. interstinctus, H. depeciens), Platyphyllum, Cystiphyllum*** etc. in the Lojoping series suggest that these two formations in Lo Jo Ping are to be correlated with the Chaotien limestone and the Chienshui limestone in Tsingling respectively. The inconsistence in fauna between the Huangpayi formation and the Lungma shale cannot, however, affect their correlation, since it is a well known fact that sediments deposited under a different facies differ also in their fauna. The Huangpayi formation is composed of red limestones alternating with shaly layers and thus must have been deposited at some distance from the shore. The Lungma shale, on the other hand, consists of black and green shales carrying a Graptolite fauna and represents deposits of ancient deltas. This marked difference in the condition of sedimentation explains the entire distinctiveness of their fauna. On the contrary in similar condition of deposit and probably equivalent with the Lungma shale in the Yangtze valley is the Graptolite shale in Shi Tien[2] south of Yung Chang Fu, Yunnan, both of them being referred to the zone of ***Monograptus sedgwicki*** and underlaid by the ***Orthoceras*** limestone probably of the same age.

In the Fuchi shale in southeastern Hupeh which has a thickness of no less than 1000 meters, the ***Coronocephalus*** bed was found by Messrs. Hsieh & Liu in its lower part. In the Yaishan shale of Kiangsi which amounts to a thickness of about 2500 meters according to Mr. C. C. Wang, the fossiliferous

1. Grabau, A. W. Stratigraphy of China. pp. 180-182.
2. Grabau, A. W. ibidem pp. 123

bed was, on the other hand, found 300 meters below the top. The most characteristic species among the collections from these two places are *Coronocephalus rex, Proetus latilimbatus* and *Spirifer hsiehi.* The former two species are also present in the upper beds of the Lungma shale and in the lower part of the Shamao formation. On stratigraphic evidence, the Fuchi shale of Yanghsin and the Yaishan formation of Kiangsi can be undoubtedly correlated with the Sintan shale of Ichang. Evidences are in favour of correlating the *Coronocephalus* bed in the Yaishan formation with the Shamao formation of Lo Jo Ping, though it is not denied that the *Coronocephalus* bed in the Fuchi shale may represent another horizon and is most probably contemporaneous with the upper part of the Lungma shale.

The great development of the limestones in the Silurian of Kiau Tchang Pa and the absence of the calcareous beds in southeastern Hupeh might suggest that the Lower Silurian sea entered the Tsingling region by way of the Himalayan geosyncline and thence sent a long enbayment northeastward to western Hupeh where it is now occupied by the eastern limb of the Huanglin anticline.

All the fossils obtained from the Sintan shale are either specifically identical with those from the Lower Silurian of Europe or very closely related to them. Hence the whole Sintan shale is referred to the Lower Silurian or Niagaran.

VII. Wushan Limestone

The Sintan shale is directly followed by the magnificent Wushan limestone. At Lo Jo Ping, the upper bed of the Sintan shale is a kind of soft yellowish shale. At Kieu Yang Ping and Sin Tan it is a thick bed of white quartzite. In the latter place, however, traces of carbonaceous shale were observed above the quartzite and local coal seams were said to be present. No physical breaks whatever have as yet been found between these two formations but on a palæontological ground there really exists a great disconformity. The hiatus includes the whole part of Devonian, Upper Silurian and a great part of Lower Carboniferous, equaling in magnitude nearly to the pre-Carboniferous disconformity in North China.

The total thickness of the Wushan limestone amounts to no less than 1800 m. and a twofold subdivision is conveniently admitted. The upper Wushan or the Tayeh limestone is composed prevailingly of thin bedded calcilutyte alternating with shaly intercalations in the lower part. The Lower, Wushan or the Yanghsin limestone constituts another unit, being massive and cherty throughout the whole formation. The division line between these two limestones is very sharp. The even surface decorated with abundant flint nodules of the lower limestone is abruptly followed by the calcareous shales and thin limestones of the Tayeh limestone. So far as can be confirmed in the gorge district, these characters are very peculiar and persistent and can be easily recognized in the field.

In Lo Jo Ping

Yanghsin limestone: In the geological map of the Ichang district by Mr. Noda, only Sintan shale is represented in those places east of Fen Hsiang Chang and Lo Jo Ping. According to our survey however, above the Sintan shale there really exists a magnificent chert limestone rising into wild ridges. This forms a great barrier between Yuan An and Lo Jo Ping on account of which the travellers from the latter to the former have to turn around either to the south or to the north. The limestone is massive and cherty, carrying local coal seams in the lower part, which are extensively mined by the natives for household purposes.

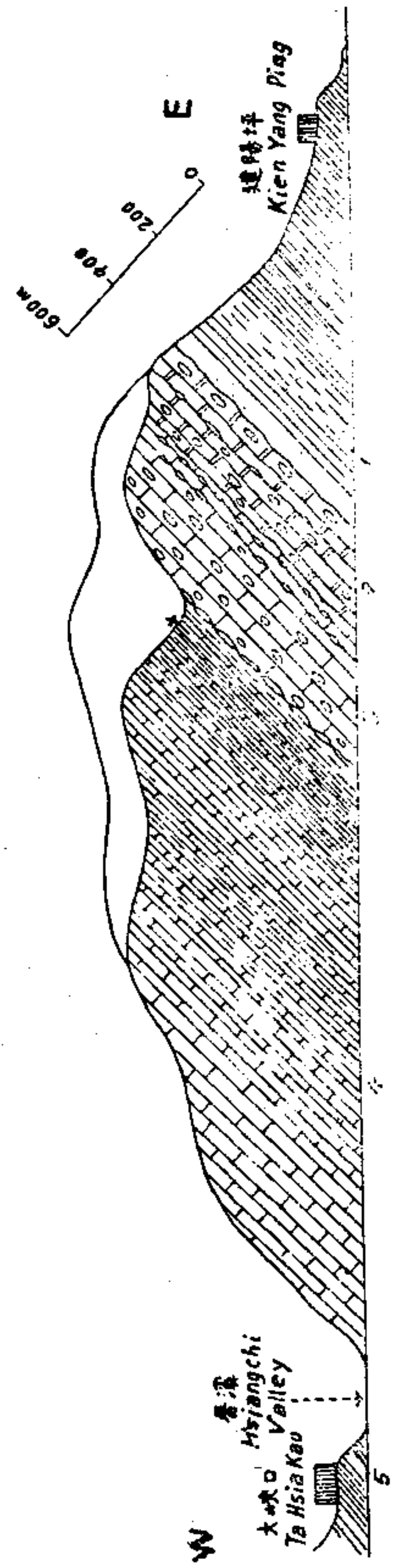
From the scattered blocks on the top of the hill at Tu Ti Yai, 15 li east of Lo Jo Ping, the following species of fossils were collected:

Fusulinella (several species)
Lonsdaleia chinensis Girty

The entire absence of the Neichiashan formation, Sintan shale, and Wushan limestone in the exit of the Ichang gorge at Nan Tsin Kuan and the gradual appearance of them below the basal conglomerate of the Tunghu series towards the north suggest that they were eroded away by a great river system possibly the ancient Yangtze after the uplifting of the Huanglin anticline. This might lead one to think that the present Yangtze river must have its origin at least before the deposition of the Tunghu series.

From Ta Hsia Kou to Kieu Yang Ping.

Ta Hsia Kou is situated on the western bank of the Hsiangchi valley. On the east comes a branch river from Liang Ho Kou which cuts through the western limb of the Huanglin anticline and along both sides of which the



第六圖 大峽口至建陽坪巫山石灰岩剖面

Fig. 6. Profile Section of the Wushan limestone from Ta Hsia Kou to Kieu Yang Ping.

1. Sintan Shale. 2-4 Wushan limestone. 2 Lower Yanghsin limestone. 3 Upper Yanghsin limestone. 4 Tayeh limestone. 5 Hsiangchi coal series.

mighty sequence of Palaeozoic rocks is completely exposed. Above the Sintan shale at Kieu Yang Ping rises rapidly the mighty Wushan limestone which swells even to a greater height towards the west until Ta Hsia Kou where it dives along its dip slope beneath the Hsiangchi valley. Along this section, the whole Wushan limestone is estimated at 1800 meters (Fig. 6).

Yanghsin limestone: In this section, the Yanghsin limestone lies disconformably above the quartzitic sandstone of the Sintan shale and amounts to a thickness of 500 meters. Black flints seem not to be abundant in the upper and lower part of the formation and they mostly assume the form of irregular nodules or lenses scattered here and there in the limestones. About 200 m. above the base, there is a division of thin bedded limestones in which black flints are extremely abundant and are generally disposed into thin layers along their bedding plane. On the other or the southern side of the river, there appears a weak bed below the thin-bedded limestones, weathered to a local gap. As to whether it represents a line of disconformity or local weakness we did not have time to confirm it, on account of the inaccessibility of the river.

Among the fallen blocks scattered here and there upon the river-bed in the lower part of the formation, loose pieces of black shale containing fossils were found. From their present position they are most probably derived from that division of the limestone ranging from 100 m. above the base to 200 m. The lithological character of these carbonaceous rocks probably indicates the existence of local coal seams in the lower part.

The whole chert limestone seems to be fossiliferous throughout. Whenever a good bedding plane is exposed, fossils are bound to exist. But owing to the massive, cherty and cliff-forming character, collection is rendered very difficult in the field.

At the very base of the limestone a little west of Kieu Yang Ping, a small collection was made which contains the following species (Loc. 834):

Fusulinella sp.
Syringopora sp.
Michelinia favositoides Girty.

From the loose pieces of black shale lying beside the lower part of the section, a single individual of *Productus* was also obtained:

Productus grandicostatus Chao

In the fallen limestone blocks about 220 m. above the base, we obtained the following species of fossils (Loc. 836):

Neoschwagerina sp.
Amplexus sp.
Productus cf. *waageni* Rothpletz
Productus cf. *punctatus* Martin.

In some of the limestone blocks lying not much over 100 m. below the top of the formation, *Neoschwagerina* was also detected. But from here upwards, no remains of foraminifera have so far been observed.

At Miao Ping about mid-way between Ta Hsia Kou and Kieu Yang Ping, the top bed of the formation yields the following three species:

Oldhamina cf. *decipiens* (Koninck)
Productus gratiosus Waagen.
Reticularia waageni L'oczy.

Tayeh limestone: The Tayeh limestone succeeds conformably upon the even surface of the Yanghsin limestone. But the sudden change of the lithological character from a massive cherty limestone to a thin bedded calcilutyte and shales and the abrupt extinction of the *Lyttonia* fauna together with the appearance of an entirely new one suggest that there must have been at least a sudden change of the condition of deposition at the end of the Yanghsinian or the Middle Permian time. The enormous thickness of the Tayeh limestone, being no less than 1300 meters in thickness and yet representing only a part of the Permian period, would also suggest that it was formed at a rapid rate involving a peculiar mode of deposition which is not readily explained from the available data so far known at present.

The upper part of the Tayeh limestone is composed of thin bedded marly limestones or calcilutyte which change gradually downwards into laminated limestones with shaly intercalations characterized by local foliations. The lower part consists mainly of alternating beds of thin shaly limestenes and yellowish shales. About 30 m. above the base at Miao Ping, a layer of greyish shale only a few inches thick yields the impressions of a concentrically wrinkled pelecypod:

Pseudomonotis chaoi Grabau

From Kuan Tu Kou to Wushan Gorge

In the geological map of the Yangtze gorges by Willis[1] & Blackwelder both Sintan shale and Kisinling limestone are represented at Nan Mo Yuan about 40 li west of Pa Tung Hsien. These authors also gave a profile of that place in the text.[2] This, however, is a great mistake, no strata older than the Wushan limestone being exposed there. The structure between Kuan Tu Kou and Nan Mo Yuan is a small anticline in the center of which the upper part of the Yanghsin limestone is exposed, just as is represented by the beautiful profile section given by Richthofen[3]. What was taken to be the Sintan shale is apparently the basal shaly division of the Tayeh limestone exposed just beside the village of Nan Mo Yuan.

Yanghsin limestone: Along this section, the Yanghsin limestone is only exposed in the center of the anticline and is mainly confined to that part of the gorge from Huo Yen Shih to Nan Mo Yuan. At the former place, the black flints in the limestones are extremely abundant and are all disposed

1. Willis and Blackwelder: Research in China, Vol. I, Pl. XXXVI.
2. Willis and Blackwelder: ibidem, p. 287, fig. 61.
3. Richthofen: China, Vol. III, Pl. I.

into distinct layers at close intervals. These features are very characteristic in the the field and have attracted the attention of perhaps every tourist. The name of the village Huo Yen Shih or "fire-stone" really originated from this characteristic feature of the limestone.

In the top bed of the chert limestone just below the foot of Nan Mo Yuan, a small collection was made which contains:

Lyttonia richthofeni (Kayser)
Productus gratiosus Waagen
Productus yangtzeensis Chao
Productus abichi Waagen
Marginifera lopingensis (Kayser)
Martinia sp.
Pseudomonotis kazanensis Golookinsky
Aviculopecten sp.
Naticopsis klurensis Waagen
Entalis sp.

Some distance below this bed at a native coal-pit on the southern bank of the river, some specimens of *Neoschwagerina* were also obtained from the fallen blocks.

Tayeh limestone: The Tayeh limestone is completely exposed in the lower entrance of the Paling Hsia or the lower WusLan gorge between Kuan Tu Kou and Huo Yen Shih. West of Nan Mo Yuan tha strike of the strata coincides approximately with the course of the Yangtze river and thus the gorge from the latter to Leng Shui Chi is entirely made up by the slightly undulating beds of the Tayeh limestone.

The Tayeh limestone exposed in these places exhibits its normal characters but for lack of time no attempt was made to confirm the fossiliferous bed at the base of the formation.

Age and correlation.

The fossils so far obtained from the lower part of the Yanghsin limestone such as *Fusulinella, Lonsdaleia chinensis, Michelinia favositoides* etc. have more recently also been found in the Chihsia limestone of the Nanking hills. Thus the correlation of the lower part of the Yanghsin limestone in the gorge district with the Chihsia limestone in the lower Yangtze admits of no question.

According to the determination of the corals collected from the Chihsia limestone at Nanking and from the lower part of the Wushan limestone at Sin Tan by Frech, both of them were referred to the Lower Carboniferous or Viséen.

The fossils collected from the top layer of the formation on the other hand, indicate essentially the horizon of the Middle Productus limestone of Salt Range or Middle Permian, both being characterized by a *Lyttonia* and *Oldhamina* fauna. The presence of *Neoschwagerina* in the limestone blocks 100 m. or more below the top and the presence of the meager fauna with apparently a Permian affinity about 220 m. above the base suggest that that division of the chert limestone should be still referred to Permian, most probably Lower Permian.

Since the lower part of the Yanghsin limestone is Viséen and the upper part is Permian, there must exist a great hiatus between the two. It is, however, strange to say that in spite of repeated search in the field no discordance whatever has as yet been found.

Now Viséen rocks in China have been reported from Sinkiang, Kansu, Yunnan and Kweichow. In all these places, they are characterized by the index fossil *Productus giganteus* Martin and other typical Viseen species. But so far as we know, no such species have ever been found in the Chihsia limestone which is characterized principally by a great abundance of corals. If the identification of the Chihsia corals by Frech were liable to other interpretation and the Chihsia limestone were really to belong to a higher horizon, then this would agree quite well with the observed fact in the field, viz, the Yanghsin limestone represents a continuous deposit from Permo-Carboniferous to Middle Permian. This, however, is nothing more than a mere personal suggestion and is based soly upon the marked uniformity of the lithological character of the Yanghsin limestone. At any rate, before a careful study of the coral fauna of the Chihsia limestone in the Yangtze valley, it seems advisable to follow Frech in regarding the lower 200 m. or less of the Yanghsin limestone as Viséen and the upper 300 m. or more as Permian, with a marked disconformity between the two.

The Wushan limestone is widely distributed in the Yangtze valley. Towards the east, however, a coal series often appears to intervene between the Tayeh and the Yanghsin limestones. Thus at Yang Hsin Hsien in southeastern Hupeh, the Tayeh and Yanghsin limestones are separated in the middle by the Tanshanwan coal series and the thickness of these two limestones is also considerably reduced. Further east in the lower Yangtze the succession is mostly incomplete, different members of the Wushan limestone scattering here and there in different localities. Thus in the Nanking region, only the coral division or the Chihsia limestone remains, while in other places the *Lyttonia* bed occurs.

From these facts, it may be inferred that the late Palæozoic sea transgressed from the southwest. Hence in the deeper waters, such as in the upper Yangtze, the mighty Wushan limestone no less than 1800 m. thick was deposited; whereas in the more shallow waters, such as in the lower Yangtze where the sea was very likely subject to temporary advance and retreat, only a single bed or more of a small thickness were formed, overlapping upon the different older formations.

VIII. Patung Series

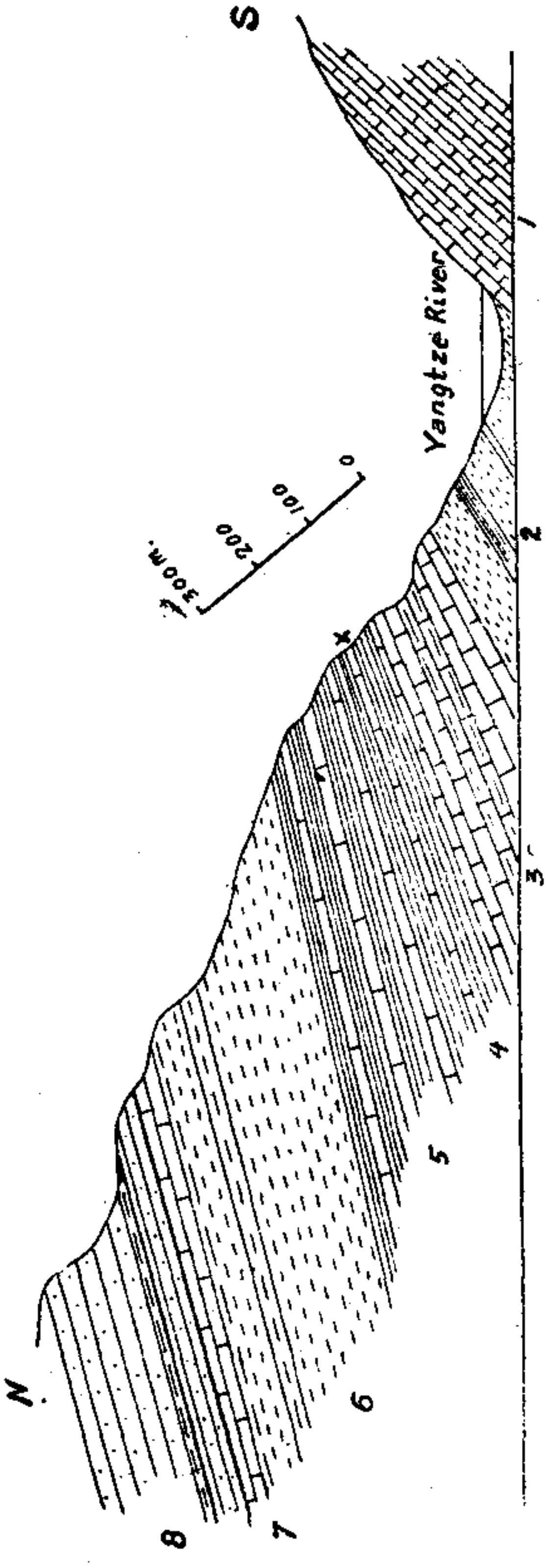
The Patung series is best developed at Pa Tung Hsien whence it derives its name. It is composed principally of purple shales and grey limestones, reaching a thickness of no less than 800 meters.

Distribution of the Patung series and its explanation: Just at the foot of the city, the contact between the Patung series and the Wushan limestone can barely be seen. The upper few meters of the Wushan limestone are somewhat abnormal, being yellow, earthy, and porous instead of grey, pure, and dense. It is immediately succeeded by a few meters of yellow shale which is then followed by a thick series of purple shale. The upper surface of the Wushan limestone shows no irregularities due to erosion, nor did we see any discordance of dip between them. A disconformity, however, is inferred from the following considerations.

In the Hsiangchi valley 25 li east of Tze Kwei Hsien, the Patung series is mostly absent. Only at one place on the left bank of the Hsiangchi river below Pei Ma Tan, did we see a little outcrop of purple shales lying beneath the coal series. West of Tze Kwei, it first crops out in the anticlinal axis at Sha Chen Shi on both sides of the Yangtze river, and then the outcrop broadens along the northern limb of the anticline on the right bank towards the west until Pa Tung Hsien where it gets its full exposure. The distance between the latter and Hsiangchi is approximately 40 miles. Richthofen apparently reported the same formation at Kwang Yuan Hsien, Szechuan, 250 miles further west; but the rocks there are mainly limestones of various colors, lying unconformably upon the folded Sintan shale and followed again by the Rhætic coal series. This irregularity in the distribution of the Patung series may be interpreted in two ways. 1. The Patung series was only sparingly deposited along the Hsiangchi valley *i. e.* the sea retreated after the deposition of the great Wushan limestone and then after a certain interval of exposure, a second marine transgression entered from the southwest which caused the formation of the thick Patung series in the earlier invaded regions such as at Pa Tung Hsien and Kwang Yuan Hsien, but only thin purple shales or none along the shore line last invaded such as in the Hsiangchi valley. 2. The Patung series was deposited in the Hsiangchi valley same as in Pa Tung Hsien but was again mostly eroded away before the deposition of the Hsiangchi coal series.

Because of the limited extent of our observations we are not in a position to say definitely which interpretation is nearer to the truth. But the marked difference in the lithological characters between the Patung series and the Wushan limestone seems to indicate an interruption of the condition of deposition, and the abrupt change in character of the upper beds of the Wushan limestone suggests exposure and solution or disintegration. Moreover, the complete absence of the Patung series in the southeastern Hupeh and other parts of the same province east of I Chang points to the fact, that the old shore line of the Triassic sea is to be located not far west of the border between the present western mountainous plateau and the central plain of Hupeh. All these consideration are in favor of the first interpretation. But at the same time, it is not denied that the rapid increase of the thickness of the Patung series from Hsiangchi to Sha Chen Shi within so short a distance which can hardly be explained merely by an ordinary transgression might argue for a subsequent erosion before the deposition of the Hsiangchi series. At any rate, the break at the base of the Patung series seems to be widespread, while that on the top is only local though the latter may be very profound along the Hsiangchi valley. This extensive erosion before the deposition of the Hsiangchi series along the Hsiangchi valley might suggest

that the Huanglin anticline was first uplifted at the end of the Patung series.



第七圖 巴東縣對河剖面

Fig. 7 Profile of the Patung series from Pa Tung Hsien to the opposite bank of the Yangtze river.

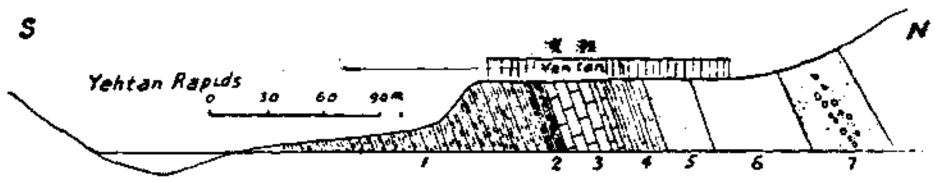
1 Tayeh limestone. 2-7 Patung series: 2 purple shale with thin intercalations of green shale, 3 grey limestone with soft calcareous layers, 4 grey compact limestone with abundant *Spiriferina*, 5 grey limestone and shale intercalated, 6 purple shale, 7 covered interval with a thin bed of grey limestone at the middle. 8 Hsiangchi series.

Section at Pa Tung Hsien: The succession of the Patung series can best be studied on the opposite side of Pa Tung Hsien (fig. 7). The lower part of the series consists of about 230 meters of bright purple shales with thin intercalations of green shale at intervals of one or half meter. East of the city of Pa Tung Hsien, these strata are mainly exposed on the northern bank of the Yangtze river, the southern bank being entirely formed by the smooth dip slopes of the Wushan limestone. West of the city, however, they crop out on both sides of the river and farther west, higher beds appear in succession. But there the strata are subject to local deformations and are thus not suitable for the study of stratigraphy.

The middle part is composed of thin bedded grey limestones and calcareous shales interbedded about 300 meters thick. The former is prevalent in the lower, and the latter in the upper part. The limestones are dense and sometimes crystalline. Crinoidal stems are occasionally present. In about the middle of this division or 390 meters above the base of the series, there is a bed of limestone one foot thick which contains abundant *Spiriferina* and some remarkable, though not well preserved, pelecypods. The fossils all appear in cross-sections and the rock is too dense to yield good specimens. This fossiliferous bed was again found at Pei Ta Sze about 15 li below Pa Tung Hsien.

The upper part is composed of 250 meters of purple shales with thin intercalations of green shale which are, after a certain covered interval, finally capped by the Hsiangchi coal series. In this covered space, a grey marly limestone is often observable beneath the debris. The succession of this division, however, is well exposed at the foot of the village Yeh Tan, 25 li west of Tze Kwei Hsien.

Section at Yeh Tan: The structure at Yeh Tan is a close anticline upon the axis of which sinks the Yangtze river. Along a small valley just beside Yeh Tan, the upper part of the Patung series and its relation with the overlying Hsiangchi series can be studied to the minutest detail (fig. 8). On the northern side of the Rapids, highly inclined beds of purple shales with thin bright green shale intercalations crop out conspicuously and upon these lie about 55 meters of grey limestones and calcareous shales which are then succeeded by the basal sandstone of the Hsiangchi coal series without any



第八圖 洩灘剖面圖

Fig. 8. Profile Section at Yeh Tan

1-4. Patung series: 1. purple shale with thin green shale intercalations, 2. green shale, 3. grey limestone, 4. green shale sandy at some layers, carrying calcareous nodules. 5-6 Lower Hsiangchi coal series: 5. green coarse sandstone, 6. covered native coal-pits. 7-8 Upper Hsiangchi coal series: 7. greenish white quartzitic sandstone and conglomerate, 8. covered native coal-pits.

evidence of erosion or discordance of dip. These thick purple shales correspond apparently to the upper purple shales in the section of Pa Tung Hsien and the grey limestones and shales represent the covered interval at the top. The grey limestones and calcareous shales in the middle part of the Patung series may be exposed in the center of the anticlinal axis but there they are buried under the water. At Sha Chen Shih about 7 li east of Yeh Tan, however, an isolated hillock or island standing at the mouth of a branch river is most probably made up by these limestones. From there westward, the Patung anticline gradually dives beneath the river and loses its appearrance.

On the way leading from Yeh Tan to Shih Men, a grey limestone with occasional intercalations of green shale often crops out beneath the Hsiangchi coal series on the northern bank of the Yangtze. In position, it corresponds apparently to the top bed of the Patung series as exposed at Yeh Tan. In this limestone, doubtful remains of foraminifera and cross-sections of brachiopods were detected.

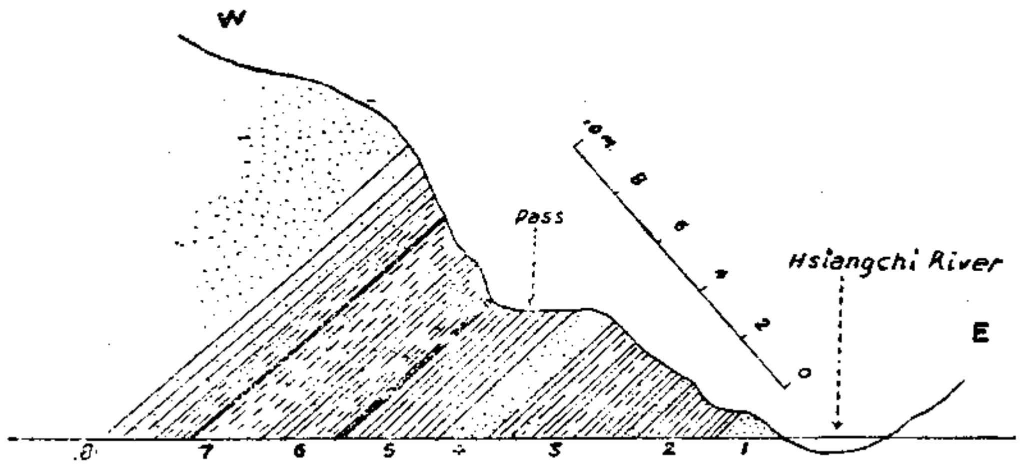
Fossils from the Patung series: The fossils collected by Willis and Blackwelder from the middle part of the Patung series at Taning Ho were studied by Girty who reported them to be Permian in age. But this learned author remarked that owing to the imperfect character of the fossils available to him, his assignment to that period was only provisional, and that it might be transformed to a later age without conflicting of evidences. Now in the course of our investigation, the Mesozoic age of the Patung series seems to be fully established.

From our fuller understanding of the geological successions in the gorge district in recent years, one might already predict the Mesozoic age of that sequence of strata which was made known by the previous investigators to lie above the thick Wushan limestone and below the Rhaetic coal series. A preliminary analysis of the fauna collected by us also points to the same thing. The spiriferinas are probably new species but have apparently no affinity with those common in the Permian strata. The pelecypods too bear no resemblance to Palæozoic genera. Moreover, we have assigned the magnificent Tayeh limestone no less than 1300 meters in thickness, to the Upper Permian. It does not seem reasonable to assign such great thickness to the Upper Permian of South China as would be given it, if we still placed the Patung series within the Upper Permian. On these considerations, we would seem to be fully justified in refering the Patung series to Triassic.

IX. Hsiangchi Series.

The Hsiangchi series is widely distributed in the Hsing Shan, Tze Kwei and Pa Tung districts. By a closer study in the field, it can be conveniently divided into two coal series separated in the middle by a thick sandstone-conglomerate bed. Along the Hsiangchi valley, the relation between these two coal series is not quite clear. Only on the north of Yen Kuai Tze and on the opposite side of Ta Hsia Kou, the middle sandstone-conglomerate bed is more or less distinguishable. West of Tze Kwei, however, the relation is well represented. Thus at Teng Tze Shih along the YangtzeRiver, the basal sandstone and the middle sandstone-conglomerate beds form two ridges, while the coal series are depressed into valleys. At Yeh Tan (fig. 8) only the basal sandstone and middle sandstone-conglomerate beds are exposed, but the existence of a coal series both above and below the latter can be determined by a consideration of the distribution of the native pits. At Shih Men, the relation between them is still clearer. Here the middle sandstone-conglomerate bed forms a conspicuous bluff along the northern bank of the Yangtze River. But the Lower coal series becomes so thin as to reach a thickness of only a few meters, a fact which is not observed in any of the other localities.

Lower Hsiangchi coal series: The Lower Hsiangchi coal series is separated from the underlying Tayeh limestone or from the Patung series by a



第九圖 游家河附近香溪下含煤系剖面圖

Fig. 9. Profile Section of Lower Hsiangchi Coal Series at Yu Chia Ho, 5 li S. of Ta Hsia Kou

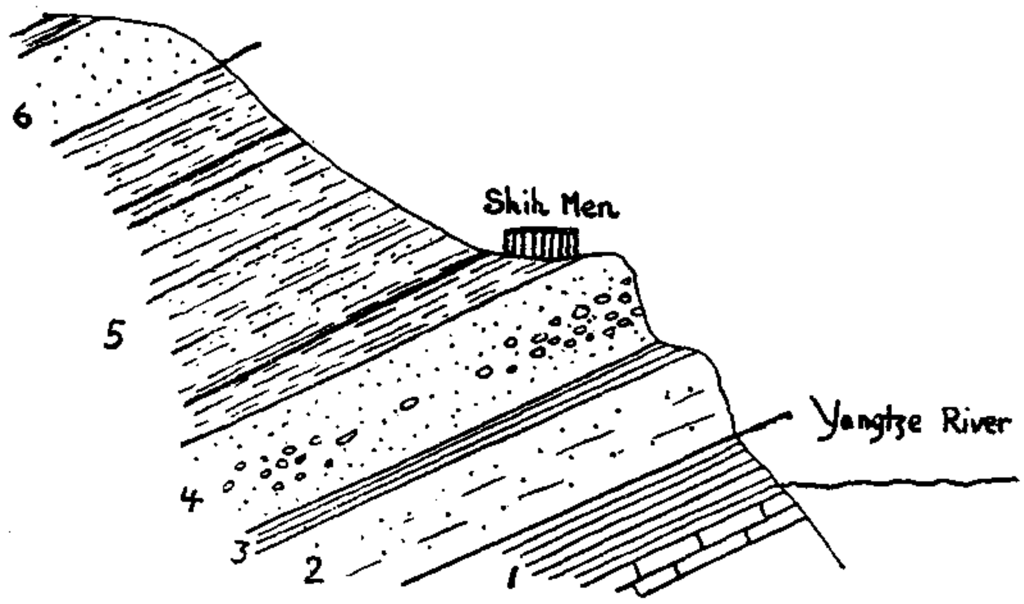
1, Sandstone base not exposed. 2. Yellowish green sandy shale with a layer of sandstone at top. 3. Dark grey shale, sandy at some layers. 4. Sandstone full of *Podozamites*. 5. Greyish green shale with a coal seam at top. 6. Greyish green shale with abundant well-preserved plant fossils. 7. Massive sandy shale with a bed of coal at upper part. 8. Massive grey sandstone shaly in lower part.

grey soft sandstone 20 to 30 m. in thickness. Above the latter lies an alternating bed of black shale, greenish shale, sandy shale and sandstone carrying coal seams (fig. 9). This coal-bearing bed varies considerably in thickness at different places. It is more fully developed along the Hsiangchi valley and amounts to a thickness of perhaps not much over 20 meters. It contains many coal seams and forms the main coal series there. Plant fossils are abundant at some horizons and are well preserved.

The Hsiangchi river flows approximately along the contact line between the Tayeh limestone and the Lower Hsiangchi coal series. And thus the latter crops out sometimes on the west side of the valley and sometimes on the east or is buried beneath the Hsiangchi valley.

At Shih Men the Lower coal series is reduced to only a fow meters as previously mentioned (fig. 10) and the upper coal series becomes the main coal series there.

Middle sandstone-conglomerate: In the restricted sense, this bed is really a coarse sandstone. It is hard and quartzitic, usually white in color, but sometimes stained with a greenish tint. At Teng Tze Shih a little west of Tze



第十圖 洩灘西二十五里石門剖面圖
Fig. 10. Profile at Shih Men, 25 li west of Yeh Tan

1. Patung series. 2-5 Hsiangchi series: 2. greyish coarse soft sandstone, 3. grey and black shale, 4. white quartzitic sandstone and conglomerate, 5. green sandstones with thin beds of black shales and coal seams, 6. Kweichow series.

Kwei Hsien, the upper layer is a kind of greyish soft sandstone. Its thickness is estimated at 20 to 30 meters. The pebbles are usually confined to the middle part of the sandstone and have apparently no definite plan in their distribution. Sometimes they are accumulated together in great numbers, causing the formation of a very conspicuous local conglomerate such as is the case at Shih Men. In other cases, they are comparatively rare and are scattered only here and there as isolated pebbles in the sandstone. Still in other cases, they have accumulated into irregular lenses.

The pebbles are almost entirely made up by black flint apparently derived from the flint nodules of the Yanghsin limestone. They are all well rounded and uniform in size generally one inch in diameter and are cemented by a white arenaceous matrix. All these indicate long exposure to the action of river erosion before deposition.

Upper Hsiangchi coal series: The Upper coal series is estimated to be 200 meters thick. It is composed mainly of green sandstone and green sandy shale with thin intercalations of black shale carrying sometimes coal seams, the sandstone being far more predominent than the others In the black layers in the lower part of the series, a kind of thin shelled *Cyrena* associated with not well preserved plant fossils is frequently observed.

Fossils from the Hsiangchi series: Plant fossils are very abundant and well preserved in the coal-bearing layers of the Lower coal series along the Hsiangchi valley The fossils collected by Pumpelly and Richthofen, described by Schenk and Newberry are apparently mostly derived from these beds. But at the date of Pumpelly and Richthofen, no detailed succession of the coal series was made and it is quite possible that some of their fossils were obtained from the Upper coal series.

On the vicinity of Yu Chia Ho on the western bank of the Hsiangchi river, the yellowish green sandy shale and sandstone of the Lower coal series yielded the following species according to the preliminary determination of Mr. T. C. Chow:

Podozamites lanceolatus (Lindl. & Hutt.) Schimp.
Dictyophyllum nilssoni (Brougn.) Göpp.
Cladophlebis sp.
Pterophyllum sp.
Taeniopteris tenuinervis Brauns
Sphenozamites sp.

In the lower part of the Upper Hsiangchi coal series, plant remains and fresh water bivalves were found associated together in the black shales. The fossils are not abundant but are of wide distribution. Whenever the Upper coal series is exposed, they are obtained at their expected positions. In the three lots of collections made at Teng Tze Shih, on the opposite side of Sha Chen Shih, and at Shih Men, a kind of small *Cyrena* is never missing and it is probably to be regarded as the index fossil of the Upper coal series. The three collections when combined yield the following species:

Cyrena hsiangchiensis (sp. nov.)
Podozamites lanceolatus (Lindl . & Hutt.) Schimp.
Pterophyllum acquale (Brongn.) Nath.
Phoenicopsis sp.
Taeniopteris tenuinervis Brauns.
Dictyophyllum nilssoni (Brongn.) Göpp.
Cladophlebis cf. *denticulata* (Brongn.)
Sphenopteris sp.

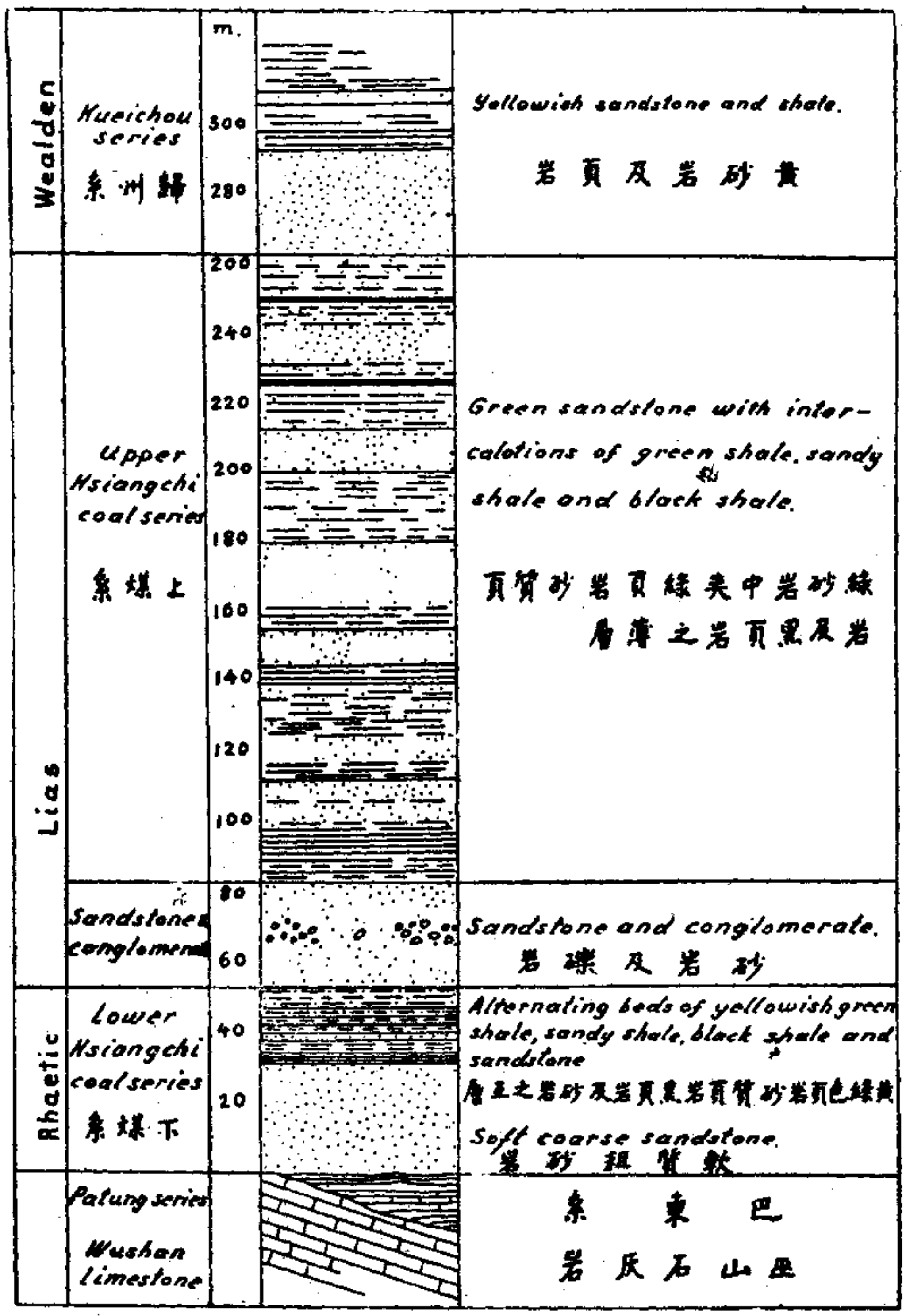


Fig. 11. Columnar section of the Hsiangchi coal series.
香溪煤系柱形圖

This flora has apparently still many species in common with that of the Lower coal series But in it have appeared some new elements which have never been found in the lower horizons. Since the Lower coal series is unquestionally Rhaetic and the Upper coal series is separated from it by a thick sandstone-conglomerate, it seems desirable to refer it to Lias instead of classing it still as Rhaetic

X. Kweichow Series

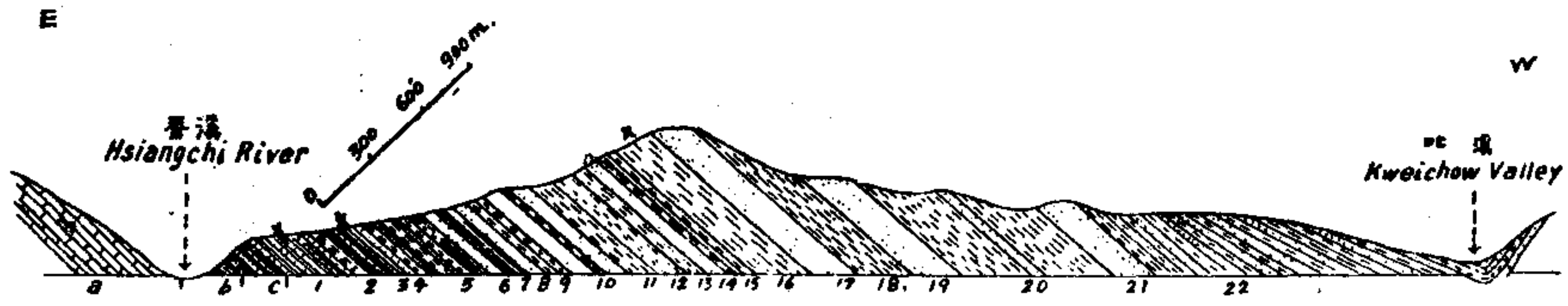
Overlying the Hsiangchi coal series without discordance of dip is the Kweichow series. A disconformity, however, is infered and is evident, if the Upper Hsiangchi coal series really belongs to Lias as we now suppose.

The Kweichow series is separated from the subjacent Hsiangchi series by a bed of coarse greyish yellow sandstone about 30 meters thick. Along the slopes below this sandstone, loose pieces of sandstone carrying black flint pebbles were frequently met with. The pebbles remain comparatively small, being not much over the size of an amygdaloid and are cemented by a greyish yellow arenaceous matrix. On account of their lithological characters and position, they cannot be derived from the middle sandstone-conglomerate bed within the Hsiangchi series and are most probably derived from the basal sandstone of the Kweichow series. But we did not confirm this derivation in the field.

The Kweichow series occupies a large area in the Tze Kwei district. Its distribution defines approximately the boundary of the Kweichow basin. On the way leading from Pei Ma Tan to Tze Kwei Hsien, the Kweichow series is well exposed (fig. 12). Along this section, its preserved thickness was estimated at about 3500 meters

The lower 200 meters of the sequence are composed mainly of yellowish green shales, sandy shales and sandstones in alternation. Fresh water molluscs are rather abundant in several horizons.

1300 meters higher up, alternating beds of green sandstones and purple shales with thin intercalations of green shale become the dominent types of rock. As a rule, the sandstones and shales are rather uniform in thickness, giving the gradually rising topography a picturesque aspect. Small Cyrenas are also present in some parts but their number seems to be greatly reduced.



第十二圖 香溪系及歸州系剖面圖（由鹽拐子之南至秭歸縣之北）

Fig. 12. Profile Section of Hsiangchi & Kweichow Series

(from the south of Yen Kwai Tze to the north of Tze Kwei Hsien)

a. Tayeh limestone. b. Lower Hsiangchi coal series. c. Upper Hsiangchi coal series. 1–22. Kweichow series.

1. Yellowish green sandstone & shale, richly fossiliferous. 2. Yellowish green shale & purple shale with a bed of sandstone at top. 3. Yellowish shale sandy at some layers with a bed of purple shale at base carrying calcareous nodules which are almost entirely made up by the shelles of *Cyrena hupehensis*. 4. Yellow Sandstone. 5. Purple shale & yellow shale intercalated. 6. Yellowish green sandstone. 7. Yellowish green shale. 8. Yellow Sandstone shaly at parts. 9. Purple shale with thin intercalations of green shale. 10. Yellow sandstone with a thin layer of purple shale at middle. 11. Purple sandy shale. 12. Purple shale and yellow sandstone intercalated. 13. Purple shale sandy at layers. 14. Light green sandstone. 15. Purple shales with a bed of white sandstone between. 16. Purple shale carrying calcareous nodules. 17. Yellow soft sandstone. 18. Purple shale. 19. Yellow sandstone. 20. Varigated shales sandy at layers. 21. Green sandstone. 22. Purple hard shale and green sandstone interbedded.

The next 1000 meters consist principally of thick beds of green sandstones and purple shales in alternation, forming a waving topography. In lithological character the rocks are essentially the same as those of the subjacent division, but their beds are considerably thicker.

The 1000 meters at the top of the Kweichow formation are composed mainly of thin bedded purple hard shales and green sandstones, the latter being more predominent. In the green sandstones, flat pebbles of purple of shale are sometimes accumulated into irregular lenses.

Fossils from the Kweichow series: The fossils of the Kweichow series are mainly confined to its lower 1500 meters and are particularly abundant in the yellowish green sandstones and shales near the base of the series. From the fallen blocks of a kind of yellowish green sandstone lying upon the western bank of the Hsiangchi valley a little north of Ta Hsia Kou, we obtained the following species of fossils:

Unio cremeri Frech
Unio chaoi Grabau
Unio johon-böhmi Frech
Cyrena kweichowensis Grabau

Essentially the same fauna was again obtained from a yellowish green sandstone block lying upon the bank of the Yangtze River at Shih Men, Pa Tung Hsien:

Unio cremeri Frech
Unio chaoi Grabau
Mycetopus mengyinensis Grabau

A little south of Ta Hsia Kou, a layer of yellowish green shale crops out on the right bank of a small valley. In this shale, a kind of small cyrenas, *Cyrena tahsiasense* Chao (sp nov.) is extremely abundant and a piece of rock is often croweded by hundreds of them along the bedding plane. The shell is well preserved and is of a bright yellow color.

In a layer of greenish sandy shale exposed on the western bank of the Hsiangchi river below Yen Kuai Tze, we obtained the following two species:

Cyrena kweichowensis Grabau
Cyrena yangtzeensis Chao (sp. nov.)

About 100 meters above the base, there is a layer of purple shale carrying calcareous concretions which are almost entirely made up by the shells of *Cyrena hupehensis* Grabau.

In a greenish shale exposed in the vicinity af Ping Shih Kou about 30 li north of Ta Hsia Kou, small shells of ***Cyrena hsiehi*** Chao (sp nov.) associated with plant remains were also obtained.

About 1500 meters above the base, fragmentary shells of bivalves were also detected in the calcareous concretions within the purple shales, but so far no identifiable specimens were obtained.

The fauna from the Kweichow series was firstly studied by Frech and more recently by Grabau, both of whom assigned it to a Wealden age Now the succession of the Kweichow series is better known and fossils are seen to be present continuously even 1500 meters above the base. Thus the Wealden age of at least the lower 1500 meters of the Kweichow series seems to admit of no question. Since the lithological characters of the Upper part of the series differ in no way from those below, it seems quite certain that the upper part of the Kweichow series still belongs Cretaceous, if not Wealden.

XI TUNGHU SERIES.

The Tunghu series is confined soley to those low hill regions east of the I Chang gorge. It lies unconformably upon different members of the Palæozoic rocks.

The basal member is a bed of conspicuous conglomerate more than 100 meters thick. The pebbles are rather large, well rounded, mostly made up by black flint, granite etc. and firmly cemented by an arenaceous matrix. On the way leading from Hsiao Chi Ta to Chu Pao Shan, it is extensively exposed and forms wall-like cliffs along the river Chang Chiao Chi.

Above this conglomerate is a mighty series of white and reddish coarse sandstones conglomeratic at different horizons.

Since no fossils have so far been obtained from this series, it is not possible at present to assign a definite age to it. But on a lithological basis, the Tunghu series can hardly be correlated even with the upper part of the Kweichow series. Since the former has an average dip angle of ten degrees towards the east, it seems probable that the deposition of the Tunghu series is prior to the last disturbance of the Gorge district. If the latest folding of the strata there correspond to the Miocene and Oligocene period of Orogenic disturbance in the Himalayas, it seem preferable to assign an early Tertiary age to the Tunghu series.

GEOLOGICAL STRUCTURES

As our observation was limited to the four districts mentioned namely Ichang, Tze Kuei, Hsing Shan and Pa Tung, it is not possible for us to discuss thoroughly at the present time the geological structure of Western Hupeh as a whole.

Within the region studied, the geological structure seems to be rather simple and may be briefly stated as consisting of two anticlines, i.e. the Huangling anticline and the Patung anticline and one syncline i.e. the Tze Kuai syncline. Faulting is unimportant if not entirely absent; the only fault we have observed is that oblique fault found northeast of Huang Lung Ping in the Hsing Shan district, where as a result of dislocation, a part of the Ta Yeh limestone is in direct contact with the Sintan shale. The following is a brief description of the three major structures just mentioned.

The Huangling anticline:—The Huangling anticline is a structure first observed by Pumpelly and afterward named as such by Willis and Blackwelder. Its position is just between the cities I-chang and Tze Kuei and its axis running from N. N. E. to S. S. W. with a pitch towards the southwest. At its central core we have an extensive mass of Pre-sinian gneiss and schist with granitic intrusions and on its two limbs a mighty sequence of sedimentary rocks, the age of which has been determined to vary from Palæozoic to Mesozoic. The outcrop of the western limb is especially noted for its complete development of the stratigraphic column; from Sinian to Cretaceous all exposed within only a short distance of about 60 li. The eastern limb and especially that part lying the vicinity of I Chang presents, on the other hand, a very incomplete stratigraphic series and the youngest member here exposed is the Ordovician limestone, the rest being entirely covered by the red sandstone formation of probably Tertiary age. At the northern part of the eastern limb, for instance near Huang Chia Chang and No Jo Ping, 70-90 li north of I-Chang, formations younger than Ordovician like the Sintan shales and Wushan limestones are abundantly exposed due to the removal here of the Tertiary sediments. East of the Wushan limestone which forms here a precipitious cliff and in the district of Yuan An Hsien, bituminous coal mines are reported to exist, which fact probably indicates the presence of the Hsiangchi coal bearing series. Thus it is evident that there is probably no unequal stratigraphic development between the eastern and the western limbs of the anticline as would seem to be the case apparently, the irregularity being chiefly due to the unequal covering by the Tertiary sediments. It is still uncertain whether the Kweichow series will be found further east. Judging from our present knowledge we are rather inclined to believe that this interesting formation which is so well developed on the western limb, probably will not retain its extension toward the east. This is one of the many problems pending further researches.

There is another structural difference between the eastern and the western limbs of the anticline. The eastern limb is characterized by very gentle dip angles varying from four or five degrees to as much as twenty degrees; while on the western limb, a steep dip from twenty to fifty degress prevails. In other words, this well known anticline is an asymmetrical one. Consequently the outcrops on the two limbs present also a very different aspect. The eastern limb, being gentler in dip and again complicated sometimes by local undulating folds, occupies a more extensive area, for instance the Ordovician limestone west of I-Chang have an outcrop area not less than fifty or sixty li in length. On the contrary, the western limb with its steep inclination occupies as a rule a limited space; thus from Kung Ling Tan to Hsiang Chi a distance of only 30 li a complete section from the Sinian formations to Hsiang Chi coal series is beautifully exposed.

The Tze Kuei syncline:—From Hsiang Chi to Sha Cheng Chi the strata form a great syncline with the city of Tze Kuei located just at the center. Its axis rums approximately from N. N. W. to S. S. E. being parallel to a part of the valley Chih Chi. It forms a symmetrical syncline having a dip of 40°-60°. The Kweichow formation occupies the central part while the Hsiang Chi coal series, Patung series, etc, fringes the two limbs of the syncline. The outcrops on the north and the south sides of the Yangtze have both a tendency to be connected to each other and thus to form a closed basin.

The Pa Tung Anticline:—A few li west of Tze Kuei the strata turn gradually from the north-south strike to a east-west direction, and form in the vicinity of Pa Tung an anticline. The oldest rock exposed is Wushan limestone which forms a central core of the anticline. The Yangtze River here coincides approximately with the anticlinal axis so that to the north of the River the strata dip toward the north but on the other side toward the south. The strate generally maintain a rather steep inclination; the dip angle reaches 70° to vertical and 55° may be taken as an average. Gentler dips sometimes nearing horizontality are not absolutely lacking, in fact at some localities they are rather common as for instance in the Hsiang Chi coal series and a part of the Pa Tung series. Such irregularities are considered to be local features of no general importance. Therefore the Patung anticline may be described as a closed and more or less symmetrical structure.

ECONOMIC GEOLOGY

Within the region surveyed mineral deposits are only sparingly represented. For lack of time, the abandoned Wu Tze Shan lead mine located near Kiu Yang Ping in Hsing Shan district has not been visited by us. Coal deposit constitutes almost the only important mineral resources within our region of travel, of which two distinct coal fields namely (1) the Hsiang Chi coal field and (2) the Yeh Tan-Pa Tung coal eld may be briefly described as follows:

1) The Hsiang Chi coal field:— This field extends from north of Hsing Shan at Hsiang Tan as far as Hsiang Chi and Yao Wan, the latter lies on the south side of the Yangtze. In general, the coal series runs approximately in a north-south direction; but between Hsiang Tan and Hsing Shan, it diverges a little, being from W. S. W. to E. S. E. forming a crescent-shaped curve. From Hsing Shan to Hsiang Chi by the way of Ta Hsia Kou, the strike is more or less parallel with the Hsiang Chi valley, that is, approximately in a north-south direction, from which small divergences can still be observed, for instance, north of Ta Hsia Kou it strikes a little east while south of it a little west from the normal direction.

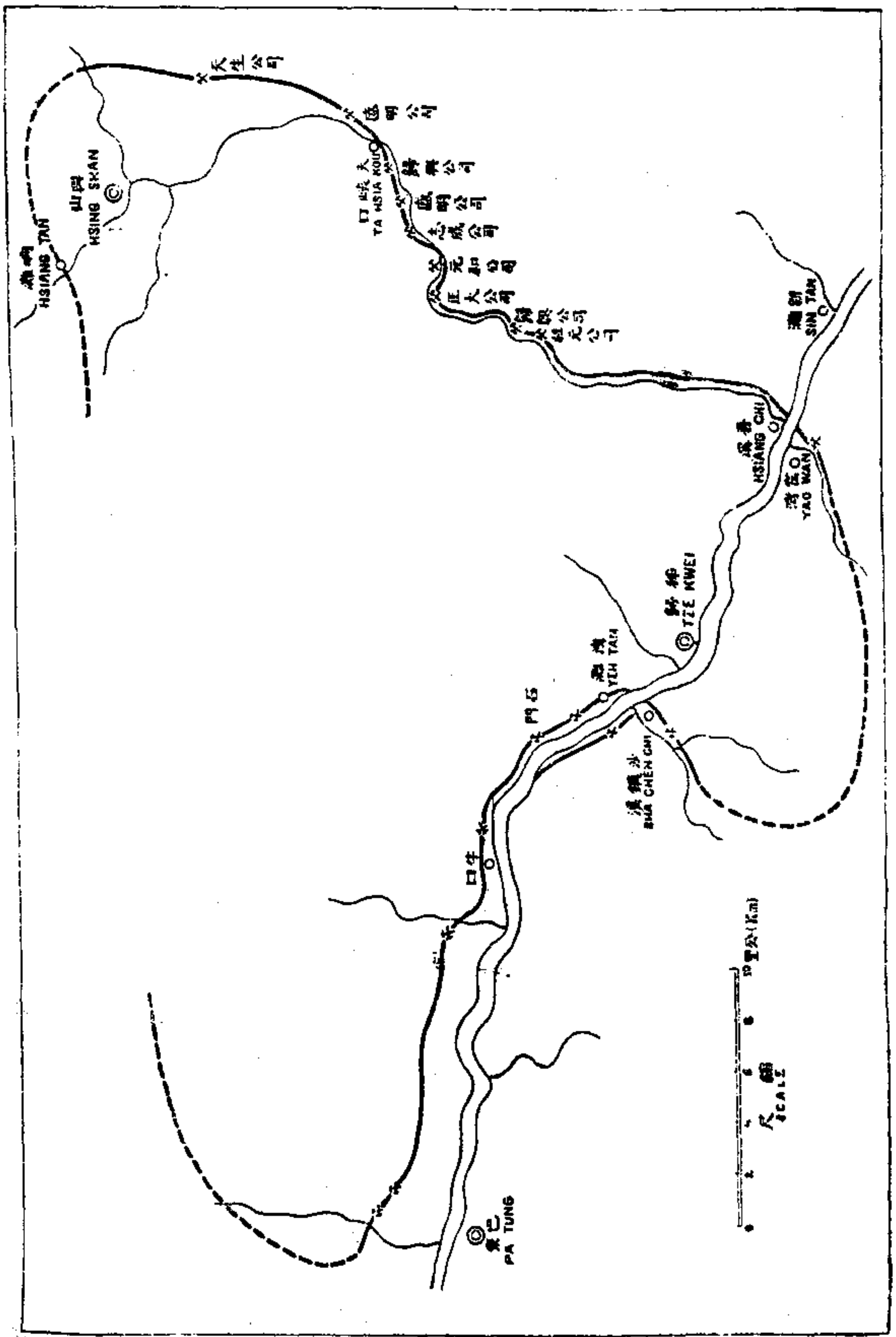
The northern part of the field including that of Hsing Shan and Hsiang Tan produces a small quantity of coal enongh only to support the local demand. East of Hsing shan, the coal series forms a closed anticline with a little part of the Ta-yeh limestone at its center which divides the field into two distinct parts. This local disturbance not only steepens the dip, making mining inconvenient, but also metamorphosed the coal into a kind of semi-anthracite and therefore deteriorates its quality to a great extent.

The most extensively worked field is to be found in that part starting from northeast of Ta Hsia Kou to as far as Hsiang Chi; here the coal series crosses the Yangtze and reappeared at Yao Wan and Yuan Chia Tsun on the south side of the River, still maintaining an approximate course from north to south.

The entire length of the coal series from Hsiang Tan to Yuan Chia Tsun has been estimated at about one hundred li which forms the western limb of the Huangling anticline and the eastern limb of the Tze Kuei syncline. We do not know what becomes of the coal series towards the north of Hsiang Tan or south of Yuan Chia Tsun, for we have not been there personally. Judging from the structural relations, it may be inferred that the coal series of Hsiang Tan may extend much farther northwest while that of Yao Wan and Yuan Chia Tsun may perhaps be connected with the Yeh Tan and Pa Tung field to form the south end of the Tze Kuei basin (Fig. 13). As the existence of the latter structure is still a question, the correctness of the above inference, therefore, waits still to be proved by observed facts.

The coal series here has a total thickness of about 250 meters; its detailed stratigraphy has already been given in the foregoing pages and will not be repeated here. Coal seams numbering not less than 13 are said to exist in this series and according to Mr. Hsiang Pi Kai, the manager of the Cheng Ta Coal mine, their thickness and superposition are approximately as follows:

Name of Seam	Thickness (in feet)	Intervening Distance (in feet)	Remarks	Geological age
Sha Mei	4 in. to 3 ft.		These two seams are generally located on higher slope being above a layer of conglomerate	Upper coal series (Lias)
		20'		
Yeh Chi Pan	5 ft. (at Yu Chia Ho)			
		35'		



第十三圖 秭歸巴東煤田之構造及煤礦分佈略圖
Fig. 13. Sketch of the Tze Kwei-Pa Tung coal fields showing its probable structure and the distribution of the native mines.

Hung Hui	Variable 5 ft. being maximum			
		20'		
Ma Wei Shih	Variable			
		about 5 ft.		
San Mo	6-7 in.		good coal	
		12'		
Cheng Mo	7 in.		Coal of best quality	
		15'		Lower coal series of Rhaetic age
Ta Tan	Few inches to 4 or 5 ft.		Rather low in calorific power	
		15'		
Hsiao T'ieh Tan	variable			
		15'		
Yu Chi Tzu	5 ft.		These two constitute the principal seams worked in the Hsiang Chi coal field.	
		120'		
Ta Chi Tzu	5 ft.			
		bout 100'		
Chou Chi Tzu	Not yet penetra		Lying generally below the present river bottom & has rarely been worked	

According to Mr. Hsiang, all the seams tabulated above have been more or less extensively worked by the local miners; their thickness as well as stratigraphical position constitute such a variable and complicate matter that the figure just listed can only be taken as an approximate information. Because of the unsanitary and dangerous conditions of most of the mining tunnels we were not able to make underground surveying ourselves in order to verify or correct what we have just listed; therefore we can only accept this information in its present form. Mr. Hsiang also stated that the mining tunnels located near the river side can only reach as far as the seam Hung Huei; to mine topmost two seams, the Sha Mei and Yeh Chi Pan, it is necessary to open new tunnels on a higher slope. This fact evidently indicates the existance of certain compact rock which may form as an obstacle for the further progress of mining. Our field observation agrees with this statement as we have found the two higher seams are located above a layer of conglomerate which is both compact and persistent. According to our stratigraphical and paleontological evidences this conglomerate forms a dividing line between the upper and the lower coal series, and consequently we consider the two higher seams to belong to the former, of Liassic age, while referring the rest to the latter, of Rhætic age.

From Ta Hsia Kou to Hsiang Chi with a distance of fortyfive li there are altogether seven mines (Fig. 13), all of them being worked after native methods and provided with no machinery. They have their mining claims laid out in such a fashion that at present no more empty space is left. The following table gives the names and approximate productions of these different mines:

Name of Mines	Approximate monthly production
Tien Sun Mining Co.	Recently organized, not yet producing
Cheng Ming ,,	500-600 tons
Kwei Hsing ,,	do
Tzu Cheng ,,	200 tons
Yuen Ho ,,	do
Cheng Ta ,,	600 tons
Kwei Yuan ,,	Not yet producing.

Besides the above mentioned mines there are two more companies, the Ta Hsing Mining Co. at Yao Wan and another one (the name of which is not known to us) at Yuan Chia Tsun, both of them have only been recently organized and, therefore have not yet reaching a productive stage.

The present total coal production of the Hsiang Chi field may be roughly estimated at about two thousand tons a month, this including however only the larger and actually producing mines. If we are to consider also the small mines, like those of Hsing Shan and Hsiang Tan, another thousand tons per month may be added. Assuming that all mines, both producing and non-producing at the present time, be worked to their full capacity, the maximum total production may be as much as 5000 tons monthly or 60,000 tons annually.

The coal produced is exclusively of the bituminous kind and is quite fitted for use in steamers in the upper Yangtze district. The price at I Chang or Sha Shih is $24.00 per ton for lump coal and $14.00 for powdered coal. For purposes of transportation, the mining companies here are generally provided with their own boats running directly from the mines to I Chang. These boats are of two sizes, the larger ones having a capactty of 50 to 80 tons while the smaller ones carry only two tons. River transportation may be carried on through the whole year but at a very different rate of speed; it generally takes two days for a trip to I Chang during winter or autumn, but much less, say half a day in the summer season. The cost of transportation usually amounts to about 6 or 7 dollars per ton, while the cost of mining requires on average of five or six dollars. The total cost for the mining and marketing of a ton of coal, therefore, requires about $13 to $14. Taking this figure into consideration and assuming a price of $24.00 at I-Chang, it will make a net profit of arround ten dollars per ton, which is certainly a very profitable business indeed.

The Yeh Tan-Pa Tung coal fields:—From Yeh Tan to Pa Tung, the geological structure forms a very closed anticline, on its northern limb, the Hsiang Chi coal series is exposed. In the vicinity of Yeh Tan, the coal series is found on both sides of the river, lying underneath Kweichow formation and overlying the Patung series. It can also be separated into two divisions, namely an upper and a lower coal series. At Yeh Tan the seams principally worked belong to the lower coal series, although the upper series is also occasionally mined, but at Shih Men, 15 li to the west of Yeh Tan, the important coal seam appears to be of Liassic age, i. e. belonging to the upper coal series.

The coal is a semi-anthracite of inferior quality. It has not only a smaller number of seams, but also much reduced thickness, as the workable seams here attain generally not more than a foot. The reason for such a deterioration both in quality and quantity is probably to be attributed to the closed nature of the Pa Tung anticline.

The coal produced is chiefly in the powdered form, which after being mixed with certain parts of Huang Tu or yellow loam, is modelled into a coal bricks measuring about 3"×1"×0.5" in dimension. These coal brick. are the principal domestic fuel used along the I Chang-Pa Tung districts For every 10,000 pieces of such bricks, a price of $ 13.00 at the mine and $ 25.00 to $ 30.00 in I Chang is charged.

There is practically no modern mining organization within this district, all the small mines now existing are worked in a very primitive way and they are almost exclusively owned by the local people. It is extremely difficult to get any exact information on their real output, as they are so scattered in distribution, and at present we must content ourselves with the rough estimate which may be put at about two thousand tons per month.

On the way leading from Shih Men to Pa Tung, outcrops of a coal series are exposed on the northern bank of the River, and most of them have been worked rather extensively by the natives. As to the southern bank, because of the gradual broadening of the Pa Tung anticline, older rocks like the Pa Tung series and the Ta Yeh limestone occupy a dominant position and no more coal series can be found. Just opposite the city of Pa Tung, on the other side of the river, there are 6 or 7 native mines working an anthracite seam of rather inferior quality, the product of which is mainly used to supply the local domestic demand.

For lack of a detailed survey and of reliable information, especially regarding the number and the thickness of the coal seams, the coal resources of the above described coal fields can hardly be determined at the present time. In the following table is given an approximate estimate which is based upon our rapid reconnaissance survey and on indirect information from the local mineis.

Coal Fields	District	Length of outcrop (meters)	Thickness (meters)	Reserve (Tons).
Hsiang Chi Coal Field (Bituminous)	Hsiang Chi to Ta Hsia Kou	20,000	4.0	31,200,000
	Yao Wan to Yuan Chia Tsun	10,000	3.0	11,700,000
	Ta Hsia Kou to Hsing Shan	20,000	1.0	7,800,000
Yeh Tan—Pa Tung coal field (semi-anthracite)	Yeh Tan to Pa Tung	25,000	0.5	4,875,000
Total Bituminous				50,700,000
Total Semi-Anthracite				4,875,000
Grand Total				55,575,000

In making the above estimate, the specific gravity of coal was taken as 1.3 and the depth along the dip, at 300 meters, which is already sufficiently deep for the present native mines; but for modern mines on a great scale, this is very low. Therefore a total tonnage of 100,000,000 tons for the whole field or just double the amount given above may not be considered too exaggerated. Among the different data listed above, the most unreliable item is the thickness of the coal seams, which according to Mr. Hsiang Pi Kai may reach in Hsiang Chi district as much as 10 meters for the aggregated thickness of all the seams. This figure seems to be much too high and for our purpose an aggregated thickness of 4 meters for the Hsiang Chi field was assumed. The coal seams at Yao Wan, Hsing Shan, as well as Yeh Tan-Pa Tung fields are said to be much thinner, sometimes not more than one meter, so that we assumed the much smaller thickness of 3.0, 1.0 & 0.5 meters respectively for these three districts. Of the different fields, the Hsiang Chi coal field may be considered the best, as it contains not only a larger tonnage but also yields a coal of better quality. The Yeh Tan-Pa Tung field is much inferior, both in quality and in quantity.

A coal sample taken from Cheng Ta Company's mine has the following composition: (Analysis made by the Industrial Laboratory, Ministry of Agriculture & Commerce).

Moisture	Volatile matter	Fixed carbon	Ash	Color of ash	Property of Coke	Calorific Power	Sulphur
1.78	28.02	58.20	12.00	Light brown	Caking	7540	0.138

SUMMARY OF THE FAUNAS FROM THE SINTAN SHALE.

by

A.W. Grabau

ANTHOZOA

1. *Halysites* cf., *cratus* Eth. Jr.

Fenestrules large, longer than wide, quadrangular to polygonal, up to 14 mm. in length, width not over 5 mm. Large autopores nearly circular, 1-6 in each chain, average 4; up to 1.5 mm. in long diameter, and 1.3 in shorter; no spines. Mesopores in short reëntrant spaces giving sausage-like form, transversely elongate. Tabulæ interspaces about 3 in 2 mm., sometimes 2 in 1 mm. Most abundant (Loc. 826, 826 A, 826"). Originally described from Silurian of Australia. Similar forms found in Canada and in Bohemia.

2. *Halysites hupehensis* Gr. (sp. nov.)

Non-spinous, fenestrules up to 25 mm. long, by 5 to 15 or more in width. Chains with 2 to 8 links in some specimens, 7 predominating. Autopores oval with truncated ends larger than preceding 3.×1 3/4, to 2.5×2 mm. in diameter, contracted at the ends to 0.5 to 0.75 mm. separated by slit-like mesopores, which are often absent. Gonopores occasionally present, then fairly large and variously shaped, Tabulæ arched, complete, about 1/2 mm. apart (Loc. 826, 826").

3. *Favosites gotlandicus* Lam.

Several characteristic fragments of large coralla of this characteristic Silurian coral occur; corallites average 2 mm. in diameter (Loc. 826, 826A, 826").

4. *Favosites nucleolatus* Gr. (sp. nov.)

A small subsphærical to strongly lenticular form, 18-28 mm. in diameter; corallites varying from 1 to nearly 2 mm. in diameter, margins indented by rather strong spines; tabulæ one-half to three quarters mm. apart (3 interspaces to 2 mm.). Often grows around foreign substances such as crinoid stems, etc. Related to *F. barrandii* Pocta but much smaller. Common. (Loc. 824).

5. *Favosites iachlowitzensis* Barr.

This characteristic Silurian form of Bohemia is represented by a large disc-shaped specimen measuring 5 inches in diameter by less than 1 1/4 inches in thickness, and by another smaller fragment 1 1/2 inches in thickness. These agree in all essentials with the Bohemian form from Etage E. (Loc. 826" 826 C ?).

6. *Favosites tachlowitzensis* Barr. var. *lentiformis* Grabau (var. nov)

This is a common form. It occurs in small disc-shaped masses the largest seen being 48 mm. in diameter by 16 mm. in vertical height, though a somewhat smaller specimen reaches a height of 22 mm. Corallites averaging 1.5 to 2 mm. in diameter. Young ones of various sizes and shapes appear between the adults. Base flat or depressed with wrinkled epitheca. Tabulæ average 1 mm. apart, but both less & more. (Loc. 826,826 B, 826 C. 827).

7. *Heliolites bohemicus* Wentzel.

This characteristic Bohemian form from Etage E. is represented by a number of fairly large disc-shaped or subhemisphæric masses. It is readily distinguished from the other forms by the closely set corallites with small areas occupied by interstitial tubules. (Loc. 826" 826A, 826).

8. *Heliolites megastomus* Linn.

Disc-shaped with flat base 70-80 mm. in basal diameter, by 35-20 mm. in vertical height, easily recognized by its large and distant macropores, up to 2 mm. in diameter (Loc. 826, 826 C.).

9. *Heliolites interstinctus* var. *yangtzeensis* Gr. (var. nov.)

Subhemisphæric, with basal epitheca. Macrocorallites somewhat smaller and more close set than in typical form. Microcorallites large and less numerous; may be distinct species (Loc. 826 C, 826).

10. *Heliolites decipiens* McCoy

A single specimen showing the small macrocorallites which are about 0.7 mm. in diameter and separated by equal or greater distances of small micropores. (Loc. 826).

11. *Palæocyclus fletcheri* E. & H.

A small corallum 20 mm. in diameter and very closely turbinate with plane of calyx of young at right angles to that of adult. Calyx of moderate depth with carinated sep'a. The species was originally described from the Silurian of Dudley, England. Several other larger specimens. (Loc. 826," 826B).

12. *Platyphyllum minor* Grabau (sp. nov.)

Pl. III, Figs. 1,2.

Small forms resembling *Calceola* but septa much longer; later stages of larger forms with alar sides sub-parallel and with cardino-counter axis scarcely increasing. When parallel growth commences the corallum is straight though slight irregularities occur. Stage at which parallel growth commences is variable, hence diameters vary. Never reach the size of *P. sinense* Lindström from the Silurian of Chautien. Common. (Loc. 826, 826 B. 826C.).

13. *Pselophyllum zaphrentiforme* Grabau (sp. nov.)

Pl. III, Figs. 5,6.

A representative of the Bohemian genus with central tabulated area and with the septa formed of superposed lamellæ as in *Ptychophyllum*. It is smaller than the Bohemian forms from Etage F. and commonly curved and like a slender *Zaphrentis* in form. Common. (Loc. 826 B, 826," 826).

14. *Cyathophyllum chaoi* Grabau (sp. nov.)

Pl. III, Fig. 3.

Characterized by subcylindrical form and deep calyx. Strong distant septa and vesicular dissepiments. Differs from *C. prosperum* Barr. in the smaller number of septa and more abrupt calyx. (Named after Mr. Y. T. Chao. Loc. 826 B, 826).

15. *Cystiphyllum* cf. *placidum* Barr.

A form closely related to, if not identical with this common Bohemian form of Etage E. Common. (Loc. 826 C, 826, 826', 827).

16. *Cystiphyllum (Microplasma) pailu* Gr. (sp. nov.)

Pl. III, Fig. 4.

A long cylindrical form generally not over 20 mm. in diameter, but specimens 120 mm. long, without change in diameter, known. More regularly cylindrical than *C. gracile* Barrande. Short septal ridges on cysts show it belongs to genus *Microplasma*. (Loc. 826 C). Not abundant.

17. *Enterolasma sp.*

Small specimens referable to this Silurian genus (Loc. 824, 825, 827 A, 827C.)

GRAPTOZOA

1. *Monograptus marri* Perner

This Silurian form found in Bohemia and Great Britain, but not before recorded from China seems to be represented by 2 fragments of polyparies. The width is about 1.8 mm. and half of this is occupied by the hook. There are 10 thecae in 10 mm. (Loc. 824).

2. *Cephalograptus cometa* (Geinitz)

A fragment 10 mm. long & 1.5 mm. in maximum width. (Loc. 824).

3. *Climacograptus* cf. *scalaris* His.

A short polypary with short stout virgulla; 11 thecæ in 10 mm.; width 1.2 mm. rectangular thecæ, horizontal apertural excavations; rare (Loc. 824).

4. *Climacograptus* sp.

A form with long virgula and oblique outer thecal walls. (Loc. 824).

BRACHIOPODA

Pentamerus borealis Eichw.

This is a common form ranging in size from young specimens 24 mm. or less in length to large shells 60 mm. or more long. There is considerable variation, as is shown in the following table:

	1	2	3	4	5	6	7
Length	23.3	23.5	59.5	63.5	60.0	56.0	33.8 mm.
Width	18.5	20.8	41.0	38.7	29.5	43.0	22.5 mm.
Thickness	15.0	16.0	32.0	33.4	38.0	32.1	19.3 mm.

Always much compressed under the beak which is flattened vertically and strongly incurved. The brachial valve is always very shallow becoming flat to gently concave near the front (Loc. 826, 826', 827 A, etc.)

2. *Pentamerus* cf. *esthonus* Eichw.

A single broad smooth shell with incipient plications, beak of pedicle valve rather depressed (Loc. 826').

3. *Pentamerus (Conchidium) tenuiplicatus* Grabau (sp. nov.)

Pl. III, Figs. 8,9.

Of the type of *P. (C.) kinghtii* but shorter and transverse with slender rather sharp & numerous plications and a well-marked false area in the pedicle valve. Resembles the transverse variety of *P. kinghtii* Sow. (Fig. 4 pl. XVIb Davidson) but smaller. Also resembles *P. (C) invalidus* Barr. from Etage E (pl. 20 fig. 9 a). Common (826) specimens generally crushed, much crushed in shale (Loc. 827 A, 826 C).

4. *Stricklandinia transversa* Grabau (sp. nov.)

Pl. III, Fig. 7.

In form like *S. lirata* but more transverse and with rectangular or even acute cardinal angles. Surface smooth except for growth lines. Pedicle valve with narrow hinge area, broad median sinus and slight concavity below cardinal angles, giving it a trisulcate appearance. Brachial valve with linear area and broad median fold. (Loc. 826, 826 C).

5. *Glassia obovata* (Sowerby) var. *magna* Grabau (var. nov.)

Pl. III, Figs. 10-12.

This characteristic European shell is very abundant, but the specimens are all larger than the English form (half again as large) and more nearly of the size of the Bohemian form. It varies from circular to wider than high and when robust has a well-marked frontal emargination. The beak is closely incurved and the shell is smooth, (Loc. 826, 826 B, 826 C?, 826").

Measurements give:

Length	19.6	14.8	17.0	mm.
Width	20.3	14.0	17.8	mm.
Thickness	13.5	10.0	11.4	mm.

6. *G. obovata* (Sowerby)

Small normal form (Loc. 824.).

7. *Dalmanella elegantula* (Dalm.)

A crushed specimen with high area (Loc. 826").

8. *Dalmanella* sp.

A crushed valve of a transverse form. (Loc. 827 C).

9. *Dalmanella* cf. *testudinaria Dalm.*

Impressions of this Ordovician form with *Triplecia grayiæ* in Loc. 825.

10. *Retzia* sp. (cf. *Rhynchonella borealis* var. *sinensis* Kayser)

Small Rhynchonelloids of which one shows the form of *Retzia*, the other the bifurcating plication given by Kayser as characteristic for his Choutien form, (Loc. 827 C).

11. *Nucleospira pisiformis* Hall

The form was also recorded by Kayser from the Silurian of Choutien, (Loc. 827 C).

12. *Stropheodonta* cf. *shönnsüinensis* (Kayser)

A small *Stropheodonta* (2 specimens) showing indistinct denticulation on the hinge line and with the surface characters of the form described by

Kayser from the West Chinese Silurian (Loc. 827 C). Also a younger shell from same locality.

13. *Stropheodonta* sp.

A small form nearly flat with strong distant striæ and many finer ones between (Loc. 826 C).

14. *Triplecia* cf. *grayiæ* Davidson

An impression of a left valve of this Upper Ordovician form, or one very close to it. (Loc. 825).

PELECYPODA.

1. *Orthonota antelonga* Gr. (sp. nov.)

Somewhat smaller but of same typo as tho form from northern Kiangsi, (Loc. 826 C).

GASTROPODA

1. *Trochonema depressa* Grabau (sp. nov.)

Pl. III, Fig. 13.

A moderate sized form with the spire unusually low for this genus, with two strong angulations; the intervening area, as well as the shoulder concave; umbilicus wide, margined by strong angulations. Common (Loc. 826 B, 826.).

CEPHALOPODA.

1. *Orthoceras* sp.

Small slender form with sub-marginal siphuncle. Septa 2 mm. apart or a little less, moderately concave (Loc. 826).

2. *Dawsonoceras* sp.

A fragment with the annulations close together, averaging 0.8 mm. apart and faint. (Loc. 824).

CRINOIDEA.

1. *Crinoid stems.*

Straight & coiled.

TRILOBITA.

1. *Coronocephalus rex* Grabau

Pygidia of small individuals of this or related species. (Loc. 827 A, 827 C, 824).

2. *Proetus latilimbatus* Gr.

Pygidia and a few cranidia of small individuals (Loc. 827, 827 C, 824)

3. *Harpes* cf. *veneulosus* Cord. var. *sinensis* Gr. (var. nov.)

Pl. III, Fig. 14.

A number of cranidia of large size showing the characteristic marking of the cephalic limb of this Bohemian species. (Loc. 825). Also one young.

4. *Acidaspis octospinosa* Gr. (sp nov.)

A transverse pygidium with 8 spines, 2 median of moderate length, next outward a somewhat longer on each side, then a large one outside of these, and a smaller one at outer margin on each side; axial portion projecting forward but not well defined (Loc. 825).

5. *Acidaspis* sp.

Another pygidium apparently with 10 spines, the median two shortest and united at their bases. (Loc. 825).

6. *Bronteus* cf. *partschi* Barr.

A small form represented by several pygidia and a cranidium, and having the essential character of this species of Etage E. of the Bohemian Silurian. The median pleural ridge of the pygidial limb is undivided, broadening gradually backwards. The axis is short, triangular and characterized by one or more pits on each side of the raised center. (Loc. 824).

7. *Illaenus asaphoides* Grabau (sp. nov.)

Pl. III, Figs. 15,16.

A form resembling *I. spitiensis* of the Himalayan Ordovician. The central part of the head is almost identical with that form but the free cheek is very much broader and the axis of the pygidium is less distinctly demarkated. (Loc. 825).

Summary.

Anthozoa	17	species & var.	8 new.
Graptozoa	4	,, ,,	—
Brachiopoda	14	,,	3 new.
Pelecypoda	1	,,	1 ,,
Gastropoda	1	,,	1 ,,
Cephalopoda	2	,,	—
Crinoidea	1	,,	—
Trilobitæ	7	,,	5 ,,
Total	47	species & var.	18 new.

DISTRIBUTION OF FOSSILS IN SINTAN SHALE

(Lojoping, 80 li N. of Tung Hu Hsien or Ichang)

	Wulung Kuan 10 li S. E. of Lojoping		Shamaoshan 10 li N. E. of Lojoping.										
	826''	826'	824	825	826 A	826 B	826 C	827 A	827 B	827 C	827 D	826	827
Anthozoa													
1. *Halysites* cf. *cratus* Eth.	×				×							×	
2. *H. hupehensis* Grabau	×											×	
3. *Favosites gotlandicus* Lam.	×				×							×	
4. *F. nucleolatus* Gr.			×										
5. *F. tachlowitzensis* Barr.	×						?						
6. *F. tachlowitzensis* var. *lentiformis* Gr.						×	×					×	×
7. *Heliolites bohemicus* Wentz.	×				×							×	
8. *H. megastomus* Linn.							×					×	
9. *H. interstinctus* var. *yangtzeensis* Gr.							×					×	
10. *H. decipiens* McCoy.												×	
11. *Palaeocyclus fletcheri* E. and H.	×					×							
12. *Platyphyllum minor* Gr.						×	×					×	
13. *Pselophyllum zaphrentiforme* Gr.	×					×						×	
14. *Cyathophyllum chaoi* Gr.						×						×	
15. *Cystiphyllum* cf. *placidum* Barr.		×					×					×	×
16. *C.* (*Microplasma*) *pailu* Gr.							×						
17. *Enterolasma* sp			×	×				×		×			
Graptozoa													
18. (1) *Monograptus marri* Perner			×										
19. (2) *Cephalograptus cometa* Gein.			×										
20. (3) *Climacograptus* cf. *scalaris* His.			×										
21. (4) *Cl.* sp.			×										
Brachiopoda													
22. (1) *Pentamerus borealis* Eich.	×	×				×		×	×			×	×
23. (2) *P.* cf. *esthonus* Eid.		×											
24. (3) *P.* (*Conchidium*) *tenuiplicatus* Gr.							×	×					
25. (5) *Stricklandinia transversa* Gr.							×						×

	826''	826'	824	825	826 A	826 B	826 C	827 A	827 B	827 C	827 D	828	827
26. (5) *Glassia obovata* var. *magna* Gr.	×					×						×	
27. (6) *Gl. obovata* (Sow).			×										
28. (7) *Dalmanella elegantula* (Da.)	×												
29. (8) *Dalmanella* sp.										×			
30. (9) *D. testudinaria* (Dalm.)				×									
31. (10) *Retzia* sp.										×			
32. (11) *Nucleospira pisiformis* Hall.										×			
33. (12) *Stropheodonta* cf. *shönnsüinensis* Kays.										×			
34. (13) *Stropheodonta* sp.							×						
35. (14) *Triplecia* cf. *grayiae* Dav.				×									
Pelecypoda.													
36. (1) *Orthonota antelonga Gr.*							×						
Gastropoda													
37. (1) *Trochonema depressa* Gr.						×						×	
Cephalopoda													
38. (1) *Orthoceras* sp.												×	
39. (2) *Dawsonoceras* sp.			×										
Crinoidea													
40. (1) Crinoid stems			×										
Trilobita													
41. (1) *Coronocephalus rex* Gr.			×	×				×		×			
42. (2) *Proetus latilimbatus* Gr.			×							×			×
43. (3) *Harpes* cf. *veneulosus* var. *sinensis* Gr.				×									
44. (4) *Acidaspis octospinosa* Gr.				×									
45. (5) *Acidaspis* sp.				×									
46. (6) *Bronteus* cf. *partschi* Barr.			×										
47. (7) *Illaenus asaphoides* Gr.				×									

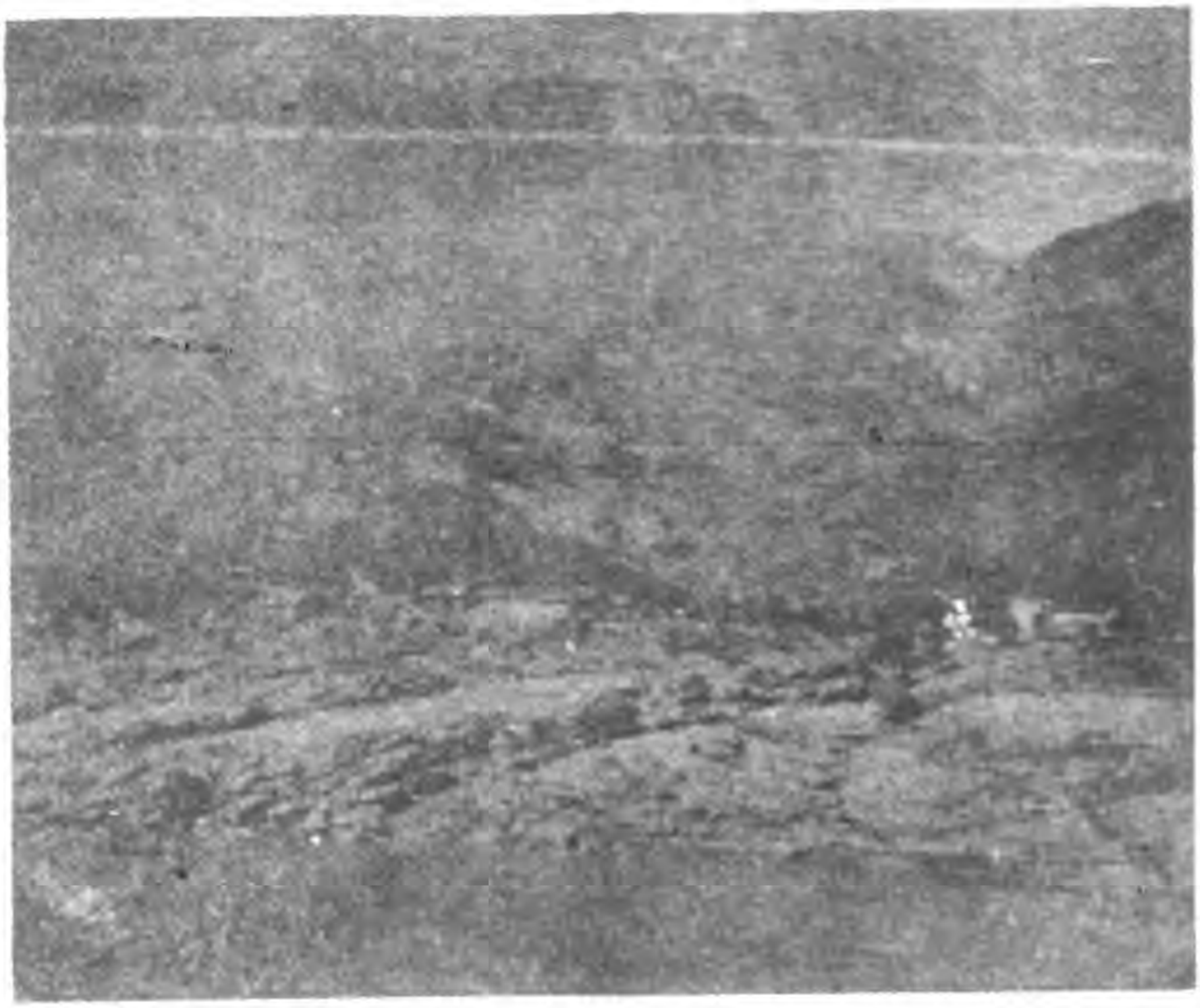
A

B

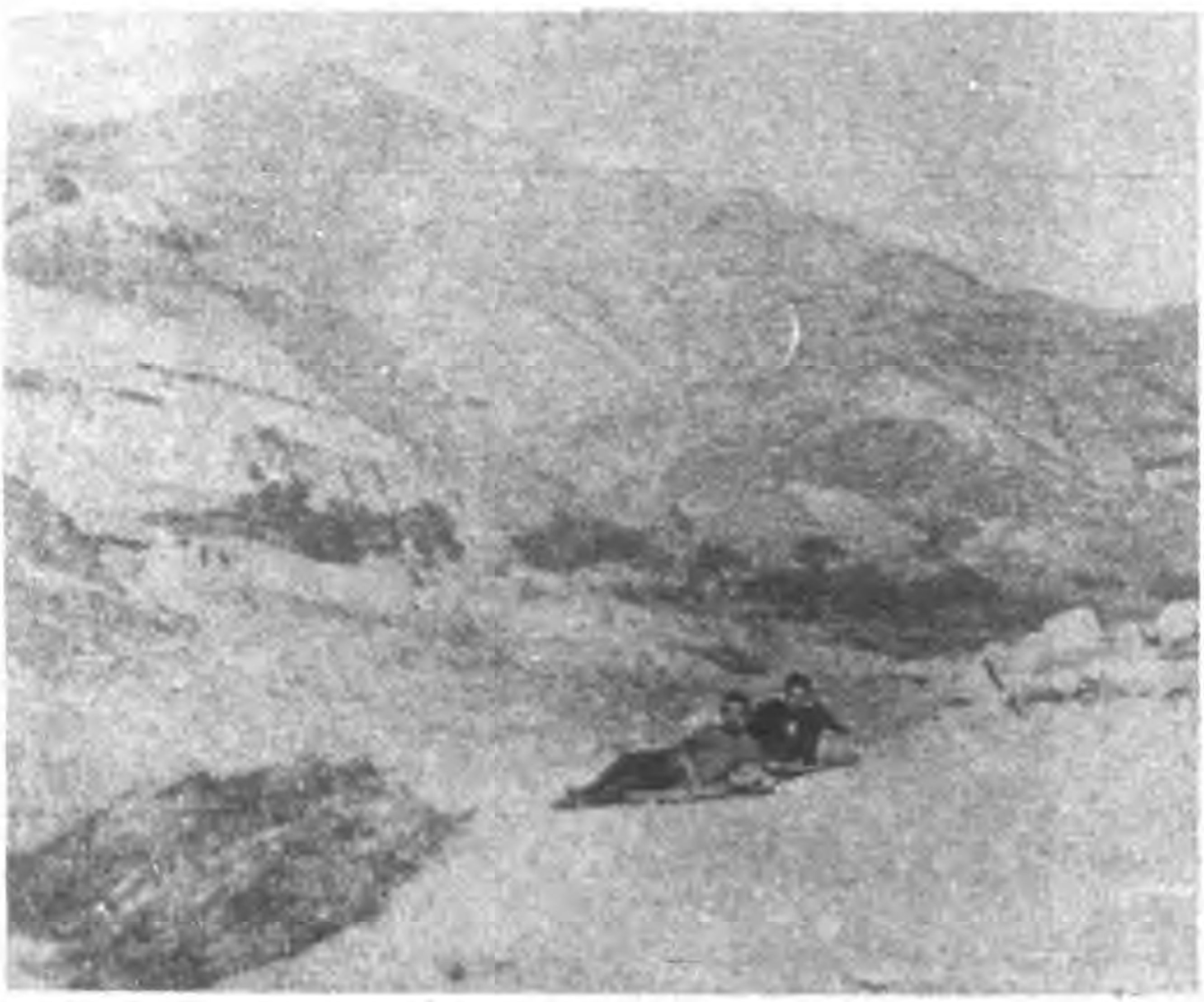
A 新灘附近波浪洶湧之狀，其後山爲志留紀頁岩．向北照．
Hsin Tan Rapid shows the foaming current. The hill in the back ground is composed of Silurian Shale. Looking N.

B 香溪東之米倉峽，其地質爲巫山石灰岩之上部．
The Mi Tsan gorge east of Hsin Chi is developed in the upper part of the Wushan limestone: Looking W.

A



B



A. 崆嶺灘揚子江北岸之剖面,示片岩與震旦層之不整合 南沱砂岩呈層次甚清,燈影灰岩則成峭壁位於圖之頂部.

View of the northern bank of the Yangtze near Kunglingtan, east of Hsin Tan, shows clearly the unconformity between Pre-Sinian schist and Nantou formation. The Nantou Sandstone exhibits here a distinct stratification in contrast with its underlying massive schist while the cliff-forming Tongying limestone is shown in the upper part of the picture.

B. 歸州系所成之地形.山勢雖高.而因岩質軟弱,故山坡尚平緩.秭歸縣沙鎮溪附近.

A typical view of the Kweichow series shows its bold topography but rather gentle slope due to the soft nature of its constituents. Looking N.W. Near Sha Cheng Chi, Tze Kwei district.

EXPLANATION OF PLATE III.

PLATE III.

SILURIAN FOSSILS FROM LO JO PING, I CHANG.

(*All figures are in natural size*)

宜昌羅惹坪之志留紀化石

Figs. 1-2. *Platyphyllum minor*, Grabau.
1, a median-sized specimen; 2, a large individual. Lojoping series (Loc. 826 B).

Fig. 3. *Cyathophyllum chaoi*, Grabau.
Lojoping series (Loc. 826).

Fig. 4. *Microplasma pailou*, Grabau.
Cystiphyllum bed, Lojoping series (Loc. 826 C).

Figs. 5-6. *Pselophyllum zaphrentiforme*, Grabau.
Pselophyllum bed, Lojoping series (Loc. 826 B).

Fig. 7. *Strincklandinia transversa*, Grabau.
A large pedicle valve from the *Cystiphyllum bed*, Lojoping series (Loc. 826 C).

Figs. 8-9. *Conchidium tenuiplicatus*, Grabau.
8, top view; 9a, pedicle and 9b, bottom views of another individual. *Cystiphyllum* bed, Lojoping series (Loc. 826 C).

Figs. 10-12. *Glassia obovata* Sow. var. *magna*, Grabau.
10a pedicle view, 10b side view; 11a brachial view, 11b side view; 12a pedicle view, 12b bottom view. *Pselophyllum* bed, Lojoping series (Loc. 826 B).

Fig. 13. *Trochonema depressa*, Grabau.
13a top view, 13b umbilical view. *Pselophyllum* bed, Lojoping series (Loc. 826 B).

Fig. 14. *Harpes veneulosa* Curd var. *sinensis*, Grabau.
A cranidium from the upper Trilobite bed in the Lungma shale, Sha Mao Shan, Lo Jo Ping (Loc. 825).

Figs. 15-16. *Illænus asaphoides*, Grabau.
15, glabella; 16, pygidium. Upper Trilobite bed, Lungma shale (Loc. 825).

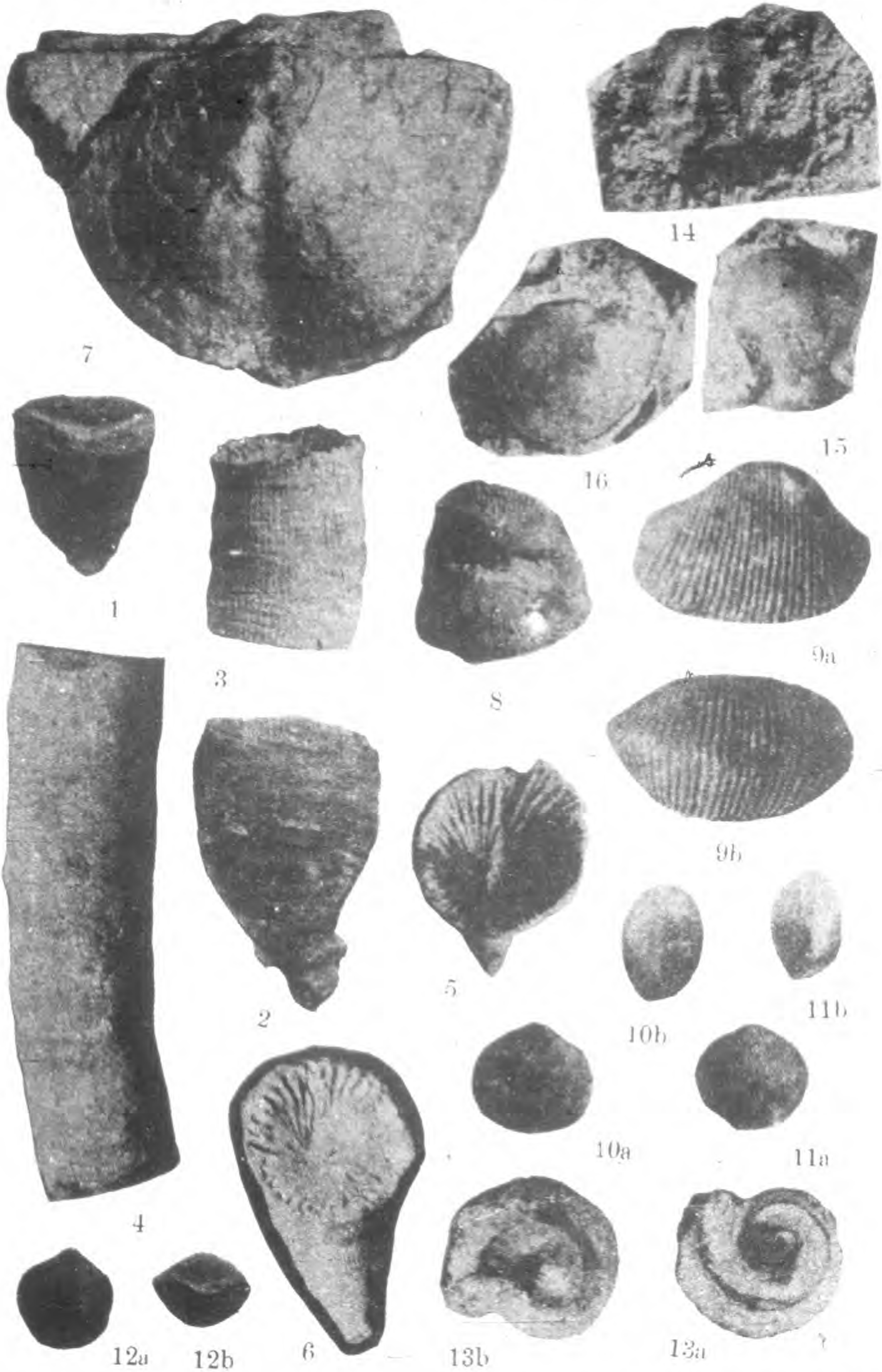
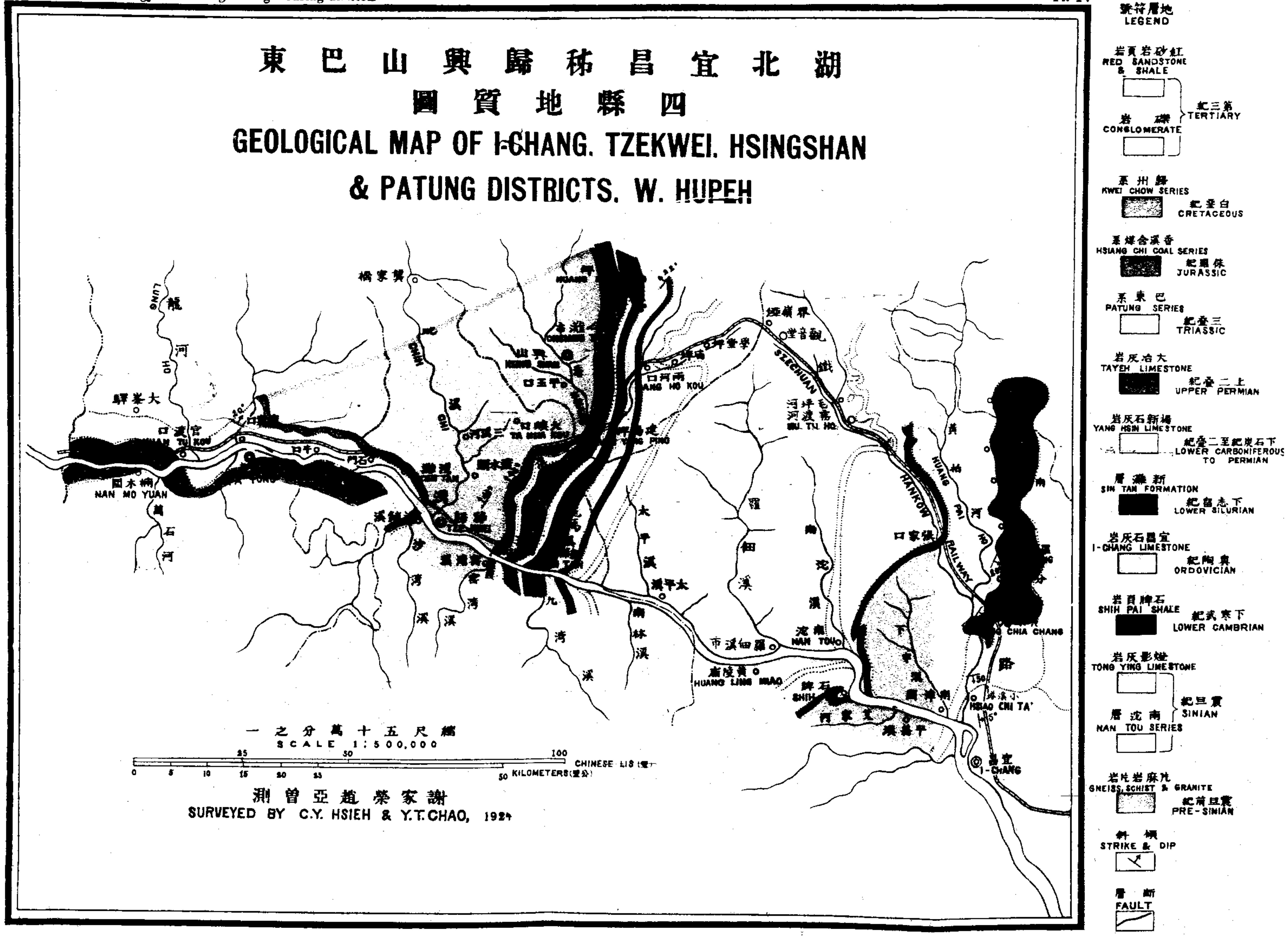


Photo. by Y. T. Chao.

Silurian Fossils.


湖北宜昌秭歸興山巴東四縣地質圖
GEOLOGICAL MAP OF I-CHANG, TZEKWEI, HSINGSHAN & PATUNG DISTRICTS, W. HUPEH
縮尺五十萬分之一
SCALE 1:500,000
CHINESE LIS
KILOMETERS
謝家榮趙亞曾測
SURVEYED BY C.Y. HSIEH & Y.T. CHAO, 1924
NAN MO YUAN
HSIANG CHI
SZECHUAN
HANKOW
RAILWAY
CHIA CHANG
HUANG LING MIAO
NAN TOU
I-CHANG
地層符號
LEGEND
紅砂岩頁岩
RED SANDSTONE & SHALE
礫岩
CONGLOMERATE
第三紀
TERTIARY
歸州系
KWEI CHOW SERIES
白堊紀
CRETACEOUS
香溪含煤系
HSIANG CHI COAL SERIES
侏羅紀
JURASSIC
巴東系
PATUNG SERIES
三疊紀
TRIASSIC
大冶灰岩
TAYEH LIMESTONE
上二疊紀
UPPER PERMIAN
陽新石灰岩
YANG HSIN LIMESTONE
下石炭紀至二疊紀
LOWER CARBONIFEROUS TO PERMIAN
新灘層
SIN TAN FORMATION
下志留紀
LOWER SILURIAN
宜昌石灰岩
I-CHANG LIMESTONE
奧陶紀
ORDOVICIAN
石牌頁岩
SHIH PAI SHALE
下寒武紀
LOWER CAMBRIAN
燈影灰岩
TONG YING LIMESTONE
南沱層
NAN TOU SERIES
震旦紀
SINIAN
片麻岩片岩
GNEISS, SCHIST & GRANITE
前震旦紀
PRE-SINIAN
傾斜
STRIKE & DIP
斷層
FAULT

GEOLOGIC STRUCTURE AND PHYSIOGRAPHIC HISTORY OF THE YANGTZE VALLEY BELOW WU SHAN

(With 8 Plates)

BY L. F. YIH & C. Y. HSIEH

INTRODUCTION

Begun by the reconnaissance survey of Raphael Pumpelly in 1863 the geological study of the Yangtze provinces has occupied probably many more geologists than those whose names[1] are nere given. The more important works were contributed by von Richthofen and the geologists of the Tokyo Geographical Society. However students of geology, who read their works and visit the fields, all realize that much revision is still necessary.

Since its establishment, the National Geological Survey of China devoted much attention to the geology of North China, and systematic field research was not extended far to the Yangtze region until 1919. In that year a new era was opened in the study of the Yangtze geology. In stead of limited observation and sectional recconnaissance, systematic mapping work by provinces was planned and carried out. Each province is taken charge by two or three geologists and to be surved by 24 to 30 months of field work. In 1919 Messrs. C. C. Liu & J. C. Chao began their field work in Kiangsu and finished in 1923. Anhui is being surveyed since 1923 by Messrs. L. F. Yih & C. Li, and Hupeh, since the same year by Messrs. C. Y. Hsieh, C. C. Liu & Y. T. Chao. Mr. C. C. Wang made two journeys in western Kiangsi in 1918 and 1924 respectively.

In the Spring of 1924 Prof. J. S. Lee with a group of students of the Peking Govermment University made an excursion in the gorge district near I Chang and contributed a great deal to our knowledge of the geology of

1) R. Pumpelly 1863-64
F. von Richthofen 1868-72
L. v. Loczy 1877-80
B. Willis & E. Blackwelder, 1903-04
E. C. Abendanon 1904
Y. Ishu & I. Sugimoto 1909-1911
S. Noda 1913-14
V. K. Ting 1917

Hupeh. In the meantime Dr. Grabau together with his students, Messrs. Sun, Chao, & Tien in the Survey, studied the fossils collected back by the above mentioned field geologists, which study of course throws much light on the stratigraphy of the Yangtze region.

The memoir on the geology and mineral resources of Kiangsu together with four sheets of geological maps have been published by the Survey 1924. Reports as regards the stratigraphy of other provinces have also been published successively either in the bulletin of the Geological Society or in the bulletin of the Survey and part of the stratigraphical data has been used by Dr. Grabau in his "Stratigraphy of China", part I, published also by the Survey in 1924.

It seems now desirable to bring together the field observations and make a preliminary study from the structural and physiographical points of view, although surveys in the Yangtze provinces are not yet complete except in Kiangsu.

The writers are much obliged to Dr. W. H. Wong and Prof. A. W. Grabau for their reading over the manuscript and making suggestive criticisms, and also to our colleagues who rendered us assistance, we shall express thanks.

STRATIGRAPHIC CORRELATION

To facilitate comparison a correlation table of the stratigraphy in the Yangtze provinces and a few words of explanation are here given. More detailed descriptions of the principal sections have been published elsewhere[1] or will be reserved for future papers.

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1). C. C. Wang:—On the Geology and Coal Resources of the districts of Chi An, An Fu, and Yung Hsin in Kiangsi. Bull. Nat. Geol. Sur. China. No. 2. pp. 81-86.

C. Y. Hsieh & C. C. Liu:—Stratigraphy of S. E. Hupeh. Bull. Geol. Soc. China, Vol. 3, p. 91.

L. F. Yih & C. Li:—Geology of the Coal Fields of Hsuang Cheng and Chin Hsien, Anhui. Bull. Nat. Geol. Surv. China, No. 6. pp. 13-20.

C. C. Liu & J. C. Chao:—Geology and Mineral Resources of Kiangsu. Mem. Nat. Geol. Surv. China, No. 4. 1924.

A. W. Grabau:—Stratigraphy of China, pt. I. Nat. Geol. Surv. China 1924.

J. S. Lee:—Geology of the Gorge District of the Yangtze from I-Change to Tzekuei...... ....Bull. Geol. Soc. China, Vol. 3, pp. 350-392.

C. Y. Hsieh & Y. T. Chao:—A Study of Silurian Section at Lo Jo Ping, W. Hupeh and The Mesozoic Stratigraphy of the Yangtze Gorges. Bull. Geol. Soc. China, Vol. 4. pp. 39-52.

Location of Section	Between I Chang and Wu Shan W. Hupeh	Northern Hupeh	Southeastern Hupeh	Northeastern Kiangsi	Southern Anhui	Southern Kiangsu
Quaternary	Alluvium	Alluvium	Alluvium	Alluvium	Alluvium	Alluvium
~~Unconformity~~~						
Pliocene		Red clay	Red clay	Red clay	Hsuannan Formation (red clay & gravel)	Basalt 120 m. Yuhuatai gravel 140m.
~~Unconformity~~~						
Miocene (?)	Red sandstone and conglomerate (Tunghu series) 1700 m.	Yincheng sandstone and conglomerate	Red sandstone and conglomerate (with diabase flow).	Red sandstone and conglomerate	Chishan sandstone (with diabase flow) 300 + m.	Chihshan formation 60 m. Pukow formation 550 m.
~~Unconformity~~~						
Cretaceous	Kweichow Series 300 + m.		Porphyry 250 m. Linghsiang sandstone and conglomerate 50 m.			Porphyry 250m. Tsungshan Formation 1800m.
Jurassic	Hsiangchi Series {Upper / Lower} 300m.		Puchi coal series 600 m.	Jurassic coal series	Jurassic coal series 200m.	
Triassic	Patung Series 800m.					
Upper and middle Permian	Wushan Limestone: Upper, Middle, Lower } 1800 m.	Tayeh limestone 600m. Peichien shale 100m.	Tayeh limestone 500 m. Ta'nshanwan series 100m.	Peshan limestone 400m. Laohushan coal series 180 m.	Shipi limestone 400m Hsuan chin coal series 100m. Kofeng limestone, Tsot'an limestone } 200+m.	Upper limestone 120-240 m. Coal series 50-80 m.
......Disconformity......						
Lower Carboniferous		Yangsing limestone 100m.	Yanysing limestone 400 m.	Tsoshan Limestone 250m.	Yehshan limestone 0-100m.	Lower limestone 30-120m.
......Disconformity......						
Silurian	Sintan shale 568 m. Lungma shale 32m.	Fuchikou shale and sandstone 1300m.	Fuchikou shale and sandstone 1000 m.	Yaishan sandstone 2500 m.	Tungkuanshan formation 300+ m.	Border Range Formation 700m.
Ordovician	Neichiashan series 110m. Ichang limestone 1350-1680m.	Chinshan limestone 400m. Pingpa limestone 1500m.	Tafan limestone	Wushihmen limestone 450m.	Chenchiashan limestone 2200+m.	Lunshan Limestone
Cambrian	Shipai shale 200m.	Chinchiapien shale (?)				
Sinian	Töngying Limestone 520m. Toushantou series 198m. Nantou formation 83m.			Shangchiaoshan formation 1700m.	Tahungling series 2000+m.	
~~Unconformity~~~						
Algonkian and Archaean	Kunglin Schist Meijentou Gneiss Hwanglin Granite	Phyllite (with Gabbro Intrusion) Gneiss (and Granite)			Ch'uchow schists Huaiyang gneiss	Chüshan schist, Gneiss.
Authority	*J. S. Lee, C. Y. Hsieh and Y. T. Chao.*	*C. Y. Hsieh, C. C. Liu*	*C. Y. Hsieh and C. C. Liu*	*C. C. Wang*	*L. F. Yih and C. Li.*	*C. C. Liu and J. C. Chao.*

Correlation Table of the Geological Columns of the Yangtze Valley, By C. Y. Hsieh and L. F. Yih.

The Tahungling (大洪嶺) series of S. Anhui consists of purplish and greenish shaly sandstones in the upper part and grey shales in the lower. The sandstones are partly schistose, while the shales are locally phyllitic. Richthofen assumed the lower part to be pre-Cambrian and the upper part to be lower Palæozoic. Now Messrs. Yih & Li consider the two parts to be of one series because the transitional part is composed of both sandstone and shale and it is hardly possible to draw a division line between. Since the lower part is an incompetant member and can easily subject to intense crumbling and folding, therefore the contrast between a complicately folded lower part and the comparatively regular upper part does not mean an unconformity.

By comparing the descriptions and the hand specimen, the Shan-chiaoshan (上樵山) formation of Kiangsi is the same as the Tahunglin series. The former lies conformably under the Wushimen (烏石門) limestone, of which the upper part bears some undoubtedly Ordovician fossils, while in its lower part a Trilobite of probably Cambrian age was found. So far no fossils have been found in the lower formation and we tentatively classify it into the pre-Cambrian or the Sinian. The phyllite mentioned in the third column may be a part of the pre-Cambrian series. Its relation to the older rocks was not observed.

It is well understood that in the Yangtze provinces there are two coal-bearing formations, the Permo-Carboniferous and the Rhætic—Jurassic. In reality the basal part of the Lower Carboniferous limestone sometimes carries several bituminous coal seams of lenticular shape, for instance, in S.E. and S.W. Hupeh, in the latter part they are the principal seams so far being worked. The next older coal series is entirely Permian, which seems to be thinning out toward I Chang; for in the Wushan limestone near I Chang only at the base of its upper division were seen some shaly beds. On the other hand below the Permian coal series is usually developed a succession of cherty limestone of the middle Permian age, *i. e.*, the Choutang (竹塘) and Koofeng (孤峰) limestone of Anhui and the middle Wushan limestones of W. Hupeh, which show characters similar to those of the Lower Carboniferous limestone. They can hardly be distinguished, unless fossils are found. For this reason, the Yangsing (陽新) limestone in N. and S.E. Hupeh may in part correspond to the middle Wushan limestone.

GEOLOGIC STRUCTURE

ARCHÆAN AND ALGONKIAN AREAS

Four separate areas of older rocks are known to occur in the Yangtze Valley below Wu Shan viz, 1° Huanglin (黃陵) near I Chang, 2° Tung-Pai—Huai-Yang range (桐柏 –淮陽山脈), 3° Chu Chow (滁州) along the Tsin-Pu railroad, and 4° Hai Chow (海州) in N.E. Kiangsu (Pl. I).

Whether the first two areas are actually connected is not known, for the upper part of the Han Shui (漢水) valley has not yet been explored. Between the second and the third, the region is largely occupied by the Ho-Fei (合肥) plain in which remain a few isolated hills of porphyry or of Tertiary red sandstone. The third and the fourth are separated by the lake basin of Hun Che Hu (洪澤湖). Most probably the last three areas form the intercepted segments of an otherwise continuous range.

The rocks are gneisses, schists and phyllites occasionally intercalated with quartzite. The direction of schistosity and bedding plane can be clearly recognized. In the gorges above I Chang, the schistosity and bedding plane trend N. by E. and S. by W. Between Chi Shui (蘄水) and An Lo (安陸) on the east of Han Shui, they trend N.W. and S.E. In the vicinity of Ta Hu Hsien (太湖縣), Anhui the main trend suddenly changes toward N.E. which direction runs continuously onward until to the coast of Hai Chow.

PALÆOZOIC AND MESOZOIC AREAS

Lying to the South of those Archæan and Algonkian areas are Palæozoic and Mesozoic rocks, of which the structures are quite complicated. On the whole folding plays an important role. In this paper we are going to present only the general trend of the axes of folding instead of describing the details of the folds, for this, we believe, will bring out much better the geological structure of the regions in question.

It must be borne in mind that a part of the Cenozoic rocks has also undergone tilting and faulting, but this is not the same deformation that first affected the Mesozoic and Palæozoic strata. For this season only the structural directions of the Mesozoic and Palæozoic formations are plotted on the map, while those of the younger rocks are excluded.

Western Hupeh:—In the vicinity of Chien Ssu Hsien (建始縣) the trend of the axes of folding is N.E. by E. and S.W. by W.. Further noth-east, it turns to N. by E. and S. by W.. In the districts of Lai Feng, Yen Fen and En Ssu (來鳳,咸豐,恩施), the axial direction is N.N.E. and S.S.W. Going north-eastward, it bends toward N. E. by E. In the districts of Wu Feng and Hao Feng (五峰,鶴峯) and to the north of the latter district in the lower course of Ching Chiang (清江) it becomes E. by S. and W. by N.

East of Han Shui and North of Yanytze:—From Hsiang Yang (襄陽) to Chi Shui (蘄水) the direction of the axes of folding is N.W. by W; and S.E. by E. After passing the eastern border of Hupeh and entering into Anhui, the strata along the Yangtze generally striks N.E. and S.W. By comparing these changes of strike with those that happened in the Archæan areas it soon becomes clear that the changes in both parts are almost everywhere parallel.

Broadly considered the structures of both west and east of Han Shui, form a syncline which is, however, much obscured by the younger sediments.

South-eastern Hupeh and Northern Kiangsi:—In S.E. Hupeh the structure has been complicated to some extent by the igneous intrusions in the Ta Yeh and Yang Sing (大冶,陽新) districts. Nevertheless it can still be recognized that the principal trend of the axes from Pu Chi (蒲圻) to Wu Yueh (武穴) changes from S.W. by W. and N.E. by E. to E. by N. and W. by S. From Hsiu Shui to Te An (修水,德安) in N.W. Kiangsi, the main axes of folding trend from E. by N. and W. by S. to E. by S. and W. by N.

Between S.E. & S.W. Hupeh lies a lake district and the intervening structure is buried under younger deposits. Judging by the outcrops of the nearer ends of both regions, the direction of the axis of folding seems to change from W. by N. and E. by S. in the western side to S.W. by W. and N.E. by E. on the eastern side. There is therefore probably an arch-like-structure convexing to the south and in a broad way parallel to the bend of the Yangtze river, north of Tung Ting lake (洞庭湖).

South of Yangtze below Kiukiang (九江):—In T'ung Liu and Chiu Pu (東流,秋浦) the strata strike E. by N. and W. by S. Further south the mian axial direction varies from E. by S. and W. by N. to N.E. by E.

From Wuhu (蕪湖) through Nanking(南京) to T'an Tu(丹徒) the axial trend along the Yangtze river generally changes from N.E. by E. and S.W. by W. to E. by N. and W. by S. From T'an Tu to Chang Chow (常州), the strata strike N.W. and S. E.

CONCLUSION REGARDING THE FOLDS

Thus though the structural data are very scattered as shown by the map, they can give fairly well a general view of the structure of the Yangtze provinces. Irrespective of the geographical divisions and the geological formations except the Cenozoic, the axial trend of the folds swings from one direction to another in rather a continuous and regular way. There are in fact many complicated features in the field especially in S.E. Hupeh and S. Anhui. These local complications are largely due to the heterogeneous nature of the rock formations in different parts of the region and also to the igneous intrusions and later earth movements. For convenience we date this movement as Early Tertiary. Further discussions are reserved to the last chapter of this paper.

The abrupt bending of the Tung-Pai—Huai-Yang range or the so-called "arc of Huoshan"§ has long been recognized. This chang of direction is not only brought out by the topographic form of the range, but also shown by the strike of the schistosity of the rocks and the bedding of the less metamorphosed strata intercalated therein. Further more it is also in full agreement with the direction of folding axes of the neighbouring sedimentary formations.

Regarding the last relation there are two explanations: I° the closely parallel structure was produced by the Early Tertiary folding which all rock formations had undergone although the schistosity and other metamorphic effects of the older rocks must have been developed in much older times. 2° The abrupt bending of the Tung-Pai—Huai-Yang range was produced early by the pre-Cambrian earth movements that affected this general region. By the Ordovician and Silurian up-warping§§ the land was elevated in such a shape that its southern margin—the Tung-Pai—Huai-Yang range—was curved just like its bending structure and this land-margin remained so through all the

§ V. K. Ting: Geol. of the Yangtze Estuary pp. 38–39, 1919, Shanghai.

§§ See Physiog Hist. in this paper.

later geological periods or the elevated land was originally irregular in shape and was afterwards so eroded that its southern margin curved according to the geological structure. Then the sediments in the Yangtze geosyncline were folded during the Early Tertiary time in accordance with the curved margin of the old land to produce the parallel structure of to-day. However it is more likely that if at the very beginning of the Early Tertiary folding the relative positions of the three land-masses—the Gobia on the North, the Tibetia on the west, and the Cathysia on the southeast—were actually as the palæographic map§ shows; the direction of folds and mountain chains of to-day in their intervenning geosynclines might be mechanically effected by the three elements and reasonably produced as such and the abrupt bending of the Tung-Pai—Huai-Yang range might be produced in the same way by the same mechanical influence.

PHYSIOGRAPHIC HISTORY

PALÆOZOIC

The more remote the time we trace back, the more obscure the physiographic history will be because the physiographic features of the old cycles have been largely destroyed by the erosion of younger cycles. For the sake of better understanding we shall, however, start the physiographic history of the Yangtze provinces by noting their geography in Palaeozoic time.

So far as can be inferred from the distirbution of various sediments and faunas there was, in the early part of Cambrian, a north-east and south-west geosyncline at the front of the Cathaysian old land. This was gradually submerged by the sea[1] without there being any marked geological difference north and south of the Tung-Pai—Huai-Yang Range. Coming to the Ordovician period we perceive a faunal difference from which we may infer that the site of the present Tung Pai—Huai Yang Range (桐柏淮陽山脈) began to be elevated and the degree of upheaval was at least enough to influence the faunal distribution, if it was not actually a land.[2] During the Silurian time, the Yangtze regions were changed into a shallow sea and the Tung Pai-Huai-

§ Grabau: Loc. cit. Plate IV.
B. Willis: Research in China, Vol. II, Plate 6.

1. Grabau: Stratigraphy of China Pt. I, p. 28.
2. Ibid. p. 242.

Yang range was the southern margin of a land-mass.[3] As no Devonian record has so far been found in the Yangtze valley, these regions probably all stood as a land during that period until the Lower Carboniferous time when the land was again submerged by the sea,[4] except the site of the Tung-Pai-Huai-Yang range remaining as the southern margin of the northern land-mass. From Upper Carboniferous to Lower Permian, and from Middle Permian to the Triassic, the region had essentially the same history[5] as in the Devonian and Lower Carboniferous periods respectively.

Now, the southern margin of the old land, *i. e.*, the Tung-Pai—Huai-Yang range is worthy of more extended notice. In N.E. Hupeh the old land is surrounded by the low hills of Tertiary deposits. In Wang Shih Chiang and Fu Chih Kou (黃山港,富池口) the rocks occuring nearest to the Archæan area are Permian limestones. South of Chien Shan Hsien (潛山縣), Anhui the Archæan rocks are separated from the hilly region of Permian limestone by a bad land of red clay, 10 miles wide. South-west to the Chu Chow (滁州) Archæan area occur the parallel ranges of Permian limestone of northern Ho Hsien, Han Shan, and Tsao Hsien (和縣,含山,巢縣). The rocks dip to the northwest in the northern part of Ho Hsien and the north-eastern part of Tsao Hsien where occur repeated strike faults. Along the fault zone hot springs are frequently present At Chu Chow the lower Carboniferous limestone lies upon the Algonkian schists. What may be inferred from all these observations is that since this part of land had been the transitional zone from an old land to a geosyncline, the overlaping condition of the sediments toward the land mass and dislocation of the formations due to the later folding process seem to have been common along this belt. However if such fault had once any scarp, it was entirely removed away by later erosion and covered by subsequent deposits.

MESOZOIC

During the Permo-Triassic interval the Yangtze valley below Sin T'an was emerged from the sea. The latter retreated southwestward so tha in the Triassic formation marine deposits gradually disappear toward the

3. Grabau:—Loc. cit. p. 116.
4. Ibid. p. 220.
5. Ibid. plate 4.

east and thick continental sediments take their place. In the Jura-Cretaceous formations the sediments are all of continental origin. Thus the Yangtze valley during a great part of Mesozoic era stood as a land. This change of geographic condition may be the result of a warping movement, by which the down-warped portions become local geosynclinal basins and received the thick continental deposits brought down from the neighbouring land-masses.

EOCENE AND EARLY OLIGOCENE

Probably beginning from late Cretaceous and during a great part of Early Tertiary, a movement of folding took place; the present configuration of the principal mountains and rivers of the Yangtze provinces is due to the Early Tertiary folding.

All the mountains of the Yangtze valley may be classed under one category, *i. e.*, folded mountains, either anticlinal or synclinal or monoclinal. And even the abrupt bending of the Tung-Pai—Huai-Yang range may be produced by the same movement.

The Han Shui at least below Hsiang Yang and the Yangtze below I Chang have their courses parallel to the direction of the axes of folding. The term, subsequent river, can not be applied to these rivers in strict accordance with the definition. As they were probably developed in the curved synclinal basin which possibly inclined slightly to the east, they may be called longitudinal consequent rivers and they in fact form one continuous river from the genetic point of view. It is true that studied in detail these rivers do not lie entirely in synclines and do not everywhere run parallel to the strike of the rock formations. These irregularities may be the result of subsequent readjustment.

Above I Chang occurs the Huang-Lin anticline across which the Yangtze river maintains an eastward course in entrenched meandering gorges. With reference to the present cycle of erosion that part of Yangtze may be called an antecedent[1] or better perhaps a rejuvenated river. It is hardly conceivable that in the preceding cycle there already existed a mighty river running eastward and antedating the period of folding. It is also impossible to suggest that this part of the river is superimposed on the peneplane (to be

1) Willis:—Res. China, Vol. I, pt. I. p. 338.

mentioned below) so it has no connection with the structure just like the rivers of the eastern North America, viz., Potomac, Susquehanna, Delaware, etc. because in the present case there has been found no slightest deposit which is likely to have occurred on the peneplane unless to suppose the river was consequently developed on the warped peneplane. However the last assumption has the necessity of excluding the existence of any old drainage on the peneplane before warping, which seems unreasonable. Therefore we consider that when the Huang-Lin Anticline began to rise, there might have come into existence a consequent stream running eastward down the initial slope and that this by headward erosion captured the drainage on the other side of the anticline. The Yangtze river above I Chang might have originated in this manner.

LATE OLIGOCENE AND EARLY MIOCENE

The folded mountain mass of S. W. Hupeh varies from 1700-2000 meters in height above sea level. The even sky-line of the mountain tops is clearly observed especially in Wu Feng(五峯)and Hao Feng Hsien(鶴峯縣). It serves a perfect evidence for the existence of an elevated peneplane in such a folded region. Messrs. Hsieh and Liu called that stage of erosion the O-Hsi (鄂西) stage (Pl. II, Pl. III fig. 1) and named that cycle of erosion the O-Hsi epoch.

According to the order of geological and physiographical events the time of completion of the peneplane must be considered as late Oligocene or Early Miocene age. It is reasonable to suppose that erosion kept up with and continued after mountain-making and finally produced a peneplane.

In N. Kiangsi and S. Anhui so far no evidence of the existence of a peneplane is observed, while in Kiangsu Mr. Liu thought that the more or less equal altitude of the high mountains of that province may be an indication of former peneplanation. However, we all believe that there is no reason to suppose the O-Hsi peneplane to be of very local extension. It might not be so perfect everywhere and was again destroyed during the next cycle of erosion in other parts of the Yangtze valley.

At the end of the O-Hsi epoch the Yangtze River was probably a sluggish meandering stream on this peneplane.

LATE MIOCENE & PLIOCENE

In the high mountains of S.W. Hupeh there exist intermontane low-lands or basins in which are sometimes found the tilted purple sandstones and conglomerates. Their height varies from 500 to 1000 meters above sea. The largest basin has a length of 20 miles and a width of more than 1 mile. The best examples are the Tai Ping Chen (太平鎮) basin south-east of Hao Feng Hsien and those occupied by Ssu Nan (施南) and Lai-Feng (來鳳) cities. Messrs. Hsieh and Liu called them Shanyuan stage (intermontane basin stage 山原期) (Pl. III, fig. 2, Pl. IV, Pl. V, fig. 1). Thus after the formation of the peneplane the land was again uplifted, warped and perhaps partly dissected. Broad valleys thus resulted to form the local basins which afterwards received the sediments now represented by the red sandstones.

The relative order of the formation of the intermontane, mature valleys and the deposition of red sandstone becomes a key to the correlation of the physiographic stages in other parts of the Yangtze valley.

In Nan Lin (南陵) and Hsuan Cheng (宣城) districts south of the Yangtze river, there are low hilly regions of red clay and gravels[1] unconformably overlying the tilted red sandstone (Chishan sandstone 祁山層) that is so commonly seen along the river below I Chang. In the hilly countries sometimes stand groups of mountains and isolated nobs constituted by the Silurian quartzose sandstone. They are residual mountains on a maturely eroded land-surface on which were laid down the new deposits. Similar topography was seen in the southernmost Anhui and in Kiangsu. This is nothing but the topography of the Shanyuan stage. This epoch was therefore so long that (1) a peneplaned area was elevated and the old drainage was rejuvenated, (2) mature valleys were formed, (3) fluvial deposits were laid down in the mature basins, (4) the new deposits were tilted or slightly faulted by less pronounced movement, and (5) further erosion deposited the still younger gravels and clay.

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1. L. F. Yih: Geol. of the Coal Fields of Chin Hsien and Hsuan Cheng, Anhui. Bull. Geol. Surv. Chin. No. 6, pp. 13-30, 1924.

QUARTERNARY

Next to the Shanyuan (山原) epoch is the gorge-cutting period. According to the observations of Messrs. Hsieh and Liu, the intermontane basins are now being cut by entrenched meandering gorges of varying depths, which they called gorge stage. Corresponding to this are the famous Yangtze gorges above I Chang. (Pl. V. fig. 2, Pl. VI. fig. 1.)

Throughout the whole region of South Kiangsu no single canyon is present. In south Anhui however there are incised meandering rivers (Pl. VI fig. 2.) on both slopes of the watershede between the Yangtze Valley and Huichow (徽州) basin and on the southeastern part of the former basin is the border range of Anhui and Chekiang. Cutting through this range is the entrenched meandering river of Sin An Chiang (新安江), i. e., the head water of Chien Tang Chiang (錢塘江).

An explanation is needed to account for the gorge topography so common above I Chang though absent bolow that place. These gorges appear to have been formed as the result of the steady and continuous uplift of the land and the downward cutting of the existing rivers. If this is the case, the south-western part of the Yangtze valley was undergoing up-warping, while its lower part on the contrary was subject to down-warping. Different phases of earth movement thus caused the different types in topography.

It is a well known fact that along the Yangtze River below I Chang there are so many lakes, great and small; some have been drained and others, silted up. They have no relation with the local geological structure and are not all ox-bow lakes, but can be explained only as the relics of a drowned river. The period of drowning was the time of down-warping. In that stage the Yangtze river below I Chang was probably an estuary like the Hudson River of to-day below Albany in New York State. The submergence of the Kiangsu coast[1] seems to have taken place during the same period, this explaining equally well the absence of deep valleys in that province.

The period of down-warping and drowning appear to have been somewhat later than the formation of the red deposits, sand, clay and gravels. This is suggested by the distribution of the lakes. On both banks of the

1. V. K. Ting: Geology of Yangtze Estuary below Wuhu, pp. 37-48, Shanghai. 1919
C. C. Liu: Geology of Kiangsu pp. 25-26, Mem. Geol. Surv. China, Ser. A No. 4, 1924.

Yangtze in the vicinity of Anking (安慶), Kuei Chih (貴池), etc. the lakes usually extend into the hills and among the terraces of the red deposits, this showing that before the occupation of the region by the water bodies the red deposits were first dissected to some extent.

On the both sides of the lower Yangtze valley there are basalt buttes.[1] It is deserved to discuss at some length that what makes the relative order of the drowning and the basalt eruption. Unquestionably this is a problem of the stratigraphic age of the basalt flow. It is natural to assume that all the basalt exposures were formerly part of one flow[2] because they occur close together in a same region. The underlying strata correspond to the younger red deposits.[3] What lies upon the basalt was not observed in S. Kiangsu, but was seen in Lin Yen Shan (靈岩山), N. of the River by Dr. Andersson and Mr. Tung. It was regarded by the former as a local development of loess and was named loam by the latter.

The loess in north China seems to decrease gradually in thickness and in occurrence toward the low latitude. It is already far less often seen in Shantung[4]. It may be present somewhere in northern Anhui and northern Kiangsu; but its occurrence near, or in the Yangtze valley is always questionable.

The writer (Yih) was strongly impressed by the sharp distinction made by Dr. Ting in his geological map[5] between the Tatung conglomerate on the South of Lang Chi (郎溪) and the loess on the north of the city, so he paid special attention to this difference during his survey last Spring and followed it up with Mr. Li to the town of Tung Pa (東壩) in the district of Kao Sheng (高淳), Kiangsu. We found that the red deposits (called Nanling formation by Yih & Li[6]) are extensively developed in the vicinity of Lang Chi city. Going northward the same formation mostly becomes yellowish. The difference in color is most probably the result of hydration of the red sediments.[7] The same kind of change is very common in the superficial

1. C. C. Liu: Loc. cit. p. 15.
2. J. G. Andersson: Cenozoic of N. China, pp. 18-19, Mem. Ser. A, No. 3, Geol. Surv. China, 1923.
3. Ibid. pp. 15 & 21.
4. H. C. T'an: Communication to the writers.
5. V. K. Ting: Loc. cit. Plate one.
6. Yih & Li: Loc. cit.
7. G. P. Merrill: Rock Weathering, pp. 243-44.

part of the red deposits in southern Anhui. Further evidence is also furnished by the agricultural condition in both parts of the region, since this formation is generally less productive everywhere than is the alluvium. Mr. Liu who has worked extensively in Kiangsu also doubts whether there is any true loess although he obtained no positive evidence against its existence. Mr. Tung once showed to the writer a specimen from Lin Yen Shan, which did not look like a true loess.

Therefore we are of the opinion that the loam overlying the basalt in Lin Yen Shan is a weathered part of the red deposits and the basalt eruption is a sub-stage of the Shanyuan epoch. When the fluvial deposits were in the making, basalt flows also came in. During the next period all the deposits were downwarped and partly drowned.

Finally while the region of western Hupeh was continuously uplifted and gorges were being vigorously cut, the lower Yangtze valley was also slightly elevated. Then the water retreated and its remnant formed the lakes of to-day.

At present the entire course of the long meandering river below I Chang is bounded on both banks either by rock formations or by the terraces of the red deposits. It is evidently a less mature valley than its preceding (山原) stage. The change of the stage of development, viz, the interruption of the erosion cycle, is the effect of the last up-warping. Now even in the high water season only the lake basins and the alluvial valleys in the dissected red beds are inudated, but water has never transgressed over the terraces or hills of the red formation, which stand usually 20 m. and more in height above the river channel (Plate VII & VIII).

According to the study of Mr. J. S. Lee,[1] the Yangtze River diverted its flow in the Mid-Tertiary time. This conclusion was based on the occurrence of the Yaotze Conglomerate at Sin T'an because the pebbles of this formation were said to be brought there only possibly by a flow running from east to west. As this deposit occurs in the gorges, it was apparently formed during the gorge-cutting period, i. e, the Quarternary period according to the general physiographic history here outlined. Most probably it was

1) J. S. Lee. Op. cit. pp. 382-391.

the time of drowning of the lower Yangtze when the river flow might bring the detrital material up the estuary for some distance during the high tide and a great part of the same material could hardly be brought back during the ebb[1] and therefore set down to form the local deposit, which explanation can agree very well with the general history of the region, and it can also account for the source of the pebbles just as good as the diversion of flow assumed by Mr. Lee.

To sum up the preceding discussions on the tectonic and physiographic history of the Yangtze valley below Wu Shan, here follows a correlation table.

DATE OF FOLDING AND CORRELATION OF PHYSIOGRAPHIC HISTORY

From the above description on the geologic structures two facts become obvious, viz., the directions of the folding axes in the Yangtze geosyncline have been most probably controlled by the existence of the neighbouring old-lands and the latter in turn have been deformed to some extent by the same folding process. Now the question is when the folding took place. Again in the section of physiography the sequence of events was described under different geologic periods. Then the question arises again how they are dated; especially the latter part of the physiographic history needs more explanation. Since physiographic features are largely the facial expression of geologic structures and the elucidation of structural and physiographical problems usually rely upon each other's support, we are going to discuss here the date of folding together with the date of the physiographic events.

By stratigraphical evidence we only can say that in the region under discussion all the formations ranging from Lower Cambrian to Lower Cretaceous in age have been conformably folded. In other words the orogenic movement began in late Cretaceous or entirely falls within post-Cretaceous time. However a movement of warping has occured during the Permo-Triassic interval. Owing to this movement, the eastern part of Hupeh and the lower

1) For influence of tides on rivers and effect of tides on transportation, see Geikie—Text Book of Geology, 1893 edition p. 398 & p. 45).

Geological period	Diastrophism	W. Hupeh	E. Hupeh, N. Kiangsi, & S. Anhui	S. Kiangsu	Yangtze River	Tung-Pai—Huai-Yang Range
Quaternary	Differential warping	Gorges stage (continuous up-warping) & youthful dissection	2. Early mature dissection. Water retreated & Lakes formed. (slight up-warping) 1. Drowning of the low land. (down-warping)	Same as S. Anhui etc.	*Above I Chang:* Stage of youth (continuous up-warping) *Below I Chang:* 2. Stage of early maturity & water retreated (due to last up-warping) 1. Drowned (due to down-warping)	Maturely dissected
Pliocene & Late Miocene	Differential warping with volcanic eruption	2. Basins filled by red deposits. 1. Peneplaned area elevated and dissected to intermontane basins—Shan-Yuan Stage.	4. Red deposits youthfully dissected. 3. Purple sandstone area tilted, dissected & covered by new red deposits. 2. Mature low lands covered by purple deposits & diabase flows. 1. An elevated land of late maturity eroded in part to mature low lands—Hsuan-Nan stage.	4. Purple sandstone land dissected & covered by gravels, clay, sand & basalt flows. 3. Tilting and dislocation of purple sand stones 2. Mature land surface covered by purple deposits. 1. An elevated land maturely eroded.	Mature stage reached by the rejuvenation of the pre-existing river.	A peneplaned area elevated & dissected probably to mature stage.
Early Miocene & Late Oligocene	End of Orogenic movement	Peneplaned stage—O-Hsi stage.	Probably same as W. Hupeh	Probably same as W. Hupeh	An advanced mature river	Advanced maturely eroded
Early Oligocene & Eocene	Orogenic movement (folding, faulting, intrusion & eruption, especially effective in SE. Hupeh & S. Anhui)	Land	Land	Land	A consequent river initiated	Complex mountains formed
Jura-Cretaceous		Land	Land	Land	Land	Land
Permo-Triassic	Epirogenic movement	Land	Land	Land	A part of shallow sea to land	Land
Upper to Middle Permian	Epirogenic movement	Sea	Sea	Sea	Sea	Land margin
Lower Permian to Upper Carboniferous	do	Land	Land	Land	Land	Land
Lower Carboniferous	do	Sea	Sea	Sea	Sea	Land margin
Devonian	do	Land	Land	Land	Land	Land
Silurian	do	Shallow sea	Shallow sea	Shallow Sea	Shallow sea	Land margin
Ordovician	do	Sea	Sea	Sea	Sea	Began to emerge
Cambrian	do	Sea	Sea	Sea	Sea	Sea

Yangtse valley were gently upwarped and the Triassic sea retreated southwestward and consequently the Triassic sediments are absent in the elevated areas. Local basins, e.g., the Kuei-Chou basin (歸州) of Hupeh, the Red Basin of Szechuan, etc were thereby formed and received the Jura-Cretaceous deposits, of which the characters and thickness vary in detail in different localities. Anyhow the Permo-Triassic movement was not a pronounced folding process. Otherwise there must be marked discordance between the Jura-Cretaceous strata and the older formations, which has never been observed in the Yangtse valley below Wu-Shan.

The end of the post-Cretaceous folding must be dated much earlier than the formation of the Tunghu series (a series of conglomerate and sandstone in E. Hupeh equivalent to the Chishan sandstone in Anhui and the purple sandstone & Ch'ishan sandstone in Kiangsu). The fact that the Tunghu sandstone lies in various erosional basins and valleys which were carved out of an elevated, peneplaned land is quite clear and definite among the physiographic features in this region. Unfortunately so far no fossils have been yet found from this formation though it has been well established by the recent observers on the structural and lithological evidences[1] as a separate group of deposits younger than the Kueichou series. This may be further proved by the observation of Willis and Blackwelder[2]. They saw all the Palæozoic and Mesozoic formations have been metamorphosed at the immediate southern flank of the Tsing Lin Shan, but not the Shi-chuan sandstone. The latter is no doubt the same sandstone that is here named under the Tunghu series though it has been regarded as Jurassic by the two geologists.

After the close of the folding process and before the deposition of the Tunghu series successively took place the completion of the O-Hsi peneplane, its elevation, and dissection. Apparently there should be an interval of time long enough to allow the accomplishment of these events.

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1) J. S. Lee:—Geology of Yangtze Gorge. Bull. Geol. Soc. China, vol. 3, 1924, pp. 382-89, C. Y. Hsieh; & Y. T. Chao:—Geol. of I Chang, Hsing Shan etc. Bull. Geol. Sur. China. No. 7, pp. 13-86.
Formerly the Tunghu series at I Chang was regarded as a "recurrence of the K'uichou series". See R. Willis:—Res. in China vol. 1, pt., I p. 286, E. C. Abendanon:—Struct. Geol. of the middle Yangtse Gorges. Jour. Geol. Chicago, vol. XVI, p. 606; 1908. & S. Noda: Geog. Research in China, vol. 2, Geol. map of NE. Hupeh.

2) Willis:—Res. China, vol. II pt. I, p. 300.

Among the previous workers on the structural and physiographical problems of Yangtze valley, B. Willis & E. C. Abendanon are to be first remembered. The following conclusions are reached by the former geologist.

> "So far as our own observations go the date of folding in the middle Yangtze provinces is later than the highest beds in the K'uichou series, that is post Triassic, as the strata appear to be conformable from the Carboniferous up. The conclusion is not final, however, since our observations are incomplete and are in apparent contradiction with those of von Richthofen in the Red Basin of Szechuan at Kuang-yuan-hsien (Kwang-yuen-hsien) 250 miles, 400, km., further west. He observed an obvious unconformity at the horizon beneath the Permo-Mesozoic, at which we observed apparent conformity of bedding in repeated exposures and over a wide area"[1]

The K'uichou series of Willis is now known to represent the Triassic, Jurassic, and Lower Cretaceous formations. The lower limit for the date of folding has therefore to be set further up that is post-Cretaceous instead of post-Triassic. As to the "obvious unconformity" observed by Richthofen[2] and Loczy[3] we can not help thinking that it is doubtful. If we compare his descriptions of the various geological sections[4] with our recent observations, the Silurian formation (h), Permo-Carboniferous cherty limestone (f), Permian coal-bearing series (e), and Permian thin-bedded limestone (A) which he described from the northern border of Szechuan all seem to occur just as completely in the middle Yangtze valley. It can hardly be understood why there is a structural unconformity, but no stratigraphical break. Therefore Richthofen's unconformity is most probably a fault contact in such a dislocated zone where his section was made. Abendanon's conclusion can be obtained from the following quotations[5]:—

> "Formerly I have already observed that the anticlines which in Red Basin strike almost NNE-SSW, are bent round in the north and east toward the NE, ENE, & E. To explain this, I assumed the Red Basin had been forcibly pressed up against the old mountain ranges of Kuenlun and Tsing-ling-shan trending in almost equatorial direction. The trends in these border ranges of the Red Basin do not therefore conform to the normal in the basin itself" (p. 588).

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1) Ibid. p. 295.
2) China vol. II, p. 603.
3) Loczy:—Reise des Szecheny, vol. I, profiltafel II & p. 685.
4) China vol. II, pp. 598–603.
5) Abendanon:—op. cit.

"The folds of the Red Basin of Sai-chuan are of later date than the K'ui-chou formation" (p. 589).

"The deviation of the anticline of Pa-tung, which in general traits has an equatorial direction, to a meridional one, the convex side of the bend turned toward the NE. * * * * This deviation must have been caused by the powerful anticline of Nan-t'ou * * * This fact shows, firstly, the capacity of resistance of the anticline of Nan-t'ou which resistance would seem to me impossible, if a great fault really existed. And, secondly, that the origin of the anticline of Nan-t'ou must date before the folding of the Red Basin" (p. 599).

Accordingly there are two episodes of folding in the middle Yangtze region, viz., the first one bringing up the Nan-t'ou anticline (called Huangling anticline in this paper) which is of the same age as the Kuen-lun and Tsing-ling-shan, i. e., Hercynian and the second building up the Pa-tung anticline and other folds, which is of Hymalayan age.[1]

As we can understand from the previous works, the European geologists and geographers who have been working in the mountain systems of central Asia and southwestern China commonly assumed that the old system of Kuen Lun and Tsing Ling Shan has a W-E trend, while the Hymalayan system represented in China has a meridional direction.[2] Thus they seem to take as granted a constant relationship between the age of mountain systems and the general trend of their ranges. Such a relationship is, however, not necessary While the direction of application of the orogenic force is constant during a definite period in a definite region, the folding axes may quite well take various directions owing to the resistance of old lands or to other local causes. For example, the sediments in a geosyncline bounded around by blocks of old lands may have their axes of folding parallel to the margin of the respective neighbouring old lands. By looking at the map of continental structure of Asia[3] and the palæogeographical maps of Asia,[4] particularly those showing the Permo-Mesozoic conditions, this possibility will be more readily recognized.

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1) See "The Alps of Chinese Tibet & their geog. relations by J. W. Gregory. Geol. Jour. London, 1913 and the references given there.

2) Dr. W. H. Wong is of the same opinion. See his summary (in Chinese) on the study of the Mountain Systems in Asia & China in "Science" published by the Science Society in China, 1924.

3) Research in China, vol. II, pl. 8.

4) Palaeog. Maps of Asia by A. W. Grabau, Geol. Surv. China, 1925.

The Nan-Tou area might have been gently uplifted with its eastern sorrounding countries by the Permo-Triassic epirogenic movement; but it was not necessarily a *fold* at that time. Furthermore the evidences[1] by which Dr. Abendanon proved the Nan-Tou area to be a land-ridge during pre-Upper-Carboniferous time and also to be part of a dividing line during the Upper K'ui-chou time are not confirmed by the recent observations.

From the preceding discussions we hope to have brought out the fact that there are no Hercynian *folds* in the middle and lower Yangtze regions. All tho Palæozoic and Mesozoic formations seem to have been *folded by only one post-Cretaceous movement.* Whether the latter is somewhat earlier than the Hymalayan episode or exactly Hymalayan remains to be further discussed.

In view of the impossibility of making direct comparizon between the latest tectonic history of the Hymalayan mountains and that of the Yangtze valley, some comparable means can be sought only from the regions adjoining the Yangtze and where the Tertiary history is better known.

Starting northward from Pukow by the Tientsin-Pukow railway there is firstly a maturely eroded landsurface in the south of Huai-Ho(淮河), of which a small part is a hilly region of moderate height and the rest is alluvial plain; the former is constituted by various geological formations and of various structures Between Pen Pu (蚌埠) and Li Kuo Yeh (利國驛) the country shows a still more advanced stage. The hills are more subdued except the group in Shu Hsien and Hsiao Hsien (宿縣,蕭縣), which is relatively higher and more extensive. From Tung Shan Hsien (銅山縣) to Li Kuo Yeh the railroad lies almost on a plane surface levelled over a series of limestones with fairly steep inclination. This proves that the land has in a great part reached the stage of peneplane, but has largely been buried under the alluvium; and the hills and mountains are simply the remnants of erosion. This advanced mature landsurface can be traced in fact southwestward as far as Ho Fei Hsien (合肥) in N. Anhui and Hsin Yang (信陽) in S. Honan and eastward as far as the Tung Hai Hsien (東海) coast in Kiangsu. The

1) op. cit. pp. 611-612.

peneplaned surface extends further northward from Li Kuo Yeh; but becomes valleys and intermontane low lands such as the Ssu-Shui (泗水), Yi-Shui (沂水), Hsin-Tai (新泰), Meng-Yin (蒙陰), and Wen-Ho (汶河) valleys in Shantung.[1]

The important bearing of these peneplaned areas lies in the fact that they are post-Eocene in age, for they have bevelled across the post-Eocene fault scarps and the very broad folds of the Eocene deposits.[2] On the same maturely eroded landsurface were laid down the younger Tertiary sediments; the Hipparion-bearing red clay of early Pliocene in Shantung and the Pukow sandstone, the Ch'i-shan sandstone and the Yuhuatai formation in the vicinity of Pu Chen (浦鎮), Shu Chien (宿遷), Ho Fei, etc..

After the personal observation of Mr. C. C. Liu in Hupeh he regarded the Pukow & Ch'i-shan sandstones and the Tunghu series as contemporaneous deposits. The reasonable correlation of the Yuhuatai formation in the vicinity of Nanking with the red clay formation in the Yangtze valley has been stated in the foregoing chapter. By comparing the lithological characters and geological mode of occurrence, the red clay of the Yangtze valley can be said identical with the Hipparion clay of Shantung and Chihli; but no equivalents of the Tunghu series have been found in Shantung. Then the basement, the advanced mature landsurface in the North of the Yangtze, can only be correlated to the erosional basin stage of the Shanyuan epoch in the South of the River, and it is, in consequence, somewhat later than the age of the O-Hsi peneplane.

Thus the foregoing discussion leads us to the conclusion that the movement of folding of the Yangtze provinces might have begun early in late Cretaceous, but accomplished its main work during the early Tertiary, Eocene or including a part of Oligocene. Therefore its age is somewhat earlier than the Hymalayan. After the folding was the completion of the O-Hsi peneplanation, whereas in Shantung only a very gently warping occurred during the corresponding period, which resulted in the formation and migration of the

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1) Nanking-Weihui Geol. Sheet (1:1,000,000) in press, Geol. Surv. China will show the fact precisely.

2) H. C. Tan:—New Research on the Mesozoic & Tertiary Geol. in Shantung, Bull. Geol. Surv. China, No. 5 pt. 2. 1923, Geol. Sections & pp. 127–135.

late-Cretaceous and Eocene deposits.[1] Next were the elevation and the dissection of the Yangtze peneplaned areas, which corresponds to the faulting and advanced mature erosion in the northern province. Afterwards both regions were locally covered by the purple sandy and clayey deposits. The latter were equally slightly tilted by late Tertiary movements and followed by accumulation of the early Pliocene clays. The rest of the tectonic and physiographic events stated in the previous chapters must fall within the Pleistocene period, which also agrees with the general experience that the Plio-Pleistocene warping was really a mountain-making process and has established the present topographic relief of eastern Asia.[2]

In closing we should mention that we are not going to correlate the physiographic stages distinguished here with those established by Willis in Shansi and Chihli and modified by J. G. Andersson,[3] and also those adopted by Deprat[4] and commented by J. Coggin Brown[5] in Yunnan and even those recently discovered in Mongolia by C. P. Berkey and F. K. Morris,[6] as we believe that the general sequences of events are all similar and correlable each other in a very broad way; but will not agree exactly, since the time of beginning and end of the earth movements and of the erosion cycles and the amount of relief brought up by different movements, etc. must be too variable in different parts of the continent. Exact relationships will be definitely understood only when enough data in proportion to the area covered become available.

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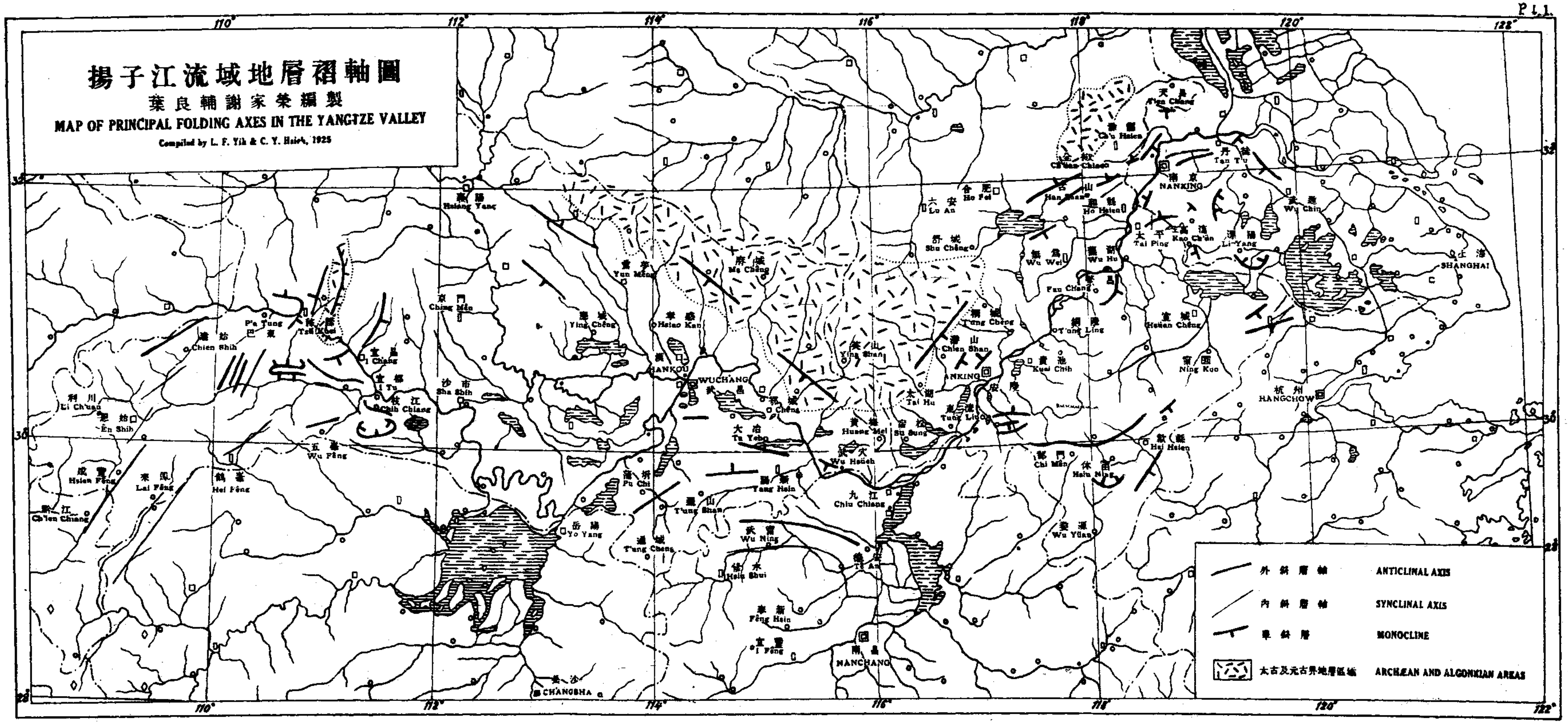
1) H. C. Tan:—op. cit.
2) Res. in China, vol. II, pp. 96-98.
M. Deprat:—Sur l'importance des movements epirogeniques recents dans l'Asie sud-orientale. Comptes rendus, t. 152, p. 1527, 1911.
3) L. F. Yih;—Geology of Hsi Shan, Mem. Geol. Surv. No. 1. pp. 65-77.
4) M. Deprat:—Étude que du Yunnan oriental. Mem. du Serv. Geol. de l'Indo Chine, Vol. 1, Fasc. 1, pp. 350-357.
5) Records geol. Surv. India, vol. XLIV, pt. 2, pp. 116-122, 1914.
6) Berkey & Morris;—The Peneplains of Mongolia, Novit, No. 130, Am. Mus. Nat. Hist. N.Y.


P1. 1.
揚子江流域地層褶軸圖
葉良輔謝家榮編製
MAP OF PRINCIPAL FOLDING AXES IN THE YANGTZE VALLEY
Compiled by L. F. Yih & C. Y. Hsieh, 1925
外斜層軸 ANTICLINAL AXIS
內斜層軸 SYNCLINAL AXIS
單斜層 MONOCLINE
太古及元古界地層區域 ARCHÆAN AND ALGONKIAN AREAS
NANKING
SHANGHAI
HANGCHOW
HANKOW
WUCHANG
ANKING
NANCHANG
CHANGSHA

EXPLANATION OF PLATE II.

Panoramic view from Chi Shu Hsia (漆樹下), Pa Tung (巴東) district, showing the structure of the Sze Tu Ho (四度河) & the elevated & dissected peneplane. The hill at the middle of the picture is formed of Ordovician limestone while the valleys on both sides are located in the zones of the Silurian soft shales. The high tops forming the distant sky-line are formed of Wushan limestone. The Ordovician limestone forms here the central core of the structure. The uniform elevation & the even landscape of these hills suggest clearly the existence of a peneplane. On the right corner of this picture is shown the valley of Sze Tu Ho. Its deep canyons & precipitous walls have rendered the travelling here extremely difficult. Looking E. (Photo by Hsieh & Liu).

湖北巴東縣漆樹下四度河圓形褶曲之全景. 居中之圓頂山爲奧陶紀灰岩, 即褶曲之中心. 其兩旁山谷. 位于志留紀之軟質頁岩帶中. 最遠之山. 係巫山石灰岩所成. 綜觀全景高下整齊之山頂. 足以表示昔日之假平面無疑　圖之右角. 即四度河. 峽谷絕壁行者苦之. 視線東向 (謝劉攝).

Plate II.

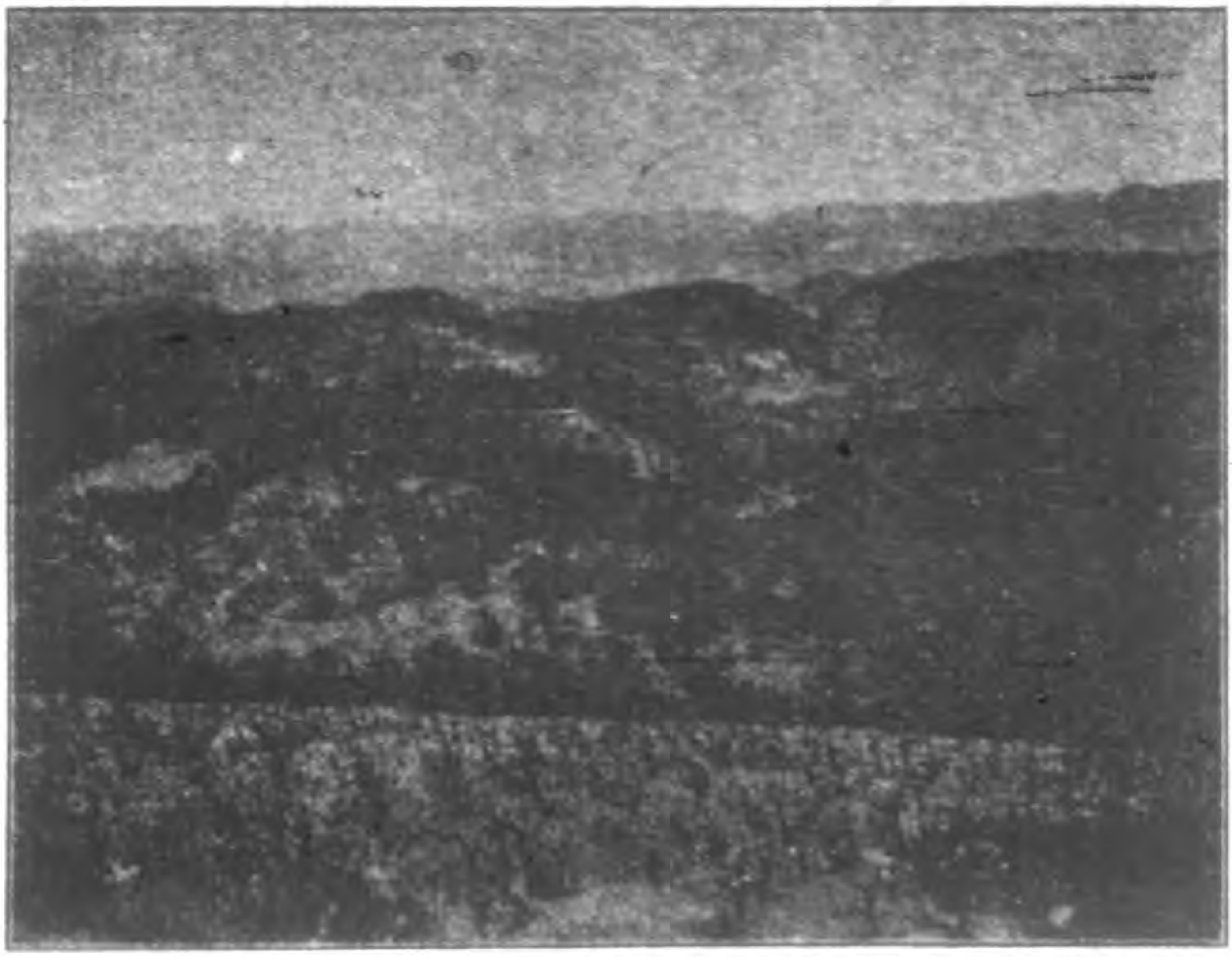
EXPLANATION OF PLATE III.

Fig. 1. A general view of the Ohsi stage (鄂西期), i. e., the stage of peneplanation which is characterized by the even sky-line in the background. The elevation of this peneplane in W. Hupeh varies between 1700-2000 meters. The maturely dissected hills with a flat depression shown in the foreground is a typical view of the Shanyuan stage (山原期). Looking E. from Shih Ma Ling (石馬嶺), N. of Sze Nan (施南). (Photo by Hsieh & Liu).

第一圖. 鄂西期似平面之地形. 背景中之天際線, 即似平面之側面. 在鄂西界內. 該平面之高度自一千七百至二千公尺不等. 已經侵蝕至壯年期之小山與前景中之窪地. 即山原期之地形 視線從施南南鄉白馬嶺東向(謝劉攝).

Fig. 2. The red basin of Yen Chia T'u (鄢家沱) south of I Chang (宜昌), a basin of Shanyuan stage. Looking N.E. (Photo by Hsieh & Liu).

第二圖. 宜昌南鄉鄢家沱之紅色盆地. 即山原盆地之一. 視線東北向(謝劉攝).



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EXPLANATION OF

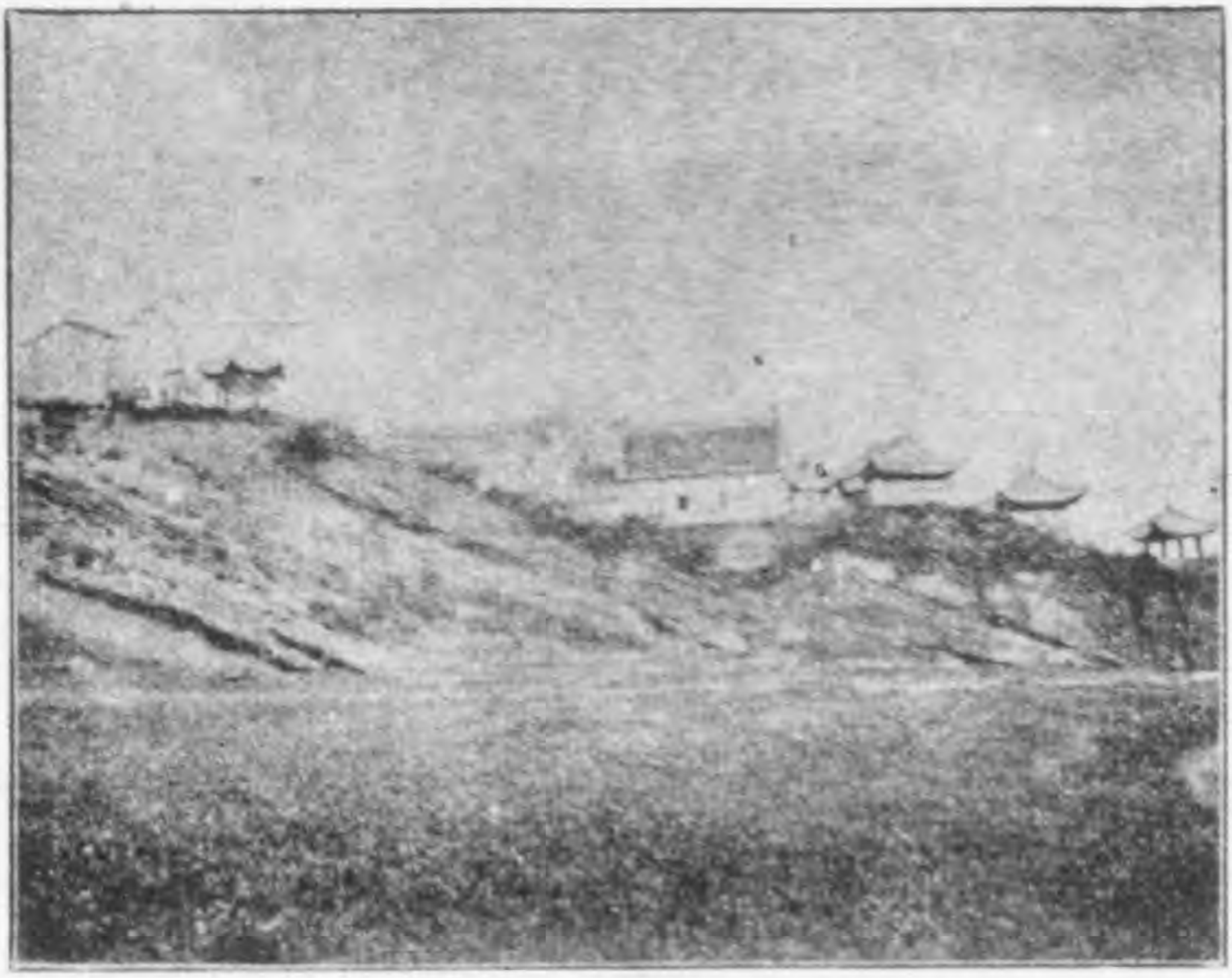
PLATE IV.

Fig. 1. The famous Chih Pi or "Red Cliff" (赤壁) on the outside of the city of Hwang Kang (黃崗). The section consists of alternating beds of red sandstone and shale (Tunghu series) dipping S. W. about 35 degrees. Looking N. W. (Photo by C. Y. Hsieh & C. C. Liu).

第一圖. 黃崗城外之赤壁. 該剖面係由紅砂岩與頁岩之互層(東湖系)所組成. 傾斜西南約卅五度. 視線西北向(謝家榮劉季辰攝)

Fig. 2. The even toped ridge behind the trees with a steep solpe on one side is formed of purple sandstone and shale (Ch'ishan sandstone) dipping gently toward. S. E. Its surrounding mountains are formed of pre-Cambrian shaly sandstones. It is the N. W. part of the Hui-Chow red basin corresponding to the Shanyuan basin of Hupeh. Taken at Yen Chiao (岩脚), Hsiu Ning Hsien (休寧縣).Anhui. Looking E. (Photo by L. F. Yih).

第二圖. 樹外之平頂山. 係紫色砂岩與頁岩(祁山層)所成. 微向東南傾斜. 其附近諸山. 均爲震旦層是爲徽州紅色盆地之西北邊緣. 與湖北之山原盆地相當者(葉良輔攝于休寧縣岩脚).



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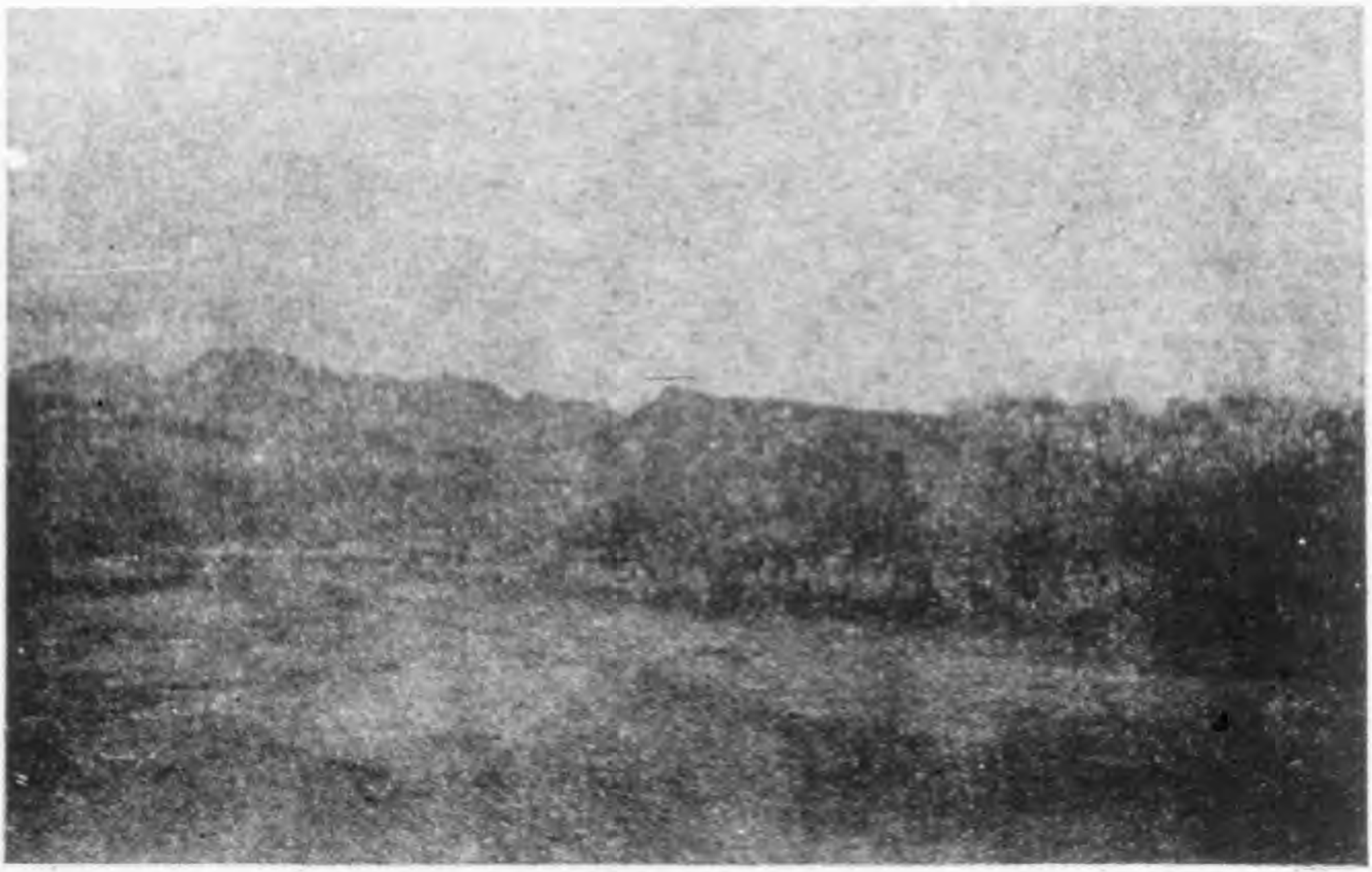

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EXPLANATION OF
PLATE V.

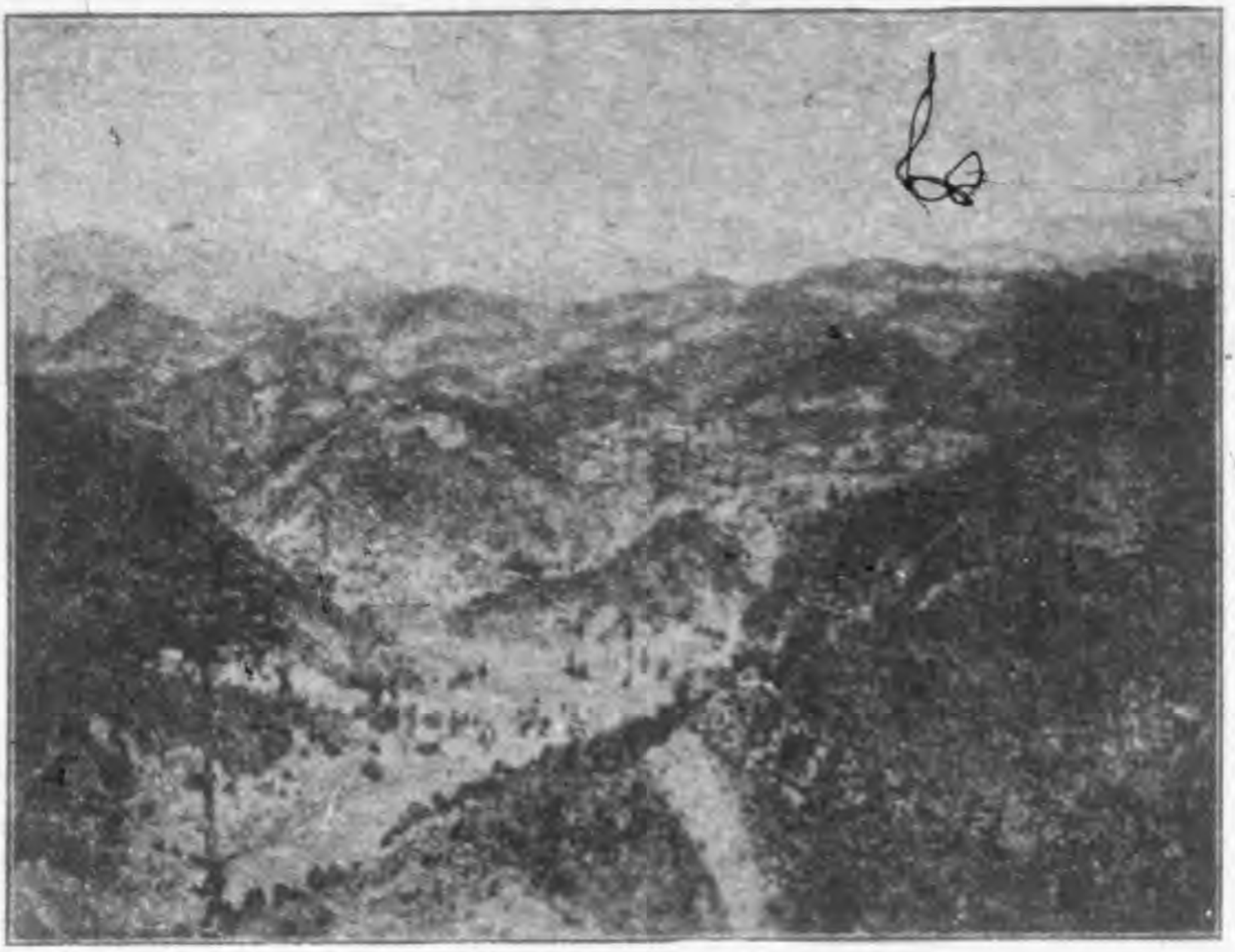
EXPLANATION OF PLATE V

Fig. 1. A close view of the topography in the basin of the Shanyuan stage. Rolling hills with rounded top and gentle slope frequently intervened here & there by flat valleys & basins at different elevations are the characteristic features of this stage. Two intermontane valleys or basins are shown here; one in the foreground 600 m. high & the other 1000 m. high near the upper middle part of this picture. Looking S. W. from the north of Ki Sin Chang (檵心場) in Sze Nan district. (Photo by Hsieh & Liu).

第一圖. 山原期盆地內部地形之近景. 圓頂緩坡高下起伏之小山, 間以平谷或盆地者, 即爲山原盆地內部最普通之形狀. 圖中有山谷二, 一現於圖之前部. 高出海面約六百公尺. 其一現於圖之中部, 高約一千公尺. 視線從施南縣檵心場西南向. (謝劉攝)

Fig. 2. A view showing the contrast between the gorge stage & Shanyuan stage, the former is illustrated by a deep canyon & the latter, by the rolling and rounded hills shown on the top of this picture. All the rocks here are Tayeh limestone with a dip varying from 20-50 degrees. Among the rolling hills there can be seen clearly from the picture a plain having an elevation of about 600 m. This plain indicates the remnant of a former local erosional plain and forms therefore one of the sub-stages in the Shanyuan epoch. As the canyon here is cutting into the Shanyuan surface the development of the former apparently marks one of the recent physiographic events of the region. Looking S. E. from Pei Lin Tou (白嶺頭) north of Sze Nan. (Photo by Hsieh & Liu).

第二圖. 此圖表明峽谷期與山原期之不同. 前者即圖中之深谷, 後者即爲圓形小山所在之地. 山中有一平原, 高六百公尺, 即侵蝕平谷之殘跡, 爲山原紀中之分期. 深谷之侵蝕, 已及於山原期之地面, 可知深谷之生成, 爲地文史中最近之一幕無疑. 視線從施南白馬嶺東南向. (謝劉攝)



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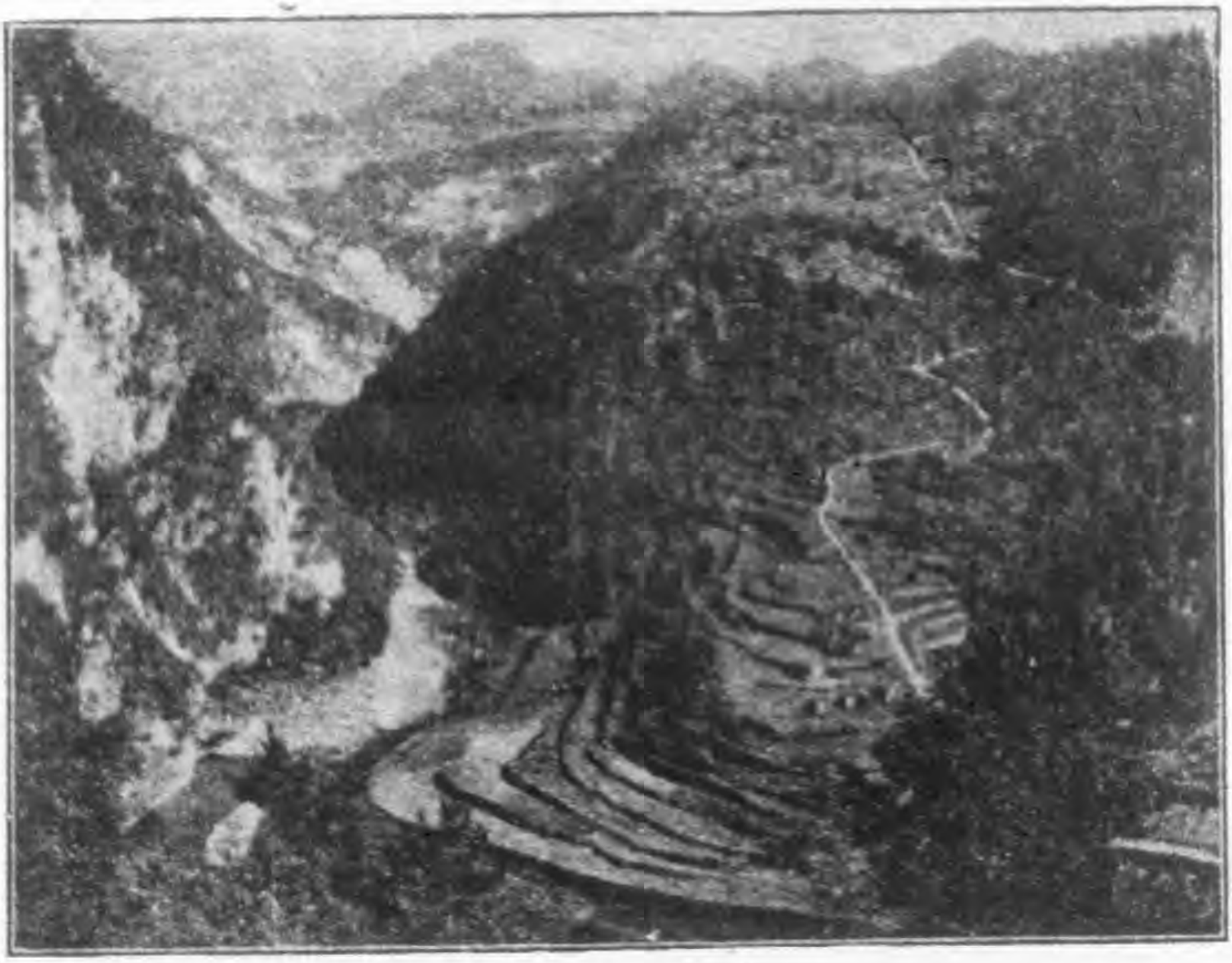

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EXPLANATION OF PLATE VI.

Fig. 1. Gorge of Tsing Chiang or Chang Tang Ho at a little distance east of Tzu Chiu (資邱) in Chang Yang district (長陽). The high picturesque mountain in the background is formed principally of Tayeh limestone. Looking East. (Photo by Hsieh & Liu).

第一圖. 長陽縣資邱稍東之清江風景. 背景中高山, 為大冶石灰岩所成. 視線向東(謝劉攝)

Fig. 2. A view of interlocking mountain spurs and narrow valleys, the typical topography of youthful dissection of the highest water-shed between the south of Yangtse and the Hui-Chow basin. The valley at the middle of this picture leads to the village of Shang Jo Keng (上箬坑) from Chu Ken Ling (筆根嶺). Looking S. (Photo by L. F. Yih).

第二圖. 表示山嘴交錯與其間之狹谷. 由長江南部入徽州盆地. 有橫亙東西之分水嶺. 其少年期之侵蝕狀態. 卽如此圖. 圖中狹谷. 係由筆根嶺流向上箬坑. 視線南向(葉良輔攝).

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2.

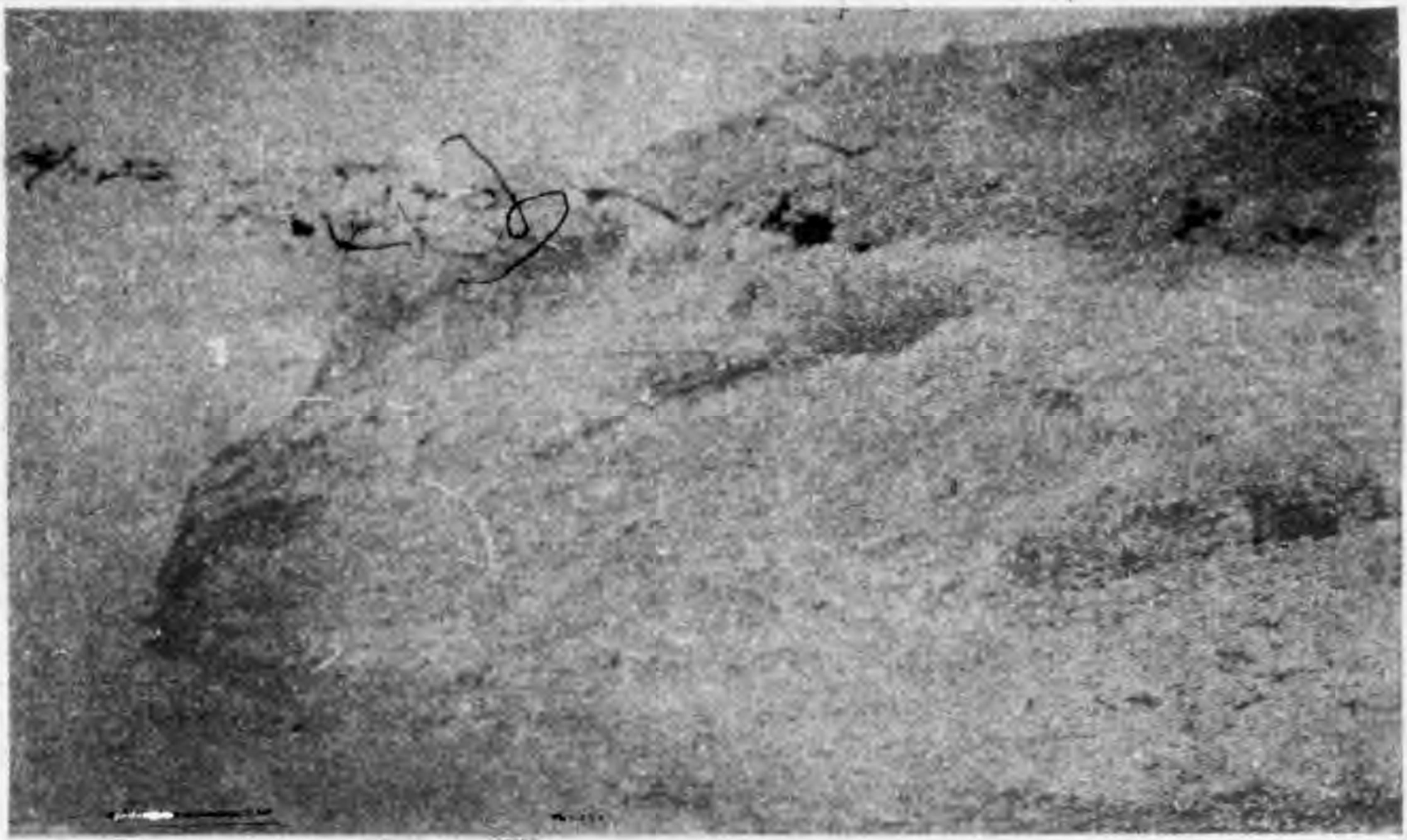
EXPLANATION OF PLATE VII.

Fig. 1. Gravel, sand & clay deposits at Yang Shan Chi (羊山磯), 2 li east of Tatung (大通), Anhui. Gravels not well sorted. Inclination of the gravel beds may be initial. (Photo by L. F. Yih).

第一圖. 大通東二里許. 羊山磯之紅土砂子礫石層. 紅土中之礫石. 雜亂無序. 可知沉澱時未經分類者. 其大致傾斜或即沉澱時之原生斜度(葉良輔攝).

Fig. 2. Showing the youthful dissection of the red clay deposits S. W. of Hung Kan Hsu (洪岡墟), Ni Feng Hsien, (宜豐縣) Kiangsi. (Photo by C. C. Wang)

第二圖、 江西宜豐縣洪岡墟紅土層之幼年期侵蝕狀態(王竹泉攝).



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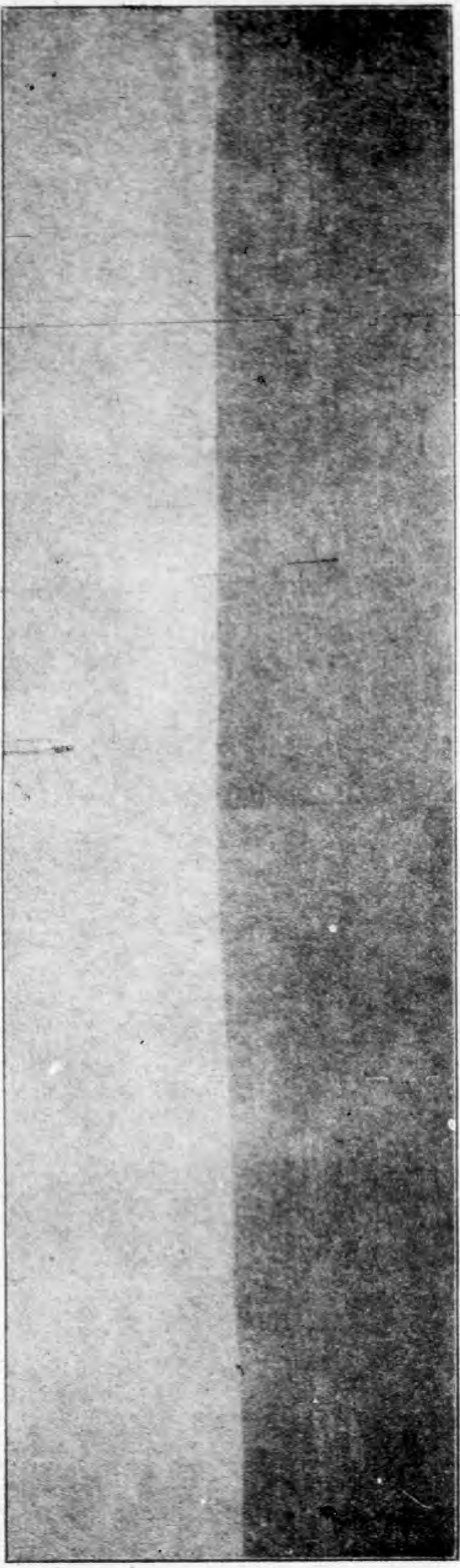
EXPLANATION OF

PLATE VIII.

A distant panoramic view showing the youthful dissection of the red clay deposits in the border region between Chin Hsien & Hsuan Cheng (涇縣,宣城). In the background & the near foreground are red clay hills or terraces. In the middle is an alluvial valley. The deposits lie upon the maturely dissected landsurface of the Shanyuan stage. Looking w. (Photo by L. F. Yih).

涇縣宣城交境間紅土崗阜之遠景。中隔沖積層之寬谷。就全體論。該層尚在幼年侵蝕期．其地床．適當于山原期中年侵蝕之地面．觀線西向(葉良輔攝)．

Plate VIII.



URMIATHERIUM INTERMEDIUM. (SCHLOSSER)

BY

A. B. BOHLIN

Syn. *Pseudobos intermedius* SCHLOSSER[1]
Chilinotherium tingi WIMAN[2]

In 1922 a curious animal from the Chinese *Hipparion*-fauna was mentioned[2] under the name *Chilinotherium tingi*. This animal has now been recognized as a cavicorne very closely related to *Urmiatherium polaki* RODLER from Maragha[3] and identical with *Pseudobos intermedius*[1] from China.

The remains consist of a great number of more or less complete skulls, some of them with the lower jaw adhering, a fragment of about the same extension as the Maraghian fossil, several fragments of upper and lower jaws with teeth and finally a perfect atlas.[4]

The most striking feature of the skull is the large common horn-base, which extends from the posterior ends of the nasal bones almost to the upper edge of the supraoccipital. The parietal bone is perhaps reduced to a narrow strip as in the case of the cow (Fig. 1).

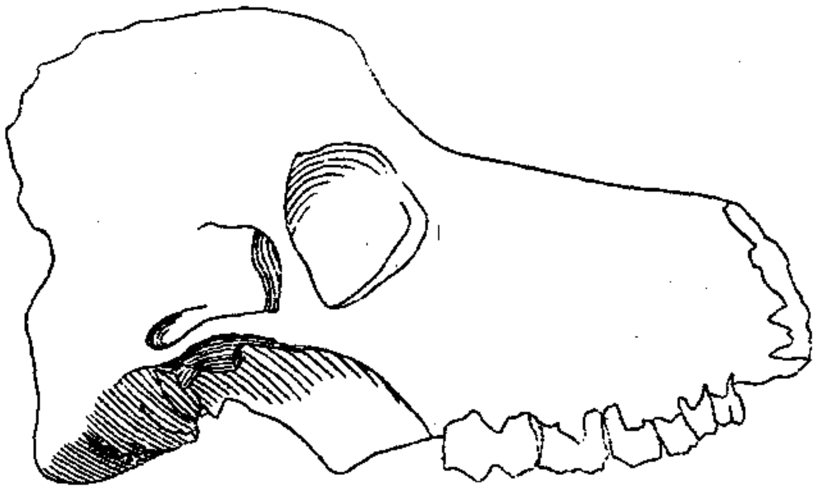


Fig. 1. *Urmiatherium intermedium* Lateral view of female (?) cranium, ⅕ nat. size.

1) SCHLOSSER, Die fossilen Säugethiere Chinas. Abh. d. K. bayer. Akad. d. Wiss. II. Cl. XXII. Bd I. Abth. München 1903.
2) G. ANDERSSON m. fl., Insamlandet av ostasiatiska fossila däggdjur. Prof. J. G. ANDERSSONS vetensk. arb. i China. Ymer H. 2, 1922. Stockholm 1922.
3) RODLER, *Urmiath. polaki*, Denkschr. d. Kais. Akad. d. Wiss. Mat.— nat. Cl. Bd. LVI, Wien 1889.
4) Lately skeleton bones, which probably belong to this species have also been found.

Such horn-bases do not elsewhere occur among the cavicornes of this period, and this explains why this species, as well as *Urmiatherium polaki*, has been grouped with the *Sivatheriinae*, the only group of Artiodactyls, where anything like this exists.

Further, the basis cranii shows a strange development. On some of the skulls, probably those of females and young animals, the basioccipital is of fairly ordinary shape (Fig. 2); on most of the skulls this bone is very thick with an inferior and a posterior surface forming an obtuse or even a right angle with one another. Probably the different development of the basis cranii has some relation to a different development of the horns in animals of different sex or age.

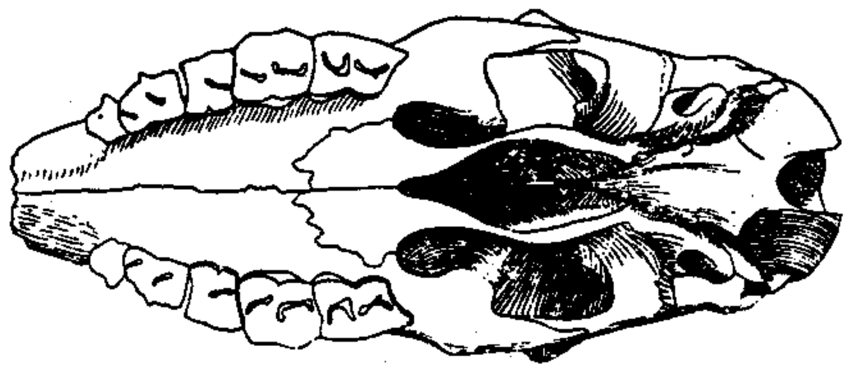


Fig. 2. *Urmiatherium intermedium* Palatal view of female (?) cranium, ⅕ nat. size.

The teeth are extraordinarily high as is shown by the following table:[1]

	P_2	P_3	P_4	M_1	M_2	M_3	P^2	P^3	P^4	M^1	M^2	M^3
length		11	17		28?	38	12	13	13	22	29	28 mm.
breadth		9	10		14?	15	10	12	15	21	25	29 mm.
height		12+	16+		41	41	16+	19+	19+	25+	36+	41 mm.

The lower teeth agree completely in shape and magnitude with those of *Pseudobos intermedius*. The unworn specimen, which I have seen,[2] of upper molars is quite different and surely does not belong to this species. It is much lower and the enamel surface has quite a different structure.

I have changed the name *Chilinotherium* to *Urmiatherium*, because the Chinese species is almost identical with *Urmiatherium polaki* from Maragha.

1) These measurements are not from the individual figured in fig. 1 and 2.
2) Professor SCHLOSSER of Munich has kindly sent me a collection of Chinese antelope teeth for comparison.

Only the size and some unessential details in the structure of the cranium are different; the massive horn-base, the development of the basioccipital, the form of the supraoccipital etc. are common to both species.

The teeth of *Urmiatherium polaki* are unknown, but probably some teeth described by WEITHOFER[1] as *Antilope n. g. maximus* belong to it. SCHLOSSER[2] put them in the genus *Pseudobos*. They are a great deal larger than the teeth of *Pseudobos intermedius*, which agrees with the fact that the skull from Maragha is larger than that from China.

The relation of the genus *Urmiatherium* to other genera is not yet quite clear. The skull shows a strong resemblance to *Criotherium argalioides* SCHLOSSER[3] from Samos but is not identical. The horns, for instance, are of different shape and their place on the skull is different. As the teeth of the two genera are very similar to one another, there is no doubt that they are related, but I think about in the same degree as *Bubalis* and *Connochaetes*

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1) RODLER U. WEITH., Die Wiederk. d. Fauna v. Maragha. Denkschr. d. kais. Akad. d. Wiss. Mat.—nat. Cl. Bd LVII, Wien 1890.
2) Fossile Säugethiere Chinas.
3) SCHLOSSER, Die fossilen Cavic. von Samos. Beitr. zu Pal. u. Geol. Österr.—Ung. u. d. Orients. Bd XVII, Wien 1905.