摘印地質彙報第七號

揚子江流域巫山以下之地質構造及地文史

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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瑋諸君、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。其餘諸省未蔵事者暫編簡報、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)民國六年卽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、或已刊印（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
上新統			紅土	紅土	宣南層 120	黃土？
不整合						玄武岩 120
中新統？	東湖系 1700	應城紅色石礫岩	紅色砂礫岩(鄖綠岩)	紅色砂礫岩	新山層夾鄖綠岩 300	雨花台層 140
不整合						赤山層 60
白堊紀	歸州系 3000+		斑岩 250 靈鄉砂礫岩 50			紅色砂礫岩 550
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	斑岩 120
三疊紀	巴東系 800					鐘山層 1800
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	石壁灰岩 400	揚子層 上石灰岩 120–250m
不連續	巫山石灰岩 1700 中部	北間頁岩 100	炭山灣煤系 100	老虎山煤系 180	宣渫煤系 100± 孤峯灰岩 0–100±	揚子層 煤系 50–80m
下石炭紀	巫山石灰岩 1700 下部	陽新石灰岩 100	陽新石灰岩 400	鑿山石灰岩 250	叶山冲灰岩 0–75	揚子層 下石灰岩 80–120m
不連續						
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	崖山砂岩層 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	大貶石灰岩	烏石門石灰岩 450	陳家岑灰岩 2200+	嵓山層
寒武紀	石牌頁岩 200	金家店頁岩 ？				

震旦紀	燈影石灰岩 520 陡山沱頁岩灰岩 800 198				
不整合	南沱冰磧層 83				
古界	蜡嶺片岩				
元古界	黃人沱片麻岩	千枚岩系(侵入體) 片麻岩 (花崗岩)			
太古界	黃陵花崗岩				
	宜昌巳東間 (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)	上雄山層 1700
				安徽南部 (葉良輔李捷王竹泉)	大拱嶺層 5000+
				江蘇南部 (劉季辰趙汝鈞)	駱山片岩片麻岩
				淮陽山片麻岩	

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。且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、一屬石炭紀灰岩之底部亦時產烟煤、成晶片形、而爲湖北東南與西南部之重要產煤地層。煤系之較新者純屬二疊紀、西向宜昌、遂漸以薄削。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　湖北興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)兩區之間爲合肥平原、其地祇有第三紀紅砂岩層之小山、故關係不明。(3)(4)兩區之間爲洪澤湖流域。就構造大致而言、最後三區其初似連續不斷者。

岩石爲片麻岩片岩與千枚岩、間有石英岩夾入其中。片理方向及層向爲北偏東、與南偏西。至漢水以東、蘄水安陸之間、則改爲西北與東南。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、允以褶曲爲最要。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。來鳳咸豐恩始一帶、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清江沿岸、褶軸方向爲東偏南與西偏北。

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、然褶軸方向大致尚明瞭。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、不獨山脉之趨向爲然、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)桐柏淮陽山脉之褶曲、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。

桐柏淮陽山脈、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、太古界區域與和縣含山巢縣等之平行山脊與二疊紀區域之間、有地爲紅土層、寬約三十華里。至滁州西南、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、均可列入褶曲山脉一類。即桐柏淮陽山脉之大折曲、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

湖北西南之褶曲山脉、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、尙未見似平面之遺跡、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。鶴峯縣東南之太平鎭、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、特由郎溪赴江蘇高淳之東壩、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。蕭君所得之壚土標本、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。玄武岩流入其中、其後一體下降、沉浸水中、而一部遂起水化之現象之分期而已。正當河積層堆積之秋、忽有玄武岩之噴發、不過山原紀中耳。

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、變遷尙頗自由、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尙有江水侵入、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蝕而成峽谷—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—後期		鄂西期之似平面成立
漸新統前期—始新統	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
志留奧陶紀	造陸運動	淺海
寒武紀	造陸運動	海
		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—宣南期 2 赭色岩沉積牀緣 3 赭色岩噴發 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 (發噴岩斑)	陸 (發噴岩斑)	長江順流河成立	桐柏淮陽山折曲成立
陸	陸	淺海—陸	陸
陸	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、尚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迥

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 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脈所致、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

謂海西甯期是也。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、而希馬拉亞期山脈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、實無所謂海西甯期之褶曲、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、與希馬拉亞山脈之最近構造史、未能直接比較、故將於長江接近之地、而於已較稱明確者、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、惟大都爲沖積土所埋沒、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）、江蘇浦鎭宿遷一帶與安徽合肥附近之浦口砂岩及雨花台層、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、有推移疊進之跡 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 及白浪氏 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普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, Jonr. 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'chenyi, 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. Journ., 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—六一二頁

註十三　參考中國百萬分之一地質圖南京衛輝幅(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册英文一二七—一三五頁間之插圖

註十五　仝上

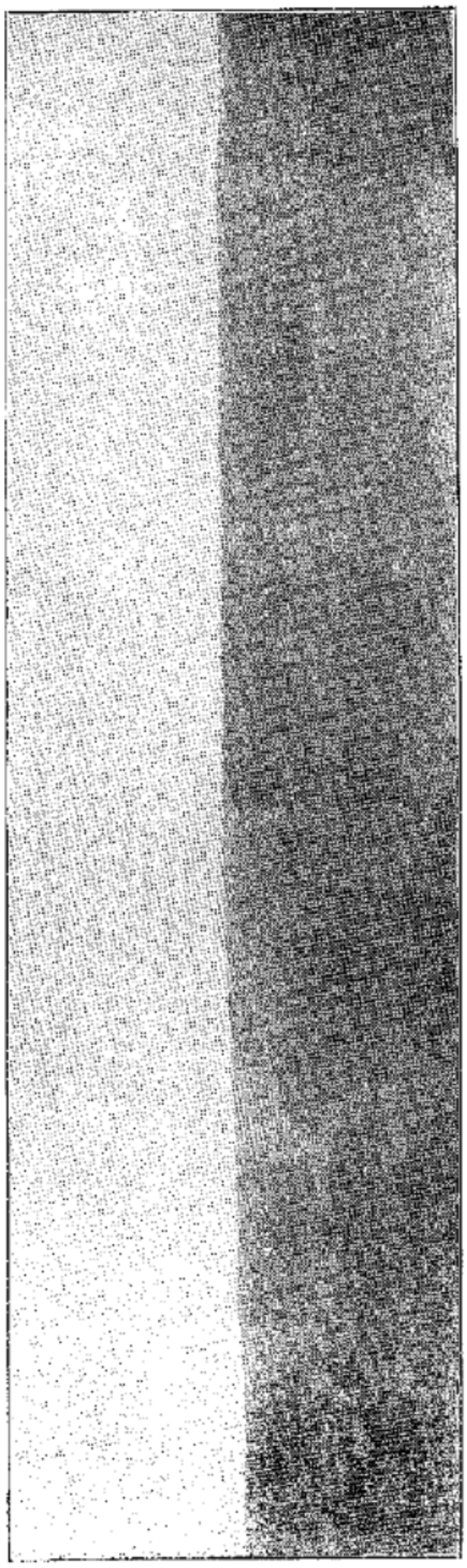
註十六　維理士　仝前著第二卷第九六—九八頁又 J. Deprat: Sur l'importance des mouvements epirogeniques recents dans l'Asie sudorientale. Comptes Rendus, t, 152, p 1527, 1911

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: Etude Géologi que du Yunnan oriental. Mem. du Serv. Geol. de l'Indochine, vol. 1. Fas. 1, pp. 350—

註十九　Records Geol. Suw. 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.



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. 中關冲積層之寬谷. 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. 視線西向(葉瓦輔攝).

EXPLANATION OF
PLATE VIII.

1.

2.

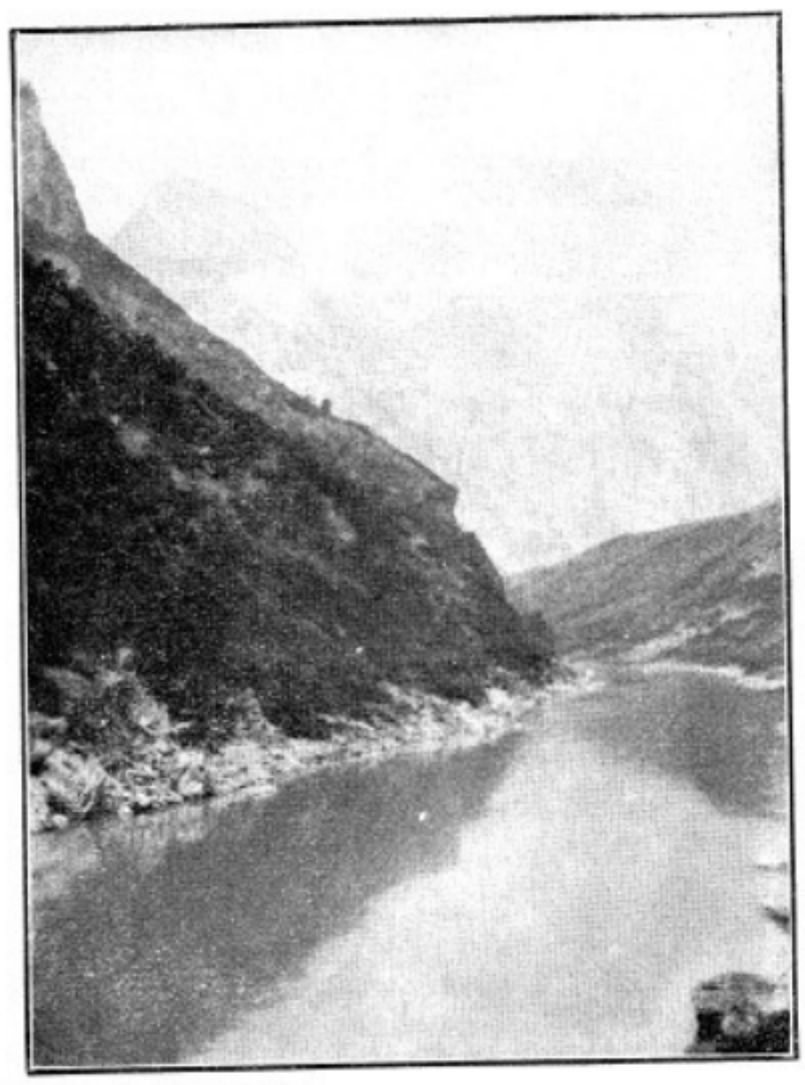
Fig. 1. Gravel, sand & clay deposits at Yang Shan Chi (羊山磯), 2 li east of Tatung (大通), Anhui. Gravels not well sorted. Inclination of the gravel beds may be initial. (Photo by L. F. Yih).

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. 其大致傾斜或卽沉澱時之原生斜度(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).

EXPLANATION OF
PLATE VII.



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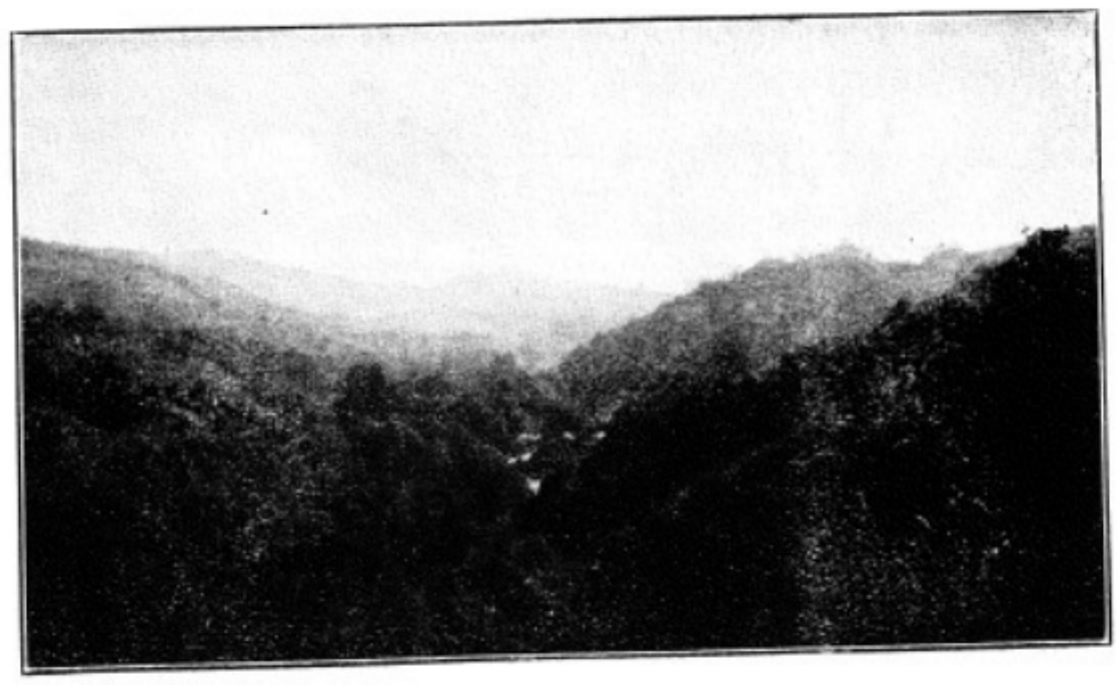


2.

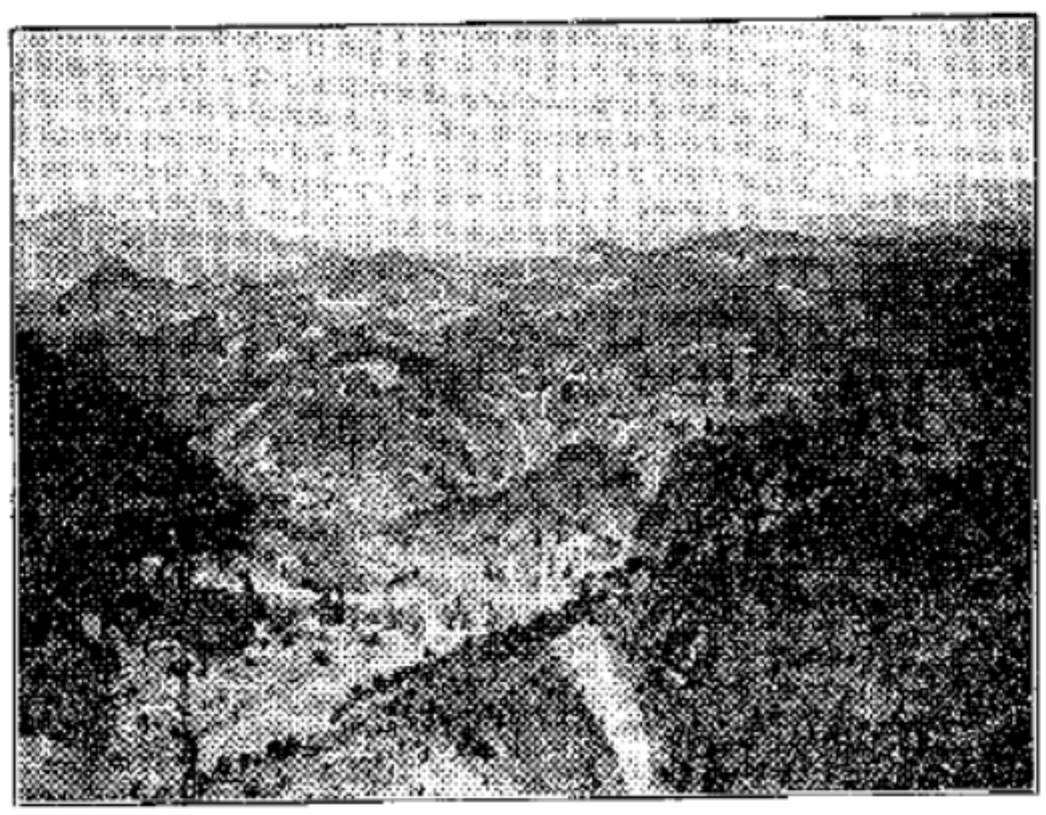
Fig. 1. Gorge of Tsing Chiang or Chang Tang Ho at a little distance east of Tzu Chiu (資邱) in Chang Yang district (長陽). The high picturesque mountain in the background is formed principally of Tayeh limestone. Looking East. (Photo by Hsieh & Liu).

第一圖. 長陽縣資邱稍東之清江風景. 背景中高山. 爲大冶石灰岩所成. 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 (舉根嶺). Looking S. (Photo by L. F. Yih).

第二圖. 表示山巒交錯與其間之狹谷. 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. 係由舉根嶺流向上箬坑. 視線南向(葉良輔攝).

EXPLANATION OF
PLATE VI.



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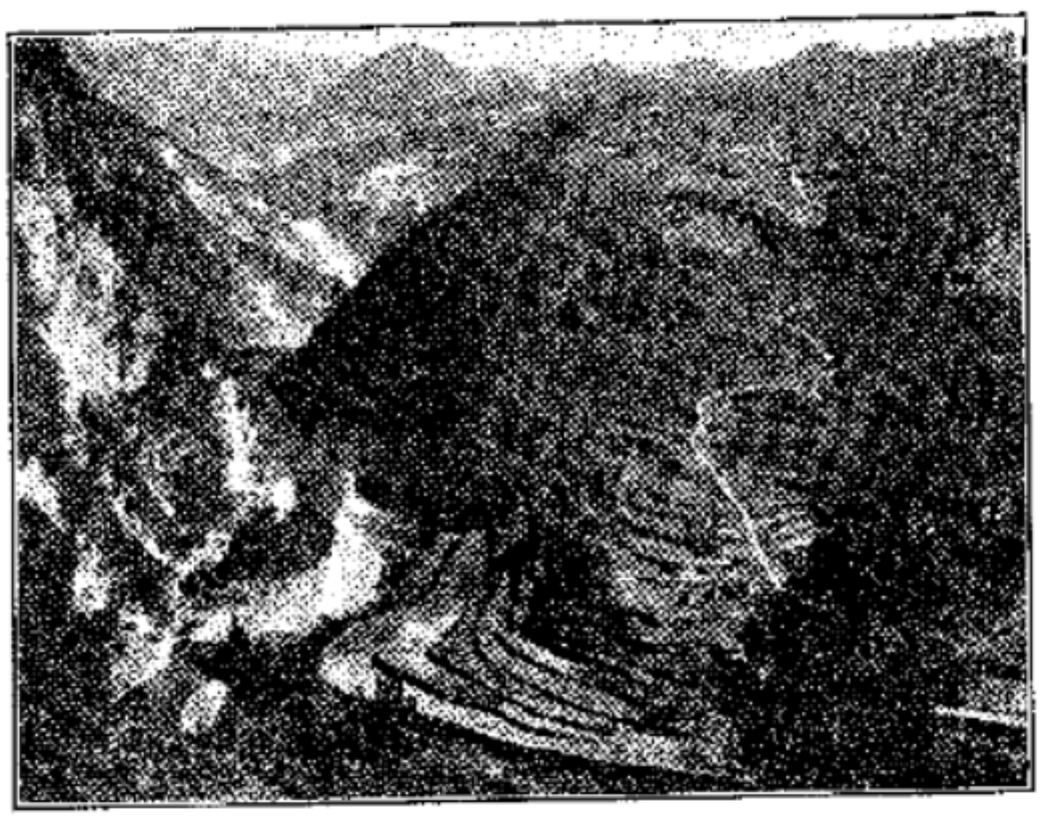


2.

EXPLANATION OF PLATE V.

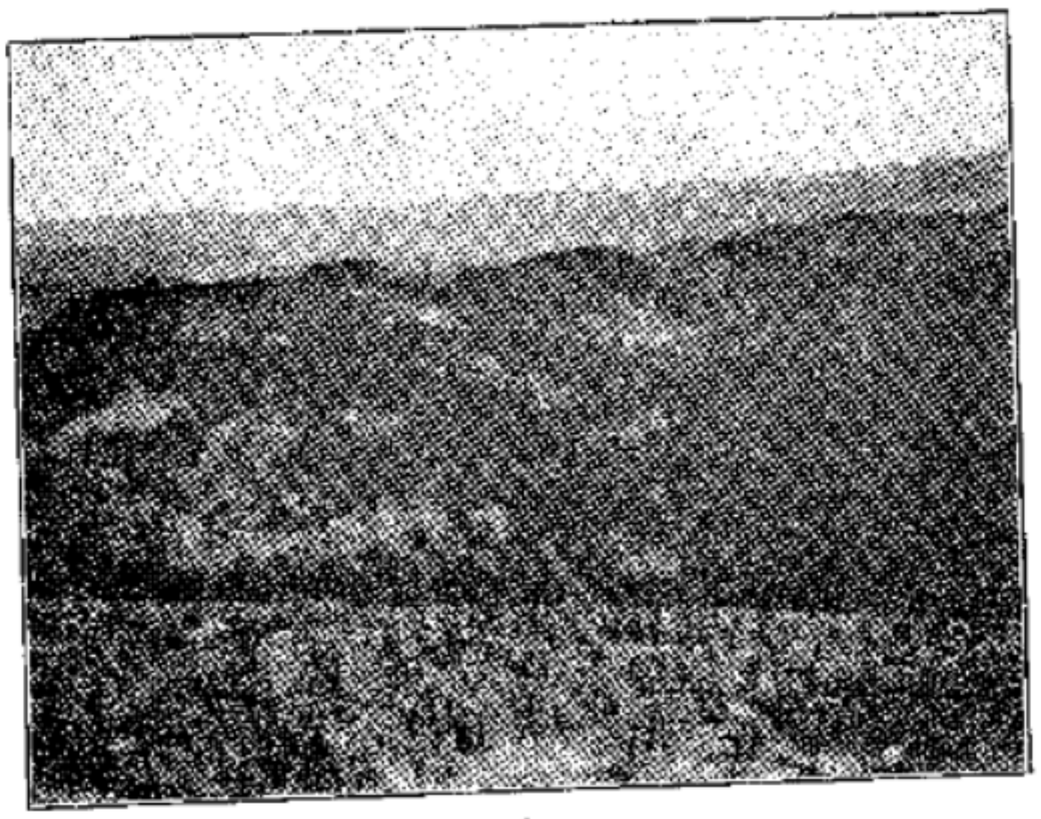
Fig. 1. A close view of the topography in the basin of the Shanyuan stage. Rolling hills with rounded top and gentle slope frequently intervened here & there by flat valleys & basins at different elevations are the characteristic features of this stage. Two intermontane valleys or basins are shown here; 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 (機心場) in Sze Nan district. (Photo by Hsieh & Liu).

第一圖. 山原期盆地內部地形之近景. 圖頂緩坡高下起伏之小山, 間以平谷或盆地者, 卽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. 視線從施南縣機心場西南向. (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. 前者卽圖中之深谷, 後者卽爲圓形小山所在之地. 山中有一平原, 高六百公尺, 卽侵蝕平谷之殘跡, 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)

EXPLANATION OF
PLATE V.



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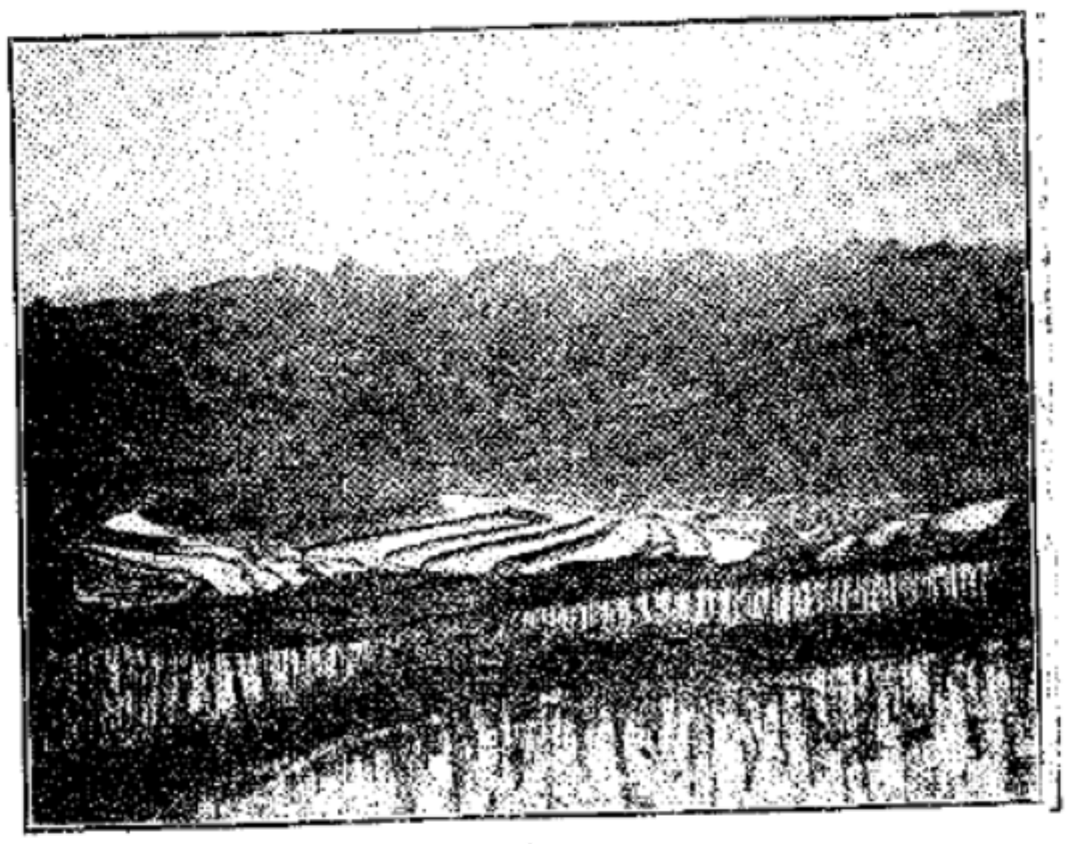

2.

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, 卽似平面之側面. 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. 卽山原期之地形. 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. 卽山原盆地之一. 視線東北向(謝劉攝).

EXPLANATION OF
PLATE III.

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, 卽褶曲之中心. 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. 足以表示昔日之侵平面無疑. 圖之右角. 卽四度河. 峽谷絕壁行者苦之. 視線東向 (謝劉攝).

EXPLANATION OF
PLATE II.

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'Indu 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.

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.

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

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1) op. cit. pp. 611-612.

"The folds of the Red Basin of Ssi-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.

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.

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 B. 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.

Geological period	Diastrophism	W. Hupeh	E. Hupeh, W. 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

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

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

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

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

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 (鑾岩山), 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

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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.

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.

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.

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.

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.

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.

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. 23.
2. Ibid. p. 242.

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.

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,恩始), 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 (䪥水) 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.

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, and4° 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 (靳水) and An Lo (安陸) on the east of Han Shui, they trend N.W. and S.E. In the vicinity of Ta i 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 Mesoz ic and Palæozoic strata. For this reason only the structural directions of the Mesozoic and Palæozoic formations are plotted on the map, while those of the younger rocks are excluded.

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 Shanchiaoshan (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.

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 disbase 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 } >1860 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 400 m 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 Archæan	Kunglin Schist Meijantou Gneiss Hwanglin Granite	Phyllite (with Gabbro Intrusion) Gneiss (and Granite)			Ch'uchow schists Huaiyang gneiss	Chilshan 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.

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.

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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 here 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 Government University made an excursion in the gorge district near I Chang and contributed a great deal to our knowledge of the geology of

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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

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From Bulletin No. 7, 1925, National Geological Survey of China

The Geologic Structure & Physiographic History of the Yangtze Valley below Wushan

By

L. F. Yih & C. Y. Hsieh

Geologists to The National Geological Survey of China

Peking