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江蘇東海縣朐山燐灰石礦

劉季辰

位置及交通　朐山位東海縣治之南。礦地緣山之南麓、距縣城東門約十三里、距西門約七里。出海要埠爲新浦鎭、礦地西端有潮河、水程十二里。均可行駛蓬船。新浦爲鹽河航線之終點、水盛時小輪直達清江、爲海屬交通之惟一孔道。自日人侵佔青島以來、載重百五十噸之外海輪船、亦有進臨洪口而於新浦下碇者。此項船隻專備運貨之用。雖亦兼載搭客、設備未周、時行時輟、非定期航路可比。故今之自燕魯來者、仍須繞道丹徒、經由清江、方可得達、他日徐海路成、交通庶益便利矣。

地質　朐山（高峯約在三百五十公尺左右）屬片麻岩系、中間略有薄層片岩、爲此部之最古地層。其上爲片岩系。二者層理一致。惟片岩底部、顯有礫石片岩 Conglomerato schist。（見於西礦東北小澗）扁豆狀之磁鐵礦塊、卽產此帶。則二者固不必整合矣。若以片麻岩系爲太古界、如泰山系、片岩系爲元古界、如五台系、殆無不可。惟所見範圍尙小、難下定論耳。片岩系岩層此處露出極少。距此五十餘里、濱海之雲台山及附近各島嶼、則盡屬此系。就露出之岩層計之、約厚五千公尺、猶未見其上下鄰接之岩層也。此系以雲母片岩爲主體、間有薄頁之綠泥片岩。上部有千枚岩一層、中含完整之磁鐵礦結晶甚夥。惟無大理片岩及石英岩。偉晶花崗岩脈或侵入岩等、亦均未見。

構造　朐山略似弯形層 Dome。除北部外、餘皆於片麻岩之邊緣、爲較新地層所包圍。出縣城西門、有白虎山、與劉頂後山同一層系、遙相連絡。城東之黃石岩山、在圖之東北、尙未入圖。距圖東側約三里許、緣山麓有薄層石英岩、傾向南五十度東、似與圖內乙姓屋北之石英層遙相銜接。是處地平面上雖不見片岩系、疑深處尙可

探見礦層也。緣朐山三麓、雖皆爲較新地層所包、惟西南麓地層傾斜向外、與東南者相反。是知朐山之構造、實一斷裂之穹形層也。斷線之位置、就大勢推測之、與圖中所表、相去不遠。其可證者、卽線東有礦層露頭連接東礦、不能跨越而過。線西「四十」山坡之片麻岩、片理東向傾斜。此部似已受斷層影響、當屬斷線左翼。比至「六十」山坡、則片麻岩中夾有薄層片岩、層理明晰、東傾之迹益著。故朐山西部之地層、全以斷層而倒置矣。

礦床　礦層居片岩系之最下部、直接片麻岩。以系統論、與片岩同屬一系。爲明瞭計、圖中另設色、以別片岩。此層在西部較窄、在東部較寬。東礦左近、厚達一百五十五公尺。下部石英薄層頗著。其上下岩層、均爲泉流浸潤、殘留粘土 Residual clay。錳鐵鑛床卽產粘土層中。西礦以鐵爲多。礦床大體作塊狀及扁豆狀、厚度不等、豐瘠隨地異。然皆體積有限、無開採之價值。東礦以錳爲主。礦床作層形、有成塊者、有成泥土者。厚度平均約半公尺許。此層之上、在西礦皆爲黃黑紅色之粘土層、不甚厚。其上卽係燐礦層。此層可採者厚約十八公尺。礦物盡係燐灰石、作細粒結晶、色黃白褐紅皆有。黃色者層較堅、餘則手捻之卽碎散。撒於火上、星星放燐光。在室內暗隙試之、雖白晝亦可見。此礦係屬交換礦床、原岩爲石灰岩。所採標本中、燐灰石薄層、有與未經交換之石灰岩殘片相間成層者、亦有灰岩殘塊包裹於燐礦中者。空隙中且多方解石結晶、則其中富有炭酸鈣可知。燐灰石爲高溫度礦物之一。當交換之時、必在地下深處、礦液溫度甚高。與之共生者、有白雲母小結晶。此亦其一證也。因此礦爲交換礦床、故礦質貧富、視交換程度之完全與否而定。全系雖厚、未可盡量採取、職是故耳。礦石佳者、燐酸 P_2O_5 成分在百分之四十以上、堪與坎那大之最佳礦石相媲美。聞現時出貨之成分、買主規定爲百分之三十三云。現時開採之部、漸近地平。礦線往西北地勢漸高、礦層漸薄、比至劉頂莊東、似無重要價值。更上礦層更

帶、礦質垂盡。燐層之上、爲雲母片岩、大理片岩、更上即屬片岩系。此西鑛之大略情形也。東鑛錳層之上、地面並無露頭。以意度之、不外粘土與片岩、相距較遠、方及燐層。故此處之礦層較厚於西部。此燐層厚約四公尺、質殊駁雜。中間薄層粘土甚多。更上爲片岩、略間錳土。次爲薄層燐礦、厚一公尺半、礦質甚佳。其上有錳礦一薄層、更上又係燐礦層、總厚約十五公尺。中含雜質甚多、層次亦不盡平勻。中間未盡交換之石灰岩一層、殆卽與西礦之大理片岩相連續者歟。凡此皆就已開掘之部而言。地質圖中、此部礦層西止於地平、東止於礦界。係以開掘露頭爲根據、非謂礦層僅限此一小段也。現東西二鑛各掘直井一口。東井深八丈餘、西井深十丈餘、期得較純潔之鑛層。已出之鑛石、皆由地面採掘而得云。

鑛業　上述東西二鑛、皆屬錦屏公司。該公司初採鐵鑛、繼改燐鑛。據述自去歲春季迄今（九辛秋、）共採六千噸。售出二千噸、積存四千噸、每噸售價日金三十九元云。錳鑛採出者、悉堆儲鑛地。據工業試驗所分析、計含錳二二・三四％、鐵五・三一％、矽酸二一・五七％云。鑛區內築有小鐵道、經東西二鑛、直達河口。

燐灰石鑛附說

東海燐灰石鑛爲我國惟一產地。其地質鑛床情形、前已述之。但燐灰石我國尚不多覯、昔亦鮮有注意者。爰將此鑛之性質鑛床成因用途四者略說梗概、藉備參考。

性質及鑛床　燐灰石西名 Apatite、主要成分爲燐酸石灰。惟亦兼含弗及綠素、故有弗燐灰石與綠燐灰石之分。代表此鑛物之化學式爲 $Ca_5(Cl.F)(PO_4)_3$。結晶屬六方晶系。每作整齊六角柱形。間聚顆粒狀結晶爲巨塊。色青藍黃紅玫瑰、或無色。硬度自四・五至五。比重三・二三。光澤如玻璃。常發見於各時期各種類之噴出

岩中。在酸性岩中者、作針狀長柱形。在基性而富鈉素之岩石、則結晶較大、形短而厚。其爲造岩鑛物之一成分者、類皆結晶微小、尋常目力、每難辨別。亦有于水成及變質岩中、作脉狀或片狀之鑛床。又時與磁鐵鑛共生。若鑛床成脉形或袋形、則最有開採價值。如坎那大腦威與我國之東海等處皆是也。坎那大爲燐灰石鑛最多之處。鑛質亦最佳、內含燐酸成分有逾百分之四十者。玆將該處阿崙達耳所產鑛石之成分、表列如左、以資參考。

成分	百分數
燐酸 (P_2O_5) §	42.229
弗	3.415
綠	0.512
石灰 (CaO)	49. 96
鈣	3.884
	100.000

§係由92.189%之第三燐酸鈣 $Ca_3(PO_4)_2$ 提出者

燐鹽鑛 Phosphorite 爲與燐灰石成分相類之鑛物。此鑛形態悉作凝塊及乳頭狀。Kirwan 氏始以名西班牙所產燐鹽石 Phosphate Rock 之成脉狀與袋狀者。今則與燐鹽石相提並論焉。

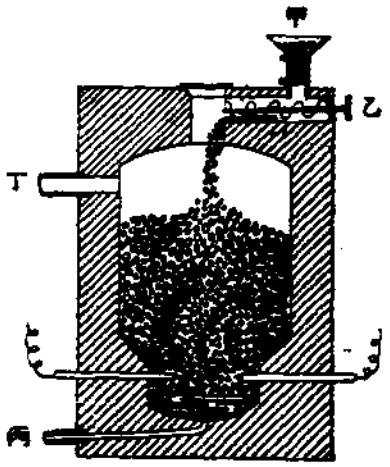
成因　各類燐鹽鑛床之生成狀態、各不相同、則其成因自難一律。昔人每謂燐質原于生物、今無或信之者。蓋燐不必出于生物、而燐灰石之化合、亦無待生物之作用也。噴出岩中每多燐灰石者、益知其成因與生物無關係矣。坎那大所產成片狀或凝塊狀之鑛石、其與圍岩接觸處、無迹可辨。有以此爲係由溶液沈澱者、溶液分泌圍岩中原有燐酸、同時復經變質結晶、乃成此鑛。爰而司氏則謂此鑛與噴出岩並生、當由接觸帶噴出之氣體

燐酸、與片麻岩中因熱融化之鈣質物體、化合而成。紐約有與鐵鑛層共生之燐灰石鑛、初以成因歸諸有機體與水成作用、今則共認爲火成成因矣。瑞威之鑛與輝長岩 Gabbro 共生、亦係噴出作用。我國東海之燐灰石鑛、就地質現象觀之、當爲交換鑛床、又與火成作用漠不相關也。故礦床成因、有未可一概論者、但視其生成狀態如何耳。

用途　以製肥料爲大宗。提燐之原料、昔每取之于骨灰。近時電爐盛行、始有從燐鹽鑛提取者。法以鑛燐和石英砂與炭、入電爐冶之、所起化學反應、計分二式如下。

$$Ca_3(PO_4)_2 + 3SiO_2 = 3CaSiO_3 + P_2O_5 \qquad P_2O_5 + 10C = 10CO + P_4$$

電爐構造、略如左圖。甲盛鑛物、經螺旋槽乙送入爐腹。燃燒後燐分氣化、自丁外洩。以水冷却之。矽酸鈣則成液而自丙外瀉。用此法提取之燐、性質駁雜、更須用蒸溜法以純淨之。



提燐電爐之構造略圖

用于農田之肥料有二類、即骨燐鹽 Bone phosphates 與鑛燐鹽 Mineralp hosphates。後者又分二種、一燐灰石、一燐鹽石。此類鑛物之成分、有天然之三基燐酸石灰、或通稱第三燐酸鈣。化學式爲 $Ca_3(PO_4)_2$、等于四五・八一分之燐酸 P_2O_5 與五四・一九分之石灰 CaO。若將此鑛研成細末、卽可作肥料。但須先經化學的調製、使易溶解、方可利用。調製之法、卽用硫酸使成過燐酸鹽、所起反應如下。

$$Ca_3(PO_4)_2 + 2H_2SO_4 = CaH_4(PO_4)_2 + 2CaSO_4$$

$$Ca_3(PO_4)_2 + H_2SO_4 = Ca_2H_2(PO_4)_2 + CaSO_4$$

設所入第三燐酸鈣之量過于硫酸、則必有一部不起反應。鐵鋁等硫酸鹽之混合物也。

燐灰石較之燐鹽石開採較費、又不易研末、故難與競爭。故所成之過燐酸鹽、卽第一第二第三燐酸鈣與鈣

售價、每一短噸平均約値美國金幣九元左右云。

山西太原附近地層詳考

那林原著
王竹泉節譯

下古生代及上中生代之岩層。在太原附近露布甚廣。茲暫分爲三系如左、

一、月門溝煤系　是系之岩層、爲黑色灰質頁岩煤層石英砂岩及石灰岩等、共厚約二百公尺。其露頭在太原西山之組織、與東山稍異、可以該系在東西山含動物化石之灰岩層列表比較之。

	西山		東山	
E	大窯石灰岩		不奈毛廟兒溝口吟溝石灰岩(4-1)	
D	整道溝石灰岩			
C				
B	一整石灰岩		不整溝石灰岩	V
A	岩灰石灰岩		關底溝石灰岩	IV
	岩灰石灰岩		關門溝石灰岩	III
	岩灰石灰岩		南窯溝石灰岩	II
	岩灰石灰岩		潤道溝石灰岩	I

關底溝石灰岩僅發見于東山。在關門澗剖面（Fig.5）內。其下尚有含動物化石之岩層四（I—IV）。而第四層似與西山之佘道石灰岩相當或尚稍新。據葛利普博士鑒定化石之結果、謂關門澗剖面內含動物化石之第三層（No.III.）與西山之峙溝石灰岩相當、第四層（No.IV.）相當于佘道石灰岩、其他皆爲東西山各自特有之動物化石層。葛氏又謂西山A－D各灰岩層屬于下石炭紀頂部、或中石炭紀底部、略相當于歐洲維新層（Viseen）與莫斯科層（Moscovian）之過渡。其特產化石爲（Spirifer bisulcatus）、可別名爲太原系。而東大窯石灰岩（E）爲上石炭紀之下部、即相當莫斯科層之下部。大抵無（Spirifer bisulcatus）之化石、可列入威烈士氏之山西系。

煤層　月門溝系在調查區內、含有可開採之煤、計達十二層。最厚者約居該系之上部。屬上石炭紀。煤層露出之厚度、恒自一公尺至二公尺、但在礦窰內則每至五六公尺。上石炭紀所產者多屬烟煤。而下石炭紀除少許烟煤外、所產皆爲無烟煤。最著之無烟煤層爲 IIIV V 等。又由月門溝剖面 Pl.2. 知含動物化石灰岩恒直接覆于煤層之上、其間僅隔以含植物遺跡之黑色頁岩。在下石炭紀之十二煤層中、約九層其頂爲石灰岩、三層位于石英砂岩下。而煤層與含動物化石岩層之密接、可表明煤質沈積時之湖沼與海相近。

二、石盒子系　是系由黃綠色泥石砂質頁岩、及石英砂岩等、相互成層、無動物化石及煤層。其上部以黑紫色土質岩層爲主。全系厚度約二百公尺、至二百五十公尺、可分爲上下石盒子系。下石盒子系屬下二疊紀（Rothliegende）、上石盒子系屬上二疊紀。試各論之。

（A）下石盒子系　此組爲綠色或黃色粘土質岩層、與砂岩相間。各岩質粗細極不一致。砂岩中粒、爲石英及長石。恒富含黑色鑛物。或含有高嶺土狀物質。常現斜層狀。又礫岩甚多、其礫石屬太古岩石。而頁岩及泥石內、每含植物化石。其中較古之部分、似與德國之路斯里層（Rothliegende）相當、因有 Callipteris, Taeniopteris 等化石也。

（B）上石盒子系　此組內最特異之岩層、爲黑紫色泥石及泥灰石等。如石盒子剖面 Pl.II, fig.2 所示。黑紫色泥石等、初于該組下部、發見少許、稍上則其層數厚度、愈增加。至該組之頂部、則易爲厚約八十公尺之一種岩層、係銘黃色軟砂岩、及黃綠色粘土質岩石、與薄帶狀之黑紫色泥質岩石相間。是種岩層內之特產化石、爲大羽植物（Gigantopteris）因名爲大羽層。

三、石千峯系　是系岩層之組織、爲紅色與黑紫色砂質泥灰石及泥石等、與白色或紅色石英砂岩相間。其上部則砂岩特著。全系厚度在調查區內、爲五百公尺。其時代大抵屬上二疊紀及下三疊紀、可分下列之三層。

（A）銀杏樹（Ginkgo）層　此層爲石千峯系之底部。其岩層爲黑紫色砂岩頁岩及泥石等、與白色或黃色砂岩、及含化石之黃綠色泥石頁岩等相間。無黑紫色砂岩。其岩層組織、頗與大羽層相似、惟紅色較著耳。該層內之特產化石、爲銀杏樹類、而大羽植物則未之見。

（B）含石膏質之泥灰石層　此層內之岩石、色澤特深、大部爲黑紫色及棕色泥灰質頁岩與泥石、含石膏之紅棕色泥灰石、黑紫色石英砂岩、及灰紅色細粒砂岩等。無含化石之粘土。其下與銀杏樹層相接觸者、爲紅棕色砂質泥石。厚由二公尺至五公尺、內含凸鏡形及薄層狀之玉髓。

（C）砂岩層　此層之組織、大部分爲斜層狀細粒砂岩、間以紅棕色薄層粘土。粘土層面、恒現波紋形。無石膏及含化石層。

山東淄川博山煤田地質

譚錫疇

歐戰告終、和議將成、山東寶藏、至是大有歸趙之望。爰于八年春、奉部派與安特生顧問、同赴山東淄川、博山、濰縣、章邱、金嶺鎮、詳細攷察該處地質鑛產、及鑛業情形。隨及歷城、章邱、兩縣鐵鑛。是役也、先與安君偕往金嶺鎮、淄川、博山、濰縣、爲初步之視察。嗣後分頭進行、作詳細之測勘。安君攷察金嶺鎮鐵鑛、及章邱煤田。疇則詳測淄博煤田、及歷章兩縣鐵鑛。除金嶺鎮鐵鑛及章邱煤田、安君另有報告外、茲先將淄博地質鑛產、分別叙述如次。

第一章　地形

第一節　山嶺

淄博煤田、三面環山、北方陡落爲平原。中有縱嶺一道、中部稱鳳凰山、劃分煤田爲二區。縱嶺以西、爲淄博本部煤田。縱嶺以東、爲西河黑山煤田。中復爲山嶺分隔、有所謂黑山前、黑山後、西河、等煤田。淄博本部煤田中、又有東西縱嶺二道。若斷若續、平行並列。其東縱嶺北部、以鑿山爲主峯。由此北延、爲盤龍山、爲唐山、狼屠殿山。南部以大奎山爲主峯。由此南向、爲萬山、南盡于博山城之北。北向成一帶叢嶺、北盡于淄川城之南。西縱嶺北部、以煥山爲主峯。北向爲星山、明山、再北爲荆山、南部以三台山爲主峯。南向爲崑崙山、蜿蜒而南盡于博山城之西北。西河、黑山、煤田中、以黑山爲主峯。山陽爲黑山前煤田、山陰爲黑山後煤田。其劃分西河煤田及黑山後煤田者、爲一帶小平嶺也。

煤田中顯著山峯、多爲煤系上部地層所組成。如鑿山、大奎山、萬山、黑山、等、悉以煤系上部爲組織中堅份子、而以石英砂岩冠其巔。其劃分兩部煤田之縱嶺、爲石灰岩組成。其突出爲三台山、煥山、崑崙山者、則後來侵入之

火成岩也。

第二節　河流

本區域河流、以孝婦河爲主幹。全部細流悉入之。源出博山之南、至博山附近而漸大。蜿蜒而北、河身狹闊不一。平時水淺不及尺、漲甚驟、旋即復原。細流紛繁、漫無統屬。約皆發源於附近之羣山、而滙歸於主幹也。

第三節　原野

原野分佈、多在本區域之北部。孝婦河兩岸、皆曠野沃土。鑿山四周、亦地廣田肥。其基底組織、爲第三紀之紅土、及我國北部習見之黃土。上覆膏壤、居民因以植田焉。

第二章　地質

淄博煤田地質、與山東西部諸處煤田地質、大致無殊。惟此間中生代地層內、常見有煤系中物。原山東中生代煤系、除雒縣坊子、確有化石可攷外、他處尙未實有所見。昔德人勞林芝嘗云山東中生代煤系、計有三處。一爲坊子、一爲新泰。一爲普集。但按兩處未得証據、不能認爲事實。今在淄川西北望娘溝地方、中生代地層內、見有舊窰廢跡。其堆積之渣滓、爲一種黑色頁岩。極似煤系中物。且時露植物化石痕跡。又村南亦有廢窰、有人在附近鑽探。就地層露頭觀察、有與坊子煤田地層中白色砂岩相類者。其爲中生代煤系也、或不致全誤。惟是否有煤、並其煤可否採掘、尙難窺悉。當據鑽探之結果、而知其究竟也。本區域火成岩、分佈頗廣。悉在淄博本部煤田內。在西部者、多露出地面、而成山嶺。在東部者、多侵入層隙、而爲岩層。其淄博本部煤田內、鮮有煉焦煤層者、火成岩炮烙所致也。茲將地質情形、分節敘述如下。

淄博地層、秩然有序。自奧陶紀灰岩、以至中生代紅綠砂岩系、與山東他處煤田地層、均相符合。惟本區域古生代煤系、發育特著、尤以上部煤系爲最。且中生代煤系。地層瞭然有跡可尋、斯與他處異焉者也。

(一)奧陶紀灰岩層　此次考察淄博地質、專注重煤田。故於煤系下之灰岩層、未能窺見全豹。惟因尋煉鐵之灰岩、察見其上部最純之部份、約有七八米突。但與不純灰岩相間而生、採取頗形不便、似無利用之價值。

(二)古生代煤系　此系地層、威利斯名之爲博山系。梭爾格曾詳細研究、分全系爲四層、各與以專名。今按岩石之性質、產煤之豐瘠、亦分上中下三部。就化石種屬攷察、下部及中部之下部、似屬於下石炭紀。中部之上部及其上部、大抵爲上石炭紀、或一部已爲二疊紀之產物。而中石炭紀、則悉付闕如。斯上下石炭紀中間、實有一大缺陷。惟上下地層、傾斜一致、層面整齊、不見不整合之觀。全系厚度、由二百數米突、至二百八十餘米突。在黌山詳測此系地層、總厚二百三十二米突有奇。在大奎山得二百八十四米突。在黑山得二百零三米突。因黌山、大奎山、有火成岩侵入層隙、故較厚。黑山則否、故較薄也。但地面測計地層厚度、與打鑽所得結果、常不相符。此次所得全系厚度、至多爲二百八十餘米突。其產煤部份、厚一百十餘米突。聞德人在大荒地打鑽、僅鑽其產煤之一部、已深至二百七十餘米突、(即今大荒地煤礦大井之深度)。附近地層傾斜角度、只十餘度。與眞正地層厚度、當無巨差。即就煤層而論、愈近地面、其層愈薄、漸深則煤層厚度漸增。此老於礦業者之論調也。故今所測全系地層之厚度、只就露出地層而言。至地層深處、厚度當然有差。非可一律推測之也。

古生代煤系下部　本部在黌山及大奎山一帶、總厚均約二十九米突。在黑山一帶、厚度頓減、僅十數米突。此

層分佈、在淄博本部煤田、悉沿東西二邊。東北由高莊一帶起、南向爲斷層分遮、至和莊之東南、西走、折而南、蜿蜒西南向、循灰岩山山麓、至博山城、折而西、遇斷層而止。在黑山煤田、沿煤田南緣、東起於岳家莊一帶、迤西、經灰岩山北麓、西抵斷層而盡。在西河煤田、沿煤田東南緣、蜿蜒西南向、至郭大碗村、爲斷層所阻。岩石以粘土、泥質頁岩、爲最多、而上覆以石灰岩、每含有薄煤層、不利採掘。今就甕山、大奎山。黑山、三處所見、詳記於次。

甕山一帶古生代煤系下部之觀察、自下而上述之。

一、棕紅色粘土、厚四米突半。

二、淺黃白色粘土、時帶赤色、厚二米突。

三、類似凝灰岩之重岩、及彩色粘土、厚十米突。

四、紅黃色粘土、厚半米突。

五、不純之石灰質岩石、厚半米突。

六、棕黃色粘土、厚半米突。

七、淺綠灰色粘土、與淺紅黃色砂岩、相間而生。上部含有黑色泥質頁岩、厚六米突

八、紡錘蟲石灰岩、厚四米突二。

大奎山一帶古生代煤系下部之觀察。

一、彩色（棕、紅、灰、黃）泥質頁岩、厚五米突。

二、黃色堅實粘土。帶有赤色、厚三米突。

三、彩色（紅、灰、黃）泥質頁岩、厚三米突。
四、黃色堅實粘土、帶有赤色、厚三米突。
五、紅棕色堅實粘土、厚二米突。
六。灰色淺黃砂岩、厚五米突。
七、淺黃色砂岩、厚三米突。
八、灰色粘土、厚一米突。
九、紡錘蟲石灰岩、厚四米突。

黑山一帶古生代煤系下部之觀察。

一、彩色（棕、灰、黃）泥質頁岩、厚四米突
二、黃灰色粘土、厚四米突。
三、紡錘蟲石灰岩。厚四米突。

古生代煤系中部　本部爲煤系之主部、重要煤層、悉產於斯。就外表觀察、其煤層數目、頗難確悉。據淄川煤鑛所得、已有十三層。按土人開採習見者、有上八層下八層之稱。淄川煤礦現採掘者、爲第四五八九十五層、第四層厚約營造尺二尺二寸、可煉焦。第五層約一尺。第八層約六尺八寸。第九層約三尺七寸（夾石七寸。）第十層約一尺九寸。淄博諸處煤礦開採者、計有八九層。最薄者約一尺許、最厚者有七尺二寸者。本部總厚、在鑿山一帶、地層較薄、尙不及八十米突。本部分佈極廣、延長約一百數米突。在大奎山一帶、約一百十數米突。在黑山一帶、

約八十里。北由高莊和莊起。西南向繞甕山四周、再南經兩大縱嶺之間、復西南、經大奎山、萬山、之東麓、至博山城、折而西、爲南北斷層隔絕。其在黑山煤田者、環繞黑山四周、東西長約二十二里、南北廣約十里。東起於岳家莊之東、西止於神頭村之西、南方地層浮露、繼乃自然垂盡、北面爲斷層所阻絕。在西河煤田、本層不甚發育、往往缺其上部、延長十數里。北自黃崖之北起、南至郭大碗之北終、東亦自然垂盡、西復隔絕於斷層。

本層岩石、以頁岩砂岩爲主。含重要煤層。夾有一層灰岩、厚一米突有半、分本層爲上下兩部。煤層在上部者、土人稱爲上八層。在下部者、爲下八層。灰岩層其顯著分界也。今就諸處所見本部地層、次第述之。

在甕山一帶古生代煤系中部地層之觀察。

一、黑色頁岩、其堅實部分、堪爲硯石、厚十二米突。

二、淺綠灰色硬砂岩、厚一米突二。

三、淺綠黑色薄層頁岩、與淺綠色砂岩相間而生、厚六米突有半、分本層爲上下兩部。煤層在上部者、土

四、輝綠岩層（威利斯稱玄武岩流、）厚一米突。

五、黑綠色薄層頁岩、厚三米突。

六、輝綠岩層。厚四米突。

七、淺綠黑色薄層頁岩、厚七米突。

八、彩色（灰、紅、紫、棕、淺黃）薄層疎鬆泥質砂岩、厚五米突半。

九、石灰岩、含腕足類化石、厚一米突半。

十、黑灰色薄層頁岩、與黃色砂岩相間而生、厚七米突。
十一、灰色薄層鬆質砂岩、與黃色堅質砂岩相間而生、厚
十二、黃色鬆質砂岩、下部夾有紫色泥質砂岩、厚二十一
十三、黃色砂岩、與含鐵硬砂岩相間而生、厚十四米突。
十四、黃色鬆砂岩、與淺綠黑紫色泥質頁岩相間而生、厚

在大奎山一帶古生代煤系中部之觀察。

一、綠灰色頁岩、及黑色頁岩、厚十米突。
二、耐火粘土、厚二米突。
三、黃色薄層砂岩、厚六米突。
四、白灰色硬砂岩、厚八米突。
五、泥質頁岩、及薄層黃色砂岩、厚六米突。
六、黃色砂岩、厚半米突。
七、石灰岩、含腕足類化石、厚一米突半。
八、黃色砂岩、厚五米突。
九、黑色泥質頁岩、厚十二米突。
十、黃色堅實砂岩、厚五米突。

十一、淺黃色頁狀砂岩、及黑色泥質頁岩、厚十五米突。
十二、淺黃色砂岩、厚十二米突。
十三、綠色頁狀砂岩、與黑色泥質頁岩相間而生、厚十二米突。
十四、淺黃綠色厚層砂岩。每與黑色泥質頁岩相間而生、厚十八米突。

在黑山一帶古生代煤系中部之觀察。

一、灰黃色砂岩、厚二米突。
二、彩色（灰、黃、綠、淺紅）泥質頁岩、及黑色頁岩、厚十米突。
三、黃灰色粗砂岩、厚十米突。
四、灰色砂質頁岩、厚八米突。
五、石灰岩、含腕足類化石、厚一米突半。
六、淺黃色砂質頁岩、厚十米突。
七、暗黃色硬砂岩、厚一米突。
八、黑色泥質頁岩、厚八米突。
九、黑色砂質頁岩、厚二十米突。
十、淺綠色厚層砂岩、厚八米突。

古生代煤系上部　在淄博一帶、發育特著。惟不含煤層。於礦業上殊不重要。本部總厚、在鑿山一帶、約一百數

米突。在大奎山、約百四十餘米突。在黑山、約百十餘米突。其煤田北部、爲甕山之重要分子。北向經盤龍山、廣佈於唐山、一帶山嶺之中堅。再南逾孝婦河、經博山之北、西南向抵斷層而隱。其在黑山煤田者、爲黑山之重要分子、居煤田之中央、平覆於煤系中部之上。

本層岩石、以泥質頁岩及砂岩爲主。在甕山及大奎山一帶、土一層。茲將地層色性、敘述如次。

在甕山一帶所見者。

一、黃色鬆質粗砂岩、含小顆礫石、厚六米突。

二、淺黃白色粗砂岩、下部夾有紫灰色泥質頁岩、厚七米突。

三、黃色硬砂岩、與紫棕灰色泥質頁岩相間而生、厚五米突。

四、紫棕灰色泥質頁岩、厚七米突。

五、黃棕色雲母質砂岩、厚八十生的米突。

六、紫棕灰色泥質頁岩、厚二米突半。

七、輝綠岩層（威利斯稱玄武岩流）厚二米突。

八、紫棕灰色泥質頁岩、厚五米突。

九、輝綠岩層、厚二米突。

十、紫棕灰色泥質頁岩、厚五米突。

十一、黃色鬆砂岩、厚三米突半。

十二、淺綠黃色砂岩、下部每呈赤色、厚十米突半。

十三、紫棕灰色泥質頁岩、厚十四米突。

十四、黃色砂岩、厚十一米突。

十五、輝綠岩層、厚三米突。

十六、白灰色堅實砂岩、厚半米突。

十七、淺綠黃色鬆砂岩、厚三米突。

十八、輝綠岩層、厚八十生的米突。

十九、淺綠黃色泥質頁岩、厚十三米突。

在大奎山一帶所見者。

一、棕黃綠色泥質頁岩、厚三米突

二、綠色砂岩、厚十米突。

三、棕綠黃色泥質頁岩、厚九米突。

四、綠色硬質粘土、厚五米突。

五、棕綠黃色泥質頁岩、厚五米突。

六、綠色砂岩、厚八米突。
七、棕綠黃色泥質頁岩、及黑色泥質頁岩、厚二十三米突。
八、暗綠色泥質頁岩、厚三米突。
九、淺綠色砂岩、厚四米突。
十、輝綠岩層、厚八米突。
十一、綠色砂岩、厚五米突。
十二、棕綠黃色泥質頁岩、厚二十二米突。
十三、綠色硬砂岩、厚九米突。
十四、棕綠黃色泥質頁岩、厚七米突。
十五、淺綠黃色頁狀砂岩、厚六米突。
十六、綠色泥質頁岩、及綠色砂岩、厚十五米突。

在黑山一帶所見者。

一、黃綠色砂岩、厚二米突。
二、棕黃綠色泥質頁岩、厚一米突。
三、黃綠色砂岩、厚二米突。
四、棕黃綠色泥質頁岩、厚一米突。

五、淺黃綠色砂岩、厚一米突。
六、棕黃綠色泥質頁岩、厚二米突。
七、綠色砂岩、厚四米突。
八、黃綠色砂岩、厚一米突。
九、棕黃綠色泥質頁岩、厚一米突。
十、黃綠色頁狀砂岩、厚二米突。
十一、棕黃綠色泥質頁岩、厚三米突。
十二、淺黃綠色頁狀砂岩、厚九米突。
十三、綠色硬質粘土、厚四米突。
十四、棕黃綠色泥質頁岩、厚十一米突。
十五、綠色砂岩厚七米突。
十六、棕黃綠色泥質頁岩、厚十一米突。
十七、綠色厚層硬砂岩、厚四米突。
十八、淺綠色薄層砂岩、厚六米突。
十九、棕黃綠色泥質頁岩、厚七米突。
二十、灰白黃色粗砂岩、厚十米突。

二二、綠色硬砂岩、一部含有鐵質、厚五米突半。

二三、淺綠色頁狀砂岩、每露化石痕跡、厚九米突。

二三、棕黃綠色泥質頁岩、厚九米突。

(三)石英砂岩層　昔在山東南部、曾目擊此層。以其直覆煤系之上、無顯著之界劃、爲層又薄、乃遂列於煤系內。今此層較爲發育、分佈亦廣。故另標一層。但其時期仍當屬於古生代末紀也。此層在淄博本部煤田、及黑山煤田內、每居高山之巔。在鑿山一帶、散佈零星。鑿山、盤龍山、唐山、狼屠殿山、均有露頭。自唐山而南、沿孝婦河兩岸、過淄川城、傍東縱嶺西麓、循孝婦而南、斜鋪大奎山、萬山、西坡、西南向、逾河、遇斷層而止。在黑山煤田者、則組成黑山之頂、直冠其上焉。此層厚度、雖未經詳測、推算所及約爲二百九十米突。全層概爲白色石英質硬砂岩。惟上下兩部、有時見淺綠色硬砂岩。其石英顆粒率粗巨。

(四)紅色砂岩層　在山東南部、亦常目擊。惟彼每與礫岩交互迭生。而此則未嘗一覩礫岩縱跡耳。就部位而論、當爲中生代開幕之地層。但向未得有化石確證、似不能不懸置之也。此層分佈、大致跨孝婦河兩岸、至白塔之南、始西南向、沒於斷層之旁。厚度計算爲六百八十米突。岩石什九爲深紅色鬆質砂岩。其下部與石英砂岩接觸處、每見棕色淺黃灰色粘土、泥質頁岩與淺綠色砂岩相間而生。上部與中生代煤系接觸處、常夾有淺黃綠色薄層砂岩。

(五)中生代煤系　本系以砂岩頁岩爲主。夾有煤層。並含植物化石痕跡。在變衣鋪一帶、特別發育。望娘溝附近、確有煤窰廢址。在西劉莊南、地層內亦見化石蹤影。在崑崙山一帶、因受輝長岩炮烙、其白色砂岩之一部、

變爲純潔之石英岩。博山製造玻璃之材料悉仰給於此。此層分佈、北自明水鎭東南起、經變衣舖、望娘溝、而南、沿煥山東麓、至崑崙山爲輝長岩分隔、逾山而南、組成一帶小嶺、西南向、至斷層而止。此層厚度、亦由計算而得、約爲一百六十米突。今就諸處所見、揭示其層序如左。

變衣舖一帶中生代煤系。

一、淺黃綠色硬砂岩、夾黑色頁岩。
二、白色粗粒砂岩、時呈赤色。
三、灰白色粗砂岩、在崑崙山變爲石英岩、用作玻璃原料。
四、淺黃綠色砂岩、有時質稍堅實。
五、淺灰黃色砂岩。
六、淺黃綠色泥質頁岩、及黑色泥質砂質頁砂。

西劉莊一帶中生代煤系。

一、黑棕色淺綠色泥質頁岩、及淺黃綠色砂岩。
二、綠色砂岩。
三、黑棕色淺綠色泥質頁岩、時露植物化石痕跡。
四、綠色砂岩。
五、白色粗粒砂岩。

六、礫岩。

七、綠色粗砂岩。

(六)紅綠砂岩系　本系直覆於中生代煤系之上、淄博煤田水成地層中之最新層也。在三台山、本甚發育。故梭爾格名之爲三台層。但北向至煥山、明山、一帶、分佈尤廣。大抵北自荆山迤南、南至崑崙山西麓、中經煥山、三台山、皆本系暴露之場也。本系夙成大地、久經剝蝕、確實厚度、無從計算。其岩石大半爲紅色砂岩、綠色砂岩、紫棕色砂岩、及灰黃色砂岩。下部與中生代煤系接觸處、爲紅色礫狀砂岩。與火成岩接近處、每變爲石英岩。

(七)紅土層　第三紀以後地層廣被吾國北部者、爲黃土。李希霍芬及威利斯均以黃土層名之。實則黃土之下、猶有紅土一層。安特生博士嘗見之於河南。今在山東、亦經目擊。安君在河南曾於本層中、得有屬上新統之哺乳類動物化石如 Aceratherium, Rhinoceros, Tragocerus, Hipparion 等、其生成時期、當在第三紀末季無疑。本層多分佈於谷中、各煤田均其發育之所。與各期地層、悉成不整合之接觸。下部爲礫岩、厚在一米突左右。上部紅土與礫岩交互迭生、紅土內或含礫石。此層厚度、甚不一致、約在五米突十五米突之間。

(八)黃土層　卽李威二氏所稱之黃土、而遍佈於吾國北部者也。有顯著直立之節理、含淡水產之螺殼。安君在本層中、嘗得屬於第四紀 Pleistocene 之動物化石如 Elephas, Rhinoceros 等、其生成時代、當在第四紀初期、地層分佈、常與紅土層有聯帶關係、而被覆於其上、成不整合之接觸。在淄博一帶、黃土層中、每含有礫石、平鋪成層。全層厚度、無由窺悉。此次所見最厚者、尙不及十米突。

第二節　岩石礦物化石

(二)岩石　水成岩及變質岩、其色性已詳見前節、茲所陳述者、爲火成岩。淄博一帶火成岩、大致可分兩類、即侵入岩與噴出岩是也。噴出岩僅見於荊山。粗視之爲黑色、質甚堅、有橢圓小孔、爲火山噴發時岩汁內氣質發散所成。其組織極密、黑色礦物占重要位置、望而知爲玄武岩之火山岩流。侵入岩在孝婦河西、暴露高者、組成煥山、三台山、嵐崙山、明山。低者、往往散見於各溝渠中、或侵入於層隙中。在孝婦河東者、概侵入於煤系地層隙縫、而成層形。惟在饕山東、有小體露出、成爲塊狀。昔威利斯嘗以此種侵入岩層、爲玄武岩流、今思之頗懷疑焉。淄博本部煤田、及西河、黑山、兩煤田、原本毗連、而爲一煤田。內受衝動、地層折斷、乃始剖分。如果爲火山岩流、應徧蓋煤系地層、併西河黑山煤系地層而亦影響之。今侵入岩僅生存於淄博本部煤田、與諸侵入岩巨塊距離頗近、而西河黑山煤田內、絕無火成岩踪跡。蓋必侵入岩上衝時、其一部岩汁沿層隙四溢、而入於煤系地層者。且侵入岩層、數亦不同。在饕山約六層、在大奎山只一層。驟觀之、兩山相距匪遙、若誠爲火山岩流、兩山應相對稱、今層數不爾者、其必侵入岩汁一部沿一層面而行、他一部循數層隙而進也。其在饕山東一處、侵入岩不沿層面成層形、有橫衝地層之勢、亦足爲非火山岩流之証。故就以上種種觀察言之、其爲侵入岩層、於理稍近。威氏謂爲火山岩流者、或未詳審歟。

侵入岩大抵可分爲三類。曰輝長岩類、安山岩類、輝綠岩類。輝長岩在淄川縣西南、崙嵐山三台山一帶、大部侵入於中生代煤系、與紅綠色砂岩層及紅綠砂岩系、亦均有接觸。大抵在山嶺高處、山嶺亦顯假水成地層被輝長岩侵入隆起而生者。岩石成巨塊、暴露面積不廣、長寬均不過數里。岩石成分斜長石與輝石均占重

要部分、輝石量似較多。斜長石結晶、大致整齊、而體多長、複雙晶頗顯著。輝石晶形完全、多作短柱狀、在平行偏光鏡下、呈淺綠色、解理極顯。輝石外猶有紫蘇石、角閃石、少許、均現多色性。角閃石淺綠色、紫蘇石有兩種色澤。直立軸垂直於主要偏光面時、呈淺紅色、平行時、呈淺綠色。黑雲母亦稍有踪跡、呈棕色。磁鐵礦每作正方結晶、佈散各處。輝長岩四周水成地層、多受炮烙而變質。在崑崙山一帶、中生代煤系內、白色砂岩變質爲石英岩、質頗純淨、人多採挖、爲製造玻璃之原料。在三台山、紅綠砂岩系與輝岩接觸者、亦多變爲石英岩。

安山岩分佈於淄川西境、侵入中生代地層內、大抵爲巨塊、亦有成岩坂者。在變衣舖一帶、安山岩侵入中生代煤系、露頭頗小。結晶爲斜長石及角閃石、斜長石結晶不甚完整、晶粒亦不甚大。角閃石一部結晶完全、體細而長、平行偏光鏡下、爲綠色。磁鐵礦常相伴而生。石基爲斜長石、在直交偏光鏡下、一部晶體尙明晰、一部晶粒叢聚、狀頗模糊。在明山煥山一帶、安山岩侵入於紅綠砂岩系、與輝岩接觸者、亦多變爲石英岩。

及角閃石爲主。斜長石結晶完整。晶體較大。角閃石結晶不全、大部變化、分出鐵質、常呈赤色、綠色者頗少、而多色性亦不著。輝石偶露踪跡、量甚少。石基爲斜長石、在直交偏光鏡下、晶形多不明晰、而晶粒羣聚者頗夥。

水成地層接觸於安山岩者、亦多變質。砂岩往往變爲石英岩。在明山、星山、安山岩上、常見石英岩遺跡。

輝綠岩侵入於古生代煤系、多成層形、每在煤系上部、中部亦間有之。在蠻山一帶、暴露者有六層、厚由一米突左右、至四米突。至大奎山、只有一層、厚約八米突。岩石成分以斜長石及輝石爲主、斜長石結晶大致完全、而晶形較小。輝石晶形、有時亦尙完整、解理頗明晰。在平行偏光鏡下、色甚淡、幾無色澤、直交偏光鏡下、現藍、黃、紅、等色。角閃石亦有踪跡、或成細長結晶、或爲巨塊、大致爲綠色、稍露棕黃色、多色性有時不甚著。磁鐵礦

觸處目擊。

輝長岩安山岩所侵入之水成地層、以紅綠砂岩爲最新、其生成時代、後於紅綠砂岩、當無疑義。輝綠岩所在、雖僅限於古生代煤系、然與輝長安山兩類岩石、地位接近、生成似有聯帶關係。蓋當岩漿上昇之際、大體凝爲巨塊、而成輝長安山等岩石、其一部循層面而進、乃結爲輝綠岩也。就地質構造觀察、山東北部、當侏羅紀中期、大地隆起、而爲陸地。火成岩石、大抵均成於此時。而輝長岩、安山岩、輝綠岩、似亦侏羅紀中期之產物也。噴出岩惟玄武岩一類、在荊山一帶、多居山頂、下有紅綠砂岩系。岩石在顯微鏡下考察、有斑晶石基之分。斑晶惟有橄欖石、結晶雖不甚完整、而腐蝕之狀尙少。平行偏光鏡下、無色澤、直交偏光鏡下、呈紅黃藍等色、甚顯著。石基由斜長石及輝石組成、大部結晶、一部爲玻璃質。斜長石成細長針狀結晶、形甚完全、常現流紋組織、與輝石交錯並生。輝石在平行偏光鏡下、呈淺黃綠色、直交偏光鏡下、呈棕黃色。晶形有時尙完整、作短柱狀。磁鐵礦晶粒、每傍輝石而生。

(二)礦物　造岩礦物而外、淄博一帶礦物最著者、固爲煤炭、將於礦產章內、特別述之。茲所言者、爲鉛鑛。產地在大荒地煤礦東南約五里、鑛生於奧陶紀灰岩內、爲方鉛鑛、兼有孔雀石、結晶頗美麗。昔日曾經開採、現日人就舊跡掘挖、穿煤系約七十餘尺（營造尺）。始達石灰岩、可得鑛石。但此鑛量既不豐、質亦抵劣、採辦又棘手、蓋無經營之價值也。此外在大荒地煤礦東北約八里、徐家莊東南約二里、亦有鉛鑛產地、舊坑尙存在、但未見鑛石露頭、豈上部已採盡歟。

(三)化石　此次所得化石、僅煤系中之產物。在煤系下部石灰岩內、見有紡錘蟲、在中部石灰岩內、有腕足類

之 Productus, Spirifer、海百合類之節片。植物化石、所獲甚夥。最普通者、爲鱗木、輪木、Calamites, Lepidodendron, Neuropteris, Callipteris 等。

第三節　構造

淄博煤田構造、極爲簡單。地層褶曲既不數覯、斷層又甚明瞭。幾乎一經其地、即洞悉其梗概也。

（一）滄桑之變遷　自奧陶紀以後、由海成陸、經歷長期、而志留、泥盆、二紀地層、因以中絕。惟此有兩種解說。其地層是否原未生成、抑或生成之後、又經剝蝕而去、斯極耐研究者也。就現存石炭紀與奧陶紀地層接觸處觀之、其間雖有如此重大之缺陷、而兩層不整合之現像、却不甚顯著。如二紀中絕地層、原已生成、而後經剝蝕去者、則奧陶紀地層、表面上當呈極不規則之狀態、或二紀地層、有殘餘之一部。蓋侵蝕之力、幷非一律。二紀地層已完全蝕去、而奧陶紀地層、毫無虧損、理似難解。今奧陶紀灰岩、與煤系無顯著不整合之觀者、不獨淄博爲然、廣覽山東全省。大抵如是。其或二紀地層、原未生成歟。自此由陸而海、石炭紀及二疊三疊紀地層、因以孕生。就化石考察、石炭紀內似乎曾經成陸、旋復爲海。至三疊紀之末、似乎又由海而陸、惟歷時不長、繼又變爲海相。而中生代煤系、及紅綠砂岩系又沉澱矣。至中生代末季、漸成陸地、積有第三紀末之紅土。後經一番剝蝕、第四紀初之黃土、被覆其上。此海陸變遷之大概也。

（二）地層之傾折　本區域三部煤田之間、互有斷層隔絕、其地層傾斜、自各有統系、均不一致。茲按三部煤田、分爲三系述之。第一系、淄博本部煤田地層之傾斜。地層傾斜、大致西北、時偏西、或西向、時偏北、或北向、其因局部變動、間有向東北、東南或東、西南或南者（詳見地質總圖中）斜角大致在十度三十度之間。最大角

度、爲四十二度。最小角度、爲四度。間亦有成水平層者。在鑿山一帶、地層成一淺平之向斜層。至鑿山遙西十里鋪、成一極平之背斜層（見剖面圖。）在鑿山及大奎山北嶺一帶、地層較爲隆起。而淄川煤礦一帶、地層略形低沉。此地層凸凹不平之狀態也。第二系、黑山煤田地層之傾斜。地層傾斜、大致向東北偏北、或西北偏北。或直向正北、其近斷層處、往往有傾向西南者。傾斜角度、大致在十度二十度之間。有時地層緩平、斜角爲五度、甚或成水平層、偶有傾斜近四十度者。第三系、西河煤田地層之傾斜。地層大致傾向西北、時偏北、間或向北。其近斷層處、往往有傾向東南者。傾斜角度、大致在五度二十度之間。時或增至二十二度。其近斷層處、地層有成水平者。

本區域顯著斷層分隔煤田者、厥數有四。第一、爲分隔淄博煤田及章邱煤田之斷層。據所見、起自博山之西、向北延長甚遠、大致爲平推斷層 Horizontal fault 初地層斷折時、動力成南北方向、平推兩煤田而遠之、以成今日之狀態。第二、爲分隔淄博本部煤田及黑山、西河、煤田之斷層。可得見者、起自博山之南蜿蜒東北向、至黃崖之北而盡。大致爲正推斷層 Normal fault。斷處不甚劇烈。仰側爲奧陶紀灰岩、俯側則煤系地層也。第三、爲分隔黑山煤田及西河煤田之斷層。可得見者、起自郭大碗村之北、東南向、至岳家莊之東、出煤田而終、大致爲正推斷層、但推動極微。仰側爲西河煤田、俯側則黑山煤田也。第四、爲淄博本部煤田北端之斷層、所見起自高家丙戌之南、西北向、遇高莊而沒、大致爲平推斷層。動力平推地層而衝斷之。至斷層生成時代、大約在中生代之末、或第三紀之初。因中生代地層曾受折斷、而第三紀末之紅土、有時被覆於其上也。

第三章　礦產及礦業

淄博煤田、礦量豐富、既甲全省、煤質亦復佳良。誠天產中之佳品、實業界之珍物也。惟因曹州教案、其一部久租讓於德。自青島戰役、復據於日。後又侵入於殘餘之一部。竊查淄博各處煤礦、率與日人有金錢之關係。而產出之煤焦、什九運銷於東北。甚有華人僅擁虛名、日人享受實利者。更有華人放棄利權、日人越俎代謀者。淄博礦業、應亟起而整飭之也。（按此報告成於民國八年、故所述情形與現在實際不甚符合。調查目的原以地質爲重、故於此章未及校改、亦以誌當時之狀況耳。）

第一節　位置

淄博煤田、山東北部之中間、占據淄川、博山、兩縣屬境。其東北一部、有伸入益都縣轄區者。淄博本部煤田、在淄博兩縣城之間。並向北延長至距淄川城三十餘里之處、向西延長離博山城約十里。黑山煤田、在博山城東、其西端距城不及二里、東端距城幾三十里。西河煤田、在博山城東北、距城最近處、約十里、最遠處、幾二十里。

第二節　運銷

交通便利、運銷匪艱。惟黑山、西河、兩煤田、僻處山叢、路途崎嶇、轉運稍形不便耳。張博鐵路、爲本煤田交通之利器、司運輸之總機關也。淄博本部煤田、大荒地煤礦、築有鐵路、以礦場爲起點、至淄川三里溝車站、與張博鐵路運軌、煤產悉由此路輸出。大奎山萬山一帶煤礦、悉以張博路之大崑崙車站、爲輸出品之總卸場。由礦場運至車站、專賴騾馬之力。博山一帶、及黑山西河兩煤田煤礦、以博山車站、爲輸出之中樞。由礦場運往車站、或以人力車、或用騾馬。其運費之多寡、以路綫之長短爲標準。運至各車站之煤炭、均由張博鐵路運出。其日人經營之大荒地煤礦、及與日人有關係之礦、產出之煤、悉由膠濟鐵路運往青島、裝船東渡、以達日本。華人開辦各礦產

出之煤、大半由膠濟鐵路運往濟南、其一部分銷於沿路各站。商人馬某、現正經營修築輕便鐵道、由各車站深入各煤田。已勘定之路綫爲二。一以博山車站爲起點、達黑山煤田。一以大崑崙車站爲起點、達萬山一帶。其達西河煤田之支路、擬有兩種計畫。一聯絡達黑山之路、繞黑山之東、向北直抵西河煤田。一聯絡達萬山之路、繞越山嶺、以至西河煤田。倘將來辦理妥善、著有成效、淄博礦業、當益發達。

第三節　礦量

計算礦量、本非易事、欲其準確、尤覺困難。蓋外表雖具一定之形態、而地腹實有無窮之變化。只可力求其準確、不能斷言其盡符也。茲按三部煤田、計算其礦量如左。

(一)淄博本部煤田　本煤田地層斜向層向、均極整齊。惟至鸞山一帶、地層稍形摺綴、成極淺平之向斜層及背斜層。故估計礦量、當分兩部計算。自博山之西煤系盡處、至鸞山之南、共約兩萬七千米突。爲可採煤層之長。傾斜角度、大致爲十度。由地面直下、採至三百米突、可無經濟的損失。但舊日小窰林立、其距地面六十米突以上之煤層、率已採掘殆盡。故計算可採煤層之寬、當由直距地面六十米突處爲起點。今依此計算、其寬度爲一千三百四十米突。茲以一・二爲煤之比重。此部分之煤量、當爲二萬六千零四十九萬餘噸。鸞山一帶、地層隆起、露頭又廣、其可採煤層之厚度、亦爲六米突。比重爲一・二。煤量約爲三萬二千五百七十二萬餘噸。淄博本部全煤田煤量、約爲五萬八千六百二十二萬餘噸。但因採礦上之手續、及地層斷折之影響、不能盡數採出。茲假定以什之七、爲實行採出之煤數。其總量當爲四萬一千零三十五萬餘

噸也。

(二)黑山煤田　本煤田略成一三角形。地層極平、部位亦高。全煤田煤層、皆在距地面三百米突以上。故煤層全部、均在可採之列。本煤田煤層可採者、共有八層。其上四層、占據地位尤高、四圍俱浮露地面、其存在之部分、僅黑山腰際一帶。茲假定上四層可採部分之長、爲三千米突、寬爲一千米突。總厚爲四米突半。比重爲一・二。煤量約爲一千六百二十萬噸、下四層分佈最廣、本煤田形成三角。茲以長寬相乘用二除之之數、爲可採煤層之面積。總厚爲三米突半。比重爲一・二。煤量爲一萬零九百二十萬噸。共計黑山煤田煤量、約爲一萬二千五百四十萬噸。舊日小窯、開採甚盛。煤層上部、大約均被採掘。假定什之三、爲已經採出之煤數。尙餘八千七百七十八萬噸。因種種關係、不能採掘者、爲什之三。餘則爲六千一百四十四萬餘噸。此黑山煤田大概之礦量也。

(三)西河煤田　本煤田地層整齊、傾斜亦小、可採煤層、彌滿全部、煤層之長、約爲八千米突。寬爲一千零七十米突。其上四層大都殘缺、下四層總厚爲三米突半。比重爲一・二。故全煤田煤量、當爲三千五百九十五萬噸。茲假定不能採取之部分、爲全量什之三。尙餘二千五百十六萬餘噸可以採掘也。

按以上計算之結果、三部煤田、可採之煤、總計幾五萬萬噸。每噸之價值、平均以五元計。約值洋二十五萬萬元。據發山煤礦、及淄博各處煤礦所述、每噸成本、不及兩元。倘辦理適宜、當有十五萬萬元之盈餘、不得謂非巨大之資藏、棄之弗顧、仰屋言貧、良可歎也。

第四節　煤層及煤質

淄博本部煤田、通常採掘之煤層、共有八層、各有專名及其特性、老於礦業者、均能辨認。在博山城東北一礦採煤一層、名小黃石炭、爲八層外之一層、惟此礦採之、他處未之見也。八層煤皆爲有煙煤、惟小黃石炭無煙。八層煤均不能煉焦、惟鑿山煤礦之第四層、及博山城西之灰石炭、可煉焦。但鑿山煤礦之第四層、已採挖殆盡。灰石炭所煉之焦、不適於用。現淄博本部煤田、謂其無煉焦煤層可也。黑山煤田、通常開採之煤層、亦有八層。下四層佈滿全煤田、上四層僅黑山腰際有之。八層煤皆爲有煙煤、均可煉焦。而大緞石炭小緞石炭、及小石炭、煉焦尤佳。惟在博山城南三里西峪及後池一帶之大小石炭、不能煉焦。或該處逼近斷層、煤層曾受推動之影響、而變其質歟。西河煤田、通常採掘之煤層有四、卽下四層是也。皆爲有煙煤、均能煉焦。茲將三部煤田煤層名稱、次序、種類、性質、厚度、及位置、表列於次、藉資比較。

（一）淄博本部煤田南部開採之煤層

表中尺數以營造尺爲準　距離爲兩煤層間之距離

名稱	獨行	黑石炭	夾層	羅柱在博山城西林灰石炭	小黃石炭
厚度	二尺五寸	二尺五寸	一尺三寸	三尺	一尺
距離	未詳	距黑石炭四十五尺	距夾層七十尺	未詳	未詳

名稱	大黃石炭	油性小石炭	大石炭
厚度	三尺	一尺至三尺	二尺至四尺	三尺至六尺五寸
距離	距大黃石炭六十尺至一百二十尺	距油性六十尺	距小石炭通常四尺至七尺有時至三十尺

（二）黑山西河兩煤田開採之煤層

西河煤田惟採掘下層

(三)淄川大荒地煤礦所見之煤層

名稱	厚度	距離
雞子炭	三尺六寸	
大綫石炭	五尺四寸	距雞子炭三十六尺
小綫石炭	三尺六寸	距大綫石炭十四尺至二十二尺
灰石炭	一尺三寸至一尺八寸	未詳
大黃石炭	二尺二寸至四尺五寸	距灰石炭八十六尺
油性大石炭	一尺至二尺四寸	距大黃石炭百五十尺
小石炭	二尺四寸至七尺二寸	距油性七十尺
	一尺八寸至三尺六寸	距大石炭五尺至七尺多至十尺有時併爲一層

名稱	厚度	距離
A層或第一層	一尺一寸	
B層或第二層	九寸	距A層四十七尺
C層或第三層	一尺二寸	距B層四十六尺
D層或第四層	二尺二寸	距C層五尺
d層或第五層	九寸	距D層五十五尺
E層或第六層	二尺五寸	距d層百五十七尺
e層或第七層	一尺二寸	距E層三十五尺
薄煤層無名	九寸	距e層十六尺
仝上	九寸	距薄煤層五十六尺
F層或第八層	六尺八寸	距薄煤層二百六十六尺
G層或第九層	三尺七寸（內夾石七寸）	距F層五十一尺
H層或第十層	一尺九寸	層G距一尺五寸
I層或第十一層	九寸	距H層二十尺

就上列三表考察之、其可注意之點有三。(一)相當煤層、厚度固常有殊、而同一煤田、同一煤層、厚薄亦隨地而異。但利於採掘之煤層、除西河煤田外、平均至少爲六米突、此蓋可信者。(二)各煤層中間距離、深淺頗有變更。卽如大小石炭、通常爲四尺至七尺之間距、有時多至三十尺、有時併爲一層。其各煤層間距、往往相差頗多。但在任一煤田內、鑿竪坑深三百米突、可盡得全數煤層。(三)通常採掘之煤層、以黑山煤田爲最厚、計約八米突、淄博本部煤田、煤層通常開採者。計約七米突、最厚煤

層、亦有兩米突餘者。西河煤田煤層可採者、厚不及四米突。其大小石炭有時併爲一層、厚約兩米突有半。

黑山西河煤田煤質分析表　民國八年農商部工業試驗所分析

煤層	水分	揮發分	灰分	灰色	焦性	硫黃	發熱量
大緞石炭	〇、七四	一六、九六	一〇、八五	白色	可煉焦	〇、五七	七三七〇克洛利
小緞石炭	〇、六三	一八、一五	七、九二	淺白棕色	同	稍有痕跡	七二六〇
大黃石炭	〇、六九	二、九〇	一一、三六	棕色	同	〇、〇九	六八二〇
油性	〇、六九	二、一七	五、七七	棕色	同	稍有痕跡	七三八〇
大石炭	一、一三	三、五七	二三、八八	棕色	同	一、五二	六四九〇
小石炭	〇、九八	一七、〇一	三、二五	棕色	同	一、〇八	七七〇〇

淄川大荒地煤礦煤質分析表一　民國六年農商部工業試驗所分析

煤層	炭分	揮發分	灰分	水分	硫	灰色	熱量	煉焦性
第四層	八一、三九	一〇、五八	六、三二	〇、七五	〇、九六	白色	七一〇〇克洛利	可煉焦

淄川大荒地煤礦煤質分析表二　日本中央試驗所分析

煤層	水分	揮發分	固定炭素	焦性粘結性	灰分	灰色	灰氣	硫黃	發熱量
A層	〇、八一	八、四一	七二、〇一	膨張	一八、七七	淡桃色	〇、八六一	一、一八	七三三三克洛利
B層	〇、八二	一五、九九	七一、四五	全前	一一、七四	全前	一、三二九	〇、九〇	八〇六〇
C層	〇、八二	一二、六六	七五、五七	全前	一〇、九〇	全前	一、二〇九	一、一七	七六五七
D層	〇、八二	一二、七二	八〇、九九	全前	五、四七	淡黃色	一、一七八	〇、五九	八一五三
d層	〇、七四	一四、六六	七七、八三	全前	六、七七	污白色	一、一七八	〇、六三	八五二五
E層	〇、八八	一三、四七	六八、一八	粘結性	一七、四七	全前	〇、八四七	〇、八九	七四七一

第八層	八一、一六	九、三六	八、五〇	〇、九八	淺紅色	六一五〇	不可煉焦
第九層	八〇、〇三	一三、九六	三、九八	〇、七九	白色	七七〇〇	可煉焦
第十層	八一、一八	一三、二一	四、九三	〇、六八	棕色	七七〇〇	不可煉焦

F層	f層	上GH層	中GH層	下GH層	I層
〇、九七	〇、三四	〇、八四	一、二三	一、二四	〇、二八八
二三、七五	一〇、四二	九、九四	九、三一	一〇、四五	一〇、七二
七七、九七	七六、六六	八四、三〇	八三、〇三	八四、二九	八一、四九
粘膠結性張	稍粘結性	膠粘結性張	弱粘結性	粘結性	稍粘結性
七、三一	一二、五八	四、九二	六、四二	四、〇二	七、一一
白色	汚褐色	灰色	赤褐色	淡桃色	汚白色
一、三六〇		一、二七〇	一、一七八	一、二六七	
一、一九	二、一三五	一、三一	二、六五	一、五七	〇、五六
七五一〇	七九二〇	七四四〇	七六五七	七三四七	六七五六

第五節　煤礦

淄博礦業、固甚發達。然細察之、其內幕之窳敗、實有出人意料外者。溯自日人占據山東路礦以來、淄博境內、日商大集。初不過以賤價購買煤焦、作商業之經營。嗣以重利誘致華人、爲權利之企圖。至民國五六年間、間有一二獲利巨萬、驟然致富者。衆人羨之、咸以爲奇貨可居。乃各四出測繪礦區、呈請採辦。或與日人訂立賣煤合同、先期取値。或由日人自行治理、代爲呈請。現淄博煤田、礦區滿佈、幾無一角隙地。此淄博礦業發達之由來也。今詳細調查各礦。獲利者、實甚寥寥。察其虧累之原、半由於資本缺乏、半由於用度奢糜。而工値過昂、不識地利、尤

其小焉者耳。大抵淄博礦商、操縱礦業、自動者少、被動者多。既未綢繆於既往、焉能收效於將來。當其開辦之初、以賤價賣煤、預支煤值、用作資本。迨採掘以後、計每噸成本、高出預賣之價、爲契約所縛、只得甘認賠累、積日既久、遂漸不支。據調查所得、有虧空至十餘萬元者。且礦商多市井游民、非老於礦業者。彼僅知辦礦爲闊綽之事業、不知礦業爲極尙經濟之事業也。既膺辦礦之銜、便事事鋪張。徵論自身需用過度、即工程浪費、亦所不惜。淄博礦商、因此虧累者、屢有所聞。資本缺乏、用度奢糜、實爲各礦虧累之原因也。

淄博煤礦、大概分爲三類。一由華人作傀儡、日人自行採辦者。其盈虧彼極守密秘、吾人無由探悉、徵聞似不爲虧累者。將來彼等之去留、以青島問題如何解決爲標準。二因上述兩種原由而致虧損者。均屬華人經營、或明與日人有關係、或暗與日人有關係、或與日人已脫離關係。此種煤礦、倘長此宕延、不圖補救、終歸于澌滅而後已。三華人自行採辦、與外人毫無關係者。大抵此種礦商、均礦業老手。不事鋪張、純以營業爲目的。雖無幸得之利益、亦無意外之損失。淄博煤礦最有希望者、卽此類也。

淄博煤礦最大者、爲日人所辦之鑿山煤礦。曾詳述於民國六年報告內、至今礦業猶昔、無贅述之必要。茲所陳者、爲淄博煤田內華人所有之煤礦。僅按查詢所得、一一詳記。其有因故未能確悉者、付闕、所以昭實也。

(一)淄博本部煤田內之煤礦　共計十九處、內有歇業者一處。除富華煤礦在淄川北南定車站附近外、餘均在淄川龍口以南至博山一帶。茲由北而南述之。

(一)富華煤礦　在淄川北南定車站西南二里。呈請人李卓階。礦區九百餘畝。民國七年領照。貨本約三萬元、由股份集成。現正興工、尙未出煤。鑿有竪坑四、深者已挖下五十餘尺(營造尺)、淺者十餘尺。十七尺下見

岩石。據工頭計算約百四十尺、方可見煤。現工人約百數、石工水工、晝夜四班、每班每人工資京錢一吊（錫元五十枚）木工鐵工、按日給資、日各七百文。（民國八年三月二十七日記。）

（二）玉生煤礦　在淄川南龍口附近。現已停工歇業。

（三）德昌煤礦　在淄川南青草溝地方。呈請人張子岱。礦區七百七十三畝有奇。民國五年呈請立案、七年十月領照、資本五千元、由股份集成、共十五股。鑿有竪井四、深坑各約二百五十餘尺、二淺坑各約二百餘尺。開採油性、厚約二尺半、不能煉焦。油性下約九十尺、見大小石炭。採煤打水工人、共約百餘、坑上工人、約二十餘。採煤工人工資每日京錢三吊、打水二人一吊六百、井上工人按月給資。日出煤約四百筐（每筐重約九十斤每斤二十兩。）每筐價值京錢五百文。現已用去約兩萬元。其礦區北部、租給召德新開、採據云已虧累約三萬元。（八年四月十八日記。）

（四）魁盛煤礦　在淄川南高家地方。呈請人姜萬魁。礦區二千餘畝。民國六年由張子佩讓渡、同年呈請立案、七年增區、尚未領照、資本暫擬一萬元、獨立籌辦。現在青石板地方開有竪坑三、均深約百四十五尺、開採油性、厚約二尺半。採煤打水工人、共約八十名、小工約五十名。採煤工人工資每日京錢三吊二百、打水工人一吊六百、小工月給六吊、由礦給食。日出煤約一千二三百筐。每筐價值京錢四百四十至五百二十、由炭商收買。尚有竪坑數口、均租給他人開採。現資本俱已用盡、亦形虧累。（八年四月十一日記。）

（五）廣和煤礦　在淄川南大奎山卓子溜地方。呈請人召德新。礦區五百十餘畝。七年九月由小礦增區改爲大礦、尚未領照。資本京錢五萬吊、由股份集成、共十股。竪坑有二、一深約四百尺、一深約二百三十尺、坑內

橫道遠約五百尺。煤層六七層、厚各數寸、開採之煤層、厚約尺許。採煤取水工人。共八十餘名、坑上工人五十餘名。工資採煤工人、日各三吊四百、取水工人、日各一吊四百。每日出煤約四五百筐。末煤每筐價値京錢四百文、大致虧累。（八年四月十七日記）。

（六）協和煤礦　在大奎山下屋簷後地方。呈請人程文章。礦區七百畝、現在呈請增區、尙未領照。資本原定一萬元、現已用去十二萬元。竪坑有四、一深約百十尺、一深約二百尺、一深約二百二十尺、一深約二百七十尺、煤層厚三尺。工人共計百五十名。採煤工人、每日工資兩吊八百文。日出煤約三百筐。購有機器一部、價洋八千五百元。（八年四月十七日記）。

（七）泰來煤礦　在大奎山南麓田家窪地方、呈請人趙方津。礦區四百零九畝餘、七年六月呈請、尙未領照。資本約三萬元。獨力籌辦。竪坑有二、均約二百五十餘尺、坑下橫道遠約七百餘尺。見煤兩層、一爲薄煤層、不便採掘、再下約七十尺、爲獨行。即開採之煤層、厚約二尺半。因修理礦坑、暫時停工。據云已虧累三萬餘元。（八年四月十七日記）。

（八）義和煤礦　在大奎山南磚瓦窰地方。呈請人李書昌。礦區一千八百餘畝。七年呈請、已領礦照。資本十萬元、由股份集成、共二十股。竪坑有六、用機器者二、各深約二百尺。用轉車者一、深約百尺。用絞車者三、一深約百五十尺、二深各約五十尺。深坑見煤三層、均可開採。先見黑石炭、約二尺五寸、再下四十五尺、爲夾層、約一尺三寸、再下七十尺、爲羅柱、厚約三尺。淺坑只見羅柱煤一層。採煤取水工人共約六十名、坑上工人約百名、機器匠二十名。採煤工人每人一晝夜工資三吊二百、取水工人二吊、坑上工人一吊二百。現機器坑尙未

布置妥善、只小坑出煤、日出約百筐、末多塊少、每筐價京錢六百文。燈用豆油、每班一人用油半斤、值銅元十二枚。置有機器兩部、一部價洋九千元、一部賃自買煤客、六節汽鍋一架。至大崑崙車站、約十五里、每十五噸脚價、約京錢六十吊、每噸脚力、約用洋一元五角。現虧累已至十餘萬元。礦內住有日人、均掌事務。（八年四月十七日記。）

（九）文泰煤礦　在淄川南萬山東五家嶺地方。呈請人宮堉。礦區一千九百餘畝。先是爲宮陽貞所辦、號稱乾豐泰。礦隔千餘畝。民國七年與宮堉合辦、同年呈請領照。資本十五萬元。竪坑有八、用機器者二、一深約三百尺、一深約百二十餘尺、均未興工。現工作者竪坑三、一深百五十尺、二深各約八十尺。機器坑見煤四層。由地面鑿下百二十尺、先見黃石炭、厚約三尺。下挖六十尺、爲油性、厚約三尺。再下六十尺、爲小石炭、厚約三尺二寸。再下三十尺、爲大石炭、厚約六尺五寸。大小石炭之間。往往有煤一層、名曰二行、人不採之。有時與大石炭合爲一層。現開採者爲大小石炭。採煤工人五十餘名、坑上二十餘名。採煤工人每日工資三吊。日出煤約五百筐、每筐價四百至五百二十文。機器兩部、價共一萬六千元。鍋爐二具。去歲頗形虧累、現稍寬裕。（八年四月十七日記。）

（十）義和煤礦　在博山東北李家地地方。呈請人王廷光。礦區一千七百餘畝。先爲小礦、張子佩獨資採辦。民國四年呈請增區、七年領照。資本原定五萬元、現已用去二十餘萬元。竪坑有六、現出煤者三、一深百五十尺、一深百三十尺、一深百十尺。見煤三層、油性下百二十尺、爲大小石炭、兩層上下相距七尺餘。此礦採者爲大小石炭、小石炭厚約二尺半、大石炭厚約三尺八寸。礦工共約二百餘人。採煤工人每日兩吊五百、取水工

人一吊六百、礦場小工月給七吊、由礦備食。日出煤約六百筐（每筐重二百四十斤每斤二十兩）。每筐價值七百六十文。由礦至博山車站八里、每筐脚力用四百五十文。機器一部。購自濟南、價約七千元。（八年四月二十七日記。）

（十一）大成煤礦　在博山東北孫家林地方。呈請人徐振常。礦區四百九十餘畝。民國三年十月呈請立案、七年領照。資本原定一萬元。由股份集成。竪坑有四、出煤者二、一深九十六尺、一深約八十尺。採大小石炭、小石炭厚約二尺、大石炭厚約三尺、兩層相距四尺餘。採煤取水工人六十餘名、礦場小工五十餘人。採煤工人每日三吊二百、取水工人兩吊、小工月給九吊、由礦備食。日出煤約五百筐（每筐九十斤）。每筐價四百四十文。機器二部、一部卽起重機、購自天津、價四千元。自開辦以來、大致不甚虧累。（八年四月二十七日記）。

（十二）復成煤礦　在博山東北塢子莊（或五子莊）李家園子地方。呈請人張恕忠。礦區二百十七畝（雖不足二百七十畝但按大礦納稅。）民國七年呈請、尙未領照。資本萬元。竪坑有二。一深約百三十尺、現正鑿挖。一深約百五十尺、已出煤。採大小石炭、小石炭厚二尺、大石炭厚三尺六寸。採煤取水工人、共約四十人、小工十餘人。採煤工人每日三吊、取水工人一吊三百。日出煤約二百筐（每筐二百四十斤）。每筐價一吊五百文。卿筒一部、爐鍋兩具、購自靑島、價共八千元。自開辦以來、大致抵本。（八年四月二十七日記）。

（十三）大成煤礦　在博山東北張家塋地方。呈請人徐振常。礦區八百二十三畝餘。形同歇業。據云將集資大辦。資本原定一萬元、由股份集成。竪坑有三、一正鑿挖、深已八十尺、擬採大黃石炭。二坑出煤、均深約六十

尺。採小黃石炭、厚約一尺、爲無煙煤。礦工共五十餘人。日出煤約二百五十筐（每筐九十斤）。每筐價四百四十文。開辦以來、大致抵本。（八年四月二十七日記）。

（十四）悅昇煤礦　在博山東高家林地方。呈請人丁敬臣。礦區六百餘畝。民國七年呈請立案、八年領照。現已用去六萬餘元。正施工掘井、尙未出煤。擬採黃石炭及油性。一坑深百十尺、已見黃石炭。據云至油性尙有六十餘尺。（八年四月二十七日記）。

（十五）玉和煤礦　在博山之西。礦區總計一千三百餘畝。租與三人採辦。一在馬嶺爲德成井局。經理人李樹培。礦區八百二十畝。竪坑有三、一正鑿挖、深已百六十餘尺。兩坑出煤、一深百二十餘尺、一深百四十餘尺。採大小石炭、小石炭厚約二尺、大石炭厚約三尺、兩層上下相距七尺、有時併爲一層。採煤工人約七十餘名、小工約二十餘人。採煤工人每日三吊。日出煤約五百筐（每筐二百四十斤）。每筐價六百二十文。機器一部、購自天津、價洋七千餘元。自開辦以來、已用去十五六萬吊、合洋五萬餘元、現已虧累。一在葦子溝、爲德通井局。經理人秦魯峯。礦區二百七十畝。竪坑有二、均出煤、一深約九十餘尺、一深約百十尺。採油性及大小石炭、油性距小石炭約八十六尺、大小石炭相距七尺。油性厚約一尺、小石炭厚約二尺七寸、大石炭厚五尺四寸。礦工每班（晝夜兩班）約五十餘人。採煤工人日給三吊、小工六百。日出煤約百五六十筐（每筐二百四十斤。末煤每筐六百二十文、塊煤一吊一百八十文。機器一部、購自天津、價七千餘元。開辦以來、已虧累六萬餘吊。一亦在葦子溝、爲東華井局。經理人朱耀如。礦區二百七十畝。竪坑有三、均出煤、一深約四十尺、一深約九十尺、一深約二百尺、採大小石炭煤層厚度與德通井局同。礦工共約百餘人。採煤工人每日三吊、取水工人

一吊三百、小工六百。日出煤約六百筐（每筐百二十斤）。末煤每筐五百六十文、塊煤一吊一百二十文。機器一部、尙未置用。現亦虧累。（八年四月二十七日記）。

（十六）振業煤礦　在博山西偏坡地方。呈請人程學曾。礦區三百九十餘畝。民國六年呈請立案、七年增區、尙未領照。資本四萬吊、程某獨辦。竪坑有六、動工者三。一正鑿挖、深已百七十餘尺。一出水、深約二百尺。一出煤、深約百五十餘尺。採灰石炭、厚約三尺。有煙、可煉焦、鐵工利用之。採煤工人二十餘名、日各三吊。取水工人十餘名、日各一吊五百。日出煤二百三十餘筐（每筐二十餘斤）。每筐價六百文。由礦至博山車站、每二百四十斤、脚力三百文。自開辦以來、已用去兩萬元。（八年四月二十七日記）。

（十七）星聚煤礦　在博山杏花天地方。呈請人張舜卿。礦區九百八十九畝餘。尙未領照。竪坑有五、出煤者二、餘坑尙未見煤。煤坑深均百四十餘尺。採大小石炭、小石炭厚約二尺四寸、大石炭厚約四尺五寸、兩層相距七尺。礦工共約六七十人。採煤工人日各兩吊五百至三吊。日出煤約四百筐（每筐二百四十斤）。每筐價一吊至一吊二百。由礦至博山車站、每筐脚力四百文。機器二部、購自濟南、每部七千餘元。自開辦以來、已虧累六萬吊。（八年四月二十七日記）。

（十八）興盛煤礦　在博山西黃崖地方。呈請人王春安。礦區二百七十七畝餘。民國七年呈請增區、改爲大礦、尙未領照。竪坑有六、出煤者一、深約百尺。採大小石炭、小石炭厚約二尺、大石炭厚約三尺六寸、兩層相距七尺。採煤工人五十餘名。工價三吊。取水工人六十四五名。工價一吊八百。日出煤約三百筐（每筐百二十斤。每筐價二百三十至二百八十文。自開辦以來。虧累甚鉅。（八年四月二十七日記）。

(十九)大興煤礦　在博山西崔家林地方。呈請人程國棟。礦區五百七十餘畝。現擬分爲二區、尙未辦竣。資本兩萬元、由股份集成。竪坑有八、出煤者二、一深約百八十尺、一深約百四十餘尺。採大小石炭、小石炭厚約三尺、大石炭厚約六尺有半。礦工共約二百人。工資採煤者日各三吊、取水者半之。日出煤約三百筐（每筐二百四十斤）。每筐價六百文。機器二部、一部購自青島、價約萬元。一部爲故機、購自嶧縣、價約六千元。自開辦以來、已用去約十萬元。（八年四月二十七日記）。

(二)黑山煤田內之煤礦　現興工者、共計十三處。散處煤田、拱山羅列。茲由東而西次第述之。

(一)樂成煤田　在黑山之東岳家莊附近殷家溝地方。呈請人王者墊。礦區一千零數十畝。民國七年呈請立案、同年領照。資本兩萬元、由股份集成。橫洞有二、均遠七十餘尺、尙未出煤。竪坑有四、出煤者一、採油性、厚約二尺四寸。礦工尙無定數、日約數十人。坑內工人日各七百文。日出煤約百筐（每筐零售九百六十文、大宗批發八百文。在礦場煉焦。用土法每窯容煤萬斤、可煉焦五千五百斤、價值約八十吊、合洋三十元。由礦場運至博山、每百斤腳力約六百文。機器二部、購自濟南。一部價洋七千五百元。一部六千五百元。汽缸八寸、馬力二十四。鍋爐兩具。自開辦以來、已用去五六萬元。（八年四月二十二記）。

(二)中興煤礦　在黑山之東蘇家溝附近青石井地方。呈請人張孝堂。礦區三百四十餘畝。民國七年呈請立案。尙未領照。資本原定京錢三千吊、由股份集成、共計十股。竪坑有二、深百七十餘尺、一深約百尺。採大黃石炭、厚約三尺六寸。礦工約五十餘人。日出煤約二百筐（每筐約六十斤）。煤價每百斤四百文。煉焦用土法

每窯容煤萬斤、可煉焦五十斤、價値四十八吊。由礦場至博山、每百斤（每斤四十八兩）脚力一吊六百文。自開辦以來、已虧累六萬餘吊。（八年四月二十二日記、）

（三）吉成煤礦　在黑山北坡紅磜窩地方。呈請人趙成吉。礦區百九十餘畝（按大礦納稅。）資本與長垙地、五畝地、等處、共定銀八萬兩。竪坑有四、出煤者二、各深約百九十尺。採大小石炭、大石炭厚約二尺四寸、小石炭厚約二尺。坑下工人四五十名。運煤夫三吊五百文、採煤夫二吊五百。小工四十餘人、日各七百文。日出煤約二百筐（每筐三百斤。）煤價大石炭每筐價兩吊。小石炭供煉焦之用、每萬斤煤可煉焦四千五百斤、售價約八十餘吊。自開辦以來、大致抵本。（八年四月二十二日記。）

（四）同聚煤礦　在黑山後村附近董家山地方。呈請人石金銘。礦區二百八十餘畝。已領礦照、資本四千吊。竪坑六、出煤者一、深約七十餘尺。採黃石炭、厚約二尺七寸。斜坑一、斜深五十餘尺。採油性、厚約尺許。採煤取水工人、共約二百名、小工約百五十人。採煤者日各三吊四百、治水者一吊四百至二吊一百文、小工晝夜一吊四百、日出煤約二百筐（每筐二百斤。）末煤每筐價一吊、塊煤倍之。每一萬二千斤煤、可煉焦五千斤。價値黃石炭焦五十吊、油性焦七十吊。自開辦以來、已用去約四萬餘元、現仍賠累。（八年四月二十二日記。）

（五）信成煤礦　在黑山根黃家大窪地方。呈請人徐永和。礦區未詳。已領礦照。原定資本兩萬二千吊、由股份集成、共二十二股。前清末季、在紅土地開採。後移至三畝塝。民國三四年間、遂移至黑山根、開採年餘、與日商東和公司訂立賣煤合同、後直接租與日人、年租八千元、期限十五年。竪坑有四、一深約二百六十五尺、一深約二百四十三尺、一深約二百八十五尺、一深約百十尺、採煤三層。由地面下挖、先見雞子炭、厚約三尺六

寸。下鑿約三十六尺、爲大緞石炭、厚約五尺四寸、再下十四尺至二十二尺、及小緞石炭、厚約三尺六寸。礦工共計千餘人、均爲包工、按煤給資。機器井採煤一筐（重六百斤）給資兩吊八百文、轉車井每筐（重三百六十斤）給資一吊二百文。機器井兩處、日各出煤百五十筐至二百筐（六百斤）。轉車井一處、日出煤約四百餘筐（重三百六十斤）他一井現未工作。斜坑二、一斜深五百四十餘尺、一斜深一千四百餘尺、尚未見煤。機器五部、均購自濟南。現用四部、兩部價洋各二千九百餘元、一部二千八百元、一部二千六百元、每萬斤煤可煉焦五千斤、計十五日煉成。三種煤所煉之焦、以大緞石炭焦爲最佳。由礦場至博山約二十里。每百斤脚力七八百文、至此礦盈虧、無從探悉。其內部經營、聞多由日人參與其間。（八年四月二十四日記）

（六）星聚煤礦　在黑山前蔣家林地方。呈請人于春芳。礦區八百餘畝。民國六年呈請立案、七年領照、與杏花天及房家地三處、共定資本三萬元、由于春芳、張舜卿、光耀、三人集資合辦。竪挖有九、現動工者二、一深約二百尺、一深約百十尺、採大黃石炭。由地面下挖三十六尺、見薄煤層、厚約五寸。下挖五十八尺、見薄煤層、厚約七寸。再下五十八尺、爲灰石炭、厚約一尺八寸、再下八十六尺、即大黃石炭、厚約四尺五寸。此本礦最深竪坑煤層之情形也。採煤取水工人、共約二百名、小工約百餘人。採煤工人日各三吊五百、治水工人日各兩吊二百、小工七八百文。日出煤約三百筐（每筐三百六十斤）。每筐價值三吊七八百文。每萬斤煤可煉焦五千斤、售價九十吊。由礦場至博山約十五里、每百斤煤焦脚力五百文。機器二部、價各七千餘元、均購自濟南。自開辦以來、不甚虧累。現日費七百餘吊、入亦相抵。（八年四月二十四日記。）

（七）星聚煤礦　在博山東兩平莊房家地地方、呈謂人光耀。礦區未詳。民國六年開辦豎坑有二、一深三百

三十餘尺、一深二百五十餘尺。由地面下挖百九十尺、見黃石炭。再下百四十尺、爲油性、厚約二尺二寸、即現開採之煤層也。礦工共計百五十餘人。工資與各礦大致相埒。日出煤二百餘筐（重約三百斤）。每筐價一吊一百文。機器一部、購自濟南、汽缸一尺二寸、鍋爐四節。自開辦以來、已虧累約三萬元。（八年四月二十一日記。）

（八）吉成煤鑛　在黑山前長垙地地方。呈請人趙成吉。礦區二千三百餘畝。民國三年呈請立案、同年領照、六年增區、與他三處共定資本銀八萬兩。竪坑有八、均出煤。最深者約二百七十尺、最淺者百五十餘尺。採大小石炭、大石炭厚約四尺五寸、小石炭厚約二尺四寸、兩層相距七尺。採煤治水工人、共計約三百六十名、小工三十餘人、採煤治水者、工資日各兩吊四百、小工日各六百文。日出煤約一千三百二十筐（每筐百八十斤、）大石炭每筐末煤價一吊一百文、小石炭一吊五百文、塊煤倍之。每煤萬斤可煉焦五千五百斤、價值九十五吊。自礦場至博山約八里、每筐脚力三百文。機器三部、卷筒一具、起重機兩架。自開辦以來、大致虧累。其礦區東部五畝地地方、分出另採、與李涵清等合辦、名爲同豐煤礦公司。資本共十萬元雙方各半。民國八年開辦。竪坑有四、均出煤。深者百四十餘尺、淺者五十餘尺。採大小石炭、厚度與長垙地煤層相等。採煤治水工人、共約百八十名、小工約四十餘人。日出煤約九百筐。其工資、煤價、煉焦、運輸等項、均與吉成煤礦相同、機器三部、卷筒一具、起重機兩架。（八年四月二十三日記。）

（九）同成煤礦　在博山東南山頭村東捨腰地地方。呈請人王立泰。礦區三百零九畝。民國七年呈請立案、尚未領照。資本兩萬餘吊、由磁瓦窰行集股採辦。竪坑有四、出煤者三、一深二十二三尺、一深約三十尺、一深

約四十尺、一坑正從事掘挖、已深七十餘尺、尙未見煤。採大小石炭、大石炭厚約七尺二寸、小石炭厚約三尺六寸、兩層相距七尺。礦工無定數。工資與他礦相同。日出煤約百七八十筐（每筐約九十斤。每筐價約一吊。塊煤外售、末煤自用燒窰。（八年四月二十五日記。）

（十）大成煤礦　在博山東南山頭村北後池地方。呈請人、礦區、呈請日期、均未詳。在後池及馮八峪村附近開採、他處均租與他人採辦。出煤竪坑有三、一深約三百尺、一深約二百七十尺、一深約百六十尺。採油性及大小石炭、油性厚約二尺、可煉焦。下挖約七十尺、爲大小石炭、大石炭厚約二尺七寸、小石炭厚約二尺二寸、兩層相距在五尺十尺之間。煤均不能煉焦。礦工共計二百七八十人、採煤者工資日各三吊、治水者日各兩吊。在後池地方修有橫洞一道、爲洩水之用、遠約四里、高約四尺、寬約三尺。日出煤約七百筐（每筐約九十斤。）煤價大小石炭每筐約六百文、油性每筐一吊。自開辦以來、虧累頗鉅。其礦區內後大窪地方、租與趙連登採辦、名福昇井局、竪坑有六、出煤者二。採大黃石炭、可煉焦。日出煤約三四百筐（每筐約九十斤）、機器一部。（八年四月二十五日記。）

（十一）吉成煤礦　在博山城東南約三里張家地地方。呈論人趙成吉、礦區六百餘畝。民國二年呈謂立案、七年領照。竪坑有二、一正掘挖、深已二百尺、尙未見煤、一深約百三十尺、採灰石炭、厚約一尺三寸。煉出之焦無味、鐵工利用之。採煤治水工人約二十餘名、小工三數。日出煤約八十餘筐（每筐約百十斤。）每筐售價一吊二百文。機器一部。（八年四月二十五日記。）

（十二）荆山煤礦　在博山城東南約二里十八畝地地方。呈請人錢汝能。礦區三百餘畝。民國七年呈請立

案。現開始籌辦諸事未妥。竪坑有二、正在施工時期、均未見煤。（八年四月二十五日記。）

（十三）振業煤礦　在博山城南約三里西峪地方。呈請人程學曾。礦區三百餘畝。民國七年呈請、由小礦增區、改爲大礦、尚未領照。開礦伊始、佈置尚未完備。竪坑有二、各深約六十五尺。採大小石炭、大石炭厚約二尺七寸、小石炭厚約二尺、兩層相距七尺、煤有煙不能煉焦。礦工尚無定數。日出煤約二百筐（每筐百二十斤。）每筐價三百餘文。由礦場至博山約三里、每筐脚力二百五十文。（八年四月二十五日記。）

（二）西河煤田內之煤礦　現開採者、計有四處。悉在西河村附近。茲由東而西述之。

（一）同興煤礦　在西河東馬道地地方。呈請人莊式如。由李爾祿讓與。原礦區一千七百餘畝。民國七年呈請增區約四千畝、尚未查勘。現方著手佈置。資本十萬元。竪坑有四、一正掘挖、深已百二十餘尺。由地面下掘深約五十尺處、見薄煤一層、厚約一尺二寸、土人名爲寸子、大抵無採者。他三坑均爲舊坑、煤已採挖殆盡、礦工約百餘人、均由舊坑尋煤採出。日出煤約數十筐。僅供自用。通常採者有煤四層、曰黃石炭、厚約二尺二寸、油性厚約二尺四寸、大小石炭、兩層時常併爲一層、共厚兩米突有半、中間夾石一層、厚一尺至二尺。（八年四月二十日記。）

（二）悅昇煤礦　在西河北松林後地方、呈請人丁敬臣。礦區九百七十畝。民國七年由姜有瑞讓渡、八年領照。悅來公司與丁敬臣合辦。資本十萬元。竪坑有五、機器坑二、一深三百十五尺、已見煤兩層。在百八十五尺處、見薄煤層、厚約一尺二寸、土人名爲寸子。在三百十五尺者、爲大黃石炭、厚約三尺七寸。即開採之煤層也。一深約二百八十尺、尚未見大黃石炭。餘三坑一深約三百尺、現正出水、一深約百八十尺、用以通風、一正掘

挖、深甫五十餘尺。工人百數。見煤方數日。尙未正式採掘。支柱用楊柳木、購自附近各地。每百斤價值京錢三吊。機器三部、現用者兩部一部價洋、七千五百元、一部六千元、一部五千五百元。均本國製造、（八年四月十九日記。）

（三）興業煤礦　在西河西西山根地方。呈請人郭子紱。由張玉恒讓渡。原礦區二百七十畝。現呈請增區、尙未查勘。竪坑有四、出煤者二、一深百三十尺、置有唧筒一具、一深八十五尺。出水者一、深七十五尺。通風者一。深約五十餘尺。採油性、厚約二尺四寸。礦工共約三十餘人。日出煤百餘筐（每筐約九十斤）。末煤每筐價八百文。塊煤倍之。在礦場煉焦、分本地法、日本法。本地法只掘坑于地、留洞燃火。日本法必以磚砌成爐形。本地法每萬斤可煉焦五千五百斤、日本法可煉焦七千斤、但焦之品質、較遜於本地法所煉者也。此礦內有日人多數掌管事務。（八年四月十九日記。）

（四）福源煤礦　在西河西後倉地地方、呈請人楊藝林。礦區三百七十畝。民國七年呈請、同年領照。資本二萬元。楊藝林與姜有瑞合辦。竪坑有三、均正工作、尙未見煤。二坑各已深百五十尺、一坑深約七十餘尺。開辦甫始、諸事尙未就緒。（八年四月十九日記。）

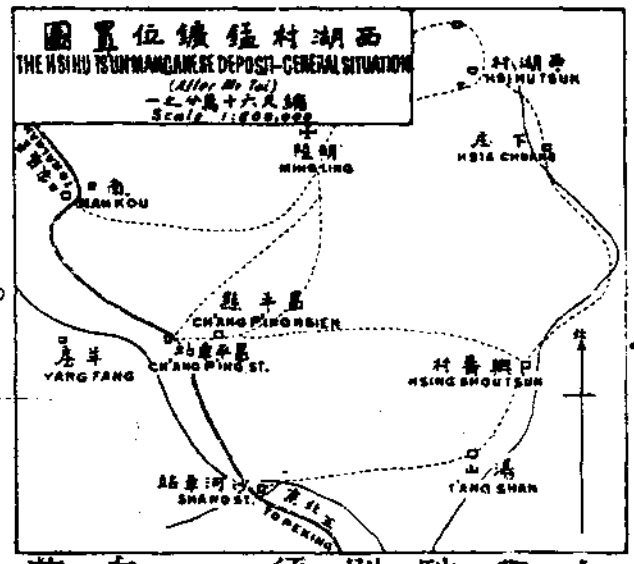
上述均爲各煤礦、已經成立從事營業者。此外尙有礦區多處。或已經呈請立案、尙未查勘、或已經得有礦照、尙未開辦、或正在探測之中、或久在封禁之列。大約不逾一年、均當先後成立。必能於中國礦業佔重要位置、可無疑也。

京兆昌平縣西湖村錳鑛

丁文江

位置及交通

西湖村錳鑛在昌平縣西湖村之西約一基羅米突。山名鐵鑛梁、高出西湖村約一百五十米突、自西湖村至鐵路、共有兩道。一經明陵達昌平或南口車站、共四十餘里。一經西壽村至沙河、共約六十餘里。自村至明陵、爲西大鞍嶺所隔、不易駝運。將來稍加修理、能否減少困難、殊未可知。現時西湖村與外界之交通、均取道興壽村。自村至山口通大車之點、約三十里、須用牲口駝運。假定每驢兩日可運三次、每次駝鑛一百八十餘斤、每驢每日駝脚五角、則自鑛至山口運費、每噸約爲二元五角。再自山口換大車轉運沙河、每噸約須洋一元五角。故照現時交通狀況言、運鑛一噸至沙河、須洋四元。



地質及鑛床

自興壽村之北、至下莊之南、山嶺均爲太古紀之矽質石灰岩所成。再北則爲花崗岩及其他之火成岩。而小部分之矽質石灰岩、往往孤立於花崗岩之中。

鐵鑛梁卽爲此例。山之北全爲花崗岩。山之上部則爲矽質石灰岩及其中所夾之砂岩及變矽石灰岩。前者生於北部、傾斜大抵向東北、南行則變而向西南、角度三十至九十不等。後者生於南部、傾斜平均約三十度向東北。故二者之間爲斷層所經。此斷層之內、復爲正長石斑岩所侵入、其形狀極不規則。錳鑛卽生於正長石斑岩附近之石灰岩中。其成分性質、至無一定。重要鑛物、厥爲軟錳鑛、PYROLUSITE MnO_2 含水硬錳鑛、MANG

ANITE MnO (OH) 矽酸錳、RHODONITE $MnSiO_3$ 及炭酸錳 RHODOCHROSITE $MnCO_3$ 此外尙有少許之不結晶硬錳鑛、PSILOMELANE H_4MnO_5 大抵炭酸錳質均不純、與未變之石灰岩相雜。不結晶硬錳鑛發生於空隙之中、其量甚微。矽酸錳與軟錳鑛相混雜、其外部因受風化、色由紅而黑、驟觀之頗似硬錳鑛、（圖中未與軟錳鑛分）鑛脈全部之形狀、亦極不規則。略如地質圖所列。蓋露頭經人試掘、岩石均極顯明也。

照上所言、鑛之成因、不難推測。正長石斑岩（或其來源）爲錳之所自出。侵入石灰岩中。流液浸潤。而鈣爲錳所替代、炭酸鈣一變而爲炭酸錳。久之則養化而成錳養。以軟錳鑛爲最後之變化。其石灰岩中之矽、與錳相合而成矽酸錳。不結晶之硬錳鑛、則因加水分而生於隙孔之中。

計曾經試掘之處、共爲三部。第一部在西北隅、橫斷鑛脈、略如第四剖面。石灰岩傾斜九十度。砂岩二十餘度向北而微偏於東。二者相接觸之處有錳鑛兩塊。中爲火成岩所隔。再西亦有火成岩、不復見鑛。東向爲浮土所掩。第二部在鐵鑛梁之東北坡、鑛脈延長約一百米突。亦生於石灰岩與砂岩之間、其西端爲火成岩所間。石灰岩傾斜約八十餘度向西南。砂岩仍爲二十餘度向東北。自此往東南、直至山頂、鑛脈相連。惟炭酸錳與錳養相間、（如第三剖面圖）質頗不純、其形狀亦極不規則、不易估計其鑛量。第三部實爲第二部之東南端。惟爲火成岩間隔、不全相連。其自山頂向下之形狀、略如第一剖面圖。石灰岩之傾斜、較之他處爲平。然其方向仍與砂岩相反。蓋斷層亦延長而向東南也。

由上所言觀之、不特鑛量之計算、絕無把握、卽鑛質成分、亦極不易定。蓋鑛脈形狀既不規則、而錳養與炭酸錳矽酸錳相間、炭酸鈣又與炭酸鈣相間。非逐一取鑛樣、逐一化驗、不能知何者爲可取、何者爲可棄也。是行也、晨

自湯山起、當晚仍歸湯山、計在鑛不足二小時、故頗匆迫。地形及交通圖、本之戴君德馨、繪剖面圖復得陳君國士之助、故能略有所得。特附記於此、以誌謝。

直隸臨楡縣石門寨附近地質

馮底幼著
袁復禮譯

石門寨在秦皇島北十九公里（三十三華里、）直隸臨楡縣柳江煤田之東部。前此農商部地質調查所技師葉君良輔劉君季辰在此調查、測有詳圖、曾刊於地質彙報第一號。近予亦至此數次、發現古生物頗夥。所得奧陶紀之古生動物、已經地質調查所古生物技師葛利普博士研究、刊於古生物誌乙種第一號。予則研究石炭二疊紀之古生植物、兼察各系地層、所得結果。正可與葉劉二君互相發明、而使吾人對於此區地質之知識、更加完備。

地層

此區地層除黃土及冲積層外、其次第自上而下、如左所列。

- 二疊紀後之火成岩
  - 大黑山火成岩
  - 層狀侵入岩
  - 脈岩
- 石炭二疊紀煤系——柳江石炭二疊紀煤系
- 奧陶紀石灰岩系
  - 上層梁家山
  - 中層石門寨
  - 下層北嶺子
- 寒武紀

太古界

二疊紀後之火成岩

古生界之末（亦即二疊紀末時）地層均被褶曲、又經冲刷作用、故至第三期之初、火成岩侵入、地形起伏、而地殼構造又大受變動矣。此火成岩侵入結果在石門寨一帶顯著者、爲（甲）大黑山火成岩、（乙）層狀侵入岩。（丙）脈岩。

（甲）大黑山火成岩　前據葉劉二君調查、似乎此大塊火岩應屬侵入類而非噴出類岩石。若然、則下列之層狀侵入岩及岩脈、不啻爲此大塊岩石之枝出。今就岩石種類觀之、則斑岩輝綠岩安山岩等均有詳加分析、於岩漿研究當有發明。

（乙）層狀侵入岩　有層形岩數層、侵入煤系及奧陶紀地層。被侵入各層均受變質作用。興業公司打鑽所得、自上而下次第如左。

（一）頁岩

（二）煤　揮發物百分之一六、五五、炭分三六、一五。

（三）黑色帶泥質炭質砂岩　愈下泥質愈多。最顯著之古生物爲 Stigmaria ficoides

（四）細粒矽質頁岩　多深黑、帶古植物碎片。

（五）炭質頁岩　所含炭質含揮發物百分之七、八〇、炭分一三、九〇。

（六）輝石安山斑岩

(七)鈣鈉長石輝綠岩　(六)(七)二岩石、均爲北洋大學毛利士教授所鑒定。較後之輝石安山斑岩(六)穿過較前之輝綠岩(七)。並包含其碎塊。至其與水成岩接觸處、亦均有變質作用。炭質受蒸發、而所含揮發物因之減少。所有植物化石葉內所含之炭質、亦變爲細粒石墨。此外並有方解石黃鐵鑛磁鐵礦。此種變質作用之結果、在開平林西亦有同等現像。

奧陶紀中亦有層狀侵入岩、惟露頭多受風化、不易確定種類。奧陶紀之石灰岩所受變質作用、亦不甚顯。

(丙)岩脈　岩脈多屬石英斑岩。煤田東邊有一岩脈厚數公尺、縱穿奧陶及煤系諸層。又柳江西南王莊山之含鎂石灰岩、有石英紅斑岩穿過、作東北走向、周圍岩石變質作用如下。

(一)東北各層多變爲石英岩大理石。或因風化呈紅色。

(二)石灰岩內多含燧石結核。

(三)石灰岩內有數處含結晶透角閃石。在裂隙處亦有透角閃石類之石棉。

以上各侵入火成岩、皆由複雜岩漿分泌所成、其結果影響柳江區域甚巨。蓋其亞無煙煤(含百分之七至十之揮發物)常於接觸處具有柱形狀態、蓋由岩漿變質作用所致。

柳江石炭二疊紀煤系

柳江煤系所含諸層、有砂岩砂質頁岩及頁岩、最多者爲以高嶺土爲膠質之砂礫岩。此砂礫岩又分二層。卽葉劉二君所稱爲雲山砂岩及南山砂岩者是也。有時並含薄層粗礫岩。

柳江左近煤層可稱完備。共計十層、惟第三第五兩層、有採掘價值。其煤爲亞無煙煤、且灰質亦頗高。

大致言之、柳江盆地係一淺坦之向斜層、作南北走向。中部及北端多爲火成岩所衝破。斷層頗多、平行大黑山之東麓者、即其一也。

北部斷層尤多、致使地殼構造更複雜。有一砂礫岩、爲他處所不經見者、在此發現、予以爲與山東之汶河礫石相當、同屬第三期。據維理士在山東新泰見此礫岩與斷層常相追隨。惟以時間匆促、未能完全解決此問題耳。

按與石炭二疊紀各層之關係、及以上種種理由、故予定大黑山等處火成岩之時代當屬於第三期之初。

予所鑒定石炭二疊紀各層之植物化石、多經予在柳江左近採集、及與業公司鑽柱所得者、其種類如左。

Neuropteris ; flexuosa

Neuropteris sp.

Cyclopteris

Pecopteris (Asterotheca)有果實頗多、但保存不全、屬羊齒類 Cyathoides。

Annularia stellata var. mucronata

Callipteridium (?)

Sphenopyllum emarginatum

Cordaites principalis

Poacordaites

Samaropsis of fluidans

Stigmaria ficoides

此外尙得一殘塊、頗似 Teniopteris multinervis(Weiss)之葉端。惟只有中間幹脈清晰可辨、其餘支脈皆不易識、故不能確定之。此地層植物化石不多、而保存亦不完。惟據 Neuropteris flexuosa, Annularia stellata, Spheno phyllum emarginatum, Cordaites principalis 等之存在、可與開平本溪湖及山東之一部相比較、而定此系屬石炭二疊紀、

此次所採集植物化石、多在煤系之中部及下部。如上層能有古生植物時、似當漸變爲純二疊紀之植物。如開平打鑽時曾在上層得純屬二疊紀之植物、卽其證也。

奧陶紀

奧陶紀石灰岩位於柳江煤系之下、顯露於柳江盆地之東部。地層傾斜向西十二度至三十度不等。予依據岩石性質、將石門寨左近之奧陶紀石灰岩分上中下三層。上下二層多含化石、曾經葛利普博士檢定、均屬奧陶紀下部、且爲前此在中國未曾發現者。故此次所得、亦屬新類。

(甲)梁家山奧陶紀上層　此層石灰岩多成薄層、其底部見於石門寨南城牆左近、在小石窰內露出極爲明顯。其底部之礫狀石灰岩與中段頂上之灰質頁岩相接觸處、均可目覩。此礫岩之上、有細粒圈層之石灰岩、在露頭處有乳黃縐紋、間含少數燧石結核。此石灰岩下部數層、成分皆極純淨。曾由三處採集標本。化驗所得、大致相同、其平均成分如左。

砂養二　六、〇六　鐵二養三　二養三　一、二八

化石保存不完、不能定其種屬。

此層中部在石門寨及石門寨至柳江之道旁、皆有露頭。此石灰岩稍含鎂、層疊清晰、間亦含石灰岩質之礫石。此層上部發現於石門寨北之梁家山。亦有石灰岩稍含鎂、間有極少數之燧石結核。予在此部上端發現含化石地層(F3)。所採各種、經葛利普博士檢定如左。

腕足類　1. Ophilata plana Grabau

2. Hornotoma docquieri Grabau

頭足類　3. Cameroceras styliforme Grabau

4. Piloceras platyventrum Grabau

此化石皆指定此層屬奧陶紀下部。此層共厚二百七十五公尺（八百六十一華尺。）

(乙)石門寨奧陶紀中層　梁家山、地層之下所有地層。在石門寨城南及自石門寨至北嶺子之路旁可見、自上至下層次第如左。

(一)石灰質頁岩及成層頁岩、呈黃或灰或紫色、厚八十公尺。

(二)密緻石灰岩及礫狀石灰岩、灰色或紅褐色。此礫岩奇特之點、褐色礫石作扁橢圓形粒、結於灰色粗粒石灰質之膠質中、礫石半徑不過三公分以上。此層厚四、五公尺。

(三)薄層石灰岩、細粒或中粒、有時含粘土質細粒時、則變爲密緻純石灰岩、厚十六公尺。

(四)褐紅頁岩灰質頁岩砂狀石灰岩外、有褐色帶雲母之矽質頁岩細層、及含砂灰岩薄層交互相間、

(五)灰色石灰岩　上部粗粒堅密作塊狀、下部細粒層疊清晰、厚四、五〇公尺。

(六)灰質頁岩及砂岩灰色或褐色、與灰色石灰岩微褐色礫狀石灰質相間成層、厚十三公尺。

此層中未有化石。其與他層不同者、岩石性質屢變、非如他層性質之一律。

(丙)北嶺子奧陶紀下層　距石門寨城牆東南少許、即見奧陶紀中層之底部直接於厚層灰色鮞狀石灰岩、厚二十公尺。此鮞狀岩特殊之點、在有多數黑色鮞狀圓粒鉗於灰色細粒之石灰岩中。鮞球直徑大者八公厘、小者四分之一公厘、平均在半公厘及一公厘之間。往南行見鮞狀漸少、岩石漸變爲灰色含鎂石灰岩。鮞狀石灰岩經化驗後所得結果如左、

鈣炭養	三九四、	二五	鎂炭養	三四、	六五
矽養二	一、	一二	鐵二養三 鋁二養三	一、	一六

近北嶺子鮞狀石灰岩層疊清晰、作南北走向。其下有厚層細粒石灰岩、色深灰或青黑、擊之作鐘聲、斷面分殼狀、稍含矽質或鎂質。此外在石灰窰中、亦有礫狀石灰岩層。

予於此層發現二帶含化石之層(F₁)及(F₂)經葛利普博士所鑒定之種類如左。

珊瑚類　1. Archaeocyathus chililense Grabau

腕足類　2. Ophilata squamosa Grabau

3. Fusispira sp.

頭足類　4. Protocarneroceras mathieui Grabou

5. Chihlioceras chingwangtaoense Grabau

6. Chihlioceras nathani Grabau

7. Philoceras platyventrum Grabau

以上化石、證明此層屬奧陶紀最下部。

寒武紀

予未得見奧陶紀岩石底部相接觸之水成岩、如葉劉二君所見頁岩石英岩礫岩等。故予對此紀以爲尙俟得化石後、始能確定也。

太古界

太古界岩石可見之處甚多、沿秦皇島至柳江之鐵路、及柳江後之村落左近、均是。此複雜岩石爲紅色正長石花崗岩、雲母花崗岩、片麻岩、偉晶花崗岩。近秦皇島及北戴河一帶、此複雜岩內又被他種岩脈侵入、如偉晶岩脈、雲母岩脈、不規則細岩脈及正長岩脈是。

地殼構造及地層不整一

予在石門寨左近、爲時短促、於構造方面、未能詳察。但就大致觀之、石炭二疊紀地層之向斜、套于其下奧陶紀地層向斜之上、其間未現有若何角度之不整一。此向斜東部石灰岩地層、傾斜又屢有變化、大致成一椅形摺曲、二邊急斜、而中部緩斜。此種摺法在直隸東部奧陶紀岩石中極爲普通。北嶺子附近奧陶紀下層石灰岩、原

作南北走向、轉而走向西北。

所有斷層、多與二疊紀後第三紀初之火成岩侵入時有關。

細察此區域及距此區域較近之他區域、則見此區域地層不整一。較他處爲多。最顯著者如左。

(甲)煤系下層　開平煤田內有海生石灰岩數層、含海百合化石。其中有一層名唐山石灰岩、與歐洲下石炭紀 Dinantien 相同、在此未見。

(乙)奧陶紀上層　此層中未見珠角石化石。

(丙)前寒武紀之岩石　元古界地層、完全未見、葉劉二君業經道及。但二君所稱爲寒武紀下部之石英岩及礫岩層雖不厚、或卽爲元古界之遺跡、亦未可知。在秦皇島及開平之間、奧陶紀下確有寒武紀含有標準化石、此寒武紀下又有元古界地層。依照維理士氏之分層、可分爲二系如下。

(一)滹沱系上部、自頂至底如左。

(子)黑石灰岩、帶方解石岩脈。

(丑)細粒薄層石灰岩、色變化不同、如紅褐綠黃、並似石印石灰岩。

(寅)紫綠頁岩及細層砂岩。

(卯)白或微紅石英岩及石英角礫。

(辰)赤粘土岩間、有薄層灰色矽質石灰岩。

(巳)白或微紅矽質石灰岩內、含雜色燧石不規則薄層。

(二)滹沱系下部　上述之滹沱系石灰岩所覆者爲厚層之石英岩及粗粒長石砂岩。在底部有時有一礫岩、其礫石皆爲太古界岩石所成。有數處所見礫石幾全爲 Itabirite 之鐵鑛石膠集于帶長石之砂岩中。凡此元古界地層、在灤州區域中猶極發達、而石門寨地方乃未之見。若謂其在古生界以前侵蝕無餘、似難盡信、不若以爲當時海岸或湖岸正在灤州與秦皇島之間、故石門寨地方又無若何之沉積。不然、葉劉二君所述之下層砂礫層、或即屬此系之代表。

(附誌)此篇爲前開灤煤礦地質技師比人馬底幼君所著其所見與本所葉劉二君從前調查互相發明其採得動物化石經木所葛利普君研究刋於中國古生物誌其標本並承馬君贈送本所故爲刋此文並記其緣起如此

山西保德地層

王竹泉

保德居山西之西北部、昔爲直隸州、民國改稱縣。縣城跨黃河之左岸、與陝西之府谷縣城隔河對峙、形勢自古爲要。其境內山川、黃土淤積甚厚。岩層率皆走向南北、傾斜西向。東部爲奧陶紀之海相石灰岩、西部爲中生代之陸相砂頁岩、中則爲海陸相交互沉積層。惟該層易被侵蝕、故顯露處甚低。在保德屬天橋扒樓溝一帶約凡百餘里、該層除在較寬之河床內微有露出外、他處率被黃土掩覆。作者研究地層之地點有二、一在扒樓溝、一在張家溝、皆係奧陶紀以上之岩層。蓋此役乃欲與瑞典人那琳君在太原附近研究上古生代與下中生代之地層相比較耳。

一、扒樓溝之岩層　扒樓溝在保德縣之南、距城九十里。所有岩層皆沿溝顯露、傾斜向西約十度左右。其間斷層及褶縐甚少、爲保德境內研究地層最適宜之地點、因得一詳細剖面如第二版所示。海陸相交互沉積層下部與奧陶紀石灰岩接近之處、在山西多含鐵鑛、如平盂潞澤其最著者。在此亦有含鐵之紅藍色頁岩、共厚約七八公尺、間亦有極劣之赤鐵礦石。其上再經厚約四十餘公尺之砂頁岩、則至產動物化石之石灰岩。該岩自下而上計四層。最下一層厚約二公尺、露出於扒樓溝村之附近、其中化石不易採集、僅得數種。次隔以含有植物化石痕跡之頁岩、厚不足一公尺。上即覆以第二層石灰岩、厚約一公尺半、因名爲扒樓溝石灰岩。曾於其中採得動物化石甚夥、今將葛利普博士鑒定種名列於左。

腕足類(Brachiopoda)

*Enteletes lamarcki Fischer

†Chonetes nystromi Grabau

†Orthothetes crenistria Phillips

†Productus punctatus (Martin)

Productus scrabiculus (Martin)

*Spirifer bisulcatus Sowerby

†Spirifer pankouensis Grabau

Reticularia lineata

*Spiriferina willisi Grabau

腹足類 (Gastropoda)

Loxonema? szichenyii Loczy

†Sphaerodona cf-mediale M and W

Macrocheilina kreitneri Loczy

化石之種名、旁冠以星標之記號者、因其亦產於太原之件廟溝石灰岩內、而冠以(十)記號者、則同產於太原之件廟溝石灰岩內、故扒樓溝石灰岩大抵與太原之煙煤層相當。再上則爲著名之煙煤層、厚約三丈六尺至四丈、重要之土窰皆集於此。

煤層之上爲厚約十公尺之土狀石灰岩，名爲保德州石灰岩（第一圖）其下部似帶砂質，上部含化石最富，經貴利華博士鑑定如下。

有孔蟲類 (Foraminifera)

Fusulina sp.

腕足類 (Brachiopoda)

Enteletes kayseri Waagen

Enteletes laeviusculum Waagen

Enteletes paotechouensis Grabau

Orthothetes crenistria Phillips

O. crenistria var. senilis Phillips

Chonetes cf. pseudovariolata Nikitin

Aulacorhynchus paotechouensis Grabau

Productus semireticulatus (Martin)

Productus subcostatus Waagen

Productus cora d'Orbigny

P. cora var. rarispina Grabau

Meekella kayseri Jaeckel

Spiriferina chuchuani Grabau

Spiriferina cristata var. octoplicata (Sowerby)

斧脚類 (Pelecypoda)

Myalina cf. ampla M and H

Entolium sp.

Aviculopecten sp.

腹足類 (Gastropoda)

Bellerophon anderssoni Grabau

頭足類 (Cephalopoda)

Huanghoceras simplicostatum Grabau

Remeleoceras subquadrangularis Grabau

Temnocheilus asiaticus Grabau

Metacoceras sp.

更上層以少許含植物痕跡之頁岩及煤層，則見含動物化石之黑色頁岩，厚約十餘公尺。內含石灰質結核，皆排列成層。近上部復含有一薄層石灰岩。而此頁岩及石灰岩結核內，皆含化石甚富，且易得完全之介殼。總上

所述、岩層共厚約百公尺、是爲石炭紀煤系。經葛利普博士鑒定化石之結果、謂三丈餘厚煙煤層之下、屬下石炭紀上部或中石炭紀下部、以之列入太原系、而厚煙煤層之上、則屬於石炭二疊紀、以之列入狹義之山西系。至厚煙煤層之眞確時代、則仍屬疑問焉。

海陸交互沉積層之上、爲過渡層。此層內無海相化石、且最著者爲黃色岩層、露出於扒樓溝村西與劉家坡之間、共厚約一百六十餘公尺。下部爲黑色頁岩煤層及白砂岩等、上部爲綠色或黃色頁岩及綠砂岩等。富含植物化石、現已發見四層。所採者現皆寄往瑞典鑒定、其時代大致似屬二疊紀。此層之底與海陸相交互沉積層接觸者、爲礫狀砂岩、有時完全爲礫岩、厚約十餘公尺。頂部漸現紅綠頁岩。全層內亦偶有少許石灰岩結核。其下部所含煤層、在扒樓溝附近不甚發育、尙未開採、但在保德城東、則此種煤層似已開採甚盛。

過渡層之上、紅色頁岩特著、是爲胡松層。（沿用民國六年平孟潞澤地質報告中之名稱）分佈於南河溝一帶、其中砂岩多綠色或白色、有時礫狀或呈紅色、而頁岩中偶現少許綠色或黑色者、則含有植物化石。此次計採集五層、最下一層在礫狀砂岩間之頁岩內、僅得一兩種、第二層得自南河溝村南之黑土溝、第三層在南河溝村西之前席子、第四層採自西南溝、第五層採自村西約六里之溝內、只得一種。所有化石、亦皆寄往瑞典、尙未鑒定、然大抵當屬二疊紀。全層厚度約三百餘公尺。層內在他處往往含石膏、當時天氣似甚乾燥。在此則未發見。因層內頁岩特別發育、故恒組成紅色低緩之山坡、在山谷間極易辨識。

胡松層之上、則砂岩爲主要岩層、前在大寧屬之馬斗關曾名爲馬斗砂岩層。其下部爲白色或紅色砂岩、間成斜層狀。（Crossbedded）上部則爲淺紅色或稍帶灰色之砂岩、成分爲斜長石雲母及石英、因名爲長石砂岩。

(Arkose) 各種砂岩之間、皆隔以薄層紅色頁岩。在此層內尙未發見化石。然其時代似仍爲三疊紀之一部、因聞陝西境內於此層上復有疑似侏羅紀之含煤系也。

二、張家溝之剖面　扒樓溝之北約二十里、爲張家溝、距縣城七十里、在此僅得海陸相交互沉積層之剖面、如第二圖所示。含動物化石者亦爲四層、惟最下一層露出於張家溝村南之河床內、其所含化石較易採集、因名爲張家溝石灰岩。化石之種名經葛氏鑒定如左。

珊瑚類 (Anthozoa)

†Lopholasma carbonaria Grabau

†Lophocarinophyllum acanthiseptum Grabau

腕足類 (Brachiopoda)

*Enteletes lamarckii Fischer

†Choncetes nystromi Grabau

†Orthotetes crenistria Phillips

†Productus taiyuanfuensis Grabau

P. punctatus var. elegans McCoy

Productus scrabiculus (Martin)

Productus cora d'Orb.

Productus semireticulatus (Martin)

*†Spirifer bisulcatus Sow.

*†Spirifer pankouensis Grabau

*Spiriferina willisi Grabau

Athyris orientalis Grabau

Camarophoria changchianense Grabau

三葉蟲類 (Trilobita)

*Griffithides quadrinodus Grabau

Phillipsia kansuensis Loczy

葛氏謂此層灰岩與太原附近之件溝石灰岩相當。其下有煤層厚約尺許、其上距村西之扒樓溝石灰岩約二十公尺、中隔以頁岩及白砂岩等。扒樓溝石灰岩與保德州石灰岩(露出於張家溝村西約一里半)間之煤層厚度、在此增至二十公尺、頁岩增至十餘公尺。於保德州石灰岩內、在此採得化石亦夥。再上亦隔有薄層之煤與頁岩、即遇最上含動物化石之頁岩層。其地點適在土門村東約五十步、因名爲土門頁岩層。內含厚近一尺之石灰岩、時斷時續、並於其中採得化石。復上則近過渡層之礫狀砂岩矣。茲將葛氏鑒定土門頁岩內之化石列於左。

腕足類 (Brachiopoda)

Orthothetes crenistria Phillips

Productus semireticulatus (Martin)

Productus subcostatus Waagen

Productus cora d'Orb.

P. cora var. rarispina Grabau

Productus pustulosus (Martin)

Athysis royssi var. orientalis Grabau

Pugnax sp.

斧足綱 (Pelecypoda)

Pseudomonotis mathieui Grabau

Pseudomonotis sp.

Allorisma sp.

Schizodus sp.

腹足綱 (Gastropoda)

Bellorophon calamitoides Grabau

Euphemus wongi Grabau

Gyronema? altispiralis Grabau

Mourlonia cf. propinqua Mansuy

Soleniscus sycumoides Mansuy

Soleniscus cf. braeris White

Soleniscus sp.

Sphaerodoma subglobosa Grabau

Aclisina sp.

Meekospira sp.

Naticopsis cf. ventricosa Norw. and Pratten

Naticopsis sp.

頭足類 (Cephalopoda)

Orthoceras sp.

Remeleoceras subquadrangularis Grabau

葛氏謂保德州石灰岩與土門頁岩之時代屬石炭二疊紀大抵與江西之樂平煤系相當。並謂土門頁岩又相當於太原附近之東大窰石炭岩云。

附錄桑園村東之地層　保德城東南二十五里當桑園村。該村之西，岩層皆埋沒於黃土之下，村東岩層露出

倘多、此剖面與前稍異者、乃不含動物化石灰岩層。此或原於不易覺察之細微斷層、乃因有不整一之現象、所有含海相化石石灰岩皆被侵蝕淨盡、亦未可知。在此共得煤六層、重要者三。又含厚約四十餘公尺之礫狀砂岩。而此礫狀砂岩相當果爾、則無動物化石石灰岩層。或由不整一所致也。

中國始新統之湖產軟體動物化石

俄德納原著
孫雲鑄節譯

（一）通論

中國第三紀初統地層、至今尚未正確證明、然據各學者之調查、已推知其當有存在者。愛本達農氏 Abendanon 於西歷一千九百零七年研究四川紅盆地地層、其層序由下而上可分七部。第五部與歐洲里的系 Rhaetic（上三疊紀）相當、第六部爲含貝殼泥岩層、第七部爲紅色岩層。法拉西氏 Frech 謂第六部與英國之 Wealden 系（下白堊紀）相當、則此紅色岩層、似屬上白堊紀或第三紀之下部。

安特生博士曾於中國山西垣曲縣黃土層下、發見湖產貝類化石多種。安博士以此類新發見之化石、極有研究價值、介紹瑞典地質調查所代爲鑑定。

產此類化石之地層有二、一爲灰色泥質石灰岩、一爲堅質棕紅色粘土。前者產腹足類之平捲貝 (Planorbis) 及 Physa 兩屬化石。後者產貽貝極多、惟平捲貝 Planorbis 不多見、Physa 則無之。

平捲貝 (Planorbis) 化石、保存尚稱完全、與歐洲德法諸國上始新統所產之 P. pseudammonius 相似。他如 Physa 一屬、保存雖不完全、然尚可以鑒定、與法國下始新統所產之 Ph. lanberti 亦極相類。據此可知產此種化石之灰色泥質石灰岩、其時代似屬始新統。又一說謂此項垣曲地層實較始新期爲新。其中所含動物、實爲歐洲種類之遺剩、其生活時代實在同類動物在歐已滅之後。此二說驟難判決、惟有就中國近代地質史中求其反證。

中國三疊紀以後不復有海相地層、自三疊紀至白堊紀底部、皆爲陸地沉積。由白堊紀至上新統、則其地層皆不可攷。大抵其時侵蝕劇烈、第四紀洪積統之黃土及河流沉積、皆由此種侵蝕物質所組成。第三紀時代東亞氣候似温和多雨、始新期內當尤甚。故由地質方面觀之、此垣曲地層之層位、僅能知其在黃土之下。而黃土中所發見之軟體動物、其時代多屬洪積統。據黑爾勃氏等 Hilber, Andreae, Sturany 及 Schlosser 之研究、確知此類軟體動物與中國近代所產之軟體動物相同。是則中國之黃土層亦猶歐洲之黃土層、其時代屬於第四紀洪積統、當無疑義。中國第四紀之陸產（或淡水產）軟體動物、與現生之種類相同、既如上述矣。然此篇所論之軟體動物則與之迥異。且據法拉西氏之研究、亦謂中國各處確可有第三紀下部之地層。是則以垣曲產此類化石之地層屬於始新期統、不得謂無根據矣。

不特近代生物在歐亞相同、即歐洲第三紀所產之各種化石、亦有相似之點。蓋歐洲之第三紀遺留生物、並發見之於中國、足證歐亞兩洲之生物、互有連續關係。即謂此連續時期在於始新統亦無不可。

（二）各論

化石保存多不完全、然尚足以鑒定其年代、略論之如下。

腹足類

Planorbis pseudammonius Schlotheim 包括 Leymeriei Desh. 一族（第一版第一至第四各圖及插圖第一）

螺環生長極緩、住螺環特別增大、螺頂微向於下。第一二兩圖爲法國始新統化石、第三四兩圖爲中國所產之

化石。中國所產之最大者（如第三圖）若不損壞、則殼之直徑約有二十八公厘。螺環有七。表面上之條紋、中法標本大致相同。

Planorbis sparnacensis Deshayes（第一版第七及第七甲兩圖）

直徑五公厘、與山德保格 Sandberger 所鑒定者極相似。上部微凹、螺旋綫極顯明。第七甲圖爲化石表面放大之形。螺環有四。

Planorbis chertieri Deshayes（第一版第八圖及插圖第二）

螺環低凹、爲此種之特別標記。其中脊頗鈍、首殼亦極小、與現在之 P. fontanus 相似。其直徑約三公厘、螺環有四、爲此種化石之最小者。

Physa cf lamberti Deshayes（中國標本以此作比較第一版第五六兩圖）

形似長卵、螺旋部破碎、頗不易鑒定。然住螺環及其相接一螺環、保存尚完全、由是可以推測其爲塔形。且其縫合綫極淺、極與法國下始新統之 Ph. lamberti 相似、爲 Physa 屬化石中形狀之最窄者。現在北美乍美嘎島 Jamaica 及南美所產之 Ph. sowerbyana 亦與之相似。

Euchilus deschiensianum Deshayes（第一版第九至第十一圖）

第九及第十兩圖爲螺蓋、第十一圖爲貝殼。螺蓋上有多數細圈、圍繞中核。殼高五·五公厘、殼口長三·二公厘、表面上有極多之細生長綫、最大殼口長三·二公厘。

Cerutodes sinensis 新種（第一版第十二至第十五各圖及插圖第二）

形如平捲貝、貝殼扁平、爲左卷式。螺頂如珠、有三螺環。自此以後、螺環增長極速。螺環有六、最末一螺環特別發育向外伸長、尤以下部爲甚、常成凹形、表面上僅有無規則之生長綫而已。如第十四五兩圖爲外部之放大形。此種貝類現在南美所產甚多。可知中國所產此種化石爲南美產之 Ceratodes 及非洲產之 Lanistes 之連接生物。而 Lanistes 一屬、似發源於亞洲、後漸移於非洲者。（詳見英文論文中）

瓣鰓類

Eufera sinensis 新種（第一版第十六至第二十二各圖）

殼有帶四角卵形者。嘴凹處距前方爲其全長四分之一。後方距嘴較遠。背邊在嘴後、常與後方邊成角度。表面上有生長綫及小點。右殼嘴之前後有側齒各一、頗不顯明。殼長四公厘、高三·五公厘。此種化石爲始新統之標準化石。

（三）地文學

總觀上列化石、足證當第三紀始新時期中國與歐非南美諸州各大陸互相連絡。其連接之處或在亞美兩洲交界之白令地腰。（現在爲海峽）當時生物之分佈、西至歐非東達南美。此頗有事實上可以證明者也。

（附誌）始新統化石在中國此爲初見民國十年本所謝家榮君續發見之於甘肅固原民國十一年冬本所譚錫疇君會同安特生博士發見之於山東新泰一帶從知此項地層在中國甚爲廣布而所以確定此層時代者實賴俄氏此著特爲誌其關係如此

直隸易唐蔚等縣地質鑛產

李捷

民國八年夏四月初旬、奉　派前赴直隸西部、調查地質鑛產。是役也、首自淶水縣、易縣、一帶、次第進行、而及於蔚縣、淶源、阜平、曲陽、唐縣、完縣、滿城、諸屬。統計南北長約三百餘里。東西寬約一百六十餘里。調查六十餘日、始獲就緒。茲將各處所見情形、分述於左。

第一章　地形

（一）山岳　由淶水至易縣、有京漢鐵路之支綫通焉。路綫以北、爲百米突內外之片麻岩、及硅質灰岩山。路綫以南、均屬平原。自易縣至下口子、仍爲片麻岩、及硅質灰岩諸山。地勢尙緩平。前進至奇峯嶺、高度約六百米突、純爲硅質灰岩所造成。由奇峯嶺而西北、經奇峰口者、長城要口之一也、抵南城司、萬壁叢錯、所在皆是。奇峰口因其位於奇峰嶺之麓、故名。自此沿拒馬河至黑兒口、衆山綿延、勢若游龍、高度自五六百至七八百米突。歷黑兒口、而迄大河南、高度漸增。中經賀嶺、高約七百七十米突。由大河南至嶺南、峰巒聳疊、道路崎嶇、以魚皮嶺爲最、高約一千三百四十米突。復由嶺南至柏樹村、道經小五台、松子嶺、山容壯偉、地勢險阻、嘗度五台山之中台、高度約一千八百米突、惟其最高之峰、當推南台、次爲中台、北、西、兩台爲最低。近柏樹村則山勢漸低、已入平地矣。以此直抵蔚城、及北口堡一帶、爲一小平原。由北口堡入四十里峪、折而南去至淶源、途經黑石嶺、高約一千六百六十米突。淶源地基高出京地八百餘米突、羣山集輳、土地瘠薄、人民寒苦。過淶源沿拒馬河而東至紫荊關、兩岸稍有平地、山勢漸呈緩平象。岩石爲略受風化之花崗岩。紫荊關高出京地六百米突。建於明萬歷十七

年。山川環抱、形勢險要、爲昔時防守重地、亦燕京西南之門戶也。過關東南行至西陵、又爲二三百米突高之片麻岩、及硅質灰岩、九龍系紅頁岩、奧陶紀純灰岩等岩層所成之邱陵、形勢稍平。復由滿城正西渡唐河、平陽河、而抵阜平、峰巒又起、高出北京平地約自四五百米突至千餘米突不等。自阜平折而東北、經走馬驛、揷箭嶺、而至淶源屬之石門村一帶、大部份爲片麻岩、及硅質灰岩所成之山嶺。高度自五六百米突、以至千餘米突。由石門村南去、越鼻子嶺、歷倒馬關而及王快鎭、山川交錯、尤爲險要。倒馬關建於明萬歷十四年、有唐河曲繞於其旁、爲燕晉咽喉之地、明清兩代、屯兵於此、視爲重鎭。由王快鎭正東經龍泉鎭、而抵唐縣、其間山勢漸低、爲燕晉往來大道、二輪大車、可以通行。

（二）河流　調查範圍內河之大者有三。一曰唐河、卽禹貢之恆水、漢志名寇河、以行經唐縣、故名。唐河源出晉北渾源縣南七十里之翠屏山。山海經高是之山滱水出焉、高是卽翠屏山也。自渾源東南流、經靈邱縣入直隸境、經倒馬關至唐縣西北隅、東流入完縣境、由神北村折而南去、經唐縣城之西、東南流入定州界、沿岸稻田甚多、頗利灌溉。故唐縣爲近畿稻鄉焉。二曰拒馬河。卽古淶水、源出淶源縣。東流至浮圖峪、折而北經王安鎭、出塔崖驛、復東流由紫荊關而北、經南城司、至蓬頭。又東流過易縣北境、及淶水縣東北境。下流入涿州、房山界、水勢甚急、漲落無常、不便舟楫、僅可藉資灌溉田地而已。每屆夏秋之交、時有漲落之害。三曰沙河、卽古派水。源出晉北繁峙縣東白頭坡。南流入直隸阜平縣。至五丈凹折而南去。經王快鎭、復東流至鄭家莊。東南流入曲陽縣界。沿流引渠灌溉、頗稱便利。其次則爲平陽河、沙河支流之一也。源出阜平縣神仙山之陽。經康家峪至賈家口、滙入沙河、水勢甚小。上流水量細微、不足爲用。下流過康家峪、水量漸增。沿岸田地稍獲灌溉之利。

(一)片麻岩系　本屆調查所見之地層最古者爲片麻岩。殆於我國泰山層相當。其展播地域、以自下口子之東、經上乘驛、金坡、喬家河、等處。西延以至倒馬關、落路口、阜平、一帶、爲一大部分。由南城司、經賀嶺、南坨嶺、一帶、爲一小部分。倒馬關阜平一帶之片麻岩、因受風化作用、岩質疎鬆。在南城司賀嶺附近者、則硬度較高、猶呈片狀組織。其含雲母質稍多之處、每呈黑色、片理分明、易於剝裂。其含雲母石較少者、則現微黃灰色、時有偉晶花崗岩脈以貫之。

(二)新元古系地層　岩石爲硅質石灰岩及黑色板岩二種。似與南口系地層相當。惟未見有石英岩層耳。板岩覆於硅質灰石之上。兩兩整合。如涞水易縣之間、魚皮嶺嶺南一帶、易屬西南石坡嶺附近、均有黑板岩之露頭。層厚約七八十米突。但於石坡嶺及易涞之間所見者、質分較粗、且含石灰質少許、厚亦不過五六十米突。至硅質灰岩分佈之地、頗爲廣大、八里坡、奇峰嶺、大河南一帶、蔚屬北口堡大嶺之間、完縣易縣境內、阜平康子台王快鎮之東、以及唐縣以北與完屬接連諸山脈、均有其露頭。岩石係灰色。薄層狀組織。中含塊狀、或帶狀、黑色燧石。層厚約自八九百米突以至千米突。但於阜平康子台附近。則僅厚五六十米突。

(三)寒武紀地層　岩石初爲紅色頁岩、內含白雲母、及鐵質、少許、有時尙含砂質、幷常挾薄層細質砂岩、略現微紅色。次爲緬狀石灰岩、與薄層微黃色灰岩相間成層。再次爲竹葉石灰岩、或爲紫紅色、或爲黃灰色。全系總厚約五百餘米突。見於蔚屬孫子嶺、柏樹村、一帶、涞源縣之黑石嶺、完縣台魚易屬塘湖、等處。

(四)奧陶紀灰岩層　其分佈地域、以自曲陽靈山鎮至完屬寨子以西爲多、而於易屬神石莊一帶、猶得見之。

岩層位於九龍系岩層之上、似相整合者。其岩石爲灰黑色灰岩。有無數白色方解石脈、交錯其間。傾斜方向、大致西北二十度、或三四十度。厚約三百餘米突。

(五)石炭紀煤系　露頭範圍厥有二部。由曲陽大七車村經靈山夜北一帶、至龍泉鎭之北爲一部。阜平炭灰舖一帶、又爲一部。岩石以灰色砂岩、頁岩、砂質頁岩、爲主。所有煤層均爲無煙煤。其詳見下鑛產章。

(六)紅色砂岩層　此層僅於曲陽大七車村西北見之。位於石炭紀煤系之上。傾斜一致。岩石爲紅色砂岩、深受風化、岩質粗鬆。厚約百米突。並無化石。其性質及地層位置、似與唐山之紅砂岩相似。

第三章　地質構造

易縣八里坡硅質灰岩層之走向、大致由東北而西南、傾斜向東南二十五度、恰與八里坡岩層相向、成一內斜層、過五里房之片麻岩而往、則爲奇峰嶺奇峰口一帶之硅質灰岩層、傾斜角度約在十度、傾斜方向與前適相反、爲一外斜層。奇峰口以北、上辛莊、金水口、以南、又見片麻岩露頭、似與五里房一帶之片麻岩互相接連、惟以花崗岩之侵入、致裂而爲二。凡花崗岩與片麻岩接觸處、片麻岩石往往錯亂紛紜、不可名狀。由上辛莊、金水口、一帶、以迄嶺南、硅質灰岩層之傾斜方向、一如其前。傾斜角度或五六十度、或二三十度。有雲母花崗岩侵入其間。露頭有二、其一在河南口子、金子片、等處、其一在嶺南附近。接觸處之硅質灰岩、俱變爲大理岩、層向亦均淆亂、或東或西、頗呈異相、其受花崗岩影響所致無疑。由嶺南至松子口、其間地層呈一內斜層。松子口附近九龍系岩層走向爲正東西、傾斜向南六十五度、惟間有小折皺、傾向變化無常、傾角有僅八九度、幾近水平者、北口堡硅質灰岩層走向東北而西南、傾斜向西北四十度、南去一

里許走向如前、而傾斜向則相背。復前進至明舖傾斜角度漸小、約十度左右。及近岔道、傾斜向西北五六度、折皺似甚平緩。至大嶺則走向未稍變、而傾斜向又復東南三十度矣。過大嶺爲紅色頁岩層、傾斜走向與硅質灰岩似相一致、傾斜角度亦相若。南去至團圓、留家莊、金井一帶、紅色頁岩層、與涞源東石門村硅質灰岩、傾斜方向、大致均取西北、傾斜角度約在二十度左右、正與大嶺附近斜向相向。適成一內斜層。石門村東南則爲大塊花崗岩、其發育地點、東起紫荊關、北至黃安嶺、南經岔嶺、插箭嶺、鼻子嶺、一帶、與片麻岩爲界。風涼溝之硅質灰岩、則直覆於花崗岩之上、已變爲大理岩、含有石棉鑛甚富。周家舖、四裡、以西之硅質灰岩、平列於片麻岩之上。藩台村南則見九龍系岩層直覆於片麻岩之上、是併元古界全部地層形銷而跡絕矣。古道村北東兩方、又見硅質灰岩層、厚約五十餘米突、其露頭南去經落路口、康子台之東、折而東北、圍繞於炭灰舖之東南、形呈狹帶狀。傾斜方向不一、在古道北東兩方、傾斜向近直立、在康子台以東、傾斜向東北七十度。（詳見炭灰舖煤田構造一至王快鎭以東之硅質灰岩、與在易縣西八里坡者兩相銜接、傾斜方向大致均取東南、傾斜角度自二十度、至三十度。東莊灣、安陽、石井、南北考、一帶之硅質灰岩、傾斜方向、大致均取正西、或西北、傾斜角度自十五度、至三十度、與大小龍華、于河、王安鎭、以東之岩層、傾斜相向、成大內斜層。其軸部岩層屬九龍系、散佈最廣、如塘湖、南台魚、寨子、窩家莊等處是。與陶紀石灰岩、大部份現於南台魚之西、龍泉鎭附近。其東部岩層。恰位於九龍系之上、兩相整合、傾斜一致。其西部則見於硅質灰岩之上、傾斜似近一致、而兩層實不整合。神石莊周圍之奧陶紀灰岩、其西部仍依地層次第位於九龍系岩層之上。而東部則又似覆於硅質灰岩之上。而九龍系岩層至此已全形絕跡矣。

第四章　鑛產

此次調查所見之鑛產、爲石棉鑛及煤鑛、至易縣滦水之鐵鑛、翁先生已經詳細調查。此行以時間有限、未及細察。茲將石棉鑛煤鑛分述如左。

第一節　石棉鑛

石棉鑛滦源及易縣均產之、鑛生於大理岩內、鑛脈交錯、形似網狀。脈寬自一二分至二寸餘不等、多沿花崗及硅質灰岩之接觸帶。附近灰岩、均已變爲大理岩、是殆受花崗岩之灼熱作用所致。而花崗岩之後於灰石而生成。似亦已無疑義。惟鑛地僻處山輒、交通不便、故鑛業未見發達。現下開採者、僅滦源水泉溝裕榮石棉公司一處。其開採方法以鐵鏃等、爲開洞之器。洞多沿鑛脈前進、所採之鑛塊、多挾石質、須用石以碾碎之、將雜質除去。鑛工人數無定額、春季秋後人數增多、夏季農忙則較少、大約多時可達百名、少時四五十名。每名每日工資銅元二十四枚。產額多寡不等、多時每日可五六百斤、少時二三百斤。所出鑛石均以騾馬自鑛地裝運至易縣車站、約一百五六十里。運費每十斤大洋兩毛。專銷售於北京天津二處。

第二節　靈山鎭煤田

(一)位置及交通　靈山鎭煤田、在直隸曲陽縣、縣東北四十里、西接阜平、東界唐縣、沙河繞其右、恒河經其間。距京漢鐵路定州靑風店各站、均約五六十里。由鑛地沿恒河東南去、約二十里、即爲平原。二輪大車可循恒河通行、交通便利。

(二)地質　靈山鎭地基、高出於北京地平、約三百六十米突。附近地層可分三系、最古者爲擊州灰岩、次爲石

炭紀煤系。再次爲紅色砂岩層。傾斜方向、三者一致。其構造乃一內斜層。內斜層之軸部、傾向東偏南、是以西部地勢較高。南翼之地層傾向北偏西、傾斜角爲三十五度。北翼之地層在燕窩一帶、傾向南偏東。在夜北一帶、傾向南偏西。其傾斜角度均爲二十度。兩翼環抱於靈山鎭之北。故沿靈山鎭、大七車村、官莊、一帶、均爲石炭紀煤系。大七車村而北、其上覆以紅砂岩系。至靈山附近、則黃土覆被甚厚、故煤系露頭、每不易窺見云。

(三)煤層　就本地土窰之開採、知共有煤七層。第一層名明片厚一尺。第二層名葫蘆沾、厚三尺。第五層名青千積、厚五尺。第六層名海拉扒子、厚二尺半。第七層名洛炭厚自五尺、至八九尺。平均約七尺。煤質以洛炭爲最佳、惜處於極深地位、往往爲水所佔、土法採掘、治水爲難、是以開採此層者、殊屬寥寥。次則青千積、亦可供普通燃料、惟不及洛炭火力之旺耳。餘如海拉扒子煤千、白煤、葫蘆沾、月片等、則品質駁雜、作暗黑色、末多塊少、且含硫分較多、燃燒之際、富於氣味、要非佳品也。惟青千積及洛炭層、在夜北燕窩一帶、據各小窰開採結果、已形薄弱、厚祇三五尺、大有愈近邊境則層愈薄之勢。卽其他各層亦復厚度稍減。官莊以南及西南、昔年開採甚盛、今已相繼停業、窰下情形無從探悉。茲就現時鑛業最發達之部、北至夜北、燕窩、以至靈山一帶、以計算其煤量大約、可得三千萬噸。

(四)沿革　據本鄉人士云、該煤田發始於清乾嘉時代、其時深谷山澗之地、經水流剝削之力、煤層漸露、煤末多有遺留於流水中者、於是鄉人從事探挖。其開採之處、率在官莊大七車之南部。沿奧陶紀灰岩之山旁、煤窰林立、運煤牲畜、絡繹於途、頗稱一時之盛。迄至咸豐同治年間、窰下工程漸形複雜、且經年既久、工程方面、未免多生困難。或以窰頂陷落、或以鑛洞道遠、得不償失、或以水勢過大、相繼歇業、而南部鑛業因之零落殆盡。而一

般粗具經驗之人、遂追踪求跡於夜北燕窩一帶、開闢新業焉。以地勢論之、實較前者爲勝、地層平緩、從工較便。然窰下水量、實比南部爲大。於靈山附近第五六七三層、往往爲水所淹、窰內工作、頗感困難。於夜北燕窩等處、水稍較小、前年曾有本地紳商、擬用新法、籌資大辦、迄未見諸事實。將來如果實行、則是地煤業、亦不難發達也。

(五)現況　南部煤窰早已廢棄。即北部窰廠亦因上數層、均經採掘殆盡、施工甚難、下數層雖蘊藏尙富、而光復以還、或以資本不足、或爲地勢所限、相繼歇業者、已有十數家。是以近年鑛業驟形減色、現時動工者、僅夜北燕窩靈山村旁四五窰而已。靈山窰以出青干積白煤洛炭著。夜北以產青干積月片著。燕窩以產胡蘆沾、煤干、青干積、洛炭著。然大半非終年工作者、每於農事完畢之時、隨便探挖、以供應用而已。惟靈山窰逐日出煤甚盛、鑛業較爲發達耳。

(六)產銷　產額以靈山窰爲最多、每日至多可出煤二十噸、少時可十五六噸。其他各窰多非常期工作、無一定產數、約計之每日總額要亦不過三十噸也。所產之煤、大都銷售附近五六十里以內者爲多、如唐縣、曲陽、阜平、東部等是。當京漢鐵路未修以前、尙可運輸保定定州一帶。每斤售制錢七八文云。

第三節　炭灰舖煤田

(一)位置及交通　炭灰舖煤田屬阜平縣、位於縣東北境、距縣城六十里、因附近出產石炭石灰故名。地多山嶺、道路崎嶇、交通不便。

(二)地質　煤田附近地質、茲由古及新次第述之。最古者爲片麻岩。次爲新元古系之硅質灰岩、此層於炭灰舖一隅爲層特薄、厚約五六十米突、傾斜向大致東北、傾斜角度約七十餘度。再次爲寒武紀下部紅色頁岩、與

薄層微黃灰色灰岩相間成層、厚約六七十米突、傾斜向東北八十度、幾近直立、其上部爲鮞狀石灰岩與竹葉石灰岩、厚約五六十米突、傾斜向東北三十度。又次爲奧陶紀石灰岩其下部灰褐色可燒石灰、厚約三百二十餘米突、其上部係淺灰色、微含硅質、間挾卵狀或帶狀燧石、厚約三百六七十米突、其傾斜方向、一致向北偏東三十度、又次則爲石炭紀岩層、以褐色頁岩及灰黑色砂岩爲主、厚約二百二十米突。含煤地層與其西部奧陶紀地層接觸處、有正向斷層、故煤系岩層稍形錯亂、傾斜向西北八十度、幾近直立。其西南則自奧陶紀以迄新元古系岩層、整然以列、未受影響。據此以推、殆當時地層以西南受擁擠之力、有東北向之趨勢、而煤系地層受其動搖、因即斷裂、然其與東部之奧陶紀灰岩層、仍秩然有序、故此斷層、僅限於西麓、範圍殊不大也。

(三)煤層　共有煤四層、盡係無烟煤。第一層厚約五尺餘、質分純良、火力耐久。第二層厚約二尺半。第三層厚約四尺、質雜不純、混合硫質、燃燒時放臭煙、名爲臭煤、第四層厚約一尺半。惟其煤層據窰洞內所見、近乎直立、施工計畫、自較爲難、加以面積狹小、限於地勢、故終未能出煤暢旺也。

(四)鑛業　該煤田自光緒初年、由土人開採、未幾被水淹沒。至光緒末葉、經一度整理、鑛業於是大盛。鑛井十餘處、深有至三十五六丈有奇者。惟煤田全部不及二方里、面積既小、又爲地勢所限、宜於土法小辦。本地紳商嘗有籌資大辦之議、亦以鑒於面積及地勢關係、旋即作罷。現時祇有三數小窰、從事採挖、每日總產額亦不到一噸云。

第五章　結論

綜觀全部地層折皺現象而論、其內斜層及外斜層之軸部、均沿東北西南方向。即諸山脈亦皆東西縱列、如奇

峰嶺、岔嶺、狼牙山、均東西山脈也。諸河流循於天然之形勢、多向東流、故造山原動力之發生、當來自西北或東南方向。惟地層自太古界以達古生界、並未有劇烈之變動、故岩層前後傾向、大體相同。論其構造大概可分南北兩部、以片麻岩爲樞紐。該二部正爲二內斜層。而片麻岩所處地位、適爲大外斜層之軸部。其成因當與花崗岩有密切關係。顧按之地史、太古界之上、應接以五台系。然調查區域內、五台系岩層、曾未一見、且新元古系之下部石英岩、亦全缺乏。僅見上部硅質灰岩、於奇峰嶺北口堡等處、最爲發育、常厚達七八百米突或千米突。於阜平康子台附近則厚度銳減、僅五十餘米突。又藩台之南、九龍系岩層、直覆於片麻岩之上。龍泉鎮、神石莊等處之奧陶紀灰岩、覆於硅質灰岩之上。其間地層進退消長之關係、尤堪令人注意也。

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CONTENTS.

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CONTENTS

THE APATITE DEPOSIT AT TUNGHAIHSIEN, KIANGSU.

(*Summary*)

BY

C. C. Liu

Location—The deposit is located on the south side of Chu Shan (朐 山), south of Tunghai. At its west end, there is the Chao Ho (river) (潮 河), which runs down 18 li to a seaport, called Hsin Pu Cheng (新浦鎮). Steamships may be placed at anchor there at high tide.

Geology—The Chu hill is composed of gneissic rocks of the Archaean system. It is partly of dome-structure. Aside from the northern part, the rocks at the hillside belong to schists of a later age. The ore lies right underneath this schist series. A fault occurs in the middle part of the mapped region. This accounts for the fact that the strata on the northwest side of the fault dip toward northeast, while those on the southeast side dip toward the south.

Ores—The phosphate ore is found together with the manganese ore. The former occurs as apatite, $Ca_5(Cl,F)(PO_4)_3$. It is a replacement deposit, in which the ascending hot water has taken into solution a part of the limestone and has deposited in its place the mineral apatite. The manganese ore occurs largely in the form of pyrolusite, MnO_2. Its origin is apparently due to the weathering of hornblende and augite in the schist series, with the resulting formation of manganese peroxide. In the course of time, this substance is dissolved in the underground water and redeposited in the present form.

The high grade apatite contains more than 49% of P_2O_5, which is comparable with the best ore produced in Canada. The commercial grade is said to contain 33%, according to the specification of the buyers.

Mineral Industry—There is only one mining company in operation. It is called Chin Ping Company (錦屏公司). Up to the present time (1919)

it has produced 6,000 tons of ore, of which 2,000 tons have been sold, while the remaining 4,000 tons are still in store. The price is 39 Yens per ton. There is a narrow gauge railway connecting the East and West Mines and the river front.

江蘇東海縣朐山燐鑛地質圖

GEOLOGIC MAP OF APATITE DEPOSIT OF TUNG HAI HSIEN, KIANGSU.

劉季辰測

Surveyed by C. C. Liu 1920.

一之分千五萬二尺縮

Scale 1:25,000

鑛層東截線面圖

Section showing eastern Apatite deposit.

一之分千四尺縮

太古及元古界

Archean and Pre-Cambrian

沖積層	系岩片晶結	片岩及鑛層	系岩麻片
Alluvium	*Crystalline Schist*	*Schist with Apatite(green) and Manganese (violet)*	*Gneiss*

THE LATE PALÆOZOIC AND EARLY MESOZOIC SEDIMENTS OF CENTRAL SHANSI

BY

E. NORIN.

CONTENTS

Bulletin of the Geological Survey of China

THE LATE PALÆOZOIC AND EARLY MESOZOIC SEDIMENTS OF CENTRAL SHANSI

BY

E. NORIN.

INTRODUCTION

In the beginning of 1921 Prof. E.T. Nyström of Shansi University, Taiyuanfu, proposed to Dr. J.G. Andersson of Peking, a scheme of coöperation with regard to my geological work in central Shansi, and on the proposition of Dr. Andersson it was decided that a considerable part of the year in question should be devoted to a stratigraphical investigation of the lower part of the socalled Shansi formation, whereby I should use the Nyström Institute as headquarters. Dr Andersson then transferred to me information regarding a number of localities in different parts of the province, where fossil plants had been found by his Chinese assistants.

The most valuable of these for my work was a locality containing a *Gigantopteris* flora, which was discovered in June 1919 by Messrs Yao (繳) and Ch'ang (張) at the village Ch'en Chia Yü (陳家峪) in the valley Shih Ho Tse (石盒子) not far from Taiyuanfu in an eastern direction. In this valley the Permo-Triassic sediments are laid bare in a very fine and complete section. The abundance of fossils in these rocks caused me to start here a systematic search of the whole sedimentary series, for the purpose of finding fossil-bearing horizons.

Thanks mainly to the very willing assistance given by the inhabitants of Ch'en Chia Yü, the result has been the accumulation of large fossil collections from not less than 15 different horizons from this section alone.

According to the same method the work has been carried on in the western marginal hills of the Taiyuan basin. In the valley Yueh Men Kou (月門溝) a complete section comprising more than 1000 meters of sediments belonging to the lower part of the socalled Shansi formation is to be found. My attention to this section was first directed by Prof. E.T Nyström in February 1920.

For the purpose of expert determination of the marine fossils found by me, Dr A.W. Grabau the well-known expert on Palæozoic faunas and Palæontologist to the Geological Survey of China has kindly promised to work out the material and to place fossil lists at my disposal. The Geological Survey has also promised to send back to Shansi a labelled collection of these marine fossils which will be presented to Shansi University.

To satisfy the interests represented by Dr. J. G. Andersson, collections of fossil plants belonging to 27 different levels within the Carboniferous, Permian and Lower Triassic are to be forwarded to the Swedish State Museum of Natural History and will be worked out and determined by the Director of the Department of Fossil Plants in that Museum, Prof. Dr. Th. Halle. As in the case of the fossil invertebrates it has been arranged that a labelled, representative collection of these plant fossils shall be presented to Shansi University.

During the year 1921 the financial support for my work has been furnished by Dr. J. G. Andersson, Dr. & Mrs. Löwenhjelm and Prof. E.T. Nyström.

TECTONIC FEATURES

The surface distribution of rock within the northern parts of western Shansi is determined by two main systems of tectonic lines: an older, trending N.N.E-S.S.W. and a younger, which cuts across the former, and strikes N.E.-S.W. Along both of these, great dislocations have taken place in post-Jurassic time. By the first of these lines the area in question has been split up into a number of land-strips of which each has come to form a more or less independent tectonic element. Plate I, fig. 1, shows a section through the region between the Yellow River and the Taiyuan basin along latitude 38°.

These tectonic units are here represented by the Mesozoic Lin-Hsien (臨 縣) plateau; he Archæan Mo Erh Tung (莫兒棟) horst; and the Mesozoic Kao Li Shan (高離山) plateau.

At a time probably simultaneous with the later phase of the epeirogenetic movements, which have caused the upheaval of the Mo Erh Tung block, followed the formation of a number of large depressions, one

of which was the Taiyuan basin. These subsidences have taken place along fault-lines running in a N.E. to S.W. direction.

The Taiyuan plain has a length of about 130 km. in a direction N.E.-S.W. Its width varies; in the north it amounts to about 33 km., in the south to 75 km. It forms an almost horizontal surface with an altitude above the sea of 800 meters. Towards the N.E. it is limited by a margin of low hills, built up by Permo-Triassic and Carboniferous sediments with a western dip. These hills gradually become higher towards the east and culminate in a continuous range composed of Ordovician limestone. Behind these, still further east, we find a Triassic sandstone plateau with more or less horizontal strata.

Towards the S.E. the plain is bordered by a high plateau-country which descends to the basin in an abrupt and rather straight escarpment.

In the N.W., from the Fen Ho (汾 河) gorge to the Fen Yang (汾 陽) indentation, the border is formed by the Kao Li Shan plateau, the horizontal strata of which have in many places, at the escarpment, been bent down towards the plain, in connection with the subsidence of the latter.

At the Fen Yang indentation, the southern part of the plateau referred to, has sunk along an east-west faultline, as a result of which the escarpment makes a sharp turn towards the west and continues in that direction for 25 km. It then continues towards the south but has now lost its precipitous character.

The Kao Li Shan plateau consists of a flat, concave "Scholle" of sediments belonging to the late Palæozoic and lower Triassic. In its marginal parts and in the escarpment towards the Taiyuan basin, we find the outcrop of its foundation, namely the Ordovician limestone. On the west it borders the Archæan rocks of the Mo Erh Tung horst, with a broad zone of disturbance.

In connection with the dislocation which has occurred within this zone, syenitic rocks rich in alkali have been pressed up In the neighbourhood of the contact-surface between the Ordovician limestone and the pliable lower Carboniferous sediments, they have been intruded in the marginal zone of the Kao Li Shan plateau, partly in the form of laccoliths.

The sedimentary complex which constitutes the Kao Li Shan plateau can be divided into three well-defined sedimentary formations namely.

1) The oldest: *the dark, coal-bearing Series* (*the Yuehmenkou coal series*) * is built up of black argillaceous shales, dark grey calcareous shales, coal seams and light-coloured quartz-sandstones rich in kaolin, interbedded with dark marine limestones and calcareous shales, often of inconsiderable thickness. The complex includes the interval from the Lower Carboniferous to the Permo-Carboniferous. Its thickness amounts to about 200 meters (Lo T'o Po Kou (駱駝鉢溝).

2) *The light-coloured series* (*the lower Shihhotse Series*) composed almost entirely of sediments of light colour: greyish, greenish and yellowish claystones and argillaceous shales; light grey or yellowish quartz sandstone. There are a few, very thin coal seams in the lower-most part of the series. Marine sediments are missing. This probably belongs to the Lower Permian. The thickness is about 130 meters (Shihhotse Valley).

3) *The Chocolate-coloured Series* (*The upper Shihhotse Series and the Shihch'ienfeng Series*). Composed mainly of redbrown or chocolate coloured probably turgite-bearing, sandy marls and claystones which are interbedded with white or chocolate-coloured quartzitic sandstones. This series probably belongs to the Upper Permian and Lower Triassic. Thickness more than 600 meters.

THE CARBONIFEROUS FORMATION

DESCRIPTION OF SECTIONS

A very fine and unbroken section through the coal bearing series is to be found in the valley Yueh Men Kou, 30 li (15 Km.) west of Taiyuanfu

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* This, as shown beyond, consists really of two distinct series separated by a disconformity and pronounced hiatus. To the lower division, of late Dinantian age, the Survey has applied the name Taiyuan series; to the upper, of Permo-Carboniferous age, it has restricted the name Shansi series, (Editor)

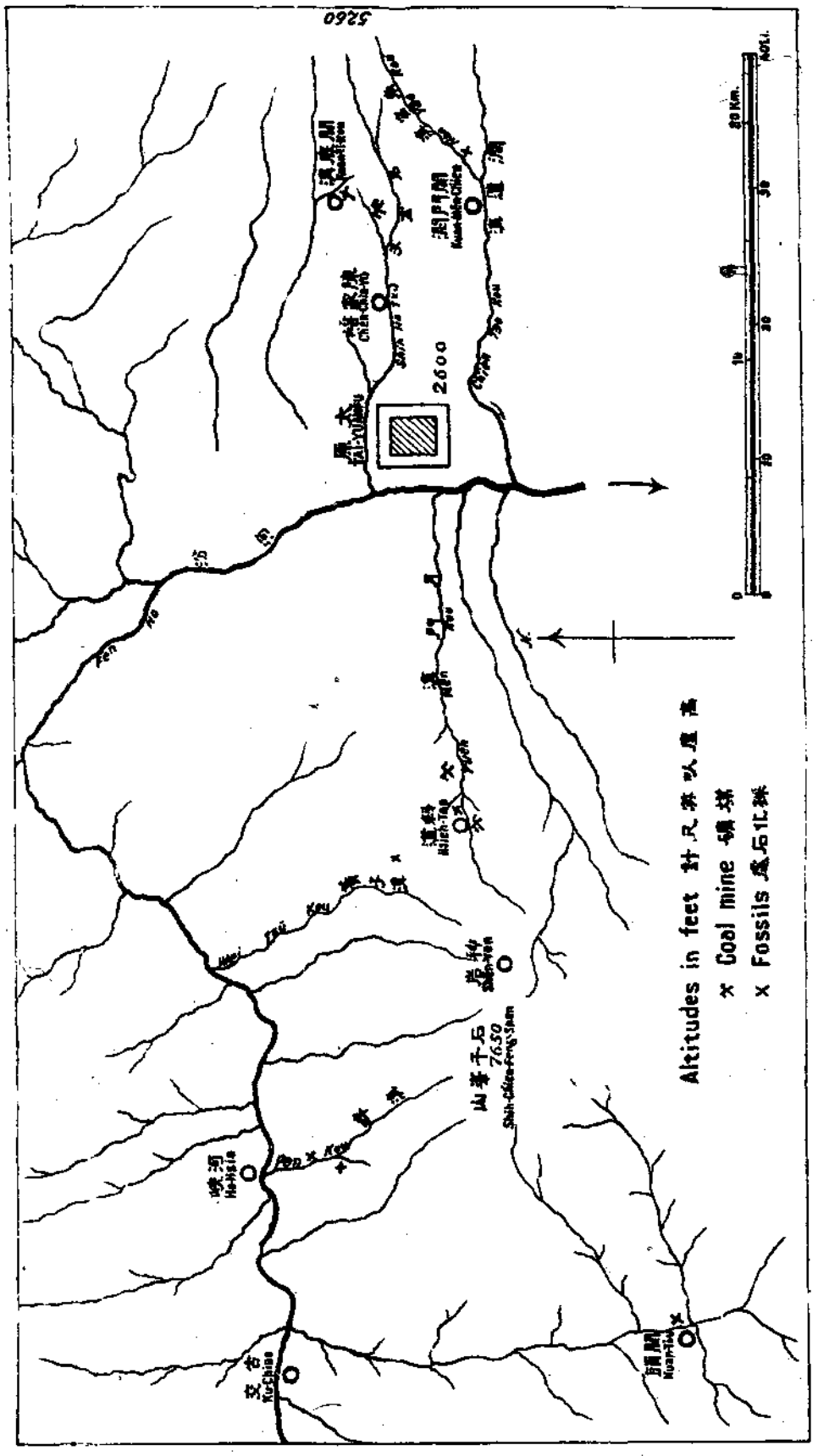

Fig. 1. Sketch map showing the localities where sections have been taken or fossils have been collected. (The river system is according to a map published in Clark and Sowerby: Through Shan-Kan, 1921)

圖 箭 處 石 化 採 及 岩 露 面 剖

(Pl. I, section 2). This valley cuts through the Ordovician limestone of the escarpment which forms the margin of the plateau, in a narrow winding canyon. The coal-bearing sediments are seen to form outcrops above the edges of this valley.

About 5 li from the mouth of this canyon a narrow road is cut in the precipitous slope and this path leads to the coal-mines at Lo T'o Po Kou.

If we follow the canyon westwards three more li, the valley bottom rises to the level of the upper surface of the Ordovician, and we enter a broader valley with gentle inclines, which are lined by nearly horizontal layers of coal seams and lightcoloured sandstones.

Here we find on the southern slope some sulphur works, the raw material for which is taken from the lowermost part of the coal series in the form of pyrite concretions and pyrite-impregnated, calcareous shale.

In the bottom of the valley, 12 li from the Taiyuan plain, lies the coal mine, Tung Ta Yao (東大窰), and on the valley slope above this the village Hsieh Tao (斜 道). The sediments lie on the whole horizontally, but in some places they assume a dip westward of varying amounts caused by minor faults. Numerous small gulleys open out into the main valley and as their sides are often precipitous, beautiful sections can easily be obtained.

The oldest sediments of the coal series however, are seldom accessible, partly because of earth-covering, partly because of sliding along the Ordovician surface. A tolerably complete section of these older strata has been obtained in the valley Pan Kou (畔 溝), 50 li N.W. of Hsieh Tao. See fig. 1; Pl. II. division Pan Kou.

On the Ordovician limestone, the strongly eroded surface of which is sparsely covered by the common iron ore nodules embedded in dark shale, follow:

1)	Dark shales with indistinct plant fragments about	10.0	Meters
2)	Dark grey marine limestone (A_1)	1.5	M.
3)	Dark shale with concretions of pyrites and sphero-siderite and containing two seams, each 10 centimetres thick, of shaley pyritic coal	3.2	M.

4)	Marine, dark grey limestone with pyritic concretions ("Pankou Limestone") fossil-bearing (A_2)	1.5	Meters
5)	Black shale	1.5	M.
6)	Marine, black limestone (A_3)	0.5	M.
7)	Black shale with a thin coal-seam	4.3	M.
8)	Marine, greyish blue limestone with pyritic concretions (A_4)	1.2	M.

The marine levels 6) and 8) are again met with at Yueh Men Kou. In a northern tributary valley to this, Mao Erh Kou (毛兒溝), we have taken the section fig 2, A & B, page 8 nects which immediately connects with the one above. See also the columnar section Pl. II. division Mao Erh Kou.

The succession of strata is as follows:

8)	Marine, greyish blue limestone, identical with the Pan-kou No. 8 horizon. On weathered surfaces it shows fragments of Crinoidea	1.25	M.
9)	Black, easily cleavable sandy shale	1.5	M.
10)	Black limestone	0.2	M.
11)	Black thin cleavable argillaceous shale with prints of plant roots	0.5	M.
12)	Fine, sandy, hard dark-grey clay slate which upwards merges into black shale; a few scattered plant fragments have been found	5.0	M.
13)	Grey sandstone, merging into sandy dark-grey slate, with some thin banks of dark-grey limestone	5.0	M.
14)	Coal seam	0.1	M.
15)	Massive dark-grey limestone	0.3	M.
16)	Dark shale	0.5	M.
17)	Coarse-grained, yellowish white quartz-sandstone with layers of black sandy shale	1.5	M.

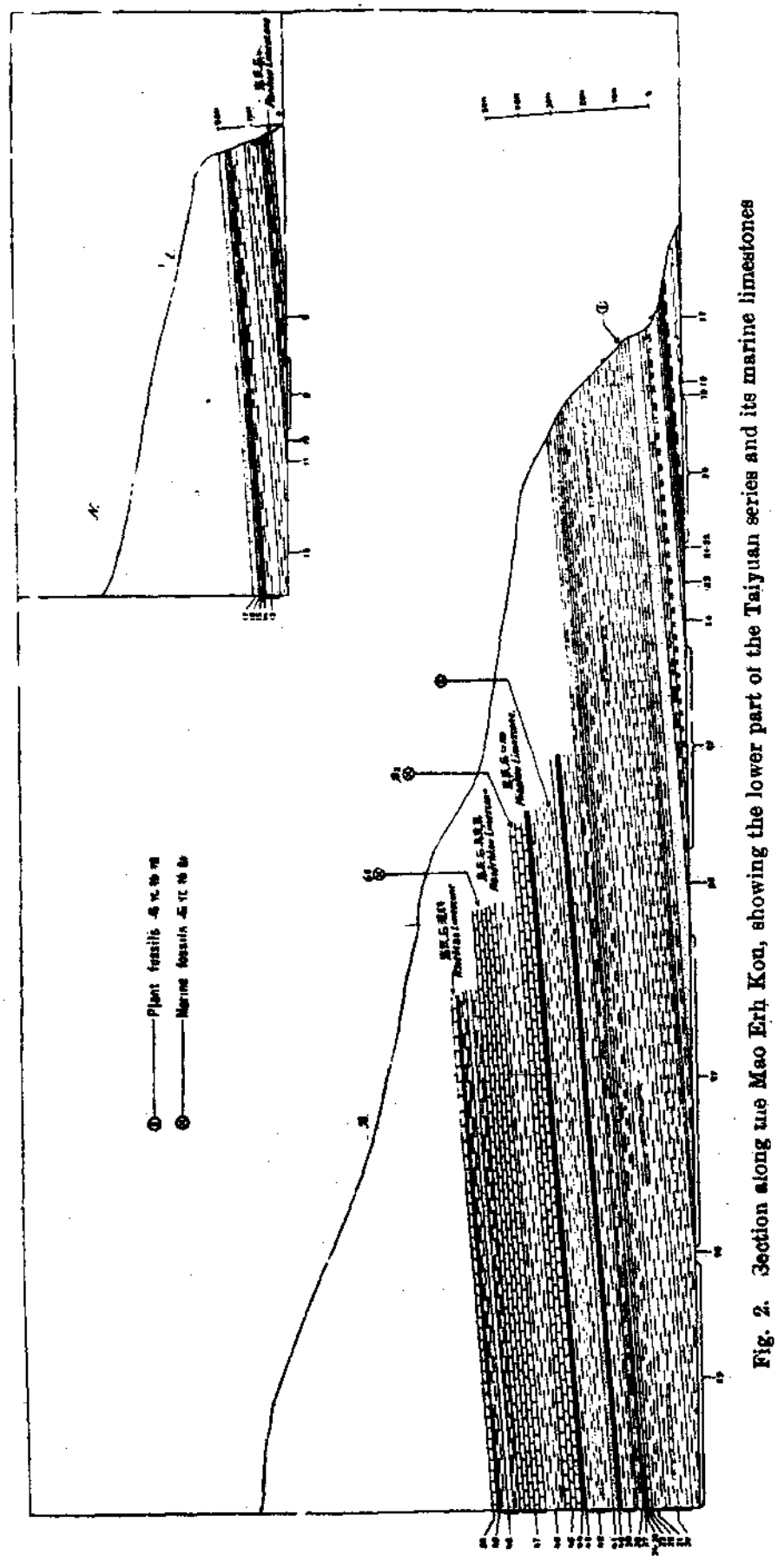

Fig. 2. Section along the Mao Erh Kou, showing the lower part of the Taiyuan series and its marine limestones

第一圖　茅兒溝一帶太原系下部及其海成石灰岩剖面圖

18)	Dark shale	0.5	Meters
19)	Coal-seam	0.15	M.
20)	Light quartz-sandstone. black clay shale which in its upper part contains pebbles up to 1 ft. in size of black iron-impregnated limestone	3.0	M.
21)	Coal-seam	0.6	M.
22)	Black clay-shale	0–0.1	M.
23)	Marine, blue-black limestone, with lenses and layers of black flint; strongly corroded and therefore of varying thickness	0.3–0.6	M.
24)	Dark slate	1.0	M.
25)	Grey sandstone with banks of sandy slate; in the upper shaley part containing a coarse, rather scattered conglomerate with oval boulders up to 1 M. in size of dark-grey limestone	4.0	M.
26)	Sandy, grey-black slate, containing in the upper part concretions of sphero-siderite (Iron-ore)	1.7	M.
27)	Grey quartz-sandstone, in its uppermost parts with layers of sandy slate.	6.0	M.
28)	Black, plant-bearing, argillaceous shale. Plant bearing horizon, No. 1.	0.7	M.
29)	Dark grey, partly sandy, slate with banks of sandstone	7.5	M.
30)	Dark slate, with layers containing lenses of greyish black limestone, up to 1 M. in size. In the middle of this bank a continuous layer of the same limestone, which at a certain distance dissolves into lenses.	8.0	M.
31)	Grey-blue, calcareous clay-stone and shale	4.0	M.
32)	Coal-seam	0.2	M.

33)	Greyish black, grainy limestone	0.5	Meters
34)	Black shale	0.5	M.
35)	Coal-seam	0.2	M.
36)	Dark shale	0.1	M.
37)	Dense blue-black limestone, containing flint	0.2	M.
38)	Dark blue-grey slate (sandy)	2.5	M.
39)	Dark, argillaceous shale	5.0 ±	M.
40)	Coal-seam	1.0	M.
41)	White quartz-sandstone with layers of shale	1.7	M.
42)	Black, argillaceous shale with banks of bluish-grey calcareous shale, about In its lower part plant-bearing; horizon No. 4.	8.0	M.
43)	Coal-seam	0.5	M.
44)	Dark, calcareous shale	0.5	M.
45)	Marine, blue-black limestone "Miaokou limestone" (B)	5.0	M.
46)	Black argillaceous shale	6.0	M.
47)	Marine, black limestone "Maoerhkou Limestone" (C)	8.0 ±	M.

The strata have, in Mao Erh Kou, a slight dip towards the north.

A short distance up the Yueh Men Kou valley the layers have locally a dip of 10° towards N.W. The Spirifer-limestones cut the valley-bottom some 300 M. below the coal-mine Tung Ta Yao. The sequence of strata at this point is shown in section *Fig. 3;* also in columnar section Pl. II, division Tung Ta Yao.

45 A)	Black limestone with Spirifer bisulcatus observed	1.4	M.
B)	Black, marine, calcareous shale	1.0	M.
	45 A and B="Miaokou Limestone" (B)		
46)	Dark shale, in its lower parts containing a conglomerate of rusty limestone and small nodules of iron ore	7.6	M.

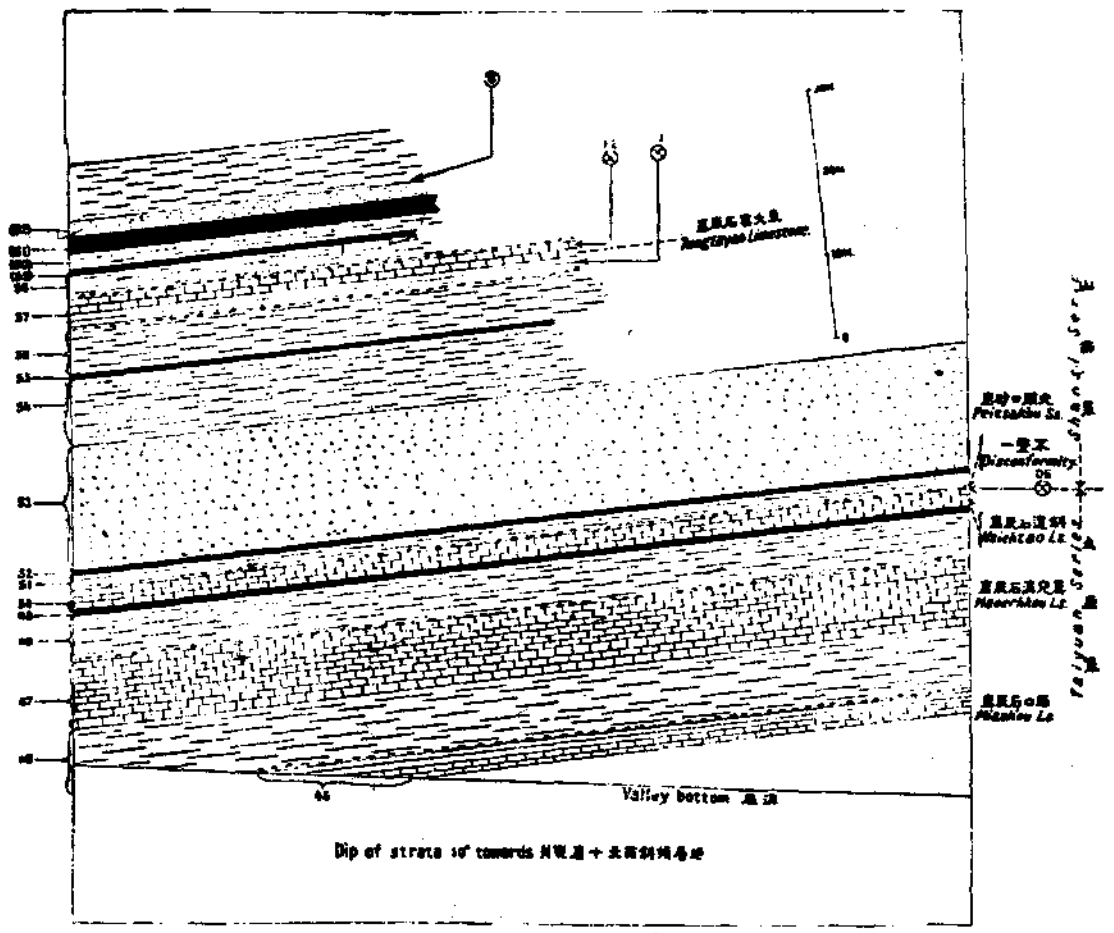

Fig. 3. Section at Tung Ta Yao, 30 li W. of Taiyuanfu, showing upper part of Lower Carboniferous, and lower part of Permo-Carboniferous in contact.

圖面剖窰大東里十三西府原太

處觸接之紀疊二炭石及紀炭石下

47)	Blue-black limestone "Maoerhkou limestone" (C)	8.0	Meters
48)	Black clay-shale, at the bottom of which are found numerous pebbles of limestone, flint and iron ore	5.6	M.
49)	Coal-seam	0.6	M.
50)	Marine limestone and shale (calcareous) "Hsiehtao Limestone" (D)	2.35	M.
51)	Black shale, with bottom-conglomerate of iron-impregnated limestone and ore-concretions		
52)	Coal-seam	0.5	M
53)	Greyish white, quartzy sandstone partly cross-bedded with charred trunk-fragments	15.0 ±	M.

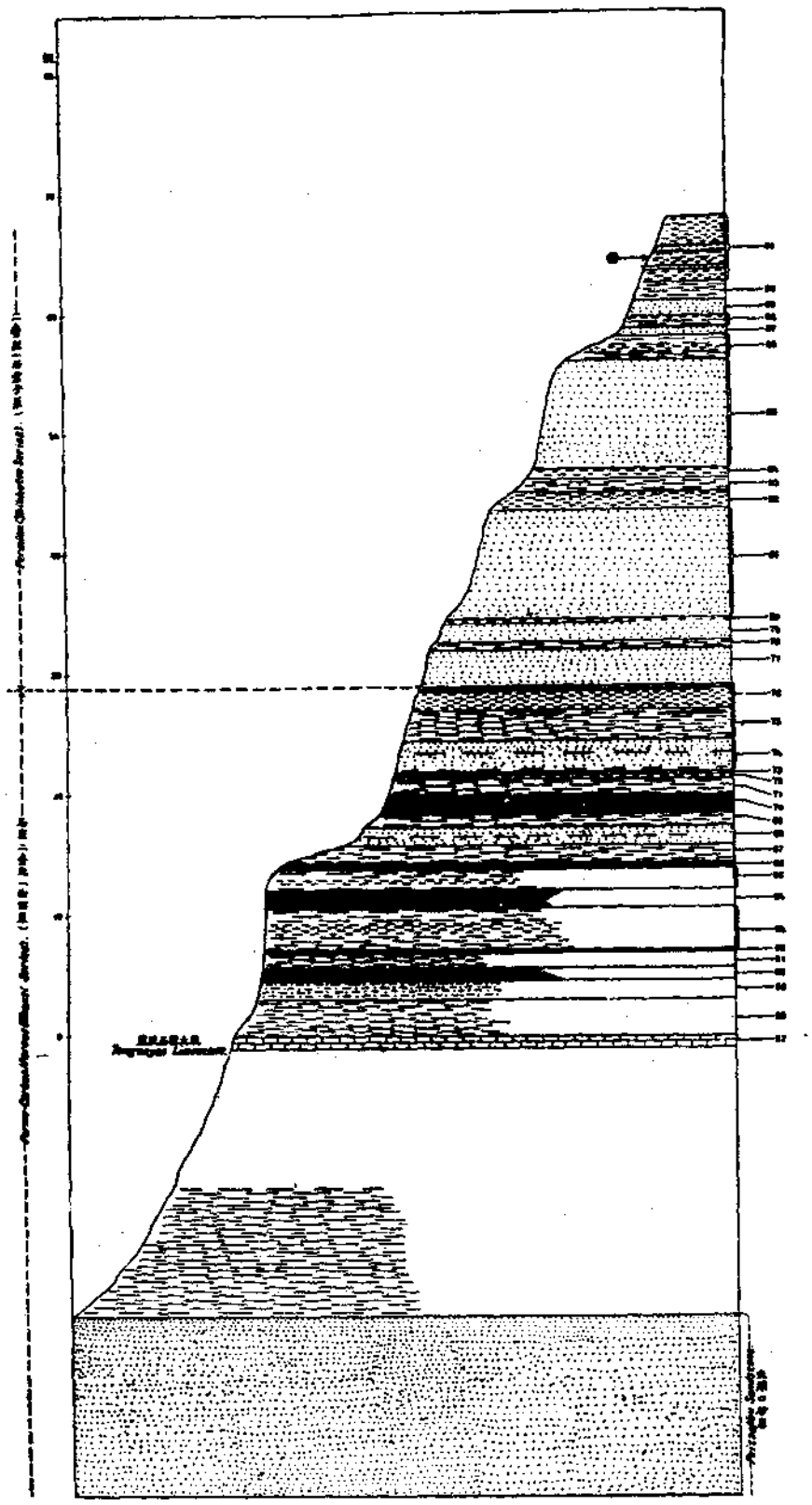

Fig. 4. Section of the sediments of the Shansi series (restricted) above the Tungtayao limestone (No. 57) and the lower part of the Shihhotze series, in the valley of the Lo T'o Po Kou 30 li west of Taiyuanfu.

太原府西三十里駱駝鉢溝露岩

54)	Sandy, grey-black clay-shale Black shale	8.0	Meters
55)	Coal-seam	0.4	M.
56)	Black, argillaceous shale	6.0	M.
57)	Marine, dark grey limestone with scattered *Fusulinas* "Tungtayao Limestone" (F)	3.2	M.

Below and above there are layers of conglomerate.

58)	Black, argillaceous shale	3.0	M.
59)	Coal-seam	0.55	M.
60)	Black clay-shale, in the upper layers with numerous prints of root-fibres	2.0	M.
61)	Coal seam, with thin, shaley interbeddings	2.0	M.
62)	White quartz-sandstone, upwards merging into sandy shale very rich in plant fossils (Flora No. 6.)	2.0	M.

A very fine section through the uppermost part of the coal series and the sediments that form the transition to the Shihhotse series has been obtained in the tributary valley Lo T'o Po Kou at the coal mine Lo T'o Po Yao (see general section Pl. II, and Fig. 4).

The Fusulina-bearing limestone (No 57 in above section) is here again met with in the same succession of strata as at Tung Ta Yao, but is strongly rusted and disintegrated.

On the limestone follows

58)	Black argillaceous sha	3.0	M.
59)	Black calcareous sandstone	1.6	M.
60)	Coal-seam	1.0	M.
61)	Layer of Iron Band Ore which quickly wedges out Black argillaceous shale with prints of root fibres	1.3	M.
62)	Coal seam	0.25	M.
63)	Black argillaceous shale; dark blue-grey calcareous claystone; black argillaceous shale	3·5	M.

64)	Coal seam	1.5	Meters
65)	Black argillaceous shale with a layer of blue-grey calcareous shale	1.7	M.
66)	Coal seam	0.5	M.
67)	Black clay-shale	1.5	M.
68)	Dark sandstone with layers of shale	1.5	M.
69)	Black argillaceous shale	1.0	M.
70)	Coal-seam	1.5	M.
71)	Black, argillaceous shale, with layers and lenses of Iron band and concretions of sphero-siderite	1.4	M.
72)	Grey, calcareous claystone	0.3	M.
73)	Greyish black, grainy limestone	0.3	M.
74)	Sandstone with layers of shale	2.6	M.
75)	Black shale with rusty nodules of limestone	2.6	M.
76)	Bluegrey, calcareous shale with thin layers of massive, grainy, dark-grey limestone	2.0	M.

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77)	White sandstone	3,0	M.
78)	Black shale	0.7	M.
79)	White sandstone	1.5	M.
80)	Blue-grey, micaceous claystone	0.5	M.
81)	White quartz-sandstone	9.0	M.
82)	Micaceous, grey claystone	1.5	M.
83)	Black clay-shale, upwards micaceous	1.2	M.
84)	Blue-grey claystone	0.8	M.
85)	White quartz-sandstone	9.0	M.
86)	Sandy dark shale; grey-blue claystone; dark argillaceous shale	2.0	M.

87)	Shaley sandstone	0.7	Meters
88)	Black, argillaceous shale; dark-grey claystone	1.0	M.
89)	Light sandstone	1.3	M.
90)	Black, argillaceous shale with numerous plant-remains	1.5	M.
91)	Greenish grey, claystone, with some sandy layers, plant-bearing (*Annularia*)	5.5	M.

The sediments from stratum No. 77 upwards do not belong to the genuine coal-bearing series; owing to reasons given further below they are to be considered as being of Permian age and belong to the lower part of the Shihhotse series.

2. The above-described section along Yueh Men Kou may be considered to give a rather typical image of the sequence of the Carboniferous sediments along the eastern escarpment of the Kao Li Shan plateau. Thus we find that a profile taken in the valley Pan Kou, 35 li W.N.W. of Hsieh Tao, is almost identical with the corresponding profile in Yueh Men Kou, not only as regards the petrographic character of the sediments, but also with regard to the thicknesses.

Essentially different conditions, especially in the upper half of the coal series, are met with in the N.E. marginal hills of the Taiyuan basin. For the sake of comparison we give below a section taken in the valley *Nan Yao Kou* (南窰溝) 3 li E. of *Kuan Men Ch'ien* (關門前). This latter place is situated 15 li E.S.E. of Taiyuanfu. (see fig. 5 page 16)

The thicknesses of strata in the upper half of the coal series are as follows: From below:

1a)	Marine, massive limestone, (N°.I)	0.9	Meters
1b)	Marine, black calcareous shale with *Fusulina*	0.4	M.
2)	Grey-blue calcareous shale (continental?)	0.6	M.
3)	Marine, massive dark-blue limestone (N°. II)	2.8	M.
4a)	Calcareous, argillaceous shale, flat cleavage, containing a very rich horizon of well-preserved plant fossils—plant-bearing bed No. 3.	3.4	M.

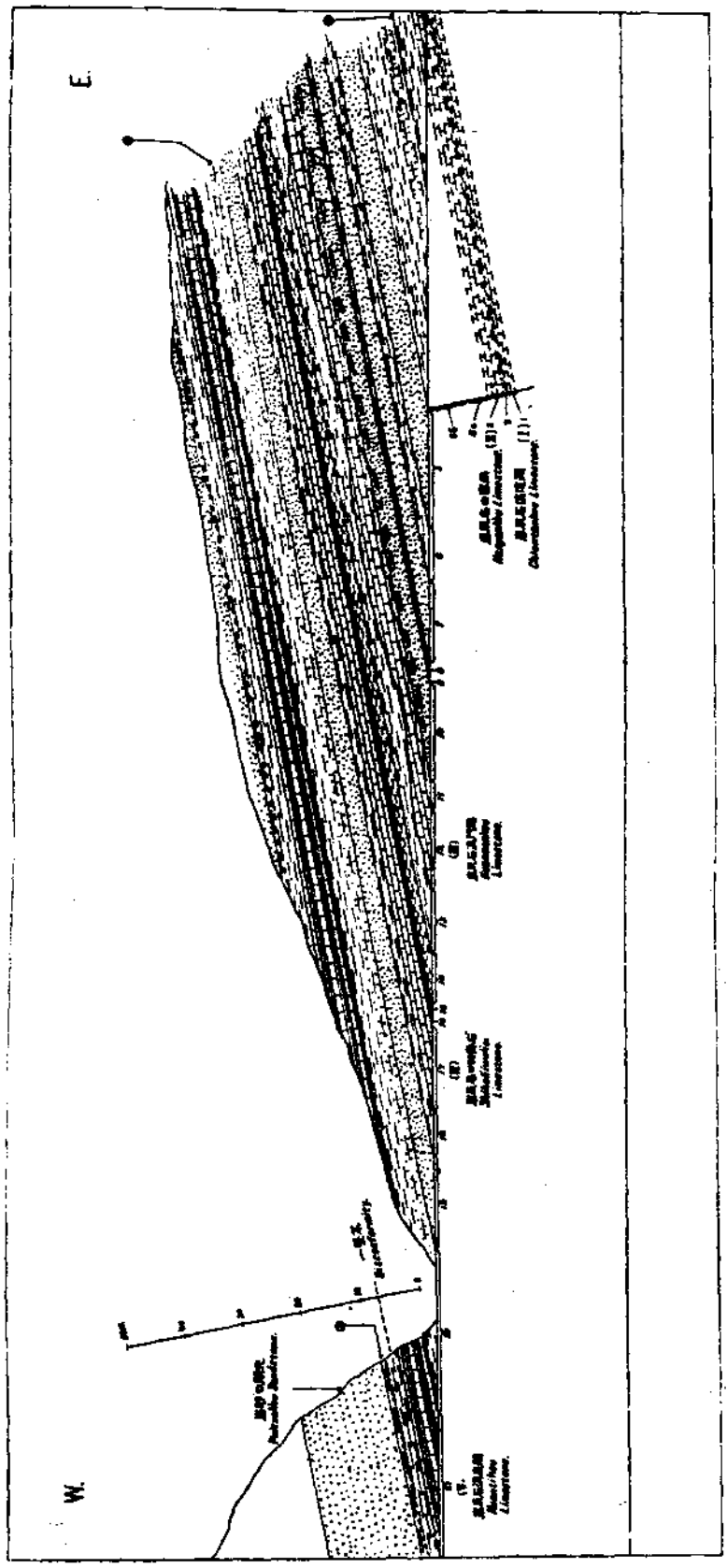

Fig. 5. Section along the Kuan Men Chien, 15 li E. S. E. of Taiyuanfu (See fig. 5a)

(5a 圖附閱參) 關面剖近左澗門關里五十東福南東城(縣曲陽)原太

4b)	Rather sandy, argillaceous shale with sandstone banks and banks of plant-bearing, grey, calcareous shale	6.9	Meters
5)	White quartz-sandstone	3.8	M.
6)	Plant-bearing argillaceous shale with sandy layers	1.8	M.
7)	White quartz-sandstone	2.5	M.
8)	Sandy, blue-grey, plant-bearing argillaceous shale	0.5	M.
9)	Coal seam	0.1	M.
10)	White quartz-sandstone with lenses and boulders up to more than 1 M. in size of marine greyish blue limestone	3.2	M.
11)	Black argillaceous, shale with layers of sandstone	1.0	M.
12)	Marine, dark greyblue limestone with strongly eroded surface and therefore varying thickness (N°. III)	1-3.0	± M.
13)	Black calcareous, argillaceous shale	15.3.0	M.
14)	Bluegrey, calcareous, argillaceous shales, containing plant-fragments and some marine fossils.	1.5	M.
15)	Black plant-bearing argillaceous shale.	0.3	M.
16)	Seam of soft coal.	0.5	M.
17)	Marine, massive limestone, blueblack, containing crinoids and corals similar to the Hsiehtao limestone. (N°. IV)	2.7	M.
18)	Black clay-shale with coal seam	1.3	M.
19)	Medium-grained, white quartz-sandstone	3.0	M.
20)a	Argillaceous sandstone with layers of shale, masses of silicified wood, locality No *4 b;* merges upwards in dark clayshale *c;* uppermost a coal seam	5.1	M.
21)	Kuantikou Limestone (N°. V)	4.5	M.

22)	Black clay-shale with nodules of iron-band and rusty limestone, uppermost a plant-bearing argillaceous shale; plant-bearing horizon No. 5	3.0	Meters
23)	White quartz-sandstone (Peitsakou Sandstone?) with a thickness of more than	15.0	M.

THE MARINE SEDIMENTS

In the Yuehmenkou series marine sediments occur in some ten horizons, separated from one another by continental deposits. Probably there has existed originally an even greater number than these, but some of them may have been eroded away more or less completely, before the younger sediments were laid down. In certain cases they may have been removed by metasomatosis. Their marine character is shown by the presence of marine fossils and flint. In a few cases fossils have not been found (Mao Erh Kou section, fig. 2, strata No. 23 and 37) but the contents of black flint suggests their marine origin. In a few other cases neither fossils nor flint have been found and therefore these horizons may be put down as dubious. (section fig. 2, strata nr. 15 and 33.)

In the lower Carboniferous shales there occur a few horizons containing very coarse conglomerates of limestone. One of these enters into the layer No. 25 in the Mao Erh Kou section. We find there lenses of greyblack limestone up to 1 M. in size, and iron-ore concretions embedded in dark sandy slate. It is remarkable that in this conglomerate Archæan material is absent, although a comparatively thick sandstone bank, composed of Archæan material, enters into the composition of the roof. Some metres higher up in the same section we meet another similar conglomerate, but here there is also an opportunity to observe how, in the plane of sedimentation, a continuous limestone bank wedges out within a short distance. In its place occur large isolated limestone lenses which evidently from the beginning formed a continuous layer. There is reason to suspect that the limestone material in these intra-formational conglomerates has been subjected to little or no transportation and that their position in the sedimentary series is about the same as the limestone horizon of which they are the remnants.

Characteristic for most of the marine calcareous sediments is their content of iron sulphide. This appears macroscopically in the shape of concretions of pyrites and pyritized fossils. On the weathering of these rocks this is recognized through the abundant formation of limonite. The content of pyrites is specially high in the horizons of marine calcareous shale which often occur in the limestones.

These pyritic shale-layers are often marked by an unusual abundance of fossils. Nothing in the appearance of the pyrites indicates a secondary formation through infiltration, but it is probable that the iron sulphide in a very fine state of division has been precipitated simultaneously with the deposition of calcareous sediments, and that later on a molecular re-arrangement and transition to crystallized pyrites has taken place.

It is not impossible that part of the iron ores existing in the coal series has in a secondary manner originated from these marine sediments. The fact is that only seldom do we find in one and the same section within the coal series all the marine horizons which we know should exist there. In their places occur more or less considerable layers of iron ore "conglomerate"; these ores occur in the form of lenses or round balls up to head-size of argillaceous sphero-siderite with the common concentric structure and often a cavity in their centers; together with these occur iron-band, and pyritic, rusty limestone.

Similar formations though of smaller thickness are also to be found almost without exception in the roof of the marine limestones and are apparently intimately connected with their foundation. In this latter case the conglomerate often contains numerous flint-balls of the same kind as those which occur in the limestones.

This question is illustrated to a certain extent by the Upper Carboniferous marine horizon which occurs below the main coal seams. This limestone has been observed only in Yueh Men Kou and even there it is very erratic in its occurrence, as it disappears sometimes entirely. In the best state of preservation we find it at the coalmine Tung Ta Yao. The marine bank consists of a lower horizon of very pyritic calcareous shale and an upper one of blue-black flinty limestone (see Fig. 2 Page 8). In the roof there exists a scattered conglomerate of argillaceous iron ore, flint and limestone.

About 400 M. downwards in the valley in a tributary gulley, called Mao Erh Kou (毛兒溝) we find again the same limestone bank. It is here strongly fissured, forming a breccia of more or less altered, rusty, soft limestone and argillaceous limonite. The underlying, marine, calcareous shale has been changed to a soft, shaley rust-brown mass of limonite mixed with clay, in which the contours of pyritized brachiopods can sometimes be noticed.

A further distance of some hundred meters estwards in the Mao Erh Kou section, the Upper Carboniferous marine horizons are entirely lacking in the outcrop and their place is taken by a bank about 1 M. thick, of sphero-siderite and lenses of iron band, embedded in rusty shale. In this case it is probable that the disappearance of marine sediments and the accumulation of the iron ore are in some manner connected with each other.

It seems highly probable that at least part of these ore formations originate from the primary content of pyrite in the sediments and especially in the marine shales.

Through oxidation processes, the sedimentary pyrite has been transformed to sulphate of iron, and part of this has through still more advanced oxidation, become hydrate of iron; another part has been converted to carbonate of iron by meeting with the calcareous sediments.

The gypsum present in fissures in the Ordovician limestone may have originated from sulphate solutions formed by the above mentioned chemical reactions within the Carboniferous.

To facilitate the distinction of the different marine horizons of the coal series, I have named each one after the locality where it occurs well exposed and where the fossils are especially abundant. Arranged in order from younger to older they are designated for the region west of Taiyuanfu

F. The Tungtayao Limestone
(disconformity)
D. The Hsiehtao Limestone
C. The Maoerhkou Limestone
B. The Miaokou Limestone
A. The Pankou Limestones. (1-4)

Here are not included the inconsiderable marine horizons which appear in the lower part of the series between the Miaokou and Pankou limestones for the reason that no marine fossils have been found in them.

Of the horizons enumerated above, B., C., D. & F. have been observed in one and the same section (fig. 7) at the coal-mine Tung-Ta-Yao in Yueh Men Kou. In the Mao Erh Kou section (fig. 2) we find A. 4., B., C. and D. and in the valley Pan-Kou, about 5 li from its junction with Fen-Ho, the horizons A.1-4, B. and C. Consequently no doubt should exist regarding the relative position of the horizons B., C., D. & F.

East of Taiyuanfu the following series has been noted in descending order.

(Disconformity)

Hor. V. The Kuantikou limestone

Hor. IV. The Shihch'iwakou limestone

(Disconformity)

Hor. III. The Kuanmênkou limestone

Hor. II. The Nanyaokou limestone

Hor. I. The Ch'ientaokou limestone

The Kuantikou horizon, has been observed only in the eastern marginal hills of the Taiyuan basin, and seems to be absent in the Kao-Li-Shan plateau. Its stratigraphical conditions are illustrated by the Kuan-Men-Ch'ien section, fig. 5. and the columnar section fig. 5a.

The roof of the Kuantikou limestone is formed by a thick sandstone horizon which is possibly identical with the one that forms the base of the Upper Carboniferous sediments. (The Peitsakou sandstone, see Pl. II.)

In the Kuan-Men-Ch'ien section occur, below the Kuantikou limestone, four strongly corroded, marine horizons, marked in the section I-IV. Of these the horizon IV. is very rich in corals and fragments of crinoids; it may be identical with the *Hsiaitao limestone* in the Western Hills, or may be above it.

The horizon I contains in its upper, shaly part masses of *Fusulina*

The stratigraphical conditions and faunas seem to indicate that, of the mixed marine-continental complex I-V in the Kuan-Meu-Ch'ien section, only one member, No. III may correspond to the complex A-D in the sections from the Western Hills, namely to the Pankou limestone (A). No. IV may correspond to D, but the others are present only in their respective sections.

Should a closer examination confirm that the Kuanmench'ien horizon IV is equivalent to the Hsiehtao limestone, or above it, then the Kuantikou limestone becomes the youngest amongst the *Lower Carboniferous* marine horizons in the Taiyuan region.

FORMATIONS OF THE WESTERN SECTIONS.

A. PANKOU LIMESTONES.

These appear in the lowermost part of the coal-series and are separated from the Ordovician limestone by a complex, 10 to 20 M. thick of pyritic, grey clay- stones or black argillaceous shale containing plant-fragments and streaks of coal.

In Pan-Kou (畔 溝) (see fig. 1), the valley after which these limestones have been named, they are four in number. Reckoned from the younger to the older they are:

A 4	1.2	Metres
A 3	0.5	M.
A 2 (*horizon of Griffithides quadrinodus*) *Coll. 30*	2.5	M.
A 1	1.5	M.

These limestones are separated from one another by black, pyritic, plant-bearing, argillaceous shales, containing some seams of shaly coal about 10 cm. thick. All four limestones are fossiliferous, but the fossils are very scarce.

The fossils found in *horizon A 2* have been determined by Dr. A.W. Grabau who has supplied the following preliminary list [1])

1) Frequency is expressed by: rr-very rare; r-rare; rc-moderately frequent; c-common; cc-very common.

Coll. 30

Brachiopoda:

Dalmanella sp.
Schizophoria sp.
Enteletes lamarcki Fischer
Chonetes sulcatus Grabau
Productus cf. pustulosus (intermediate between pustulosus & punctatus)
Productus sp.
Spirifer bisulcatus (rc)
Spirifer pankouensis Gr. (rc)
Reticularia sp.
Martinia sp.
Spiriferina willisi Gr. (r)

Gastropoda:

Loxonema? sp.

Trilobita:

Griffithides quadrinodus Gr. (c)

The Pankou limestones are, in spite of their inconsiderable thickness, rather constant horizons and when the conditions of stratification are not too disturbed by tectonic movement they are usually found in their expected place.

In Yueh Men Kou two horizons appear, probably A 3 & A 4, with the same thicknesses as in Pankou, and at Chin Szu temple 45 li S.W. of Taiyuan, three horizons have been foumd.

B. MIAOKOU LIMESTONE

In the Western marginal hills at the Taiyuan basin this is the oldest in a series of three rather thick marine horizons B., C. and D. in the middle part of the coal series. (see general section 2, Pl. II and the section fig. 6,7 & 8).

From the Pankou limestones it is separated by a complex built up mainly of continental sandstones with banks of plant-bearing, argillaceous shales, coal-seams and strongly eroded and thin marine horizons of limestone, often wedging out, and coarse conglomerates of marine limestone.

The Miaokou limestone has been studied at the following localities:

1) *In Miao Kou*, a western tributary to Pan Kou, draining into the latter about 6 li from its junction with the Fen Ho. (see sketch-map, fig. 1 (Sect 6).

2) *In Mao Erh Kou*, a northern tributary to Yueh Men Kou, draining into the latter about 1 li from coal-mine Tung Ta Yao.

3) *At* the coal-mine *Hsi-Yao-Tung-Yao* (西窑東窑) in Pei Tsa Kou, (北岔溝) a tributary to the valley Liu Tse Yu (柳子峪) draining into the Tai-Yuan plain 6 li S.W. Chin Szü (晉 寺) temple. This temple is situated 45 li S.W. of Taiyuanfu. (Sect 8)

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1. MIAO KOU

(See Section Fig. 6)

The limestone which has been named after this valley is here underlaid by brownish black, plant-bearing, argillaceous shale, which in its turn forms the roof of a seam of anthracitic coal about 1 M. thick. The roof of the marine bank is formed of black, argill. shale; the boundary is marked by a conglomerate of small pebbles of marine limestone and concretions of sphero-siderite. The layers lie almost horizontally.

In the Miaokou limestone the following components can be distinguished from above:

Stratum No. 2. Black, flat-cleaved calcareous shale fossiliferous	0.5	M.
Stratum No. 1. Blue-black, massive limestone; in the lower levels more shaley, fossiliferous (Coll. 31) *Horizon of Reticularia obscura*	5.1	M.

The fossils found in the lower part of *stratum No. 1* (*Coll. 31*) have been determined by Dr. A.W. Grabau who has supplied the following list:

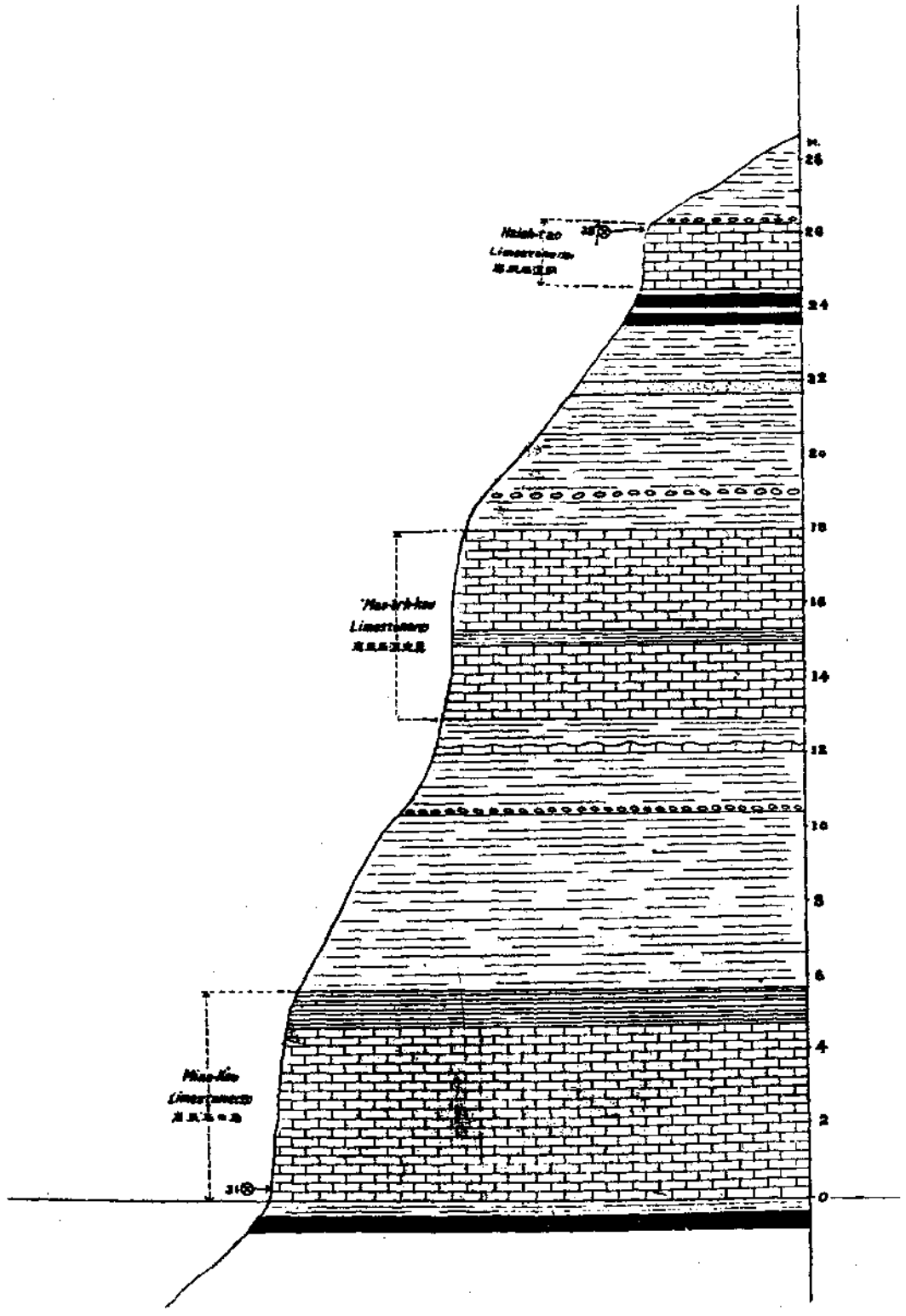

Fig. 6. Section on the Miau Kou near the Pan Kou, 55 li N. W. of Taiyuanfu showing limestones of the Upper Dinantian series.

太原府西北五十五里畔溝左近廟溝露岩

Anthozoa

Lophophyllum carbonaria Gr. (r)
Lopholasma acanthiseptum Gr. (r)

Bryozoa

Fenestella sp.

Brachiopoda

Dalmanella sp.
Chonetes nyströmi Gr. (c)
Chonetes pankouensis Gr. (r)
Orthothetes, 2 species
Productus taiyuanfuensis Gr. (c)
Productus punctatus Martin (rc)
Productus sp.
Spirifer bisulcatus Sow. (c)
Spirifer pankouensis Gr. (r)
Reticularia obscura Gr. (c)
Reticularia sp.
Camarophoria (?) striatoplicata Gr. (rr)

Pelecypoda

Aviculopecten norini Gr. (r)
Acanthopecten shansiense Gr. (r)

Gastropoda

Euphemus orbygnii (Portlock) (r)
Cyclonema carbonaria (Cox) (r)
Sphærodoma cf. mediale (Meek & Worthen) (r)

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2. MAO ERH KOU

The Miaokou limestone is found at Tung Ta Yao (see section, fig. 7) and in Mao Erh Kou. Its thickness at these localities is about 5 M. It consists here also of:

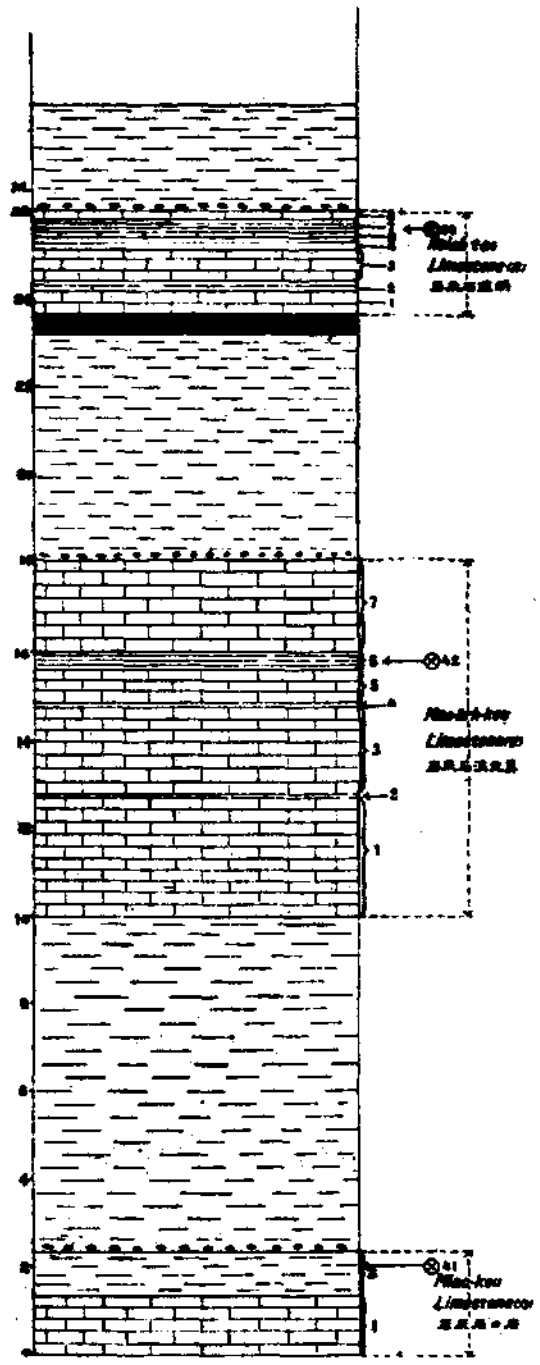

Fig. 7. Columnar section at Tung Ta Yay coal mine, in the Yüeh Men Kou valley 30 li west of Taiyuanfu.

太原府西十三里月門溝河域
煤窰大東內近附之精形剖面圖

Stratum No. 2, Black, flat-cleaved calcareous shale with rusty weathering; fossiliferous (Coll. 41) *Horizon of Chonetes nyströmi and Orthothetes taiyuanfuensis*		1	M.
Stratum No. 1, Massive, blue-black limestone with *Spirifer bisulcatus* and *Productus*	About	4	M.

The rock is composed of black argillaceous shale which in its lower part contains a scattered conglomerate of small pebbles of marine, fossiliferous limestone. In Mao Erh Kou, in the calcareous shale horizon, *stratum No. 2, the collection 41* has been taken, in which Dr. A.W. Grabau has found the following species:

Protozoa

Fusulina sp.

Bryozoa

Fenestella sp. (c)
Pinnatopora sp. (c)
Polypora sp. (r)

Brachiopoda

Lingula longa Gr. (r)
Chonetes nyströmi Gr. (c)
Orthothetes taiyuanfuensis Gr. (cc)
Productus taiyuanfuensis Gr. (c)
Productus punctatus (rc)
Productus cf. pustulosus (r)
Productus cf. cora (r)
Productus sp.
Productus cf. semireticulatus (r)
Marginifera sp.
Spirifer bisulcatus (rc)
Reticularia rotundata Gr. (r)
Aulacorhynchus sp.
Dielasma sp.

Meekella cf. striatocostatus (r)
Hustedtia bella Gr. (c)
Camarotoechia sp.

Pelecypoda

Aviculopecten norini Gr. (r)
Aviculopecten alternatostriata Gr. (r)
Acanthipecten shansiensis Gr. (r)
Aviculopecten sp
Entolium obtusum Gr. (r)
Sphenotus macrosulcatus Gr. (r)
Sphenotus sp.
Leiopteria minor Gr. (r)

Trilobita

Griffithides quadrinodus Gr. (rc)
Phillipsia cf kansuense Leczy. (r)

3. PEI TSA KOU

The oldest of the marine sediments in section fig. 8, taken at the coal mine Hsi-Yao-Tung-Yao in the valley Pei Tsa Kou, belongs probably to the same marine transgression which has formed the Miaokou limestone. The thickness of the marine bank is here about 12 M. being thus considerably more than at Miao Kou and Yueh Men Kou. In is underlaid by black, argillaceous shale which in its turn is underlaid by a thick seam of anthracitic coal. Most of the coal taken from the mines along Pei Tsa Kou and in the main valley Liu Tse Yu is mined from this seam. The stratification is slightly undulating.

The Miaokou limestone has here the following structure. From above:

Stratum No. 7. Marine, blue-black to grey-blue limestone with flint lenses	1.55	Meters
Stratum No. 6. Marine black calcareous shale	0.3	M.
Stratum No. 5. Limestone same as No. 7	0.6	M

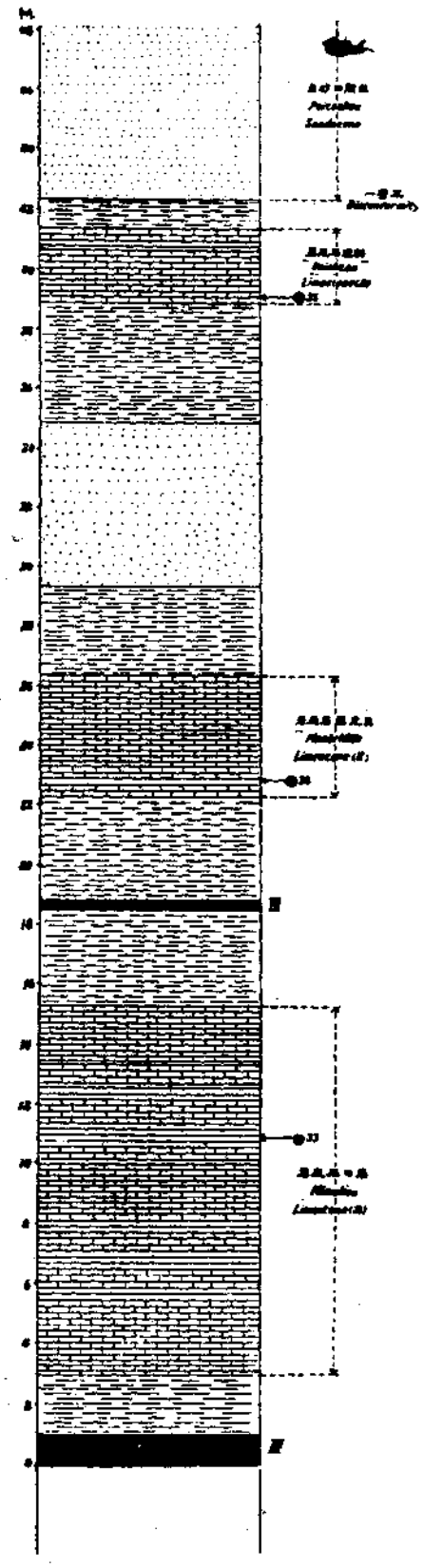

Fig. 8. Section at Pei Tsa Kou coal mine, Hsi Yao Tung Yao S. W. of Taiyuanfu showing Hsiehtao limestone followed disconformably by Permo- Carboniferous beds.

太原府西南之北谷口煤礦東窰西窰剖面
圖中明示石灰石上有不整合之石灰石疊二紀石層

Stratum No 4. Strongly cleaved and shaly bluish-black limestone with banks of black pyritic calcareous shale rich in fossils. Coll. 33. *Horizon of Chonetes nyströmi and Orthothetes taiyuanfucnsis*	2.75	M.
Stratum No. 3. Limestone same as No. 7.	1.85	M.
Stratum No. 2. Limestone same as No. 7 with banks of marine, black calcareous shale	2.65	M.
Stratum No. 1. Limestone same as No. 7	2.50	M.
Total Meters	12.20	

The fossile of *Coll. 33* gathered in *Stratum No. 4* ("Pyrite Shale Horizon") have been determined by Dr. A.W. Grabau who has furnished the following list:

Brachiopoda

Dalmanella sp.

Chonetes nyströmi Gr. (cc)

Orthothetes taiyuanfuensis Gr. (r)

Orthothetes sp. (several)

Productus taiyuanfuensis Gr. (cc)

Productus punctatus (Martin) (r)

Productus cf pustulosus

Productus sp.

Marginifera lopingensis Kayser (r)

Reticularia rotundata Gr. (c)

Spirifer bisulcatus (r)

Spirifer pankouensis Gr. (rc)

Athyris vasculosus Grabau

Meekella cf. striato-costata (c)

Hustedtia chinszuensis Grabau (r)

Camarotoechia sp.

Pelecypoda

Aviculopecten alternatostriata Gr. (r)
Aviculopecten sp.
Entolium obtusum Grabau
Parallelodon (?) shansiensis Gr.
Pseudomonotus duplicostatus Gr. (r)
Myalina obscura Gr. (r)
Allorisma sp.
Cypricardella sp.

Gastropoda

Mourlonia sp.

C. THE MAOERHKOU LIMESTONE

(Re stratification see fig. 6.7 & 8 and general section, Plate II.)

This limestone is named after the small tributary valley Mao Erh Kou which from the north drains into Yueh Men Kou about 2 li below Tung Ta Yao coal-mine. The same horizon re-appears at Miao Kou (Pankou) and in Pei Kou (near Chin Szü).

Its thickness in Miao Kou amounts to 5.1 M. in Mao Erh Kou to 8.2 M. and in Pei Tsa Kou to 4 M.

In these three localities it is separated from the Miaokou limestone below by a 6 to 8 m. thick plant-bearing bank of black argillaceous shale which at Pei Tsa Kou also contains a workable coal-seam.

The upper surface of this limestone is strongly corroded; in the lower layers of the superimposed plant-bearing shales a scattered conglomerate of marine limestone and concretions of sphero-siderite occurs.

1. *In Mao Erh Kou* the marine bank has the following character; from above:

7) Massive. blue-black limestone with Spirifer bisulcatus 2.1 M.

6)	Black calcareous shale rich in fossils (Coll. 42)	0.5	M.
	Horizon of Productus perundosus and *Camptonectes? pustulatostriata*		
5)	Limestone same as 6	0.7	M.
4)	Black, argillaceous shale, no fossils found	0.2	M.
3)	Limestone same as 7 rich in Productus	2.0	M.
2)	Black calcareous shale, no fossils found	0.05	M.
1)	Blue-black limestone same as 7	2.65	M.
	Total	8.20	M.

The fossils found in *horizon No. 6* (*Coll. 42*) have been determined by Dr. A.W. Grabau who has supplied the following list:

Brachiopoda:

Lingula sp.

Chonetes mesolobiformis Gr. (r)

Chonetes sp.

Productus cf. semireticulatus

Productus perundosus Gr. (r)

Reticularia rotundata Gr. (r)

Athyris vasculosus Gr. (c)

Camarotoechia cf. pleurodon (r)

Pelecypoda:

Aviculopecten alternatostriata Gr. (c)

Entolium obtusum Gr. (r)

Camptonectes (?) pustulatostriata Gr. (r)

2. *In Pei Tsa Kou* some fossils have been collected in a horizon of calcareous shale in the lower part of the Maoerhkou limestone (0.4 M. from its base) (Coll. 34) (see section No. 8) Dr. A.W. Grabau has found here the following species:

Brachiopoda:

Chonetes sp.
Productus (Marginifera) lopingensis Kayser
Productus sp.
Marginifera sp.

D. HSIEHTAO LIMESTONE

Among the *Lower Carboniferous* marine horizons occurring *in the Western marginal hills* of the Taiyuan basin, the Hsiehtao limeston is, as far as I know the youngest.

From the limestone next in succession downwards (the Maoerh ou limestone) it is separated by a complex, 6 to 13 M. thick, of plant-bearing clay sediments and sandstones.

In Miao Kou (Pankou), along Yueh Men Kou and in Kuan Men Kou (?), the Hsiehtao limestone is underlaid by a seam about 1. M. thick of anthracitic coal; this seam is absent in Pei Tsa Kou.

The Hsiehtao limestone is succeeded by the thick Peitsakou sandstone which forms the foundation of the Upper Carboniferous sediments. (See general section Pl. II, and fig. 3 & 8).

The surface of the limestone in question is usually strongly corroded and consequently of varying thickness; between 2 & 3 M. but it is seldom entirely absent. When encountered in the field-work it is rather easily recognised by the abundance of corals and fragments of crinoids which it contains, which appear specialy distinct on weathered surfaces.

The Hsiehtao limestone has been found at the following localities: In the Miao Kou section; in Yueh Men Kou and some of its tributary valleys; along Pei Tsa Kou; and at Shang Pai Ch'üan (上白泉) in the eastern margin of the Mo Erh Tung (莫兒棟) horst, 120 li W. of Taiyuanfu;

It is also possible that it is identical with Limestone IV. in the Kuan Men Ch'ien section (fig. 5).

1. PEI TSA KOU

The structure of the marine bank is shown by the section, fig. 8, taken at the coal-mine *Hsi-Yao-Tung-Yao*. We find from above downwards;

Stratum No. 3 Grey-blue, marine limestone, massive	0.4	M.
Stratum No. 2 Black calcareous shale	0.3	M.
Stratum No. 1 Limestone same as No. 3 (Coll. 35) *Horizon of Pinnatophyllum norini*	1.8	M

The fossils collected *in the lower part of stratum No. 1 (Coll. 35)* have been determined by Dr. A. W. Grabau who has supplied the following list:

Anthozoa

Pinnatophyllum norini Gr. (c)

Brachiopoda

Spirifer bisulcatus (rc)
Productus cf. taiyuanfuensis Gr. (r)
Productus sp.
Reticularia sp.

Pelecypoda

Conocardium carditiforme Gr. (r)

---

2. MIAO KOU

The Hsiehtao limestone has here a thickness of 1.8 M. and appears as a thoroughly massive limestone without intercalations of shale. (see section, fig. 6).

From the *upper* part of this bank originates collection 39, of these fossils Dr. Grabau has furnished the following list.

Anthozoa

Lophophyllum acanthiseptum Gr. (?)
Pinnatophyllum norini Gr. (r)

Brachiopoda

Chonetes bilobus Gr. (r)
Orthothetes sp
Spirifer bisulcatus (r)
Spiriferina willisi Gr. (r)
Reticularia perplexa (Mc Chesny) (c)
Athyris vasculosus Gr. (c)
Productus taiyuanfuensis Gr. (r)
Productus (Marginifera) lopingensis K. (c)
Productus scabriculus (Mart.) (r)

Gastropoda

Naticopsis hemistriata Gr. (r)
Straparollus sp.
Euphemus sp.

---

3. TUNG TA YAO (YUEH MEN KOU)

The marine bank has here the following structure: see section, fig. 7. From above:

Layer No. 8. Rusty limestone with strongly corroded surface containing numerous crinoid-fragments	0.20	M.
Layer No. 7. Black calcareous shale containing scattered pebbles of flint of nut-size rich in fossils (Coll. 39)	0.3	M.
Layer No. 6. Blue-black limestone with corals and crinoids	0.1	M.
Layer No. 5. Dark brown loose clay	0.02	M.
Layer No. 4. Hard black calcareous shale with scattered marine fossils	0.25	M.
Layer No. 3. Blue-black limestone with numerous corals and crinoid fragments	0.7	M.
Layer No. 2. Marine, black, calcareous shale	0.3	M.
Layer No. 1. Blue-black limestone like No. 3	0.5	M.

Collection 39 from layer No. 7 has been examined by Dr. Grabau who has found the following species:

Anthozoa

Lophophyllum acanthiseptum Gr. (c)
Pinnatophyllum norini Gr. (rc)
Lopholasma carbonaria Gr. (c)

Brachiopoda

Chonetes nyströmi Gr. (rc)
Spirifer bisulcatus (c)
Spirifer sp.
Reticularia sp.
Athyris vasculosa Gr. (r)
Productus taiyuanfuensis. Gr. (rc)

Pelecypoda

Acanthipecten shansiensis Gr. (r)

Echinodermata

Crinoid stems

E. TUNGTAYAO LIMESTONE (see section fig. 3 and Pl. II)

This Upper Carboniferous marine horizon is *the youngest marine formation within the Palæozoic series in Central Shansi.* It has only been found along Yueh Men Kou and its immediate neighbourhood. In Miao Kou (Pankou) and in Pei Tsa Kou, iron-ore conglomerates occur at the corresponding level. At the coal mine Tung Ta Yao (in Yueh Men Kou) after which this limestone has been named, its thickness is 3.4 M. Subjacent to it occurs black, coaly, argillaceous shale (14 M.) separated from the limestone above by a coarse limestone conglomerate. The shale in its turn is underlain by the Peitsakou sandstone.

The roof of the Tungtayao limestone is formed of a complex, about 25 M. thick, built up of black clay sediments and thick seams of bituminous coal.

The marine bank at Tung Ta Yao has the following composition: From above

4.	Massive, blue-grey limestone with *Fusulina* and Crinoid stems	1.5	M.
3.	Loose, black, argillaceous shale	0.62	M.
2.	Grey-black, pyritic calcareous shale which upwards becomes more like limestone, fossiliferous, *Coll. 40;*	1.7	M.
1.	Conglomerate consisting of pebbles up to 10 cm. in size of light grey-blue, fossiliferous limestone with matrix of black, argillaceous shale, **Total**	3.4	M.

The fossils found in *Stratum No. 2: Coll. 40* have been determined by Dr. A.W. Grabau with the following result:

Brachiopoda

Orbiculoidea sp.
Enteletes cf keyseri (r)
Chonetes tungtayaoensis Gr. (cc)
Productus subcostatus Gr. (rc)
Productus pustulosus Mart. (c)
Spiriferina cristata var. octoplicata Sow.

FORMATIONS OF THE EASTERN REGION

HORIZON V, THE KUANTIKOU LIMESTONE

This horizon is the youngest marine one in the coal series *in the Eastern Marginal Hills* of the Taiyuan plain. The stratigraphical conditions are illustrated by the Kuan Men Ch'ien section, fig. 5.

As pointed out above, the relation of the Kuantikou limestone to the marine horizons in the West is not yet definitively known. From the determinations of the fauna of this limestone by Dr. Grabau it is proved that it belongs to the same general division as the marine horizons B-D.

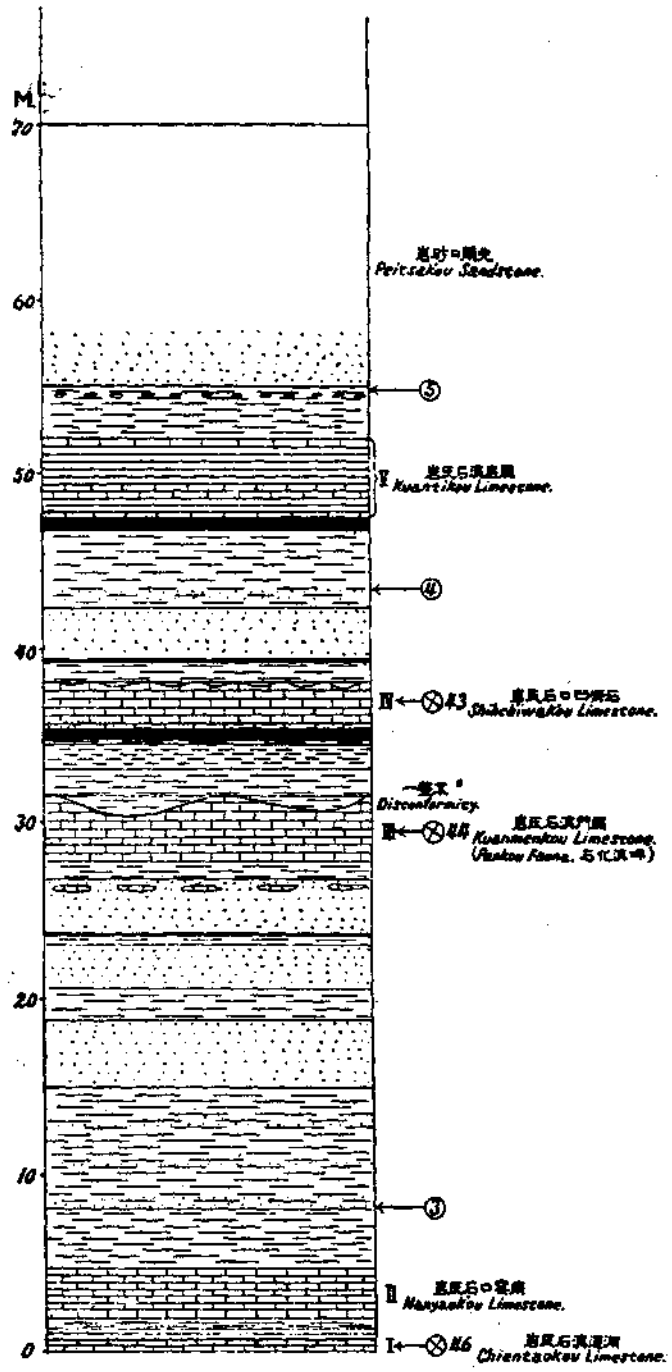

Fig. 9. Columnar section of the Lower Carboniferous rocks o Kuan Men Chien, 15 li E. S. E. of Taiyuanfu. (See fig. 5)

太原府東南偏東十五里關門前
下石炭紀石層柱形剖面圖

The Kuantikou limestone has been found in a similar development along a rather large stretch at the Eastern hills; it is generally very abundant in fossils. The name is taken from a fossil locality at the village Kuan Ti Kou situated at a distance of 10 li east of Taiyuanfu.

The marine bank has here the following composition: From above:

6.	Rusty limestone with strongly corroded surface, about	0.3	M.
5.	Black calcareous shale, turning bright yellow by weathering, rich in fossils	1.3	M.
4.	Rusty limestone often wedging out	0.1	M.
3.	Black argillaceous shale with bright yellow weathering, rich in fossils (Collection 37)	0.65	M.
2.	Massive, black, argillaceous limestone with bright yellow weathering (Collection 37.)	1.1	M.
1.	Bright yellow clay-stone	0.5	M.
	Total	3.95	M.

Subjacent to these marine sediments we find black plant-bearing, argillaceous shale (*Sphenophyllum*, *Annularia*, *Cordaites* and others). In the boundary between this and the marine claystone there occurs a thin coal-seam.

Coll. 37 which has been taken *from the strata No. 2 and 3* has been examined by Dr. A.W. Grabau who has supplied the following list of fossils:

Anthozoa

Lopholasma carbonaria Gr. (c)
Lophophyllum acanthiseptum Gr. (cc)
Pinnatophyllum sp.

Brachiopoda

Chonetes nyströmi Gr. (cc)
Chonetes sp.
Orthotetes sp. (several, including probably O. taiyuanfuensis)
Productus taiyuanfuensis Gr. (cc)

Productus (Marginifera) lopingense K. (r)
Productus echidniforme Gr. (c)
Marginifera cf. longispina (r)
Spirifer bisulcatus (cc)
Spiriferina willisi Gr. (rr)
Reticularia rotundata Gr. (r)
Aulacorhynchus sp. (c)
Athyris vasculosa Gr. (cc)

Pelecypoda

Aviculopecten irregulare Gr. (r)
Aviculopecten concentrica Gr. (r)
Acanthipecten shansiensis (c)
Pecten (?) kuantikouensis Gr. (r)
Entolium obtusum Gr. (r)
Pterinea (?) nodostriata Gr. (r)

Horizon IV, *The Shihch'iwakou limestone* (the name from the valley Shih-ch'i-wa-kou, a northern tributary of Kuan-Mên-Kou, 1 li east of Kuan-Men-Ch'ien). (Collection No. 43.) This horizon may be subdivided into:

IV_2 (the upper part) grainy limestone with a few thin shaly levels. The limestone is mainly built up of crinoid fragments; besides these there occur a few scattered corals and brachiopods. Thickness 0.2-0.5 M.

IV_1. Massive blue-black limestone containing corals and brachiopods. The corals seem to be rather common, especially in the middle part of the limestone bank. Among the brachiopods *Spir. bisulcatus* seems to be the most frequent. Thickness 2.5 M.

The following species from this horizon have been determined by Dr. Grabau

1. Lophophyllum pendulum Gr.
2. Pinnatophyllum cf norini Gr.

3. Productus costatus (typical)
4. Spirifer bisculcatus Sow.
5. Spirifer pankouensis Gr.
6. Phillipsia sp.

This and the overlying Kuantikou limestone appear both to be higher than the Hsiehtao limestone horizon of the sections west of Taiyuanfu. A marked disconformity separates these limestones from those next below in this section.

Horizon III. The Kuanmenkou limestone. (Collection No. 44.)

The name is taken from the valley Kuan-Men-Kou, 15 li E-S-E of Taiyuanfu.

This horizon shows the following subdivision: (From above)

III_5.	Greyish-blue mudstone with brachiopods (mainly Productoids) and a few scattered plant remains. Thickness up to	1.5	M.
III_4.	Black calcareo-argillaceous shale	1.5-3	M.
III_3.	Yellowish, weathered, grainy limestone with abundant crinoid fragments. A few shaly leaves are interbedded.		
III_2.	Bluish-black, massive, flinty limestone (Coll. 44.)		
III_1.	Bluish black flinty limestone, partly shaly. I am not quite sure that there is not a disconformity between the strata III_4 and III_{3-1}. The boundary plane is strongly corroded and the thickness of the complex III_{3-1} varies between 1.5 and 3 m. It may also be possible that the horizon III_4 is not marine. Yet the transition between this and III_5 is continuous and a sharp boundary line can not be drawn.		

In the stratum III_2 *corals* are rather common and also *Spir. bisulcatus*. But on the whole this limestone is poor in fossils, and in the shaly levels very few have been found.

The following fauna has been determined by Dr. Grabau.

Pinnatophyllum cf. norini Gr.

Chonetes nystromi Gr.

Enteletes lamarcki Fisch.

Productus cf. costatus

P. taiyuanfuensis Gr.

Spirifer bisulcatus Sow.

Spirifer pankouensis Gr.

Spiriferina willisi Gr.

This is the fauna of the Pankou limestone of the western sections, as shown especially by the presence of *Enteletes lamarcki*. If this is the Pankou limestone, then the disconformity above it cuts out all the formations above this horizons which are found in the western sections.

Horizon II. *The Nanyaokou limestone*, named from the valley Nan-yao-kou, a northern tributary to Kuan-Men-Kou. No fossils have been collected. Thickness 2.8 M.

Horizon I. *The Ch'ientaokou limestone*, named after the main valley Ch'ien-Tao-Kou.

I_2. Greyish-black, grainy limestone with abundant *Fusulinas*. In the more shaly levels a few other fossils have been found. Coll. 46. Thickness 0.4 M.

I_1. Greyish-black to bluish-black massive limestone in which fossils are very scarce. Thickness 0.9 M.

The horizon II is separated from horizon I by a bank of greyish blue mudstone and shale, 0.6 m. in thickness, in which only a few plant fragments, but no marine fossils have been found.

The following fauna has been determined from the Ch'ientaokou limestone (Hor. I) by Dr. Grabau.

Fusulina sp. very abundant

Productus taiyuanfuensis Gr.

Pleuronautilus? pernodosus Gr.

This horizon appears to be lower than anything seen in the western sections.

COMMENTS ON THE FOSSIL LISTS

BY

A. W. GRABAU

The Pankou limestone of Loc. 30 is on the whole distinct from the others, although it belongs to the same general division as the majority of the horizons (except that of Loc. 40 The Tungtayao limestone). Its most distinctive species are *Griffithides quadrinodus* Grabau (c) and *Enteletes lamarcki* Fisch (r). The presence of *Spirifer bisulcatus* which is common in the higher beds, shows its relationship to them. *Spirifer pankouense* is another characteristic form though not wholly restricted to it. This horizon is again seen in the Kuanmenkou limestone of the eastern sections where it is underlain by lower limestones not found west of Taiyuanfu.

Collections 31,33,37 and 41 have many species in common, especially *Chonetes nyströmi* Grabau. But horizon 41 is especially characterized by *Orthotetes taiyuanfuensis* Gr. being the horizon *par excellence* of this fossil (*Orthotetes taiyuanfuensis bed*). *Productus punctatus* is another species common in collections 31 & 41. The very charcteristic *Reticularia obscura* Gr. is however confined to horizon 31, and this is believed to be below the others, as is indeed shown in the sections.

Horizon of Coll. 42 (fig. 7; stratum C. 6.) is also colsely related, all the species found in it occurring in one or the other of the three horizons (33,37 & 41) except:

Camptonectes (?) pustulatostriatus Gr.

Chonetes mesolobiformis Gr.

Productus perundosus Gr.

These three species are so far only known from this horizon (42).

So far as the few fossils found in horizon C, fig. 8, (Coll. 34,) are concerned, that horizon may be equivalent to C. 6. mentioned above.

The Tungtayao limestone, Coll. 40, is higher than all the others. Its distinctive species are:

Chonetes tungtayaoensis, Gr. *Enteletes kayseri*, Waagen, and *Productus pustulosus*, which is most typically developed here. No *Spirifer bisulcatus* is found here.

The limestones A-D and I-V apparently reperesent *late Lower Carboniferous* or *earliest middle Carboniferous.* They may perhaps best be regarded as *transition from Viseen to Moscovian,* without being as yet true Moscovian. They are characterized by *Spirifer bisulcatus.* The Tungtayao limestone is *Permo-Carboniferous,* i. e. *Artinskian. Spirifer bisulcatus* is absent from this horizon.

THE SANDSTONES

The most important sandstone-formations within the Yuehmenkou coal-series in the Western Hills are found as follows (see general section, Pl. II.)

1) Between the Pankou limestones and the Miaokou limestones (*The Chinszu sandstone complex*).

2) In the base of the Upper Carboniferous sediments (*the Peitsakou sandstone*)

3) In the base of the Permian sediments (*the Lot'opo sandstone complex*)

1. The Chinszu Sandstone complex is the name I have given to a zone mainly built up of sandy sediments, which appear in the roof of the Pankou limestones. It has been identified in Pankou, along Yueh Men Kou,

along Pei Tsa Kou and at several other localities in the western hills. A sandstone complex probably corresponding to this occurs also in the lower part of the coal-series in the hills east of the Taiyuan plain.

In Mao Erh Kou this sandstone zone is built up of quartzose, grey sandstone with banks of black, plant-bearing argillaceous shales, coal seams, strongly eroded thin banks of marine limestone, often wedging out, and coarse limestone conglomerates.

The sandstones are often darker coloured than those existing in the higher levels of the coal-series, and are probably richer in argillaceous and calcareous material than these

2. The Peitsakou Sandstone is the thickest, and most constant homogenous sandstone formation within the Carboniferous series. Its thickness amounts to 15-25 M. In the western hills it probably occurs everywhere forming the roof of the Hsiehtao limestone. It is probably also identical with the thick sandstone-bank which at Kuan Men Ch'ien and Kuan Ti Kou is superimposed on the Kuantikou limestone.

The Peitsakou sandstone may be considered as a basal formation of the Permo-Carboniferous sediments. It consists usually of rather pure white quartz sandstone consisting of grey water-worn quartz, more or less strongly weathered feldspar, sericite. dark minerals, probably mostly ore-grains, and, in varying quantity, a white flour-like substance of kaolinic character Cross-bedding is common, likewise gravel-layers with pebbles up to the size of an egg; these pebbles consist mainly of Archæan material: pegmatite-quartz, red feldspar, brown and black porphyries, crystalline schists and sometimes also yellow or black flint.

Charred trunk-fragments and prints of *Lepidodendron* sp. are often found.

Clay-material is very scarce within the main mass of the sandstone but more frequent in the higher layers.

3. The Lotopo Sandstone Complex. By this name I have designated a zone of light-coloured sandstones about 35 M. thick with banks of clay-sediments, which occurs in the uppermost part of the Yuehmenkou

series. It has been observed in a state of fine development along Pankou and Yueh Men Kou and the tributaries of these. With the coal-series, as well as with the Lower Permian sediments it is intimately connected through transitions. This sandstone zone contains, beside the black argillaceous shales characteristic for the coal-series, also sediments of a new type which is foreign to the coal-series but characteristic for the Permian Shihhotse series, namely light-coloured, greyish green and grey argillaceous shales and clay-stones. The Lotopo sandstone can therefore in a certain sense be considered as a transition-zone between the Carboniferous coal-series and the coal-free Permian Shihhotse series.

THE CONTINENTAL CLAY SEDIMENTS AND THEIR PLANT-BEARING BEDS

The shales are partly black or greyish black, pyritic alum shales, partly black argillaceous shales. Interbedded with these and especially in the argillaceous shales, beds are often found of greyish blue, dense, calcareous claystones or marl.

A shaley zone, specially rich in pyrites, occurs in the lowermost part of the coal-series just below the Pankou limestones and also interbedded within these. The pyrite occurs partly as impregnation in black shale, partly in the form of nodules of varying size in greyish calcareous claystones. At Yueh Men Kou this horizon is mined and the pyrites used for the production of sulphur.

Apart from this, alum-shales occur in several horizons within the Lower Carboniferous but only comparatively seldom their percentage of sulphide of iron is large enough to make them workable. These alum-shales often show salty crusts, probably ferric sulphate, especially in winter and after prolonged drought, when they are visible in the joints or bedding-planes in the escarpments.

The black, argillaceous shales are here and there rich in plant fragments, but unfortunately these are most often ill preserved. The richest finds have been made in the sandy shale-levels which form the roof of the

sandstones, or in sandy layers embedded in the shales. The main mass of pure shale seems generally to be poor in fossils. Levels with root-prints are not infrequently met with. These seem to be most frequent in those beds of argillaceous shale which immediately underlie the coal-seams.

In the Carboniferous coal-series six rich, plant-bearing horizons have been found at the following localities:

1) Mao Erh Kou, section fig. 2, stratum No. 28
2) Mao Erh Kou, section fig. 2, stratum No. 48
3) Kuan Men Ch'ien, section fig. 5, stratum No. 4 b.
4) Kuan Men Ch'ien, section fig. 5, stratum No. 20
5) Kuan Men Ch'ien, section fig. 5, stratum No. 22
6) Tung Ta Yao, section fig. 3, stratum No. 62

The flora of *loc No. 2* found at Mao Erh Kou, occurs in a horizon of sandy, argillaceous shale, which is subjacent to the Miaokou limestone. The plant-remains belong mainly to *Cordaites*, *Neuropteris* (probably *N. schlehani*) and *Lepidodendron;* rootprints are common.

Loc No. 3, Kuan Men Ch'ien. Plant-remains occur very abundantly in a flat-cleaving, calcareous, argillaceous, black shale upon which is superimposed an argillaceous sandstone. Among others occur *Neuropteris* cf. *schlehani*.

Loc. No. 4, The horizon No. 20 in the Kuan Men Ch'ien section. Here we find large trunk fragments of silicified wood embedded in argillaceous sandstone or sandy, grey-black, argillaceous shale.

Loc. No. 6, Tung Ta Yao, section fig. 3, horizon No. 62; Black argillaceous shale forming the roof of a white quartz-sandstone rich in kaolin. The shale contains a flora composed of only few species mainly *Cordaites* and *Annularia*, the latter often completely covering the bedding surfaces.

The same horizon, also plant-bearing, has been found at Hsiao Nan Kou (小南溝) at the village Sai-Chuang (賽庄) 30 li W. Taiyuanfu. This locality was first discovered by Mr. Yao in 1919, and was transferred to me by Dr. J. G. Andersson. The black, argillaceous shale, here also abundant in *Annularia*, is succeeded by dark brown-grey claystone, containing *Neuropteris* cf. *flexuosa*, *Lepidodendron* and trunk fragments of *Calamites*.

THE COAL SEAMS.

A glance at the general secetion, pl. II, will show that the coal-seams occur throughout the Yuehmenkou series. In the section referred, to the larger workable seams have been marked I to XII. Beside these there are especially in the lower part of the series, a number of seams measuring in outcrops only 10 or some tens of cm. The thickest coal seams which possibly represent the time of maximum coal-formation, occur in the upper part of the coal-series and are of Permo-Carboniferous age.

Nothing can be said of the chemical character of the coal in the various seams, as analyses of samples have not yet been made. However, it has been found that most of the bituminous coal is taken from the large Permo-Cabonifrerous seams VIII. to XII; and probably all anthracite which is mined in the Taiyuan district originates from the Lower Carboniferous Taiyuan coal horizon, especially from seams III, IV and V.

The largest mines of Bituminous Coal are Fu Ho Yao (富合窰) 40 li W. of Taiyuanfu; Tung Ta Yao (東大窰) and Lo T'o Po Yao in Yueh Men Kou, 30 and 25 li respectively W. of Taiyuanfu. These mines are sunk in the Upper Carboniferous seam which here in outcrops show a thickness of 8½ to 2 M. Inside the mines greater thickness is found; according to information received the seams that are mined at Tung Ta Yao (see fig. 3) measure: the lower one 5.5 M., the upper 2.5 M.

Bituminous coal occurs however also in the Lower Carboniferous. In the Eastern hills at Taiyuan where most of the Upper Carboniferous sediments are eroded away, a very good bituminous coal is mined at Lu Chia Wan (陸家灣) at the upper end of the Shih Ho Tse valley, 15 li E. of Taiyuanfu. This coal is taken from a seam subjacent to the Kuantikou limestone.

The largest Anthracite mines are situated along the valley Liu Tse Yü which drains into the Taiyuan plain, 6 li. S. W. of the Chin Szü temple; and in the upper tributaries of this valley, namely Chung Tsa Kou (中岔溝) and Pei Tsa Kou. (北岔口)

The dip is here undulating and the strike is generally N. or N.E.

Much anthracite is taken from seams below the Miaokou limestone (see section, fig. 8), corresponding in the Yueh Men Kou, section Pl. 2, to the seam No. III. Part is taken from seam IV which appears in the complex of argillaceous shale which separates the Miaokou and Maoerhkou limestones. Also this seam contains anthracitic coal. Its thickness in outcrops is at the mine Hsi Yao Tung Yao 0.3 M.

Another considerable anthracite mine is Chi Sheng Yao (吉盛窯) situated in the upper part of valley Hung Yai Wan (紅崖灣) 25 li W.S.W. of Taiyuanfu. The seam mined here occurs in the argillaceous shales subjacent to the Hsiehtao limestone (seam V).

Concerning the coal area in the plane of straification it seems that generally those seams which are subjacent to the marine limestones have a wider extension than those upon which quartz-sandstone is superimposed.

The anthracitic coal-horizon No. III in the general section, Pl. II, has been observed all along the eastern escarpment of the Kao Li Shan plateau from Chin Szü temple in the south to the Fen Ho gorge in the north. Its thickness in outcrop usually amounts to 1 M. Sample of coal from this horizon taken at a small mine south of village Pei Tao Tsun, 20 li W. of Taiyuan city, has been analysed by Prof. E.T. Nyström; it proved to be a fairly good anthracite, containing 4.49 % ash.

The seam No. IV. shown in section, fig. 8, is encountered only in Pei Tsa Kou and is absent in Yueh Men Kou and Pan kou.

The seam No. V, occurring just below the Hsiehtao limestone, has been traced along a distance of some 40 li from Miao Kou, (Pankou) to Hung Yai Wan valley with a thickness of ½ to 1 M. This horizon has not been found in outcrops in Pei Tsa Kou. It is not improbable that to this complex of anthracitic coal-seams belong also those large anthracite-seams in the Ping-Ting (平定) mining region in eastern Shansi. At Yang Ch'uan (陽泉) 20 li N.W. of Ping Ting Hsien the anthracites are, in the same manner as in the Taiyuan region, connected with a series of marine limestone, occurring in the middle part of the coal-series. Whether these marine sediments include the same horizons as those at the Taiyuan basin is however not yet settled.

The Yueh Men Kou section, Pl. II, shows that in most cases the coal-seams are intimately connected with the marine horizons and generally appear immediately below these, being separated from them sometimes by a thin, sometimes by a thick horizon of black, often plant-bearing argillaceous sediments. The roof of the coal seams is however sometimes formed of quartz sandstones, often very rich in kaolin which gives them a characteristic yellowish white color and easily disintegrating structure.

Out of twelve observed Lower Carboniferous coal-seams, nine are succeeded by limestones, whereas three are subjacent to quartz-sandstone.

The intimate connection between the coal-seams and the marine sediments indicates that the material which has formed the coal-seams has been accumulated in basins in close proximity to the sea. If we now examine more closely the change in lithological character as we proceed from below upwards within a certain part of the stratigraphical sequence, we find in most cases a regular change in the following manner:

1) Quartz-sandstone, often cross-bedded
2) Black, argillaceous shale; not seldom containing plant-remains
3) Greyish blue, calcareous shale
4) Black, argillaceous shale
5) Coal-seam
6) Black, argillaceous shale with plant-remains
7) Marine limestone
8) Black, argillaceous shale
9) Quartz-sandstone, same as 1.

The frequent occurrence of marine sediments as intercalations in continental deposits and the variation of petrographic character of sediments in a direction perpendicular to the plane of sedimentation shows that the region in question has been subjected to rhytmic subsidences with accompanying minor transgressions of the sea. Parts of these invaded areas may possibly, in the course of continued sedimentation, have been separated from the sea, and the continental sediments have accumulated until, through a renewed subsidence and a renewed transgression, the same cycle has been repeated. The coal-seams may have been swamps situated within a low-lying shore-district or lagoons in

which large quantities of rotting plant-remains have accumulated and afterwards, through an invasion of the sea, been saved from annihilation.

AGE AND SUB-DIVISION OF THE YUEHMENKOU COAL SERIES

The time of formation of the oldest sediments of the Yuehmenkou series is determined by the age of the marine fauna which has been found in the Pankou limestone. This has according to determinations of Dr. A. W. Grabau, been found to belong to Younger Lower Carboniferous (see above page 48).

It is more difficult to obtain an exact age-determination of the younger sediments of the coal series, because of the fact that fossil-bearing, marine horizons have not been found in the uppermost part of the formation. The sandstone complex which enters into the uppermost part of the Yuehmenkou series (the Lot'opo sandstones) contains beside the black argillaceous shales characteristic for the coal series, also sediments of a new type which is foreign to the coal series, but characteristic for the Permian Shihhotse series, namely light-coloured greenish-grey claystones and argillaceous shales. This zone can therefore, in a certain sense, be considered as a transition zone between the proper coal series and the younger light-coloured, coal-free series.

In the roof of the Lot'opo sandstone complex there appears in the greenish grey claystones a very typical flora characterized specially by masses of *Annularia, Taeniopteris* (probably *T. multinerva*) and more sparsely *Callipteris sp.* These last two species show that the clay sediments in question belong to Lower Permian (Rothliegende). Any visible disconformity between these claystones and the underlying sandstone complex does not exist, and the transition seems to be continuous. The Lot'opo sandstones belong probably to oldest Permian or Permo-Carboniferous.

The youngest marine horizon of the Yueh Men Kou series within the region dealt with in this essay, is the Tungtayao limestone, which appears immediately below the large complex of coal seams which in Central Shansi probable represents the time of maximum coal formation. The limestone belongs according to Dr. Grabau to Early Permo-Carboniferoue.

Through comparison with the stratigraphical conditions which obtain in other parts of werstern Shansi in the neighbourhood of the coal seams which

represent there the maximum coal formation, it is highly probable that this period of maximum coal deposition falls in the Permo-Carboniferous.

In the general section, Pl. II, a tentative subdivision of the Yuehmen-kou coal-series has been made.

The Permo-Carboniferous is separated from the Permian by a disconformity. The proofs of its existence are given below, page 54-55, and is revealed by a comparison of the Permo-Carboniferous boundary zone, in the scetions in Pl. II & III. In the eastern hills at the Taiyuan plain almost the entire Upper Carboniferous is missing. The Rothliegende-sediments rest on a sandstone-horizon, probably equivalent to the Tungtayao sandstone.

A considerable disconformity is supposed to exist between the Hsiehtao limestone (D) and the Tungtayao limestone (F) and it is also assumed that this disconformity indicates the hiatus between the Lower and the Upper Carboniferous. The Lot'opuyao sandstone may in that case be considered as forming the base of the Upper Carboniferous sediments.

In case future research should reveal that the Kuantikou limestone (E) is younger than the Hsiehtao limestone (D) which seems very probable, then the existence of this disconformity is proved.

A third, considerable disconformity is prbably too be looked for in the boundary zone between the Pankou limestone (A *4*) and the Miaokou limestone (B). Its existence is made probable by appearance of traces of denuda tion (the Chenszu sandstone complex and its limestone-conglomerates).

THE PERMO-TRIASSIC FORMATION

THE PERMO-CARBONIFEROUS BOUNDARY ZONE

The thick complex of sandstones which appears in the upper part of the Lot'opo section, forms the base of a formation about 250 M. thick, composed mainly of greyish green, yellow green, and, in the highest levels, yellow claystones, and sandy shales, interbedded with light-coloured quartzose sandstones. Marine sediments and coal seams are absent. As a rule coaly sediments are scarce and are completely missing in the uppermost part of the formation.

I have called this sedimentary formation the Shihhotse series using the name of the valley Shih Ho Tse, 9 li East of Taiyuanfu, where these sediments are laid bare in a very handsome section. (Pl. I. sec. 3, Pl. II & III.)

Against the coalbearing series below it is well defined through the Lot'o-po sandstones. It has the nature of a uniform complex. The transition to the Triassic chocolate coloured marl sandstone formation above is continuous.

This complex of light-coloured sedimentary rocks is in such a sharp contrast to the Yuehmenkou series with their black argillaceous shales, coal seams and kaolin-bearing sandstones, and on the other hand to the Triassic formation red brown turgite-bearing rocks, that it is difficult to avoid conclusion that these light-coloured sediments have been formed during different climatic conditions, as will be discussed later on.

The same stratigraphical conditions existing in the Lo T'o Po profile are also apparent in the Permo-Carboniferous transition zone is other places along the escarpment which borders the Taiyuan plain in the West.

Observations have been taken from the Fen Ho gorge in the north to the town Chiao Ch'eng (娇城) in the southwest, viz. along a distance of 60 km. Everywhere we find the large Permo-Carboniferous coal seam superceded by a thick sandstone formation which merges upwards into the light-coloured clay sediments of the Shihhotse series. The stratification further to S. W. is not known.

Quite different conditions are met with in the eastern marginal hills bordering upon the Taiyuan basin. Here we find that almost the whole of the Upper Carboniferous complex is missing and that Permian light-coloured claystones with Rothliegende flora are underlaid by a thick Carboniferous sandstone probably equivalent to the Tungtayao sandstone (Yuehmenkou Stratum No. 53) separated from this by banks of black argillaceous shales which in some places are filled by conglomerate-layers. The marine Tungtayao limestone, the large bituminous coal seam and the entire thick Lot'opo sandstone complex are missing.

The stratigraphical conditions are shown in the Shih Ho Tse section, Plate III.

If we now contemplate the Shih Ho Tse section we find the following succession.

1) The white quartz-sandstone above the Kuantikou limestone (see section fig. 5; page 16) possibly identical with the Lot'opuyao sandstone,

merges upwards into a sandy shale with layers filled by sphero-siderite concretions. Then follows:

2) Black argillaceous shale of varying thickness, here and there filled by round sphero-siderite concretions and lenses and banks (quickly wedging out) of iron band, which cause the argillaceous shale sometimes to look like conglomerate shale.

The upper horizons assume the nature of black shale, where foreign matter does not occur. This merges into:

3) Greenish-grey, calcareous claystone with a flora characterized by masses of *Annularia*, *Taeniopteris*, (Probably *T. multinerva*) and more sparsely *Callipteris*. What is most striking in this profile is the absence of sandstone material in the base of the Callipteris-zone. It seems quite improbable that if the thick Lot'opo sandstones had once occurred here but then been eroded away, remnants of these should not be found here in the form of conglomerates in place of the removed sandstone. The fact is that not a trace of those sandstones is to be found here. The only explanation of this is that the Lot'opo sandstone has never been deposited in this locality.

The masses of sphero-siderite and iron band that enter into the underlying black shale complex may be remnants of the Upper Carboniferous Tungtayao limestone.

We are thereby led to the conclusion that during the youngest Upper Carboniferous, in a time before sedimentation of the Lot'opo sandstones commenced, epeirogenetic movements took place. By these the strip of land bordering the Taiyuan basin in the east has been raised more than the country west thereof.

THE SHHIHOTSE SERIES

DESCRIPTION OF SECTIONS

In the valley Shih Ho Tse we find the first outcrops at the village Ch'en Chia Yü, 9 li East of Taiyuanfu (see fig. 1). These consist of Triassic sandstones and redbrown marls with a dip of 30° W. If we follow the valley eastwards, we notice that the sediments assume a more and more horizontal position; and at the upper end the dip is scarcely more than the inclination

of the bottom of the valley. Larger faults are absent; smaller subsidences with a throw of 10.20 M. occur in a few places.

The illustration, Pl. I, sec. 3, on the scale of 1:7500, shows a section through Shih Ho Tse from the village Ch'en Chia Yu eastwards ascending the valley. The lithologic character of the sediments is shown in the columnar section Pl. III. The thicknesses of the sedimentary strata have been taken at the bottom of the valley.

The Permo-Carboniferous transition zone has, as we have stated, the composition of black argillaceous shale, the lower levels of which are filled by concretions of sphero-siderite and layers of iron-band .....8 M.

This shale is succeeded by

2) Light grey green claystone, containing a very characteristic flora (*Annularia, Taeniopteris, Callipteris*—Flora No. 10).....3.5 M.

In the boundary zone between the dark shale and the light coloured claystones we find in several localities pebbles up to 1 M. in size of iron-impregnated, argillaceous limestone.

3)	Light grey, porous, argillaceous limestone with banks of iron-band	.....1.8 M.
4)	Black argillaceous shale	aboat 1.0 M.
5)	Thin coal seam (often wedging out)	0—0.2 M.
6)	Yellowish white sandstone	about 4.0 M.
7)	Light-colored claystones merging upwards into dark marls	3.7 M.
8)	Black argillaceous shale	1.0 M.
9)	Light-coloured, sandy and micaceous shale	1.5 M.
10)	White micaceous, argillaceous sandstone	1.5 M.
11)	Light-colored claystones or marls	3.6 M.
12)	Light-colored, argillaceous sandstone	1.5 M.
13)	Light grey claystone	1.0 M.
14)	Black coaly argillaceous shales	0.5 M.
15)	Light grey plant-bearing claystone	0.5 M.
16)	Black argillaceous shale	0.3 M.
17)	Layer of soft coal	0—0.1 M.
18)	Light-coloured argillaceous sandstone (fine-grained)	1.0 M.

19)	Light-coloured claystones or marls which upwards become darker	4.0 M.
20)	Fine-grained argillaceous micaceous sandstone	1.2 M.
21)	Light grey claystone	0.4 M.
22)	Fine-grained, greyish green sandstone	1.0 M.
23)	Light grey claystone	1,5 M.
24)	Dark grey argillaceous shale	0.5 M.
25)	Light grey, micaceous claystone	1.3 M.
26)	Fine-grained, light-coloured sandstone	1.0 M.
27)	Light grey clay stone	0.5 M.
28)	Light and dark marls interbedded	5.2 M.
29)	Yellow grey greywacke sandstone	3.2 M.
30)	Sandy dark shale; plant-bearing horizon No. 13	1.0 M.
31)	Sandstone same as 29)	7.0 M.
32)	Dark micaceous sandy shale, dark grey marl (dense) with scattered grains of sericite	2.0 M.
33)	Light grey, calcareous claystone; blue grey shale	1.0 M.
34)	Dark grey, dense marl; thin layer of dark, plant-bearing shale	1.3 M.
35)	Fine-grained, micaceous, grey sandstone	1.5 M.
36)	Light grey claystone. Black, plant bearing shale	0.8 M.
37)	Sandy shale; dark grey claystone	1.0 M.
38)	Light-coloured sandstone	0.6 M.
39)	Sandy shale, dark, argillaceous	1.2 M.
40)	Dark grey marl	0.6 M.
41)	Fine-grained, green-grey sandstone rich in quartz	2.2 M.
42)	Sandy and calcareous shale	1.0 M.
43)	Dark, yellowish grey marl plant-bearing horizon No. 14	6.5 M.
44)	Fine-grained, black shale, light grey claystone	1.0 M.
45)	Grey sandstone with banks of light grey claystone and sandy shale	20.0 M.
46)	Sandy, grey green shale; plant-bearing horizon No. 15a	1.0 M.
47)	Greenish grey to yellowish grey claystone; plant bearing horizon No 15b.	5.0 M.

48)	Grey fine-grained sandstone with prints of tree trunks	0.5 M.
49)	Laminated, argillaceous sandstone	1.0 M.
50)	Greenish yellow claystone	2.0 M.
51)	Yellowish grey sandstone	6.0 M.
52)	Yellow claystone with two banks of reddish brown claystone	8.5 M.
53)	Fine-grained, yellow, argillaceous sandstone containing in its lower, more clayey, parts a plant-bearing layer horizon No. 16	1.5 M.
54)	Yellowish grey, micaceous, solid marl, plant bearing horizon No. 17	0.5 M.
55)	Violet, micaceous marl or claystone	6.0 M.
56)	Yellow-grey claystone, uppermost a thin bank of blue-grey shale	1.0 M.
57)	Reddish brown marl	7.0 M.
58)	Yellow grey solid marl; plant bearing horizon No. 18	2.0 M.
59)	Chocolate-coloured, micaceous claystone or marl in the bottom containing some banks of yellowish grey solid marl	9.0 M.
60)	Dark greyish green claystone	0.2 M.
61)	Grey green sandstone	2.5 M.
62)	Light yellowish grey claystone	1.0 M.
63)	Chocolate-coloured marl or claystone	20.0 M.
64)	Interbedded bands of about 1 M. each of yellow-green and chocolate-coloured claystones	7.0 M.
65)	Yellow claystone with brown spots	1.5 M.
66)	Bright yellow (chrome yellow) sandstone with some bands of greenish yellow crossbedded claystone (Lower Gigantopteris-sandstone)	5.8 M.
67)	Yellow green claystone; plant-bearing, horizon No. 19	0.45 M.
68)	Sandy, yellowish green claystone	1.25 M.
69)	Interbedded yellow-green and chocolate-coloured claystones	4.0 M.
70)	Whitish grey, solid marl; plant-bearing horizon No. 20	1.0 M.
71)	Greyish green claystones with some thin chocolate-coloured layers	23. 0M.
72)	Coarse, grey-green sandstone	0.5 M.

73) Grey-green claystones partly sandy with some thin bands of red-brown claystone 51.0 M.

28 m. from the bottom of this we find in grey green claystone plant-bearing level, No. 21

74) Chrome yellow (light) sandstone 2.0 M.

75) Greyish green claystones with bands of red-brown claystones 7.5 M.

In a grey-green claystone in its upper part plant-bearing horizon No. 22

76) Light chrome yellow, soft sandstone with layers of gravel (Upper Gigantopteris-sandstone) 4.0 M.

If we now contemplate the corresponding sedimentary formation in the *Western* marginal hills bordering upon the Taiyuan basin, we find there on the whole a similar succession of sediments.

Light-coloured, greenish yellow, greyish green and blue-green claystones and often sandy argillaceous shales, interbedded with inconsistant bands of light-coloured greywacke-sandstones which are often intersected by sharply wedging out layers of gravel. As in Shih Ho Tse the clay sediments are rich in well-preserved plant remains In the bottom of the series we find again the characteristic *Callipteris* flora, and the uppermost part of the series is also here represented by the same complex of chrome-yellow sandstones and light coloured claystones with *Gigantopteris* flora as in the eastern section.

A section through the sediments is taken through the northern slope of Yueh Men Kou between Tung Ta Yao in the bottom of the valley and the village Hsieh Tao (斜 道) on the crest of the slope. The sediments lie here almost perfectly horizontally. Along a distance of 1.5 Km. the strata descend westwards about 50 M. The sequence of sedimentation is shown in section Pl. No. II Hsieh Tao division.

The strata that build up the hill Pt. 1390 (the highest part of the section) belong to the lower part of the *Gigantopteris* zone. This zone is found completely developed in the terrace, Pt. 1490, from which a section is given in Pl. II division Pt. 1490.

The thickness of the Shihhotse series calculated from the bottom of the *Callipteris* Zone to the uppermost part of the upper *Gigantopteris* sandstone is in Shih Ho Tse about 280 M. in the profile at Hsieh Tao 250-260 M.

SUB-DIVISION OF THE SHIHHOTSE SERIES.

According to the chemical character of the weathering products that have given material to the Shihhotse series. this may conveniently be divided in two parts

1) *The Lower Shihhotse series*

composed almost entirely by light-coloured sediments

2) *The Upper Shihhotse series*

in which the chocolate-coloured sediments form an important ingredient.

The lower Shihhotse series is formed, as mentioned, mainly of argillaceous sediments with grey, green and yellow colouring in different shades, interbedded with light-coloured sandstones of varying grain. A characteristic feature is the frequent interbedding of coarser and finer material. The sandstones, which often show cross-bedding, merge into sandy shales and these in their turn into solid claystones or solid marls, which often lack distinct stratification. This variation is repeated throughout the whole series. A characteristic feature is furthermore the variation of the sediments along the surface of deposition. Even a quite thick bank of sandstone dissolves within a short distance into several thinner layers which are interbedded by sandy argillaceous material and soon wedge out completely. The compact bands of claystone are also soon split up by sandy strata and perhaps ultimately merge into a massive banded sandstone.

The sandstones are coloured light grey, yellowish or greyish green. The most important mineral ingredients are: Quartz and felspar but dark minerals enter sometimes rather abundantly. Some bands, perhaps the majority of them contain also kaolin-like substances. The size of grain varies considerably, often within the same bank. Crossbedding is common, even if it does not seem to be the rule. Often they contain quickly thinning-out layers of gravel with round pebbles which often reach the size of a hen's egg. These pebbles consist always of *Archean* rock material; the most frequent is waterworn pegmatite quartz, red fresh felspar, red and dark porphyries, dark metamorphosed schists, gneiss and, more scarce, yellow or black flint.

In view of the floras found in the lower Shihhotse series this can be divided into two main zones: one lower characterired by plants belonging to the *Callipteris* family (floras No. 10-14) and one upper, in which species of *Callipteris* have not been observed by me. The former zone may be equivalent to Rothliegende.

To form a conslusion regarding the climate during which these sediments have been formed, we can state the following.

1) The abundance in the sediments of kaolin-like weathering-products (light-coloured argillaceous shales)

2) The absence of hydrated compounds of iron

3) The manner of preservation of the fossil plants

These facts taken together indicate a humid, and a relatively cold climate at the time of deposition of these sediments.

This composition, uniform in regard to chemical weathering products, is maintained by the Permian sediments until a distance of 120-180 M. from the bottom of the Callipteris zone.

In the succeeding sediments, the Upper Shihhotse series, a new element enters which before was completely absent, namely bands of redbrown and chocolate-coloured marls and claystones. These probably turgite bearing sediments are first found as inconsiderable, quickly thinning-out layers in the light-coloured claystones of the Upper Shihhotse series. In the higher levels they increase in thickness and number, until at last in the Shihch'ienfeng series they become the main part of the sediments.

These conditions are illustrated by the Shih Ho Tse profile Pl. III and a section through the mountain, point 1725, Shih Ch'ien Feng Shan, in the Western hills Pl. II.

In the lowest part of the chocolate-coloured series or rather in the transition zone between the light-coloured and chocolate-coloured series enters a zone, 60-100 M. in thickness, composed of chrome-yellow soft sandstones and yellow and dark-green clay sediments.

In these latter ones are interbedded scattered thin bands of chocolate-coloured argillaceous material. The light-coloured shales contain a flora of partly Mesozoic character especially characterized by plants, belonging to the *Gigantopteris* family. This zone with its characteristic flora will be called hereafter the Gigantopteris zone

Through the characteristic colour of the sediments and their position on the boundary between the light-coloured and chocolate-coloured series, the Gigantopteris zone becomes one of the most readily traced leading levels within the socalled Shansi formation (Willis).

With, on the whole similar sedimentary composition, this zone has also been found at Hsieh Tao, (斜 道) at Shang Pai Ch'uan, 120 li west of Taiyuanfu, at Niu Chia Mo (牛 家 磨) in the western marginal border zone of the Mo Erh Tung horst, 70 li E.S.E. of Lin Hsien (臨 縣), at Hsing Hsien (興 縣) 350 li N.W. of Taiyuan; at Fen Ho (汾 河) 15 li N.W. of Lao Fang Tsun 180 li W.N.W. of Taiyuanfu.

THE SHIHCH'IENFENG SERIES

Description of Sections.

The above name has been given to a series of clay sediments and sandstones in the roof of the Shihhotse series characterized by their chocolate-brown or dark red colour and mainly arid weathering products. The name is chosen from the peak Shih Ch'ien Feng Shan (1720 M. altitude above sea-level) situated within the Kao Li Shan Plateau, 50 li (25 km.) W. of Taiyuanfu. (see Pl. I section 2).

In the southern slope of this peak which is in some places very precipitous, the lower and middle part of the formation in question are well exposed. A continuous profile has been obtained from the Ginkgo-sandstone to the Gigantopteris zone, which latter crops out in the valley-bottom below the south slope.

The sediments lie almost horizontally. Between point 1490 and point 1720, a distance of 5. 5 km., the strata descend towards west 100 Meters (see Pl. I; fig.2).

The Upper Gigantopteris sandstone, which has here a thickness of 10 M. is superimposed by:

1)	Greenish yellow claystones with bands of chocolate-coloured claystone	8.5 M.
2)	White sandstone, uppermost with some red-brown layers	3.0 M.
3)	Chocolate-coloured claystone or marl	8.0 M.
4)	Argillaceous sandstone with red spots, cross-bedded	4.5 M.
5)	Chocolate coloured, partly sandy marl or claystone	6.0 M.
6)	White sandstone	3.0 M.
7)	Chocolate-coloured, sandy marl with small sandstone bands	33.0 M.
8)	White sandstone with layers of coarse gravel; in the upper levels with red-brown, argillaceous layers	7.0 M.
9)	Light yellow-green claystone, in the upper levels greyish black and containing plant fragments	3.5 M..
10)	Chocolate-coloured sandy marl and clay stone	26.0 M.
11)	Yellowish green claystone; white sandstone	2.5 M.
12)	Red-brown, sandy marl and claystone	6.0 M.
13)	Greenish yellow claystone with scattered plant fragments	0.5 M.
14)	White sandstone ("The Ginkgo sandstone")	6.5 M.

Towards W. the sediments descend slowly, and at village Kuan T'o 14 km. W.S.W. of Shih Ch'ien Feng Shan, the Ginkgo-sandstone crops out in the bottom of the valley T'ai Ch'üan Ho which drains towards the north (see Fig.1). On the east slope of this valley one finds a very fine section through the middle part of the shihch'ienfeng series.

The stratigraphic sequence is illustrated by the profile, Pl. II; the Kuan T'o division. The following thicknesses have been measured:

Stratum No.		
13)	Yellowish green claystone with thin bands of fine-grained yellowish green sandstone; in the upper part with plant bearing horizon No. 27.	2.5 M.
14)	Fine-grained, yellowish green sandstone, partly crossbedded, "The Ginkgo sandstone"	6.0 M.
15)	Yellowish green claystones with plant remains and some thin sandstone bands	4.0 M.
16)	Interbedded yellow and chocolate-coloured claystones	2.0 M.
17)	Dark grey-green sandstone	1.0 M.

18)	Finely interbedded red-brown and yellowish grey argillaceous shale	7.0 M.
19)	Medium-grained, light-coloured, brown-red sandstone with white stripes, rich in silica	1.5 M.
20)	Dark chocolate-coloured argillaceous shale	0.2 M.
21)	Lightcoloured, grey-green, argillaceous shale often wedging-out	about 0.1 M.
22)	Yellowish, white, soft sandstone with layers of Archaen gravel	5.0 M.
23)	Chocolate-coloured, dense claystone	1.0 M.
24)	Yellowish white, soft quartz-sandstone with gravel layers	8.0 M.
25)	Interbedding between grey-white, sandy claystone and chocolate-coloured claystone	1.5 M.
26)	Chocolate-coloured, fine-grained argillaceous shale	6.0 M.
27)	Chocolate-coloured, soft medium-grained sandstone,	1.7 M.
28)	Chocolate-coloured, partly sandy argillaceous shale with stripes of chalcedony	3.4 M.
29)	Chocolate-coloured, soft sandstone with gravel layers and bands of shale; in the upper parts with layers of chalcedony	3.4 M.
30)	Chocolate-coloured claystone with chalcedony balls*	3.4 M.
31)	White sandstone, in the lower part speckled with red spots	2.3 M.
32)	Chocolate-coloured, argillaceous shale	2.0 M.
33)	Dense, grey-white sandstone	0.3 M.
34)	Chocolate-coloured argillaceous shale	0.8 M.
35)	Light greyish green, feldspathic, small-grained sandstone	7.5 M.
36)	Chocolate-coloured argillaceons shales with some interbedded sandstone-banks	25.0 M.
37)	Chocolate-coloured, crossbedded fine-grained sandstone,	4.5 M.
38)	Red-brown argillaceous shale, merging upwards into light redbrown marl	3.4 M.
39)	Gypsum breccia	1.6 M.
40)	Light red-brown sandstone, small grained	7.0 M.
41)	Chocolate-coloured claystone, merging upwards into light red-brown marl, uppermost a bank of Gypsum-breccia	2.7 M.

* The field work has proved that in Central Shansi the chalcedony-bearing layers (m. 28-30) are no loose formations but found in an horizon of regional distribution always situated near the border between the probably humid and lateritic sediments of the Gigantopteris-Ginkgo Zone and the arid gypsiferous marl zone.

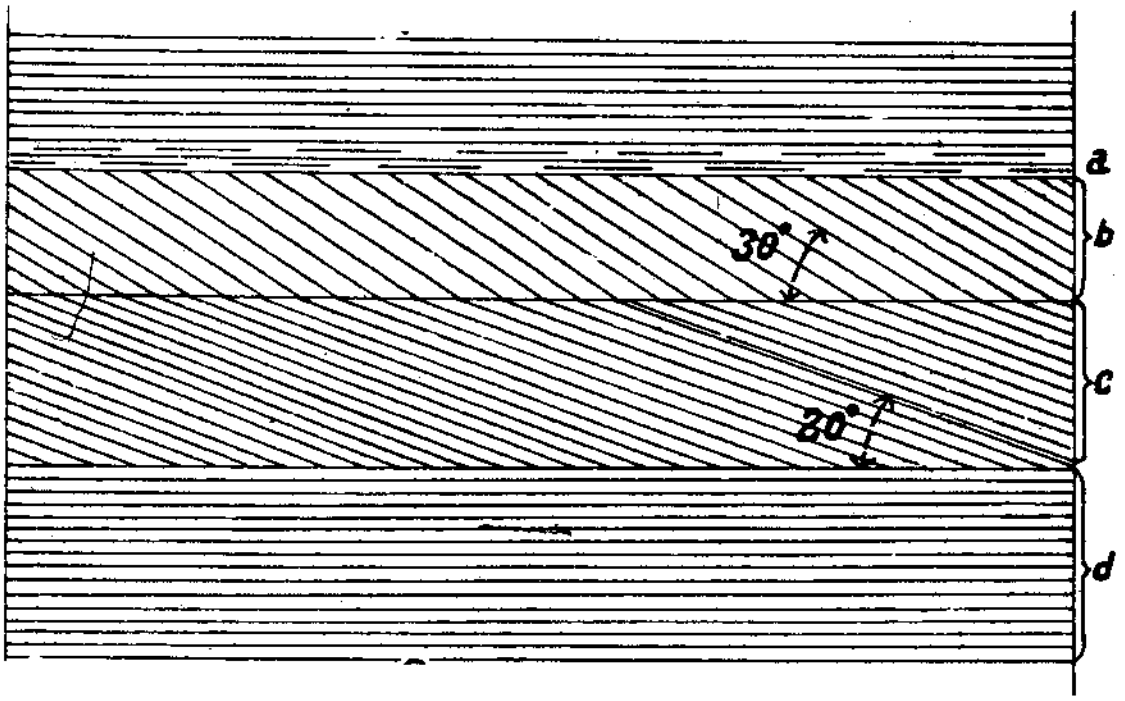

Fig. 10. Cross bedding observed in the lower part of the Triassic Sandstone Zone.
a. Chocolate-colored argillaceous shale.
b. White sandstone, cross bedded.
c. Fine-grained reddish sandstone, cross bedded.
d. Horizontally stratified, fine-grained sandstone.

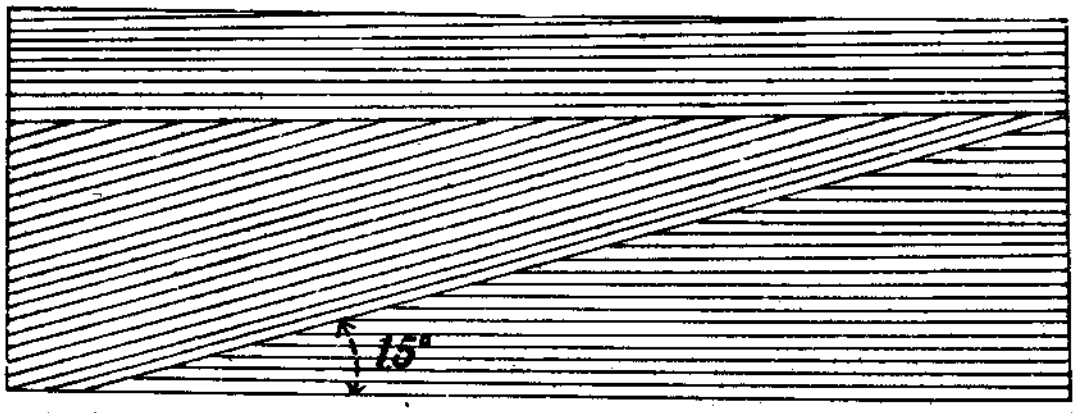

Fig. 11. Cross bedding observed in the KuanTo section (stratum No. 44)

42) Fine grained, light reddish-grey sandstone, bedded 4.0 M.
43) Chocolate- coloured argillaceous shale, light red-brown marl, light-coloured breccia 2.0 M.
44) Well-stratified, reddish grey sandstone partly with cross bedding (Fig. 11) 6.0 M.
45) Chocolate-coloured, argillaceous shale, light red-brown marl. gypsum-breccia 13.0 M.

46)	Sandstone, same as 44)	7.5 M.
47)	Chocolate-coloured clay-sediments with scattered bands of light-red sandstone; gypsum-breccia	6.0 M.
48)	Light red-brown, gypsiferous marl	1.5 M.
49)	Argillaceous, chocolate-coloured sandstone	2.0 M.
50)	Light red-brown clay-sediments with a few sandy layers	12.0 M.
51)	Light red-brown sandstone with shale bands, partly cross-bedded	2.0 M.
52)	Light red-brown marl, upwards merging into chocolate-coloured claystone and argillaceous shale	7.2 M.
53)	Fine grained, light red-brown and pink, distinctly bedded sandstones, partly with cross-bedding, with thin bands of chocolate-coloured, argillaceous shales	more than 10.0 M.

SUB-DIVISION AND LITHOLOGICAL CHARACTER

According to the above section the Shihch'ienfeng sersies can be divided in

1) *The Ginkgo-zone* comprising the sedimentary division which occurs between the upper Gigantopteris sandstone and the Ginkgo sandstone (Horizon No. 14). This zone is mainly built up of chocolate-coloured, more or less sandy argillaceous shales and claystones, interbedded with white or yellowish sandstones and plant-bearing yellowish green and dark green claystones and argillaceous shales. Homogeneous, chocolate-coloured sandstones are missing. Its thickness is about 120 Meters.

2) *The Gypsiferous Marl-Zone*, comprising layers 19 to 52 in the Kuan T'o section, is built up almost exclusively of strongly coloured sediments. The main mass consists of chocolate-brown, argillaceous shales and claystones, often of marly character, gypsiferous light brown-red marls, chocolate-coloured, easily disintegrated, argillaceous quartz-sandstones and bands of greyish white or light reddish, fine-grained to small-grained, compact sandstones. Plant-bearing, light-coloured sediments are missing. Thickness about 150 Meters.

3) *The Sandstone Zone*, is built up exclusively of plainly stratified and often cross-brdded sandy material and, more subordinate clay-sediments of red-brown colours in different tints. Gypsiferous sediments have not been observed, nor have lightcoloured plant-beaing clay sediments been found. Thickness more than 500 Metres.

1. *The Ginkgo Zone* is, with regard to lithologic composition similar to the Gigantopteris zone, but with one modification, namely that in the former the red-coloured sediments predominate. Both these zone form together a transition between the older Permian sediments and the Triassic red series.

The light-coloured sandstones and the light plant-bearing sediments of the Ginkgo-zone are intimately connected with each other; the latter generally occur immediately below the sandstones in question. Next to these banks of claystones or argillaceous shales the sandstones are coloured pure white, yellowish or light greyish green, but in the higher levels we find that there sometimes enter layers of chocolate-coloured, sandy material which quickly wedge out. Cross-bedding is sometimes observed.

The light-coloured claystones contain plant fragments; these are usually very fragmental and scattered, but are seldom entirely absent. A very rich flora, with well-preserved plant-fossils, has been found in layer No. 13 at Kuan-T'o. The shaley levels contain a flora characterized by masses of large-leaved *Ginkgophytes* and *Taeniopteris*. The fossils are often coated with a silvery skin of sericite; coarser trunk-fragments are not infrequently changed into jet.

Within the Ginkgo-zone gypsiferous sediments and typical marls have not been observed with any degree of certainty. The absence of homogeneous red-brown or chocolate-coloured sandstones is also remarkable.

2. *The Gypsiferous Marl-Zone* entirely lacks sediments of the Permian type. The light-coloured sandstones occurring here in some horizons have probably all been formed through a re-deposition of the unhomogen ous sedimentary material once deposited, whereby the red-brown clay-sludge has been separated out and the light coloured quartz-felspar sand has been left behind. This process of separation can sometimes be followed step by step. The

surfaces of stratification in these light-coloured sandstones are often wholly covered by chocolate-coloured, thin scales of clay. It is probable that these clay scales have originally formed a continuous thin clay-skin on the sandstone and this skin has, when exposed to sun-heat, dried up and become curled-up.

The sandstones of the marl-zone are generally of dark chocolate-brown colour, small to medium-grained with easily disintegrating structure, depending on the often considerable admixture of clay. They contain very often layers of gravel and are not seldom cross-bedded. The pebbles in the gravel consist of Archæn material: Pegmatite-quartz, porphyries, metamorphous schists, gneisses and also not infrequently black or yellow flint.

The thicker ones of these sandstone bands become, at higher levels, often distinctly stratified with alternating more sandy and more clayey layers. In these horizons cross bedding is common.

The chocolate-coloured, argillaceous sandstone bands merge often without distinct boundary into sandy argillaceous shale.

In the sandstone, stratum 44, we find that, where redeposition has not taken place, the colour is light red-brown, whereas the re-deposited formation shows a frequent bedding with light grey sand-layers separated by thin skins of chocolate-coloured argillaceous shale. The sandstone is often diagonally bedded.

The chocolate-coloured, argillaceous sandstone bands merge often without distinct boundary into very fine sandy, argillaceous shales. In the lower part of the marl-zone these latter ones are sometimes intercalated by siliceous layers. The silica sometimes forms a thin layer, often thinning out, sometimes it forms round concretions of goodshape.

The gypsiferous marls entering in the upper part of the marl-zone are distinguished by their light brown-red colour from the older, non-gypsiferous marl horizons. The largest content of gypsum is usually found in the upper part of the marl banks in the form of a breccia often 1 M. thick, consisting of round or angular marl-fragments cemented together by bluish white, crystalline gypsum and calcite. The roof of the gypsum bands is formed of red sandstone (see profile, Pl. 2).

In the Kuan-T'o profile five such gypsiferous horizons of considerable size have been found. All of them show similar conditions of stratification. On a re-deposited, light red-coloured, solid sandstone (1) follows.

2) Chocolate-coloured, argillaceous shale or claystone
3) Light brownish red marl.
4) Gypsiferous breccia.
5) Sandstone same as 1).

3. *The Sandstone Zone* is built up mainly of fine-grained, brown-red sandstones often with thin intercalations of chocolate coloured, argillaceous shale. Marls and gypsiferous sediments have not been observed.

The sandstones show usually distinct stratification with alternating lighter and darker layers. They are often easily cleft along the bedding planes. Here these surfaces also are often covered by thin scales of argillaceous shale of the same kind as those above-mentioned (page 48.). Cross bedding is very common. Gravel layers occur sometimes, especially in the lower levels of the sand banks. The gravel consists of Archaean material. It has often been observed that in the lower levels of the sandstone bands, as in the sandstones of the marl-zone, the clay and sand-material is not distinctly separated, but form together an argillaceous sandstone of more or less uniform colour. In the higher levels the sandstone, on the contrary, becomes plainly bedded and striped, its colour becomes lighter; a large part of the argillaceous component has been washed away and appears as intercalations of clay-shale. Cross bedding is also very common in these re-deposited and often very finegrained upper horizons of the sandstone. Examples of this kind of cross bedding are given in figs. 9 a & b.

The sandstones often merge into very finegrained chocolate-coloured, argillaceous shales; in these are often observed well developed *ripple-marks*.

Genuine argillaceous shale occurs generally superimposed on the sandstone, forming banks which seldom exceed ½ M. in thickness. These clay-shales are usually coloured dark chocolate-brown, thin-bedded, and cleave easily in thin, elastic sheets. The bedding-planes are often covered by sericite scales. In spite of diligent search no fossils have been found, neither here, nor anywhere else within the sandstone-zone or marl-zone.

PLANY BEARING BEDS IN THE PERMO-TRIASSIC FORMATION

Within the Shihhotse and Shihch'ienfeng series altogether twenty very rich, plant-bearing horizons have been found, (see general profile, Pl. II and III.) Most of the extensive collections made at these localities are to be handed over to the Swedish Musum of Natural History and will be described later on by Prof. T. Halle.

The lithological character of the plant-bearing beds is shown in the description of the section.

Most abundant in plant-fossils are the greenish and yellowish, argillaceous shales and marls of the Shihhotse series.

With regard to the Shihch'ienfeng series, plant fossils have been found only in the light coloured clay sediments in the lower part of the series (within the Ginkgo-zone), whereas in the chocolate-coloured and reddish sediments no fossils of any kind have been observed.

The lowermost part of the Shihhotse series contains a very rich flora The following tentative list of fossils, found at the Loc. No. 7 – 14, Pl. II & III aims to give a crude idea of the composition of this flora. In the list here given species are enumerated which show the greatest similarity to the fossils found.

Odontopteris cf subcrenulata
Pterophyllum sp. (large-leaved)
Cordaites sp.
Taeniopteris cf multinervis
Callipteris sp.
Annularia sp.
Sphenophyllum cf. emarginatun
Sphenophyllum cf. oblongifolia
Sphenophyllum cf. thoni
Sphenophyllum sp. (large-leaved)
Pecopteris sp.
Sphenopteris sp.

Apart from this is found also a very large-leaved Cycadae with undivided leaves and numerous species unknown to me.

The occurrence of *Taeniopteris* and *Callipteris* shows that this part of the Shihhotse series belongs to Lower Permian (Rothliegende).

The youngest flora found, characterized by plants belonging to the *Callipteris* family is flora No. 14. In the younger ones *Callipteris* species have not been observed by me.

As pointed out above, these Lower Permian sediment with their characteristic flora are found both in the eastern and western marginal hills at the Taiyuan basin.

During the field work I have got the impression that the sediments in the Hsieh Tao profile as a rule are more sandy than the corresponding formations in the east. This may also be a cause of certain differences in composition between the floras in the east and west. In the Shih Ho Tse profile are found fifteen very rich plant-bearing horizons, which are rather evenly distributed over the entire series. Of these floras only two have been found in Hsieh Tao, the rest differ more or less. In the first named profile appear in several horizons dark-grey and light grey, solid marls or calcareous claystones, which have not been found at Hsieh Tao. These marlstones are often very rich in fossils and contain floras which are often dissimilar in composition to those which appear in the more sandy sediments (probably originated nearer the shore) in the strata underlying and superimposed in relation to the marls. Especially striking is the abundance of *Annularia* in the calcareous layers; in the sandy claystones however *Annularia* is only sparsely found.

If we compare in the Shih Ho Tse and Hsien Tao sections the sedimentary complex which is nearest to and underlying the *Gigantopteris* sandstone, we find considerable dissimilarities. In Shih Ho Tse appears underlying the sandstone in question a complex about 60 M. thick of mainly chocolate-coloured, marly clay sediments without distinct stratification with a few banks of light yellow, solid marls. These latter contain floras rich in species of *Annularia* and *Pterophyllum* (plant-bearing layer No. 17 and 18 Pl. III). This complex rests on a light-coloured fine-grained sandstone which in its turn is underlaid by sandy shale containing a very characteristic flora (No. 16).

In the corresponding zone at Hsieh Tao we find the following sequence;

From below:

1)	Grey-green claystone, plant-bearing. Flora No. 23	8 M.
2)	Light-coloured sandstone	7 M.
3)	Sandy light-coloured shales with thin sandstone bands	7 M.
4)	Light-coloured clay stones with a few chocolate-coloured layers	10 M.
5)	Blue grey, unstratified marl with a few nodules of jet	6 M.
6)	Light-coloured shales, partly sandy	10 M.
7)	Gravelly sandstone	2 M.
8)	Greyish green claystones and sandy shales with quickly wedging-out sandy layers	30 M.
	10 M. from the bottom of this we have a plant-bearing level; flora No. 25	
9)	Chrome-yellow sandstone bands and yellow claystones belonging to the lower part of the Gigantopteris zone.	

The characteristic floras rich in *Pterophyllum* and *Annularia* in the chocolate-coloured marl complex at Shih Ho Tse (Floras No. 17 & 18) has not been found and probably does not exist at Hsieh Tao. In its place we find here a quite different flora (Lawer No. 8; flora No. 25) and in the sandy shales we find abundantly silicified wood. At point 1390 above Lo T'o Po the surfaces of deposition of these latter sandy shales are laid bare by erosion and form a plateau. The surface of this level ground is sprinkled with lumps up to ½ M. in size of silicified wood. Probably this is the origin of the name Shih Shu Yen (石 樹 岩) "The Stone Tree Cliff" given to this locality by the local people. This silicified wood does not show annual rings.

The conditions in this special case show that the appearance of different floras in homotaxial zones east and west of the Taiyuan basin probably is caused by different conditions of life. In the east there existed a lake with not inconsiderable depth, bordered to the west by mud-flats; the lake and the flast possessing different floral life.

The flora, most important from a stratigraphical point-of-view, is the *Gigantopteris flora* appearing in the uppermost part of the Shihhotse series. Within the Gigantopteris zone which is about 100 M. thick, five plant-bearing horizons have been found. In relation to each other, the floras in these horizons are more or less different, but all of them are characterized by the presence of plants belonging to the family *Gigantopteris*.

Beside three or four species belonging to this family we find amongst others also *Annularia maxima* (common) and a large-leaved species of *Baiera* (rare). None of these species have been found in the sediments subjacent to the Gigantopteris zone.

Regarding the age and the occurrence of the Gigantopteris flora in southern and middle China I quote accordidg to J. Deprat[1] following:

"Quant au *Gigantopteris nicotianaefolia* et a l'*Annularia* "*maxima*", leur présence ne fournissait aucune indication precise, l'attribution que Schenk avait faite au Houiller du gisement de Lui-pa-kou (Hou-Nan), le seul où ces deux espèces fussent connues, ayant été plus d'une fois contestée.....

La seule conclusion admissible consistait à ranger ces gisements au voisinage immediat de la limite entre la série paléozoique et la série secondaire, c'est à dire vere le sommet du Permien ou à la base du Trias..... .....

J'ai donc ete plus satisfait que surpris lorsque j'ai appris ultérieurement que les observations de M. Counillon le conduisaient precisement a ranger la bande charbonèuse de Tou-tza Mi-leu entre les grés rouge de Lou-nan qui reposent sur des calcaires d'age permien inférieur. et les calcaires à Trachyceras de Kouéi-tien qui sont situés a la base du Trias supérieur. Des conditions géologiques générales conduisent d'ailleurs M. Lantenois à regarder cette zone charbonneuse comme triassique plutôt que comme permien".

In analogy to the conditions in Yunnan and Hunan it may be assumed that also in Shansi the Gigantopteris-bearing sediments belong to the transition between Permian and Triassic.

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1) J. Deprat et H. Mansuy: Etude Geologique du Yunnan Oriental. Vol. I. fasc. 1 p. 185 (Mem. Serv. Geol. de l'Indochine) Hanoi, Haiphong 1912.

It is to be noted that in Shansi *the appearance of the Gigantopteris flora which is a flora of partly Mesozoic character coincides with the entrance of sediments of a new weathering type*, namely chocolate-coloured clay-sediments; these have in all probability been formed during climatic and geographical conditions entirely different to those prevailing when the older Permian light-coloured claystones were deposited.

Within the *Shihch'ienfeng series* only one horizon rich in plant-remains has been found. (Flora No. 17. Pl. II.) This occurs in the uppermost part of the Ginkgo series and has been described above. Its flora is characterized by large-leaved *Ginkgophytes*, which occur very abundantly.

THE GEOLOGICAL CHARACTER OF THE PERMO-TRIASSIC SEDIMENTS

In early Permian time the sea receded definitively from this part of China. In the entire Shihhotse series and the Shihch'ienfeng series no certain marine sediments are present (see Pl. II.)

The sediments of the Shihhotse sereis have the nature of fresh water deposits, laid down in closed basins with drainage to the sea.

Concerning the nature of the mainly Triassic Shihch'ienfeng series it is difficult to arrive at any definite conclusion. All the plant-bearing horizons are, as mentioned, bound to the ligh-coloured clay sediments immediately below the white sandstones and occur only in the lower part of the series. It is however probable that these are of another origin than the chocolate-coloured sediments. These latter are exceedingly poor in fossils and in spite of diligent searching no certain organic remains have been found.

However, if we contemplate the sequence of sedimentation within the transition zone between the Shihhotse series and the Shihch'ienfeng series, we may arrive at a certain opinion regarding the development of sedimentation.

The first traces of chocolate-coloured sediments appear in the lower part of the Upper Shihhotseseries in the shape of quickly out-wedging layers and thin bands of fine-grained and argillaceous material in the light coloured clay-stones. But they do not seem to occur together with the more sandy sediments. Higher up in the series the chocolate-coloured sediments assume a more and more important role. They have still the form of chocolate-coloured claystones with a few bands of red-brown marl; their roof and foundation is still composed of white or yellowish white sandstones, from which they are separated by thinner or thicker bands of light coloured claystone and sandy, argillaceous shale.

In a few cases we have observed in this claystone-marl complex a very distinct lamination caused by frequent alternation of differently coloured material, which gives to the rock a superficial ressemblance to the glacial laminated clay. A very fine example of this is found in the claystone bank No. 18 in the Kuan T'o profile. We see there a very regular alternation of greenish yellow and chocolate-coloured zones, whereby one dark and one light coloured stripe form together one layer. The thickness of each zone is rather equal and about 2-3 cm. Each layer begins with dense, red-brown claystone, which with an absolutely sharp line borders upon the foundation. The red-brown zone becomes upwards more sandy and merges without sharp boundary line into sandy greenish yellow claystone; this in its turn changes to dense, greenish-yellow claystone ,which form the foundation to the succeeding red-brown zone. Sometimes there are 20 or 30 such layers which are repeated in a regular succession. Below and above this complex we find yellowish claystones and sandy shales associated with thick bands of white sandstone.

It is possible that this chocolate coloured material has been carried by rivers from a distant origin, whereby only the finest ooze has been kept suspended, partly perhaps in colloidal condition, but finally been deposited in enclosed basins with more or less stagnant water. This seems to be the only way to explain the accumulation of chocolate-coloured claystones and calcareous marls which in Shihhotse are immediately underlying the lower Gigantopteris sandstone, but which are missing in the same horizon at Hsieh Tao.

Also in the lower part of the marl-complex the conditions are largely the same, but already here sandy probably turgite-bearing material begins to enter in the shape of sandy marls and scattered chocolate-coloured sand layers in the white sandstones.

The sediments of the Gigantopteris and Ginkgo zones, that is to say, the sediments which appear in the transition between Permian and Triassic, have in common with the main mass of the Permian sediments the character of fresh water formations, deposited in lakes with drainage to the sea.

Probably in early Triassic time a thorough geographical revolution took place whereby these regions, formerly possessing outward drainage, lost this character and became perhaps embodied in the marginal zone of a desert region.

The characteristic red-brown and chocolate-brown colour of the sediments may be caused by presence of the iron-hydroxide turgite which is typical for the sub-tropical semi-deserts.

The sandstone division of the Shihch'ienfeng series with its masses of sand often with cross-bedding may possibly be interpreted as representing a later stage of the sanding up of the undrained basin.

It is one and the same formation which has supplied the original material as well to the Shihch'ienfeng series. as to the Shihhotse series and the coal series, namely rocks mainly belonging to the Archean: porphyries, metamorphous schists and gneisses penetrated by pegmatites. The chemical transformation which this material has afterwards undergone by the chemical weathering depends upon the climatic conditions prevailing at that time.

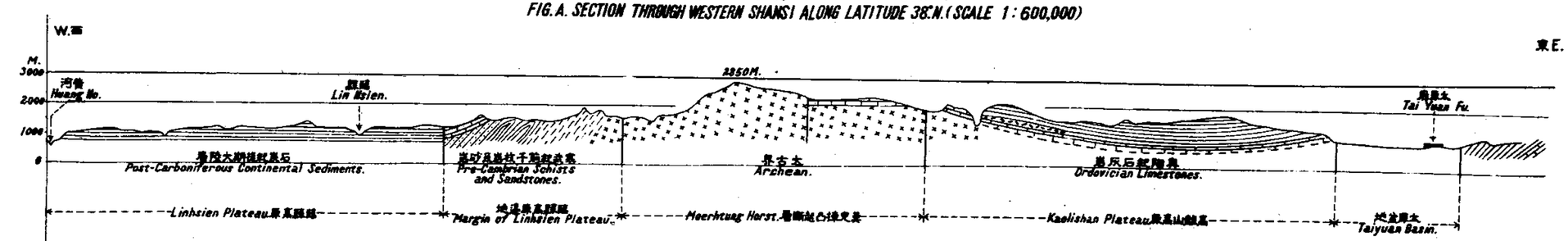
The regional changes of the climate which occurred at the end of the Palaeozoic era and which here and there resulted in glaciation is thus possibly the cause of the accummulation of weathering products rich in silicates of alumina which we find in the older Permian sediments.

On the othe hand, the abundant occurrence of arid weathering products in the sediments of the Shihch'ienfeng series (which as we have seen are built up of the same Archean material as the Shihhotse series) shows that in late Permian and Triassic time the chemical weathering proceeded along other lines than hitherto.

The material which enters into these sediments is probably formed during a dry and warm climate This gains additional interest from the fact that the appearance of this new type of weathering is accompanied by the occurrance of a new flora with partly Mesozoic character: the Gigantopteris-flora.

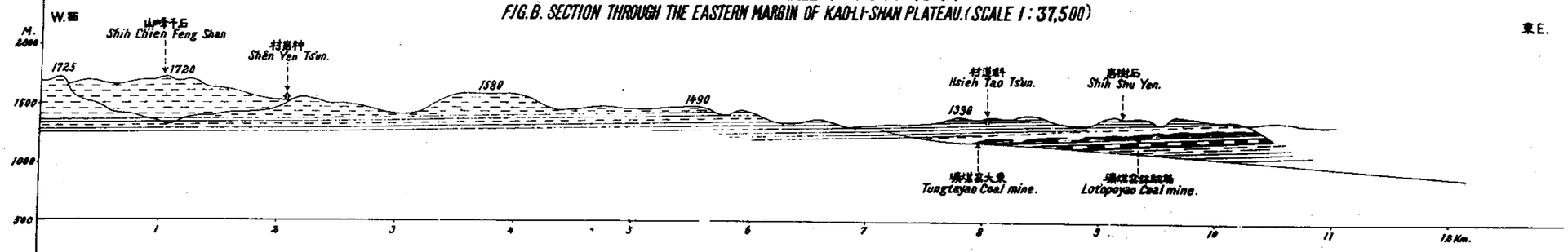
(一之分萬十六尺縮)圖面剖度八十三緯北沿部西西山

FIG. A. SECTION THROUGH WESTERN SHANSI ALONG LATITUDE 38°N. (SCALE 1 : 600,000)



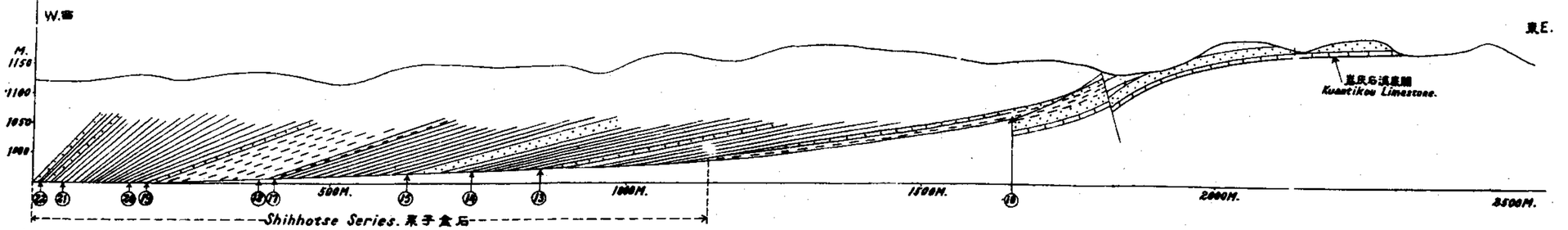
(一之萬百五十七尺縮三緯)圖面剖麓東原高山離高

FIG. B. SECTION THROUGH THE EASTERN MARGIN OF KAO-LI-SHAN PLATEAU. (SCALE 1 : 37,500)

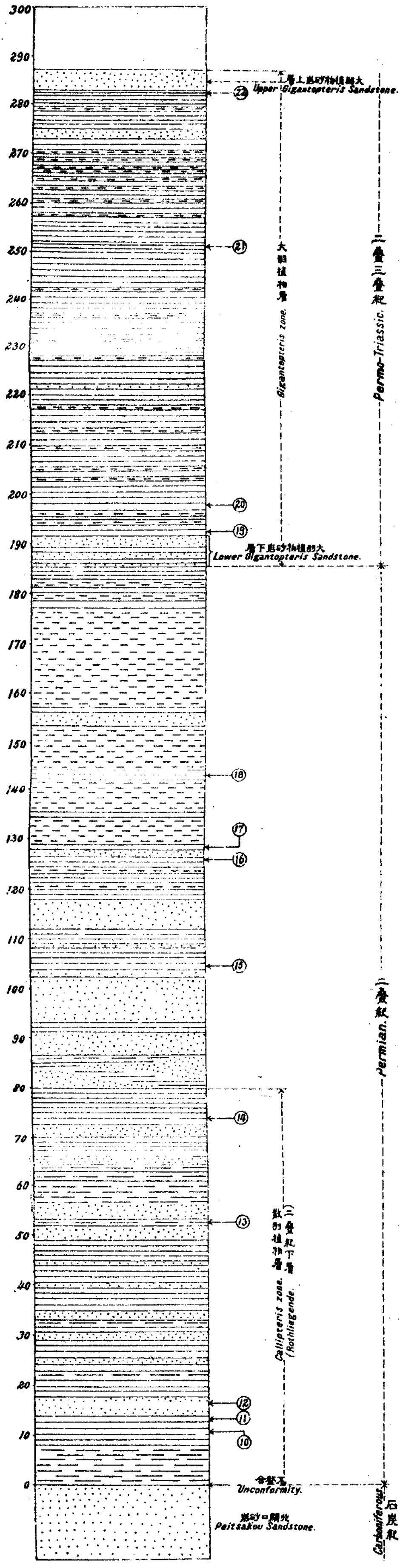


石盒子河域剖面圖(一之萬百五十七尺縮)

FIG. C. SECTION ALONG SHIH-HO-TSE VALLEY. (SCALE 1:7,500)




M.
Triassic
Permo-Triassic
Permian
Permo-Carboniferous
Lower Carboniferous
Disconformity
Ordovician



THE SHIHHOTSE SERIES

石盒子系柱形剖面圖

GEOLOGY OF TZŬ-CH'UAN PO-SHAN COAL FIELD, SHANTUNG.

(*Summary*)

BY

H. C. T'AN

INTRODUCTION

The coal field is situated in the north-central part of Shantung, and divided by faults into three divisions, viz. Tzu-Po coal field proper, Hei shan coal field, and Hsi Ho coal field, the first being by far greater than other two combined. It is distant about 120 km. from Tsi-nan and 300 km. from Tsing-tao; the Shantung Railway passes the northern end of the field and has a branch line from Changtien running into this coal field.

The Tzú-Po coal field proper is depressed to a plain at the north, surrounded by mountains and hills on the eastern, southern and western sides, and separated by a mountain range from the Hei shan and Hsi Ho coal fields, which are also enclosed by mountains on all sides. The main river is called Hsiao Fu Ho, and it receives all the minor streams running out from adjacent mountains, and meanders northward through the fertile plain with varying widths and of shallow depth.

STRATIGRAPHY

The basal member of the formations is the Ordovician limestone upon which lie the Carboniferous, Permian and Mesozoic strata with not less than 1400 m. of total thickness.

1. Ordovician Limestone—Only the uppermost part was observed, the limestone is mostly pure and can be utilized for preparing lime. This formation is disconformably covered by the Palaeozoic Coal Series, the interval form the Silurian to the lower Carboniferous being unrepresented

2. Palaeozoic Coal Series.—This formation was named by Bailey Willis the Po-Shan Series, and divided by Dr. F. Solgar into four divisions. According to the lithological character, however, the present author groups it into three parts, viz. Lower, Middle and Upper. The total thickness is from 203-284 meters. Three good exposures which were carefully measured show the variations of the thickness of the three divisions.

	Hung Shan	Ta-K'uei Shan	Hei Shan
Upper division	101.6 m.	142 m.	112.5 m.
Middle division	102.7 m.	113 m.	78.5 m.
Lower division	28.2 m.	29 m.	12 m.

a) *The Lower Division* consists chiefly of clay, clayey shale and at top Fusulina limestone of about 4 meters in thickness. It occasionally contains thin coal seam.

b) *The Middle Division* is composed of shales and sandstones and all the important coal seams. It contains in the middle portion a bed of limestone 1.5 meters thick, which includes an abundance of *Productus*, *Spirifer* and *Crinoid* remains and subdivides the Middle division into two portions. In the shales near the coal seams there are many plant fossils, of which *Annularia*, *Sigillaria*, *Calamites*, *Lepidodendron*, *Neuropteris* and *Callipteris* are the prevailing types.

c) *The Upper Division* comprises variegated clayey shale and sandstone, without coal seam, but with intrusive sheets of diabase along the bedding planes.

Owing to the presence of Fusulina in the lower part and on the basis of the plant remains so far determined the coal series here dealt with can be safely referred to the Carboniferous in the wider sense. But from the examination of the Carboniferous fauna by Dr. A. W. Grabau, the Palaeozoic coal series of northern China mostly comprises two groups of formation; one belonging to the late Lower Carboniferous; the other to the Permo-Carboniferous, i.e., the Upper Carboniferous and the Permian; there exists a great hiatus between them and the Middle Carboniferous is unrepresented.

In this region the Lower Division containing the Fusulina limestone and the lower portion of the Middle Division containing the Productus limestone seem to correspond to the T'aiyüan Formation of Shansi, which is regarded as late Lower Carboniferous by Dr. Grabau who has made a study on the fauna included in it. So I propose to restrict the name *Poshan Formation* to the Lower Division and the lower portion of the Middle Division, which may be referred to the Lower Carboniferous, and to name the upper portion of the Middle Division and the Upper Division the *Hungshan Formation* one part of which may be late Upper Carboniferous and the other part perhaps Permian.

3. Quartzose Sandstone.—This consists of white coarse hard quartzose sandstone, greenish hard sanddstone being found in the uppermost and lowermost parts. This formation follows the Permo-Carboniferous coal series comformably and underlies the Jurassic coal series at a considerable depth. Its age may be regarded as Permian and its approximate thickness amounts to 290 meters.

4. Red Sandstone.—This formation is largely composed of deep red loose-textured sandstone. The part in contact with the underlying quartzose sandstone includes brown and yellowish-gray clay and clayey shale, interbedded with greenish sandstone, and the part near the Mesozoic coal series frequently contains thin yellow-greenish sandstone. On account of its stratigraphic position, it may be considered the first member of the Mesozoic. The total thickness is estimated to be about 680 meters.

5. Mesozoic Coal Series.—This series consists mostly of sandstones and shales and occasionally of conglomerate in the upper part, with non-productive coal and plant beds. One part of the white sandstone contained is converted through metamorphism by the gabbro into pure quartzite, which can be utilized as the essential material of the glass work at Po Shan. The thickness is estimated to be about 160 meters.

6. Red and Green Sandstone.—This formation rests conformably upon the Mesozoic coal series and is the last member of the consolidated sedimentary formations occurring in this field. It is composed of red, green, brown, violet and greyish yellow sandstone, becoming conglomeratic in the part in contact with the underlying coal series and metamorphosed into quartzite in contact with the igneous intrusions. On account of its having undergone erosion the thickness is undeterminable.

7. Red Clay, (or Hung t'u Formation).—This formation is differentiated from loess and named the Red Clay by Dr. J. G. Andersson who found the corresponding formation in Honan, in which he obtained many mammals of Pliocene age, such as *Aceratherium*, *Rhinoceras*, *Tragoceras*, *Hipparion*, etc. This indicates beyond doubt that the Red Clay is of late Tertiary age. It consists mostly of red clay alternating with thin conglomerate or containing pebbles scattered through it. In the lowermost portion there exists a layer of conglomerate of about one meter in thickness. The thickness of this formation varies from 5 to 15 meters. This clay is disconformable with the overlying loess and unconformable with the underlying formations.

8. Loess (or Huang-t'u Formation).—This is correlated with the typical loess which is well developed in northern China. It exhibits vertical cleavage and includes many shells of land-water animals. Dr. Andersson found many mammals of Pleistocene age in the loess, such as *Elephas* and *Rhinoceras*, etc , indicating that the formation is of early Quaternary age. The loess here frequently contains pebbles arranged in layers. Its thickness is variable and often less than 10 meters in this region

IGNEOUS ROOKS.

The western part of this field is much diversified by igneous rocks which invade into the sedimentary strata forming mostly laccoliths. These project above the plain forming numerous hills in the region. The igneous rocks were also found in the eastern part, but most of them constitute sheets along the bedding planes. They are either intrusive or extrusive; the former comprising three types: Gabbro, Andesite and Diabase. Only Basalt is found in the latter.

a) Gabbro occurs in the vicinity of K'un Lun Shan and San T'ai Shan, forming laccoliths in the Mesozoic coal series and also in contact with the red sandstone and the red-green sandstone. It is made up principally of plagioclase and augite. Hypersthene, hornblende, biotite and magnetite are also found as accessories, the hypersthene possessing polychroism, reddish when the vibrations are perpendicular to the vertical axis and greenish when the vibrations are parallel to it.

b) Andesite occurs at Huan Shan and Ming Shan, included in the red and green sandstone, constituting laccoliths and partly branching from the main body to form dykes. It is porphyritic; the phenocrysts are plagioclase and hornblende, the former being idiomorphic and large in crystal the latter often in corroded shape mostly altered. Augite is occasionally found but of very little amount. The ground-mass consists of plagioclase of a finely granular texture.

c) Diabase forms intrusive sheets in the upper and middle parts of the Palaeozoic coal series. The sheets are six in number and 1-4 meters in thickness at Hung Shan, but only one sheet of about 8 meters in thickness was met with at Ta K'uei Shan. The essential constituents are plagioclase and augite. Hornblende is sometimes present, forming elongated crystals, or is allotriomorphic, green or brownish yellow in color and with slight polychroism. Magnetite is also found.

The youngest of the sedimentary formations which were invaded by gabbro and andesite is the red and green sandstone, and therefore the age of the igneous rocks is younger than that of this sandstone, and there seems to be little doubt that the diabase is contemporaneous with the gabbro and andesite on account of the nearness of their position and the circumstance of their generation. From structural considerations most of the igneous rocks in Northern Shantung are believed to be of Middle Jurassic Age and this seems also to be true of the igneous rocks here dealt with.

d) Basalt is extrusive, occurring in the vicinity of Ching Shan and covering the red-green sandstone. Under the microscope the phenocrysts are constituted by olivine and the ground-mass is made up of plagioclase and augite. Magnetite is frequently associated with the latte mineral.

STRUCTURE

The structure of this coal field is very simple. There are no complicated folds whereas the faults are actually apparent.

On examining the chronological sequence, it is evident that one disconformity exists between the Ordovician and the Carboniferous, while another seems to occur between the red sandstone and the Mesozoic coal series. If the separation of the Palæozoic coal series into Poshan and Hangshan series prove to be correct there would be also a disconformity between the two divisions. During the periods of exposure of the lands, however, no potent movement affected the strata; for they were not markedly folded or dislocated. Consequently there are no true unconformities, but only disconformities. At the close of the Mesozoic the strata of this region were folded and faulted.

In the Tzŭ Po coal field proper, the direction of dip of the strata is generally north-west, sometimes to the north or to the west with the angle of dip 10 °-30°. Occasionally it is 4° or 42° and the strata may even be horizontal. In the vicinity of Hung Shan, the strata form a shallow syncline connecting with a low anticline. They are up-lifted at Hung Shan and Ta K'uei Shan and depressed in the environs of the Ta Huang Ti coal mine. In the Hei Shan and Hsi Ho coal fields the direction of dip of the strata is generally to the north, north-west and north-east with the dipping angle 5°-20°, and occasionally, 40° whereas at some other localities the strata may also be horizontal.

There are four prominent faults which divide the field into different parts: (1) That separating the Tzŭ Po coal field from the Chang Ch'iu coal field is a horizontal displacement running south-northward; (2) that separating of Tzŭ Po coal field from the Hei Shan and Hsi Ho fields is a normal fault, running from south-west to north-east, the Ordovician limestone forming the upthrow side and the coal series the downthrow side; (3) that dividing the Hei Shan and Hsi Ho fields is a normal fault, running from north-west to southeasti the dislocation being not violent; finally (4) that developed at the northern end of the Tzŭ Po coal field is also a small horizontal fault, effecting a discontinuity in the coal series.

COAL SEAMS.

The coal seams known to the Chinese miners are named 'Upper 8 seams' and 'lower 8 seams', according to the information received at the Ta Huang Ti coal mine (then worked by Japanese) 13 seams have been met with, but the seams usually worked at present are only nine in number, ranging from about 1 foot to 7.2 feet, the total thickness being about 8 meters in average. The tables I, II, and III are given to show the names and thickness of the coal seams, and the interval between them.

QUANTITY AND QUALITY OF THE COAL.

The determination of the coal reserve depends in part on the length and thickness of the coal seams and in part on the structure of the coal field. The structure is generally simple and the inclination of the strata is comparatively gentle, so the part of the coal seam, which lies above a depth of 300 meters from the surface can be economically worked out. But the part of the coal seam, above the level of 60 meters below the surface was mostly worked by native pits and must not be taken into account while one part of the seam must be left for the support of the roof. This has been taken into account, and hence the resources here estimated can be actually worked out. The estimate of the coal reserves in different fields is as follows:

Tzu Po field	410,356,800 tons
Hei Shan field	61,446,000 tons
Hsi Ho field	25,166,400 tons
The total	496,969,200 tons

The coal in the Tzu Po field proper is bituminous, but mostly non-coking, and that in the Hei Shan and Hsi Ho fields is bituminous and mostly coking with the exception of those parts near the faults. The analyses of the coal in different fields are given in the IV and V tables.

MINING INDUSTRY.*

Formerly the natives worked those mines by the old method. The Germans appropriated the northern part of Tzu Po field proper in 1897, entered into mining operation, and established the Shantung Mining Company (Schantung Bergbau Gesellschaft). With the fall of Tsingtao in 1915 the Japanese wrested the establishment from their hands and worked the mines continually to the present time. The average production is about 1500 tons per day. Lately the native miners have attempted to reform their old method, and to adopt the new system of mining, but at present the mines worked by machine are more than 30 in number and the total daily output is not less than 1000 tons. Most of the coal worked out is transported to Tsingtao, the remainder chiefly to Tsinan.

* in 1919, when this report was made.

TABLE I

(Showing the coal seams in the southern part of Tzu Po coal field proper)

Name	Tu-hsing	Hei-shih-t'an	Chia-kang	Luo-chu or Hui-shih-t'an	Hsiao-huang-shih-t'an	Ta-huang-shih-t'an	Yiu-hsing	Hsiao-shih-t'an	Ta-shih-t'an
Thickness	2.5 ft.§	2.5 ft.	1.3 ft.	3 ft.	1 ft.	3 ft.	1-3 ft.	2-4 ft.	3-6.5 ft.
Interval		not accurate	45 ft. from Hei-shih-t'an	70 ft. from Chia-kang	not accurate	not accurate	60 ft. from Ta-huang-shih-t'an	60-120 ft. from Yiu-hsing	3-4-30 ft. from Hsiao shih-t'an

§. Chinese foot (named Ch'ih)

TABLE II.

(Showing the coal seams in Hei Shan and Hsi Ho coal fields).

Name	Chi-tzu t'an	Ta-tuan-shih-t'an	Hsiao-tuan-shih-t'an	Hui-shih-t'an	Ta-huang-shih-t'an	Yiu-hsing	Ta-shih-t'an	Hsiao-shih-t'an
Thickness	3.6 ft.	5.4 ft.	3.6 ft.	1.3-1.8 ft.	2.2-4.5 ft.	1-2.4 ft.	2.4-7.2 ft.	1.8-3.6 ft.
Interval.		36 ft. from Chi-tzu-t'an	14-22 ft. from Ta-tuan-shih-t'an	not accurate	86 ft. from Hui-shih-t'an	150 ft. from Ta-huang-shih-t'an	70 ft. from Yiu-hsing	5-7-10 ft. from Ta-shih-t'an

TABLE III.

(Showing the coal seams at Ta Huang Ti coal mine).

Name	No. A or 1st. seam	No. B or 2nd. seam	No. C or 3rd. seam	No. D or 4th. seam	No. d or 5th. seam	No. E or 6th. seam	No. e or 7th. seam	Thin seam	Thin seam	No. F or 8th. seam	No. G or 9th seam	No. H or 10th. seam	No. I or 11th. seam
Thickness	1.1 ft.	.9 ft.	1.2 ft.	2.2 ft.	.9 ft.	2.5 ft.	1.2 ft.	.9 ft.	.9 ft.	6.8 ft.	3.7 ft.	1.9 ft.	.9 ft.
Interval		47 ft. from No. A	46 ft. from No. B	5 ft. from No. C	55 ft. from No. D	157 ft. from No. d	35 ft. from No. E	16 ft. from No. e	56 ft. from above seam	266 ft. from above seam	51 ft. from No. F	1.5 ft. from No. G	20. ft. from No. H

TABLE IV

(Showing the analyses of coal in Hei Shan and Hsi Ho fields).

Seams	Water	Volatile matter	Ash	Color of ash	Nature of coal	Sulphur	Caloric Power
Ta-tuan-shih-t'an	0.74	16.96	10.85	white	coking	0.57	7370
Hsiao-tuan-shih-t'an	0.63	18.15	7.92	Whitish-brown	,,	trace	7260
Ta-huang-shih-t'an	0.69	12.90	11.36	brown	,,	0.09	6820
Yiu-hsing	0.69	12.17	5.77	,,	,,	trace	7380
Ta-shih-t'an	1.13	13.57	23.88	,,	,,	1.52	6490
Hsiao-shih-t'an	0.98	17.01	3.25	,,	,,	1.08	7700

TABLE V

(Showing the analyses of coal worked by Ta Huang Ti coal mine).

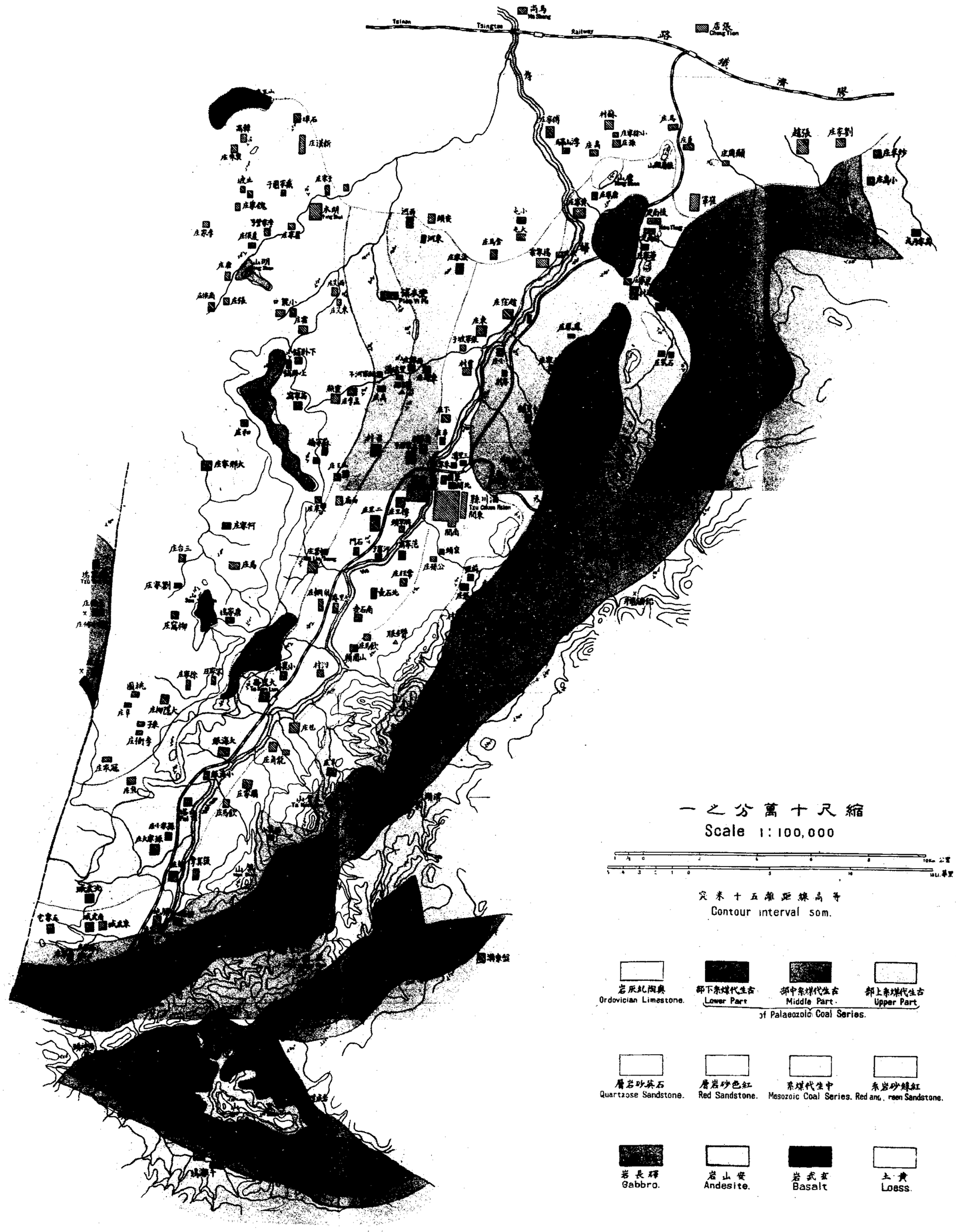
Seams	Water	Volatile matter	Ash	Color of ash	Nature of coal	Sulphur	Caloric Power
4th seam	0.75	10.58	6.32	white	coking	0.96	7700
8th seam	0.98	9.36	8.50	pink	non-coking		6150
9th seam	0.79	13.96	3.98	white	coking	1.24	7700
10th seam	0.67	13.21	4.93	brown	non-coking		7700

山東淄川博山煤田地質圖

GEOLOGICAL MAP OF THE TZŬ-CHUAN—PO-SHAN COAL FIELDS. SHANTUNG

Surveyed by H. C. Tan

PLATE I



譽山荊山一帶地層剖面圖
SECTION OF THE FORMATIONS FROM HUNG SHAN TO CHING SHAN.

一之分萬十尺縮
Scale 1:100,000

鳳凰山萬山一帶地層剖面圖
SECTION OF THE FORMATIONS THROUGH FÊNG HUANG SHAN AND WAN SHAN.

一之分萬十尺縮
Scale 1:100 000

GENERALIZED SECTION OF THE FORMATIONS OF TZŬ-CHU'AN AND PO-SHAN

Quaternary	Loess		Loess
Tertiary	Red Clay		Conglomerate and red clay
Jurassic	Red and green Sandstone		Red sandstone with green, yellow, violet, brown, gray sandstone Red conglomeratic sandstone
	Mesozoic Coal Series	160 m	Yellowish-green clayey shale, black clayey and sandy shales Yellowish-green sandstone Yellowish-green sandstone, black shale and white sandstone
Triassic (?)	Red Sandstone	680 m	Yellowish-green thin-bedded sandstone Deep-red sandstone Brown, yellowish, gray clay, clayey shale and greenish sandstone
Permian (?)	Quartzose Sandstone	290 m	Greenish hard sandstone White quartzose sandstone (grit) Greenish hard sandstone
Permo-Carboniferous	Hungshan Formation	280 m	Red clayey shale and sandstone; green, yellow, brown clayey shale and diabase sheets Sandstone, clayey shale and coal seams
Lower Carboniferous	Poshan Formation		Sandstone, black shale, limestone and coal seams Clay, clayey shale, sandstone, limestone and green heavy rock
Ordovician	Tsinan Limestone		Actinoceras limestone

SECTION OF THE COAL SERIES AT HUNG SHAN

Permian	Quartzose Sandstone		White quartzose sandstone (grit)
Hungshan Formation	Upper Part	101.6m	Yellowish-green clayey shale Diabase sheets, white-gray sandstone and yellowish-green sandstone Yellow sandstone Violet, brown and gray clayey shale Yellowish-green sandstone Violet, brown, gray clayey shale and diabase sheets Violet, brown, gray clayey shale with yellow and brown micaceous sandstone Yellow hard sandstone, violet, brown and gray clayey shale Yellow, white sandstone, violet and gray clayey shale Yellow coarse sandstone, partially conglomeratic
Poshan Formation	Middle Part	102.7m	Yellow loose sandstone, greenish-black and violet clayey shale with coal seams Yellow sandstone and ferruginous hard sandstone Yellow loose sandstone and clayey sandstone Gray loose sandstone and yellow hard sandstone Black-gray shale interbedded with yellow sandstone containing coal seams Productus limestone Variegated clayey sandstone Greenish-black thin-bedded shale with coal seams Black-green shale and diabase sheets Greenish-black shale interbedded with sandstone Greenish-gray hard sandstone Black shale containing coal seams
	Lower Part	28.2 m	Fusulina limestone Yellowish-green, gray clay, reddish-yellow sandstone and black clayey shale Red, brown and yellow clay with one seam of impure limestone Variegated clay and heavy rock Red-brown and yellowish-white clay
Ordovician	Tainan Limestone		Actinoceras limestone

SECTION OF THE COAL SERIES AT HEI SHAN

Permian	Quartzose Sandstone		White quartzose sandstone (grit)
Hungshan Formation	Upper Part	112.5m	Brown, yellow and green clayey shale Green sandstone with trace of plant fossils Yellow and white-gray sandstone Brown, yellow and green clayey shale Green sandstone Brown, yellow and green clayey shale Green sandstone Brown, yellow and green clayey shale Green hard clay Green and yellow shally sandstone Green, yellow sandstone and brown, yellow, green clayey shale
Poshan Formation	Middle Part	78.5m	Greenish sandstone Black sandy shale with coal seams Black clayey shale Dark-yellow sandstone Yellowish sandy shale with coal seams Productus limestone Gray sandy shale with coal seams Yellow-gray sandstone Gray, yellow, green, reddish clayey shale, black shale and gray-yellow sandstone, with coal seams.
	Lower Part	12m	Fusulina limestone Brown, yellow and gray clayey shale and clay
Ordovician	Tsinan Limestone		Actinoceras limestone

SECTION OF THE COAL SERIES AT TA K'UEI SHAN

Permain	Quartzose Sandstone		White quartzose sandstone (grit)
Hungchan Formation	Upper Part	142 m	Green clayey shale and gray sandstone Yellowish-green shally sandstone Brown, yellow and green clayey shale Green sandstone Brown, yellow and green clayey shale Green sandstone Diabase sheet Greenish sandstone Dark-green clayey shale Brown, green, yellow and black clayey shale Green sandstone Brown, yellow and green clayey shale Green hard clay Brown, yellow and green clayey shale Green sandstone Brown, yellow and green clayey shale
Poshan Formation	Middle Part	113 m	Yellowish-green sandstone and black clayey shale, with coal seams Green shally sandstone and black clayey shale, with coal seams Yellowish sandstone Yellowish shally sandstone and black clagey shale, with coal seams Yellow sandstone Black clayey shale with coal seams Yellow sandstone Productus limestone Clayey shale and yellow sandstone with coal seams Yellow and white-gray sandstone Fireclay, green-gray shale and black shale, with coal seams
	Lower Part	29 m	Fusulina limestone Gray clay Yellow and gray sandstone Brown, red, yellow and gray clayey shale and clay
Ordo-vician	Tsinan Limestone		Actinoceras limestone

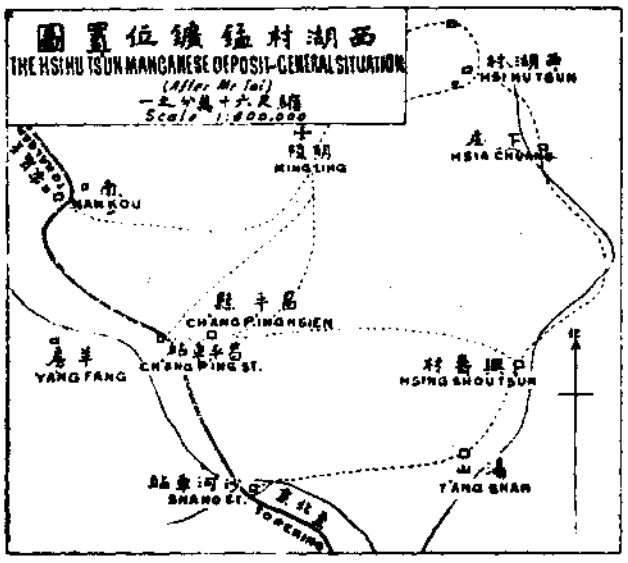
THE MANGANESE DEPOSITS AT HSI HU TS'UN, CHANG PING HSIEN, CHIHLI.§

BY

V. K. TING

LOCATION AND COMMUNICATION.

The Hsi Hu Ts'un manganese deposit is situated on the hill called Tieh Kuang Liang about one kilometer west of Hsi Hu Ts'un, Ch'ang P'ing Hsien. The mountain is about 150 meters above the surrounding plain.



There are two routes from Hsi Hu Ts'un to the railroad: (a) One is via Ming-Ling to Ch'ang-P'ing or Nan-Kou, a distance about 40 li. But between the village and Ming-Ling lies the mountain Hsi-Ta-An-Ling making it difficult for the pack animals to cross. Further improvement of the road might eliminate this difficulty. (b) The other is via Hsing-Shou-Ts'un to Sha-Ho, a distance of about 60 li. and this is the one now in use. From the mines to the cart station, a distance of 30 li, only donkeys can be used. Supposing that each donkey can cover the distance back and forth three times in two days and each time it can carry 180 catties and that each donkey costs 50 cents per day, for one ton of the ore, the transport by donkeys alone will cost $ 2.50. The rest 30 li covered by cart costs about $ 1.50 per ton. Thus under the present conditions the transportation form the mine to the railroad station will cost $ 4.00.

§ This paper is translated by P. L. Yuan.

GEOLOGY AND ORE DEPOSIT.

From north of Hsing-Shou-Ts'un to south of Hsia-Chuang the mountains all consist of Pre-Cambrian cherty limestone. Further north there are granite and other igneous rocks. But small bodies of the sedimentary cherty limestone often occur isolated in the igneous mass. The Tieh-Kuang-Liang is one of them.

The northern part of the hill is composed of granite. The top of the hill is of cherty limestone, together with interbedded sandstone and silicified limestone. The cherty limestone occurs in the northern part dipping 30°-90° at first towards N.E., but changing towards S. W. in the south. The sandstone and silicified limestone are in the southern part, dipping 30° N. E.

Between these two beds there is a fault. It is in this fault zone that an intrusion of trachyte-porphyry occurs.

The intrusive body is very irregular, and the manganese ore occurs in the limestone near the contact. The minerals are Pyrolusite (MnO_2), Manganite ($MnO(OH)$), Rhodonite ($MnSiO_3$), Rhodochrosite ($MnCO_3$), and a little Psilomelane (H_4MnO_5.). Rhodochrosite is very impure and much mixed with limestone. Psilomelane occurs in cavities and is of small quantity. Rhodonite and Pyrolusite are often mixed; when weathered they have the appearance of Psilomelane. The shape of the ore body is very irregular as shown in the geological map. Since the outcrop has been well excavated, the contact with country rock is very clear.

From what has been said, it is evident that the origin of the deposit is due to the intrusion of trachyte-porphyry. The calcium is replaced by manganese, and calcite is changed into Rhodochrosite ($MnCO_3$). When the latter is oxidized, the final product of oxide of manganese (Pyrolusite) is formed. The silicon in the limestone forms, with manganese, Rhodonite, and water circulating in the rock forms Psilomelane.

The results from 3 testing pits are:

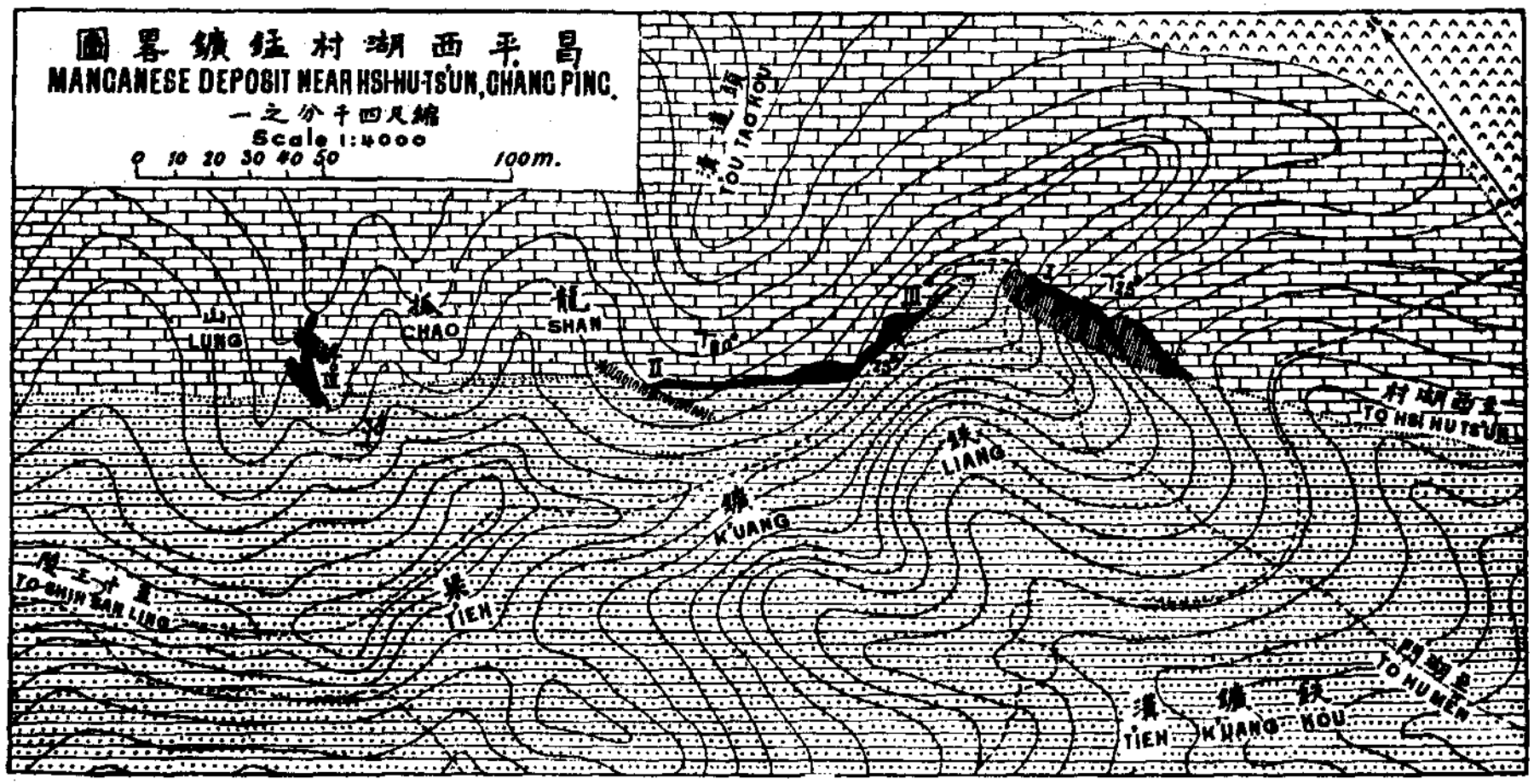
I. In the northwest corner (which section is shown in Fig. 1) the dip of limestone is 90° and that of sandstone. a little more than 20° towards

昌平西湖村錳鐵礦圖

MANGANESE DEPOSIT NEAR HSI-HU-TS'UN, CHANG PING.

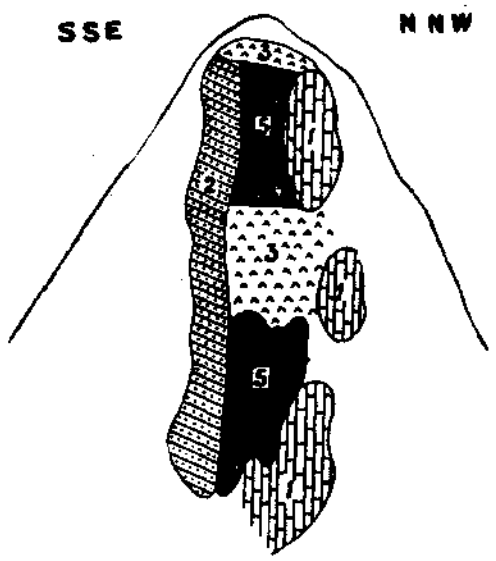
Scale 1:4000 一之分千四尺綿

0 10 20 30 40 50 100m.



岩崗花	岩斑石長正	鑛錳	岩灰石質矽	岩石砂
Granite	Orthoclase Porphyry	Manganese Ore	Cherty Limestone	Sandstone & Silicified Limestone

N and NE. The ore body is separated by igenous rock. The latter is found also further west where no ore is visible.

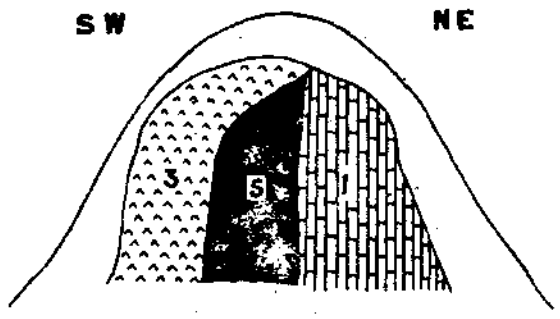


第四剖面圖
SECTION Ⅳ.
一之分十八尺縮
Scale 1:80
1. 岩灰石 Limestone 2. 岩砂 Sandstone
3. 岩斑石長正 Orthoclase porphyry 5. 養錳 Oxide

II-III. NE of Tieh-Kuang-Liang, the ore body, about 100 m. long, occurs at the contact between limestone and sandstone and is cut off by the trachyte porphyry. The dip of the limestone is 80° SW and that of sandstone 20° NE (Figs. 2 & 3). The ore body runs SE ward continuously up to the top of the hill, but the oxide is mixed with the carbonate and quite impure. Its shape is very irregular, making it difficult to estimate the available quantity.

IV. This is the SE end of the deposit and is separated from the latter by an igneous body. The limestone dips more gently than elsewhere, but in the opposite direction from the sandstone. (Fig 4)

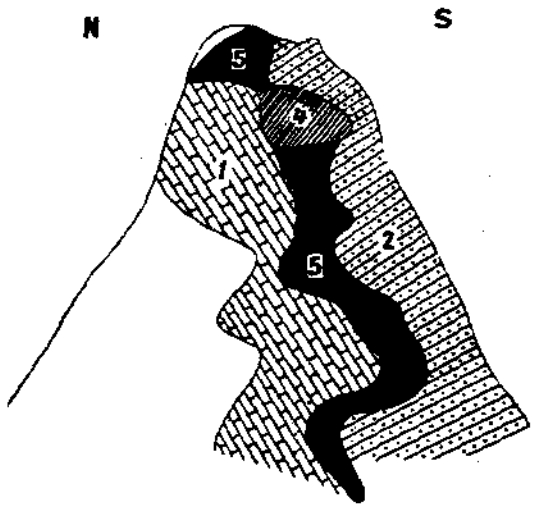
Since the ore is a mixture of Rhodonite, Rhodochrosite and Pyrolusite, Psilomelane, it is almost impossble to know its average quality. Its irregular shape also makes the quantity difficult to estimate. Further careful samlping and detailed analyses are both necessary.



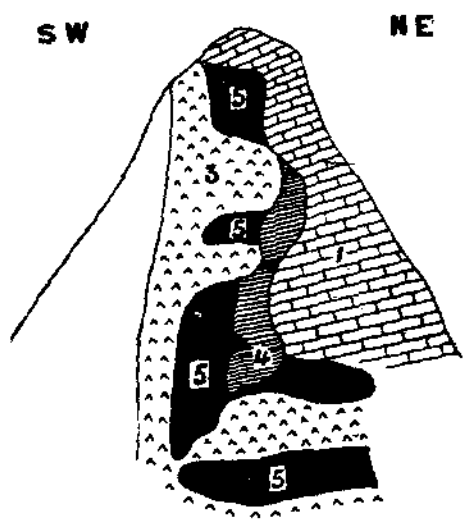
第二剖面圖
SECTION Ⅱ.
一之分十三尺縮
Scale 1:30
1. 岩灰石 Limestone 3. 岩斑石長正 Orthoclase-porphyry 5. 養錳 Oxide

My observation of this deposit was made during an afternoon trip, lasting a little less than two hours. I wish to take this opportunity to record

my obligation to Messrs. T. H. Tai, and K. H. Chen. The geological and the general map were based on Mr. Tai's topographical sketches, and Mr. Chen helped me to draw the sections.



圖面剖三第
SECTION III.
一之分十八尺縮
Scale 1:80
1 岩灰石 Limestone
2 岩砂 Sandstone
4 錳酸炭 Carbonate
5 養錳 Oxide



圖面剖一第
SECTION I.
一之分十八尺縮
Scale 1:80
1. 岩灰石 Limestone
3. 岩斑石長正 Orthoclase-porphyry
4. 錳酸炭 Carbonate
5. 養錳 Oxide

NOTE SUR LA GEOLOGIE DE LA REGION DE SHI MUN JAI,

PAR

F.F. MATHIEU,

La cité de Shi Mun Jai (Hsih-Men-Chai) est située à environ 19 kilomètres au Nord de Chinwangtao sur la bordure Est du bassin houiller de Liu Kiang. L'étude de ce bassin houiller a fait l'objet d'un intéressant travail de MM. Yih et Liu paru en 1919 dans le Bulletin of the Geological Survey of China.* Au cours de plusieurs voyages dans ces régions j'eus l'opportunité d'en faire l'étude rapide et de découvrir quelques niveaux fossilifères dont l'étude par le Professeur Grabau pour la faune Ordovicienne et par moi-même pour la flore Permo-Houillère permettent de compléter la documentation.

STRATIGRAPHIE.—

Abstraction faite du loess et des alluvions, l'échelle stratigraphique de cette région comprend du haut en bas les séries suivantes:

Roches éruptives post-primaires.
Terrain houiller Stephano-Permien.
Ordevicien.
Cambrien (?)
Archéen.

Je passerai rapidement en revue ces différentes formations.

ROCHES ERUPTIVES POST-PRIMAIRES,—

A une époque correspondant probablement au début du Tertiaire, les formations primaires antérieurement plissées par les mouvements hercyniens, furent bouleversées par d'importantes venues éruptives qui modifièrent considérablement le relief et la tectonique de ces régions, activement érodées depuis la fin des temps primaires. Ces éruptions se manisfestent dans la région de Shi Mun Jai sous les formes suivantes:

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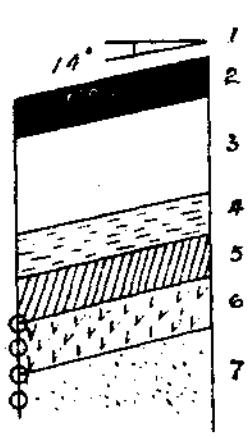
* Bulletin of the Geological Survey of China. Number 1. July 1919. Pages 6 and 7. Texte anglais ance une carte géologique.

a) **Massif de Ta Hai Shan.** La partie médiane du bassin Permo-Houiller disparait sous l'important massif éruptif de Ta Hai Shan que MM. Yih et Liu considèrent comme étant intrusif plutôt que comme une nappe d'epanchement; les nappes intrusives et les dykes dont il sera question plus loin ne seraient dans ce cas que des apophyses et des épiphyses issues du pseudo-laccolith principal. Les specimens prélevés sur les affleurements montrent un polymorphisme remarquable comprenant surtout des roches de types porphyroides, diabasiques et andésitiques. Nul doute que l'étude pétrographique de ce massif amènerait des conclusions intéressantes pour la théorie des magmas composites.

b) Nappes intrusives.—Il existe plusieurs nappes intrusives dans la serie houillère et le calcaire ordovicien: ces intrusions probablement en rapport avec le massif précédent ont produit un métamorphisme de contact et post-éruptif d'intensités variables.

Un sondage effectué dans les couches houillères de Hsin Yeh a recoupé à partir de la profondeur de 321 pieds la série suivante; dont nous donnons la coupe géologique dressée d'après les carottes recueillies au cours du sondage:



1) Toit schisteux.

2) Charbon.—Une analyse effectuée sur la pulpe recueillie au cours du sondage donne 16.55 mat. volatiles et 36.15 de carbone fixe.

3) Grès argileux noir, charbonneux, devenant de plus en plus argileux vers le bas; caractères de mur, *Stigmaria ficoides.*

4) Schiste siliceux, noir-mat, finement grenu, à débris végétaux.

5) Schiste charbonneux. L'analyse de la pulpe donne 7.80 de matières volatiles et 13.90 de carbone fixe.

6) Andésite augitique porphyroide.

7) Diabase à labrador.

L'étude pétrographique des roches 6 & 7 a été faite par le Professeur Morris de l'université de Peiyang dans une remarquable étude dont la publication sera une importante contribution à la connaissance des nappes composites. L'andésite porphyroide plus récente a pénétré les fissures de la diabase englobant complètement quelques xénolythes de cette roche; au contact des roches sédimentaires le métamorphisme s'est manifesté par une distillation partielle du charbon amenant une forte réduction de la teneur en matières volatiles et transformation de certaines pellicules charbonneuses des empreintes végétales en une sorte de graphite finement grenu; il y a eu en plus apport de calcite, pyrite et magnétite. *

J'ai pu observer quelques nappes intrusives ou filons-couches dans les calcaires ordoviciens; les roches éruptives sont toujours trèp fortement altérées aux affleurements pour qu'on puisse en donner une détermination certaine: la réaction métamorphique sur le calcaire encaissant est toujours très faible.

c) Dykes.—Les dykes, assez fréquents, sont dans la plupart des cas constitués d'un porphyre quartzifère.

Sur le flanc Est du bassin houiller on peut voir l'un de ces dykes, épais de quelques mètres, traverser le calcaire Ordovicien et continuer dans le Terrain Houiller.

Au Sud-Ouest de Liu Kiang, la colline Wang Chwang, formée de calcaire dolomitique, est traversée par un dyke fortement redressé de porphyre quartzifère rose, dirigé Nord-Est dont la réaction métamorphique sur les roches encaissantes s'est manifestée sous les aspects suivants:

1) Silicification partielle ou totale, marmorisation et rubéfaction des bancs situés au Nord-Ouest de ce dyke.

2) Formation de nodules et lits irréguliers de chert.

3) En quelques points le calcaire renferme des cristaux de trémolite et certains joints sont remplis sur de faibles longueurs d'une asbeste siliceuse trémolitique.

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* Il existe au siège de Linsi, dans le bassin de Kaiping, une importante série de dykes éruptifs qui produisirent sur le charbon et les roches sédimentaires encaissantes un métamorphisme similaire à celui des nappes de Hsin Yeh.

Toutes ces venues éruptives que l'on peut considérer comme résultant de la différentiation d'un magma complexe, ont fortement affecté le bassin de Liu Kiang dont le charbon semi-anthracitique renfermant en moyenne de 7 à 10 % de matières volatiles présente souvent une structure colomnaire caractérisant le métamorphisme du charbon au contact des roches éruptives.

TERRAIN PERMO-HOUILLER DE LIU KIANG.—

Le terrain houiller de Liu Kiang est constitué d'une alternance irrégulière de grès, psammite et schiste, la roche dominante étant un grès grossier à ciment kaolineux: il existe 2 horizons caractéristiques de grès dur parfois quartzitique renfermanant quelques lits peu épais de poudingues: ce sont les grès de Yun Shan et de Nan Shan * de MM. Yih et Liu.

Parmi les 10 couches reconnues aux environs de Liu Kiang ou la série est complète, deux seulement, dénommées No 3 et No 5 sont susceptibles d'exploitation et fournissent un charbon semi-anthracitique à haute teneur en cendres.

Dans son ensemble, le bassin de Liu Kiang est plissé en un synclinal plat dirigé Nord-Sud, dont la partie médiane et la pointe Nord ont été forteemnt affectées par les venues éruptives post-primaires: il existe de nombreuses failles dont l'une parait suivre parallèlement la limite Est du massif éruptif de Ta Hai Shan. Au Nord, la tectonique est compliquée par de multiples failles, et l'on voit apparaitre un conglomérat qui n'existe pas ailleurs et que je ne suis pas éloigné de considérer comme étant l'équivalent du poudingue de Wen Ho, d'âge Tertiaire, qui, d'appès Bailey Willis, jalonne souvent les failles de la région de Sin Tai (Shantung):, le peu de temps dont j'ai pu disposer ne m'a pas permis de solutionner le problème.

Ces consideration, jointes à d'autres, me font admettre que les grandes venues éruptives de Tai Hai Shan ont dû se produire au début de l'époque Tertiaire.

J'ai recueilli sur le terril de Liu Kiang et dans les carottes d'un sonnage effectué à Hsin Yeh les fossiles suivants:

Neuropteris flexuosa.

Neuropteris sp: grande pinnule rectangulaire isolée; probablement pinnule anormale de l'espèce précédente.

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* Bulletin of the geological Survey of China. No 1. July 1919. Page 7. Texte anglais

Cyclopteris.

Pecopteris (*Asterotheca*): échantillon fructifié très mal conservé, appartenant au groupe des *cyathoides.*

Annularia stellata, var. *mucronata.*

Callipteridium (?).

Sphenophyllum emarginatum.

Cordaites principalis.

Poacordaites sp.

Samaropsis cf fluidans.

Stigmaria ficoides.

J'ai en outre recueilli un fragment fortement abimé qui pourrait être, par sa forme, l'extrémité d'une feuille de *Taeniopteris multinervis* (Weiss); la nervure médiane est bien marqués, mais l'altération ayant fait disparaitre les nervures secondaires, la détermination spécifique reste douteuse.

D'une maniére générale, les fossiles sont rares, mal conservés et fragmentaires; il faut y voir sans doute un effet du métamorphisme.

La présence de *Neuropteris flexuosa*, *Annularia stellata*, *Sphenophyllum emarginatum*, *Cordaites principalis* permet de rapprocher cette flore de celle de Kaiping, de Pen Shi Hu, du Shantung (pro parte) et de considérer ce bassin comme étant lui aussi d'age Permo-Houiller; la plupart des espèces ont été recueillies dans les couches médianes et inférieures du bassin: il est vraisemblale que les horizons les plus élevés fourniraient une flore plutôt Permienne, comme c'est le cas pour la flore de Tangchiachwang dans le bassin de Kaiping, où les nouveaux puits en creusement ont recoupé les couches supérieures avec flore nettement Permienne.

ORDOVICEN.—

Le calcaire Ordovicien forme le substratum sur lequel repose le terrain houiller de Liu Kiang; sur le flanc Est du bassin les couches calcaires sont dans leur ensemble inclinées de 12 à 30 degrés Ouest.

L'étude stratigraphique m'a permis de subdiviser l'Ordovicien de Shi Mun Jai en trois assises différentiées par l'ensemble de leur caractère lithologiques; les fossiles recueillis dans les assises 1 & 3 appartiennent, d'après le Professeur Grabau* qui en a fat l'ètude, à l'Ordovicien inférieur non encore signalé en Chine.

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* A.W.Grabu Ordovician fossils from Northern China, Palæontologia Sinica, series B vol 1.

a) *Assise supérieure de Liang Chia Chan.*—Cette assise supérieure est constituée d'une importante série de calcaires bien stratifiés en bancs peu épais dont la base est visible près de la muraille Sud de Shi Mun Jai, où quelques petites carrières permettent d'observer le contact d'un calcaire conglomeroide et de calcaires feuilletés avec les calcschistes du sommet de l'assise sous-jacente.

Le banc de conglomérat est recouvert de calcaire gris à grain fin, zonaire, montrant aux affleurements une patine jaune-crême; quelques minuscules noyaux de chert noir sont alignés suivant les zones dont la structure est soulignée par une inégale altération météorique; ces bancs inférieurs fournissent un calcaire tres pur, ainsi qu'il résulte d'analyses concordantes (1) effectuées sur trois échantillons différents, donnant la moyenne suivante:

$CaCO_3$	93,03
$MgCO_3$	1,44
SiO_2	6,06
Al_2O_3—Fe_2O_3	1,28

Je n'ai recueilli dans ces carrières que quelques débris d'*Orthoceras* (?), sndéterminables spécifiquement.

La partie moyenne de l'assise affleure dans la cité même de Shi Mun Jaï et sur la route de Shi Mun Jai à Liu Kiang; c'est un calcaire gris, plus ou moins dolomitique, bien stratifié et renfermant quelques intercalations de conglomérat calcaire.

Les horizons supérieurs sont visibles sur la colline de Liang Chia Chan, au Nord de Shi Mun Jai, et sont également constitues d'un calcaire gris, plus ou moins dolomitique, avec rares noyaux de chert noir.

J'ai localisé, vers le sommet de cette assise, le niveau fossilifère F_3 (Voir coupe): les specimens recueillis ont été examinès par le Professeur Grabau, qui a déterminé les espèces suivantes:

GASTROPODA

1. *Ophileta plana* Grabau
2. *Hormotoma docquieri* Grabau

CEPHALOPODA

3. *Cameroceras styliformis* Grabau
4. *Piloceras platyventrum* Grabau

(1) Analyses de M. Sun, Chimiste de la K.M.A.

Cette faunule indique l'Ordoricien intérieur.

La puissance totale de cette assise déterminée par un survey rapide est d'environ 275 mètres.

b) *Assise moyenne de Shi Mun Jai.*—L'assise moyenne sous-jacente à celle de Liang Chia Chan est bien visible près de la muraille Sud et le long du sentier allant de Shi Mun Jai à Pei Lin Tze.

Cette assise comprend du haut en bas:

1) Calcschistes et schistes bien stratifiés, jaunes, gris, ou violacés. Puissance totale environ 80 mètres.
2) Calcaires compacts et calcaires congloméroides, gris ou brun-rougeatres; les conglomérats particulièrement intéressants sont constitués de galets de calcaire brun ayant généralement la forme d'un ellipsoide aplati réunis dans un ciment grossièrement grenu, surtous formé de calcaire spathique grisâtre. Le diamètre des galets dépasse rarement 3 centimètres. Puissance environ 4,50 mètres.
3) Calcaire feuilleté, parfois argileux, à grain moyen ou fin, passant souvent à un véritable calcilutite. Puissance 16 mètres.
4) Schiste brun-chocolat, calcschiste, psammite calcareux, alternance de minces lits de schistes siliceux micacés bruns et de lits de calcaire siliceux gris. Puissance 21 mètres.
5) Calcaire gris, grossièrement grenu, massif vers le haut, feuilleté, à grains plus fins vers le bas. Puissance 4,50 mètres.
6) Schistes et psammites calcareux gris ou bruns avec minces intercalations de calcaire gris et de calcaire conglomeroide brunâtre. Puissance 13 mètres.

Plusieurs dykes, fortement altérés, en conformité avec les couches, sont visibles le long de la coupe.

Aucun fossile n'a été recueilli dans cette assise, dont les nombreux changements de facies lithologique contrastent avec l'uniformité des autres assises.

c) *Assise inférieure de Pei Lin Tze.*—Non loin du coin Sud-Est des murs de Shi Mun Jai on peut voir le terme inférieur de l'assise précédente reposant sur des bancs épais de calcaire gris oolithique. Cette roche, particulièrement intéressante est constituée d'un grand nombre d'oolithes sphéroidaux à surface généralement patinée noire, cimentés dans une masse grise finement grenue. Le diamètre des oolithes varie de ¼ millimètre à 8 millimètres exceptionnellement, avec une moyenne comprise dans la plupart des cas entre ½ et 1 millimètre.

La puissance de cet horizon dépasse 20 mètres; vers le Sud, le caractère oolithique s'atténue, les oolithes deviennent rares et la roche semble passer latéralement à un calcaire dolomitique gris.

Une analyse effectuée sur un échantillon moyen du calcaire oolithique typique a donné les résultats suivants:

$CaC0_3$	94,25
$MgC0_3$	4,64
$Si0_2$	1,12
Al_20_3—Fe_20_3	1,16

Près de Pei-Lin Tze, le calcaire oolithique bien stratifié en bancs dirigés Nord-Sud, repose sur une épaisse formation de calcaire finement grenu, gris foncé ou noir-bleuâtre, sonore, à cassure esquilleuse, très légèrement siliceux et dolomitique. Quelques horzions de calcaire conglomeroide sont visibles dans les carrières ouvertes pour l'exploitation de la chaux.

J'ai pu localiser dans cette assise les horizons fossilifères F_1 et F_2, qui d'après le Professeur Grabau, renferment les espèces suivantes:

ANTHOZOA:

1. *Archæocyathus chihliense* Grabau

GASTROPODA:

2. *Ophileta squamosa* Grabau; 3. *Fusispira* sp

CEPHALOPODA:

4. *Protocameroceras mathieui* Grabau; 5. *Chihlioceras nathani* Grabau
6. *Chihlioceras chingwangtaoense* Grabau; 7? *Piloceras platyventrum* Grabau

L' ensemble de l'assise inférieure de Pei Lin Tze est visible avec certitude sur une puissance d'environ 100 mètres.

CAMBRIEN.—?

Je n'ai pu observer le contact des calcaires inférieurs avec les roches sous-jacentes: schistes bigarrés, quartzite et conglomerat que MM. Yih et Liu considèrent comme étant du Cambrien inférieur; cette détermination demande à être vérifiée par des arguments paléontologiques.

ARCHEEN.—

Le substratum Archéen est visible en plusieurs endroits, le long du chemin de fer Chinwangtao-Liukiang et aux environs de ces derniers villages; c'est un complexe de granite rose à orthose, granite à biotite, gneiss et pegmatite rosée. Près de Chinwangtao et le long de la côte de Peitaiho on trouve dans ce complexe, outre les intrusions de pegmatite et de granite a biotite, des veines irrégulières, peu épaisses de syénite.

TECTONIQUE-LACUNES STRATIGRAPHIRUES.—

Le peu de temps dont j'ai pu disposer ne m'a pas permis de pousser bien loin l'étude de la Tectonique.

Dans l'ensemble, le Permo-Houiller forme un bassin synclinal emboitant sans discordance angulaire apparente le bassin ordovicien. Le calcaire du flanc Est présente des variations fréquentes d'inclinaison résultant de l'existence de plis peu accentués en forme de chaise: un palier de faible pente étant intercalé entre deux tronçons à pente plus forte; ce type de pli parait assez fréquent dans l'Ordovicien de l'Est du Chihli. Près de Pei Lin Tze, les couches calcaires de l'assise inférieure, dirigées Nord-Sud, subissent une inflexion très nette les orientant Nord-Ouest.

J'ai parlé plus haut des failles du terrain Permo-Houiller qui paraissent surtout en rapport avec les grandes venues éruptives post-primaires.

L'examen de l'échelle stratigraphique permet de conclure à l'existence de nombreuses lacunes relativement aux séries normales des régions voisines. Ces lacunes comprennent notamment:

a) Assise inférieure du bassin houiller.—Je n'ai observé aucun affleurement de cette assise à niveaux marins et à calcaires à crinoides, particulièrment bien représentée dans le bassin de Kaiping où elle comprend le calcaire de Tangshan, dont la faune présente des affinités Dinantiennes.

b) Assise supérieure de L'Ordovicien.—On n'a pas jusqu'ici localisé la faune à *Actinoceros*.

c) Pré-Cambrien.—Comme le font remarquer MM. Yih et Liu, tout le Pré-Cambrien manque, à moins toutefois qu'il ne soit représenté par la faible épaisseur de quartzite et de conglomerat que ces auteurs classent dans le Cambrien inférieur. Dans la région de Lanchow, entre Chingwangtao et Kaiping, on retrouve l'Ordovicien typique et le Cambrien avec leurs faunes bien caractérisées: ces formations reposent sur une forte épaisseur de roches Pré-Cambriennes que je subdivise en deux séries correspondant aux termes de la classification de Bailey-Willis.

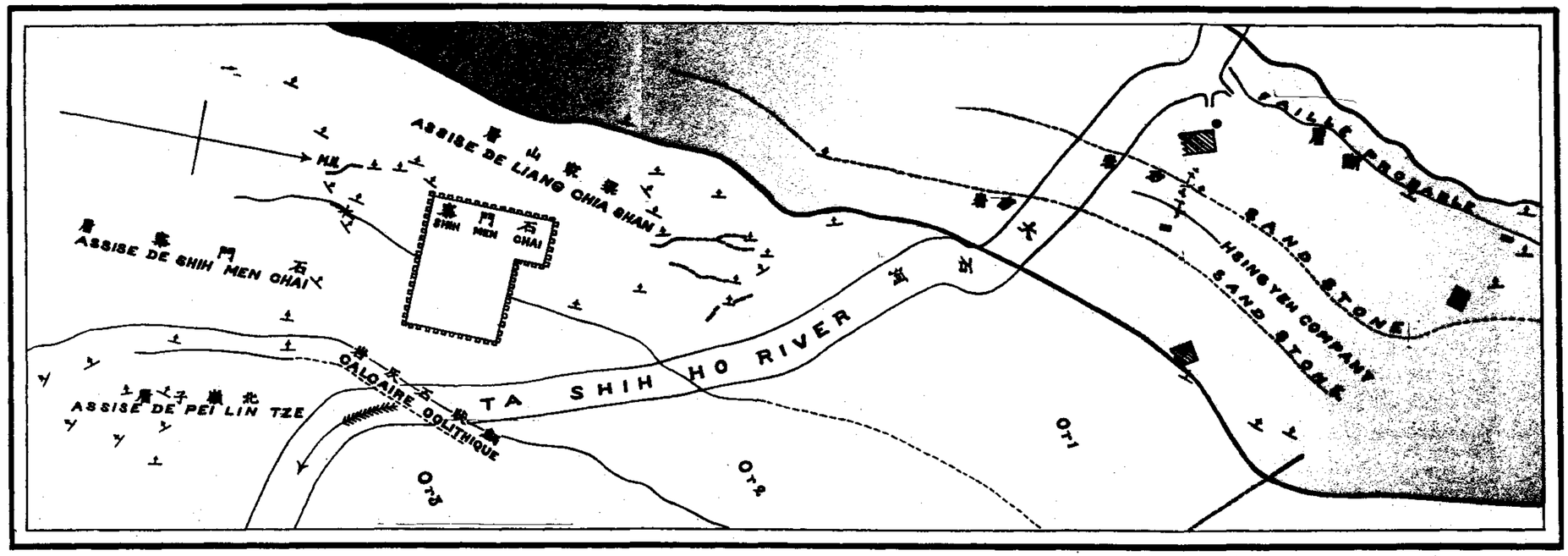
1) Pré-Cambrien supérieur.–Ce système comprend de haut en bas:
Calcaire noir bréchoide veiné de calcite.
Calcaire feuilleté à grains très fins, multicolore, rose, brun, vert, jaune; pseudo-calcaire lithographique,
Schistes vert et violacé: grès feuilleté.
Quartzite blanc ou rose; brèches quartzeuses.
Argilite rouge avec intercalations peu épaisses de calcaire siliceux gris.
Calcaire siliceux blanc ou rosé veiné de cherts bigarrés; bancs de cherts.

2) Pré-Cambrien inférieur.–Les couches précédentes reposent sur une épaisse formation de quartzite et d'arkose grossière appartenant au Systeme de Nan Kou, à la base duquel on trouve parfois un conglomérat dont les éléments roulés sont dérivés des roches Archéennes: en quelques points, ce conglomérat est constitué presqu'exclusivement de fragments, à peine arrondis, de minerai de fer du type *itabirite*, réunis par un ciment grenu, greso-feldspathique.

Cet ensemble correspond exactement au Système de Hu To de Bailey-Willis. Etant donné l'importance de cette série, il est difficile de croire qu'elle ait été complètement enlevée, dans la région de Shi Mun Jai, par l'érosion anté-Primaire; il est plus simple d'admettre que la ligne du rivage (marine ou lacustre) Pre-Cambrienne devait passer entre Lanchow et Chingwangtao et peut être est elle représentée par le conglomérat inférieur de MM Yih et Liu.

圖質地近附寨門石縣榆臨隸直
GEOLOGIE DE SHIH MEN CHAI

ECHELLE 1600 FEET TO 1 INCH　尺英百六千一爲寸英一以尺縮



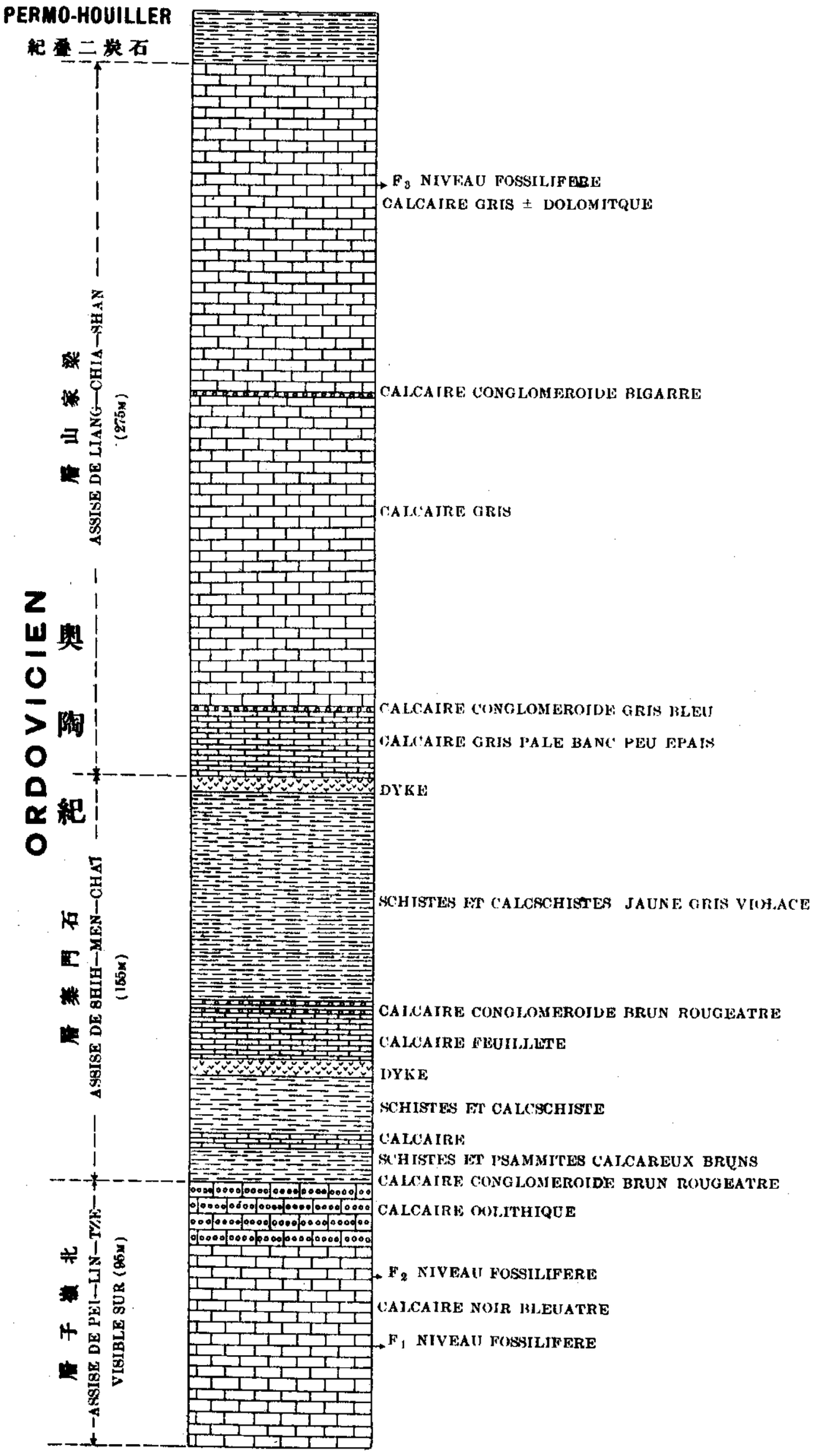
岩成火後紀叠二　ROCHES ERUPTIVES POST-PRIMAIRE

紀叠二炭石　STEPHANO-PERMIEN

紀胸奧　ORDOVICIEN

脈岩成火　DYKE

臨榆石門寨地層剖形柱圖
SECTION DU TERRAIN ORDOVICIEN, REGION DE SHIH-MEN-CHAI



ON THE STRATIGRAPHY OF PAO TÊ CHOU, N. W. SHANSI.

BY

C. C. WANG

Pao Tê (保 德) city is situated in N. W. Shansi on the left side of Yellow River opposite to Fu Ku (府 谷) city in Shensi on the right side of the river. Consequently, it occupies an important geographical position. All the hills in the district visited are thickly covered with loess, under which the strata dip generally towards the west. Between the Ordovician limestone on the east and the lower Mesozoic sediments on the west, lies a narrow belt of alternating marine and continental deposits of late Palæozoic age. These deposits, being easily eroded, are generally exposed only in the bottoms of deep ravines. Thus, throughout the extent of nearly one hundred li including the localities of T'ien Ch'iao, (天 橋) Chang Chia Kou (張 家 溝) and P'a Lou Kou, (扒 樓 溝) only a few valleys are observed which cut into the bed rock, all the others being limited to the loess. Two of the rocky valleys have been studied; 1. along P'a Lou Kou, and 2. along Chang Chia Kou. As I intend to make a comparison between the strata which occur here and the Upper Palæozoic or Mesozoic sediments studied by E. Norin[1] in Taiyuan, central Shansi, only post-Ordovician formations will be treated in this paper.

1. SECTION OF P'A LOU KOU.

P'a Lou Kou is 90 li south of Pao Tê city. Here all the strata along the valley are well exposed, dipping with a gentle angle of about 10° towards the west, any faulting or folding which may have affected them, being scarcely visible. By all means P'a Lou Kou is the most suitable valley for studying the stratigraphy of the Pao Tê Chou region, hence a detailed section has been taken as shown in Pl. II. In the lowest part of the alternating marine and continental sediments, which rest directly upon the Ordovician limestone, the iron-ore-bearing layers often occur, as in other coal fields of Shansi, such as, for example, the famous iron producing region of Ping-Yü-Lu-Tzai. In P'a Lou Kou, the iron-ore-bearing red and blue shales have a total thickness of 7 or 8 M. with, however, very poor ore of hematite of lenticular

[1] E. Norin: The late Palæozoic and early Mesozoic sediments of central Shansi in the present bulletin

shape. Above these follow shales, and a few beds of sandstone followed by more shale, the whole having a thickness of more than 40 M. Then follow the marine fossil-bearing limestones which include four horizons as follows: The lowest limestone horizon is about 2 M. thick and crops out very near the village of P'a Lou Kou. From it a few species of Brachiopoda were collected. Then follows a shale nearly 1 M. thick with plant impressions which is covered by the second limestone horizon. The latter with a thickness of about 1.5 M. is comparatively rich in marine fossils and this I have called the P'aloukou limestone. The fossils collected from this limestone and determined by Dr. A.W. Grabau include the following species:

Brachiopoda

* Enteletes lamarcki Fischer
† Chonetes nyströmi Grabau
† Orthothetes crenistria Phillips
† Productus punctatus (Martin)
Productus scrabiculus (Martin)
*† Spirifer bisulcatus Sowerby
† Spirifer pankouensis Grabau
Reticularia lineata (Martin)
* Spiriferina willisi Grabau

Gastropoda

Loxonema? szechenyii Loczy
† Sphærodoma cf. mediale M & W.
Macrocheilina kreitneri Loczy

The species marked by an asterisk (*) also occur in the Pankou limestone at the base of the Taiyuan series in central Shansi[1] and those marked with a dagger (†) in the Miaokou limestone of central Shansi. The latter is probably the equivalent of the Paloukou limestone. After another interval of shale follows the valuable bituminous coal seam from 36 ft. to 40 ft. in thickness, its outcrop being indicated by the important native pits which are worked everywhere. Upon the coal seam lies the Paotechou limestone 10 M. thick (Fig. 1. p. 111). This is an argillaceous limestone of which the lower part

[1]Ob. Cit. p. 26-35.

seems to be a little sandy, while the upper is purer and very rich in marine fossils. Still higher up, above two thin beds of shale with plant impressions and coal, a marine fossil-bearing black shale appears. It has a thickness of more than 10 M. and contains a great many limestone nodules arranged in separated layers. Near its upper portion it is interbedded with a thin layer of limestone. Both in the black shale and in the limestone nodules marine fossils are abundant, and often well preserved.

All the strata described above have a total thickness of about 100 M. and they represent the whole of the Carboniferous series here observed. According to fossils determined by Dr. Grabau those beds below the coal belong to the Taiyuan series of late Lower or early Middle Carboniferous age, while the beds above the coal belong to the Shansi series (restricted) of Permo-Carboniferous age. The precise age of the coal is not yet determined.

These alternating marine and continental deposits are succeeded by what is here named "Transitional formation", in which the marine fossils are absent. This formation is also marked by its predominant yellow tint. It is exposed between the villages of P'a Lou Kou and Liu Chia P'o (劉家坡) and is 160 M. or more in thickness. Its lower part consists of black shales, coal seams, and white sandstones, while its upper part is composed of green or yellow shales and greenish sandstones. Fossil plant are abundant, having been found at four horizons in this series. The collections from these beds have all been sent to Sweden to be determined by Dr. Haile of the Ricksmuseum in Stockholm. Until these fossils are definitely determined, a Permian age is provisionally assigned to these beds. The lowest bed of this transitional formation which lies directly upon the upper marine member of the Shansi series, is a conglomeratic sandstone, or sometimes a conglomerate with a thickness of more than 10 M. The higher members gradually change into red or green shales. There are also a few limestone nodules in some part of the formation, as well as some coals in its lower portion. These coal seams are, however, not thick enough to be workable in the neighbourhood of P'a Lou Kou, though they are commonly mined to the east of Pao Tê city.

Above the transitional formation follow the red shales which are well exposed in the vicinity of Nan Ho Kou (南河溝) and constitute what I

propose to call the "Husung (胡 松) series"§. The sandstones in this series are generally thinly bedded with green, white, or reddish colors, and sometimes conglomeratic. Besides red shales referred to above, a few thin layers of green or black shales occasionally crop out, and these bear remains of fossil plants. There are five horizons, in which fossil plants were collected. The lowest bed from which only two pieces of plant fossils were obtained, lies within the conglomeratic sandstones in the bottom of the series. The second crops out at Hei T'u Kou, (黑 土 溝) south of the village Nan Ho Kou; the third at Ch'ien Hsi Tzu, (前 蓆 子) west of the village; the fourth in its S.W. valley; and the fifth in the valley, 6 li west of Nan Ho Kou. All the collections from these horizions have likewise been sent to Sweden for determination. The whole series has at least a total thickness of 300 M. and may belong to the Triassic, though it is more probably of Permian age. It often bears gypsum at other localities in Shansi, indicating semi-arid conditions during its deposition. In the district visited, however, gypsum has not been found. Owing to its essential composition the shale usually forms the gentle rolling red hills, so that it may generally be readily distinguished from other formations.

Lying on the Husung series is a formation, of which the principal ingredient is sandstone and to which has been given in 1917 the name "Matou sandstone" from Ma Tou Kuan, (馬 斗 關), Ta Ning, (大 寧), S.W Shansi, where the rock is typically exposed. The lower part of the formation comprises white or red sandstonss sometimes cross-bedded, while the upper part consists of reddish or greyish sandstone composed of plagioclase, mica, and quartz, constituting essentially an arkose. All the sandstones are interbedded with thin red shales. So far as our present knowledge goes, no fossils are found in them. As in the northern Shensi province this formation seems to be covered by a coal series of possibly Jurassic age, hence it may probably still be Triassic.

2. Section at Chang Chia Kou.

About 20 li north of P'a Lou Kou, lies Chang Chia Kou, which is about 70 li from Pao Tê city. In this valley only the alternating marine and continental beds are exposed as shown in fig. (Fig. 2. p. 112.). The marine

§ The Geology of Ping-Yü-Lu-Tzai, S.E. Shansi, to be printed in Bull. Geol. Sury. No. 6.

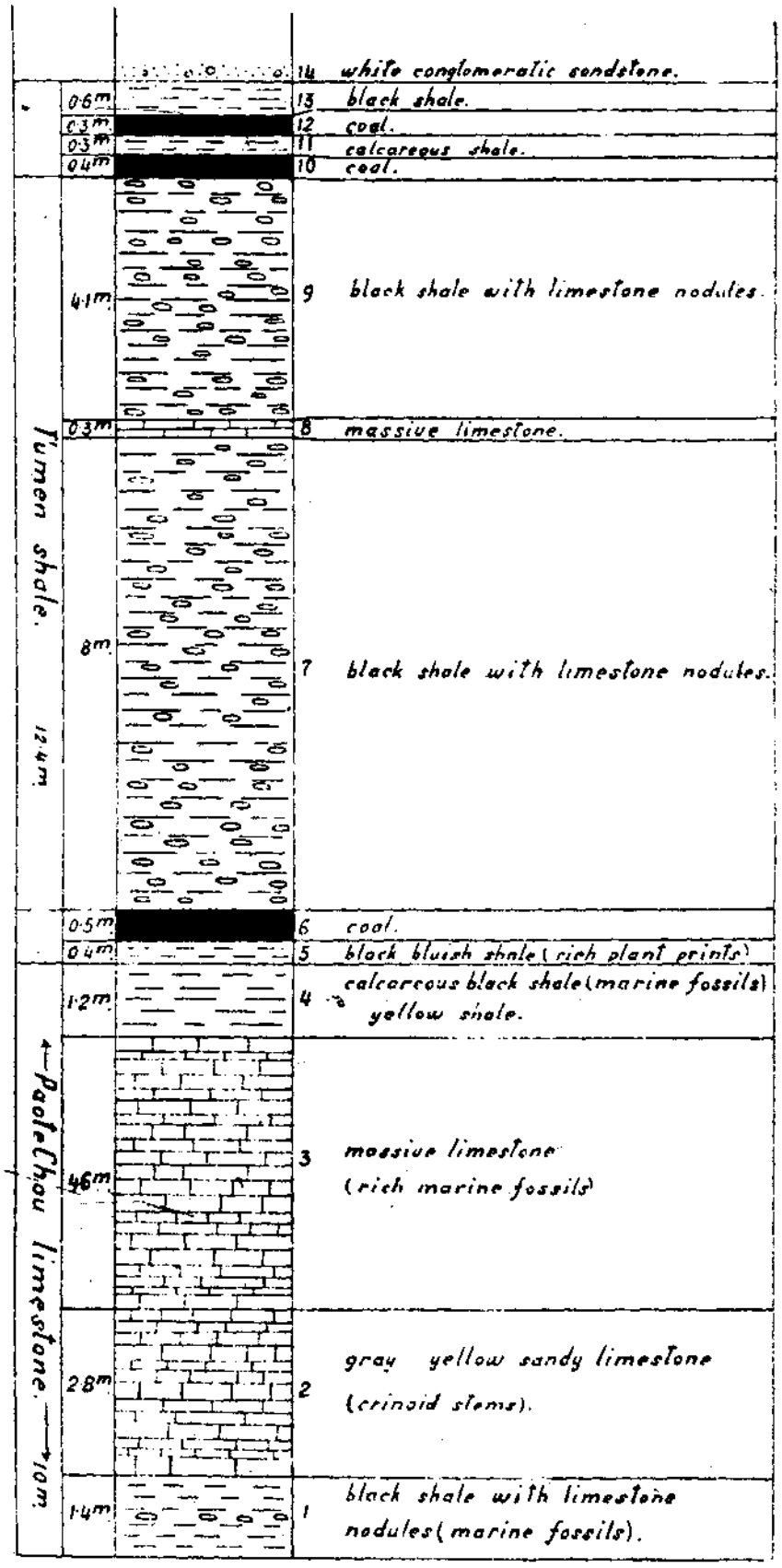


Fig. 1. Detail Section of the fossiliferous beds of Po Tê Chou

圖面剖細詳層地石化含德保圖一第

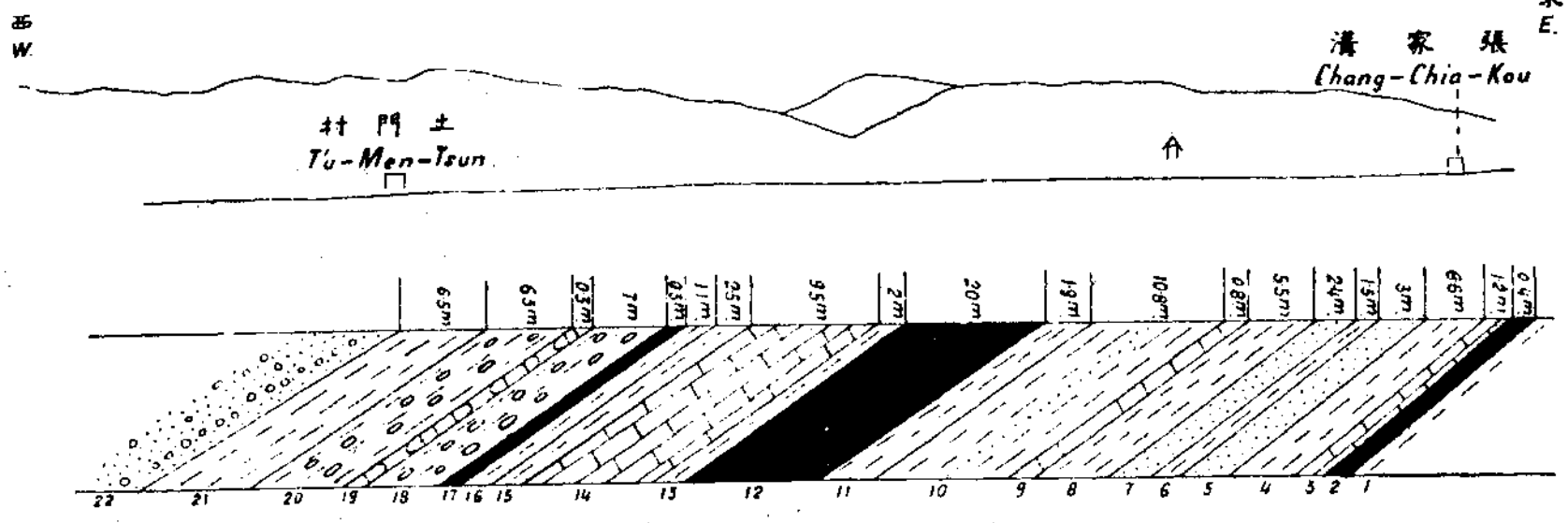


Fig. 2. Section of Chang Chia Kou 70 li S of Pao Tê Ctiy.

第二圖保德南德十七里張家溝剖面圖

1. Gray shale. 2. coal seam 0.4 M. 3. Changchiakou limestone 1.2 M. 4. gray and black shales 6.6 M. 5. yellowish white sandstone 3 m. 6. yellowish shale 1.5 M. 7. white sandstone 2.4 M. 8. black and blue shales 5.5 M. 9. Paloukou limestone. 0.8 M. 10. black shale with thin sandstone 10.8 M. 11. blue shale 1.9 M. 12. bituminous coal seam 20 M. 13. gray shale 2 M. 14-15, Paotêchou limestone 12.1 M. 16. black shale (plant prints) 1.1 M. 17. coal seam 0.3 M. 18-19-20, T'umen shale 13.6 M. 21. blue and brownish calcareous shale (plant prints) with thin iron colored beds 6.5. M. 22. white sandstone and conglomerate.

fossil-bearing horizons are also four in number. The lowest one exposed in the valley bottom, south of the village of Chang Chia Kou, bears some fossils which can easily be collected, and is called Changchiakou limestone. It is underlaid by a coal seam nearly one foot thick. Stratigraphically it is separated by about 20 M. from the P'aloukou limestone, west of the village. Between them are interbedded shales and white sandstones. The fossils found in the Changchiakou limestone, according to Dr. Grabau's determinations, are:

Anthozoa

† Lopholasma carbonaria Grabau

† Lophocarinophyllum acanthiseptum Grabau

Brachiopoda

* Enteletes lamarckii Fischer

† Chonetes nyströmi Grabau

† Orthotetes crenistria Phillips

† Productus taiyuanfuensis Grabau

P. punctatus var. elegans McCoy

Productus scrabiculus (Martin)

Productus cora d'Ord.

Productus semireticulatus (Martin)

*† Spirifer bisulcatus Sow.

*† Spirifer pankouensis Grabau

* Spiriferina willisi Grabau

Athyris orientalis Grabau

Camarophoria changchianense Grabau

Trilobita

* Griffithides quadrinodus Grabau

Phillipsia kansuensis Loczy

This horizon is correlated with the Pankou limestone of central Shansi.

Upon the Paloukou limestone follow the shale and the coal seam seen in fig. 2, but they have been increased in thickness to about 10 M. and 20 M. respectively. They are in turn covered by the Paotechou limestone, from which a large collection has been made. After a thin coal seam and

* Found in the Pankou limestone, central Shansi
† Found in the Miaokou limestone, central Shansi

shale, the uppermost marine fossil-bearing shale appears at about 50 M. east of T'u Mên Tsun (土門村), and this is called the T'umên shale. It has an interbedded limestone of 1ft. thick in a discontinuous layer, from which a few fossils have been collected. Above the marine shale the conglomeratic sandstone of the transitional formation is shown. The following is a preliminary list of the species found in the Paotechou limestone according to Dr Grabau's determination.

Foraminifera

Fusulina sp.

Brachiopoda

Enteletes kayseri Waagen
Enteletes laeviusculum Waagen
Enteletes paotechouensis Grabau
Orthothetes crenistria Phillips
O. crenistria var. senilis Phillips
Chonetes cf. pseudovariolata Nikitin
Aulacorhynchus paotechouensis Grabau
P. cora var. rarispina Grabau
Meekella kayseri Jaeckel
Spiriferina chuchuani Grabau
Spiriferina cristata var. octoplicata (Sowerby)

Pelecypoda

Myalina cf. ampla M & H.
Entolium sp.
Aviculopecten sp.

Gastropoda

Bellerophon anderssoni Grabau

Cephalopoda

Huanghoceras simplicostatum Grabau
Remeleoceras subquadrangularis Grabau
Temnocheilus asiaticus Grabau
Metacoceras sp.

The fossils found in the T'umen shale include the following species

Brachiopoda

Orthothetes crenistria Phillips
Productus semireticulatus (Martin)
Productus subcostatus Waagen
Productus cora d'Orb.
P. cora var. rarispina Grabau
Productus pustulosus (Martin)
Athyris royssi var. orientalis Grabau
Pugnax sp

Pelecypoda

Pseudomonotis mathieui Grabau
Pseudomonotis sp.
Allorisma sp.
Schizodus sp.

Gastropoda

Bellerophon calamitoides Grabau
Euphemus wongi Grabau
Gyronema? altispiralis Grabau
Mourlonia cf. propinqua Mansuy
Soleniscus sycumoides Mansuy
Soleniscus cf. braevis White
Soleniscus sp.
Sphærodoma subglobosa Grabau
Aclisina sp.
Meekospira sp.
Naticopsis cf. ventricosa Norw. & Pratten
Naticopsis sp.

Cephalopoda

Orthoceras sp
Remeleoceras subquardrangularis Grabau

These horizons are, from Dr. Grabau's conclusion, provisionally correlated with the Loping horizon of Kiangsi, and are regarded as of Permo-Carboniferous age. The Tumen shale is believed to be the approximate correlative of the Tungtayao limestone of Mr. Norin's sections in central Shansi.

Explanation of plate II

Late Palaeozoic and Early Mesozoic strata of Pao Tê Chou Section along P'aloukou, 90 li S. of Pao Tê city.

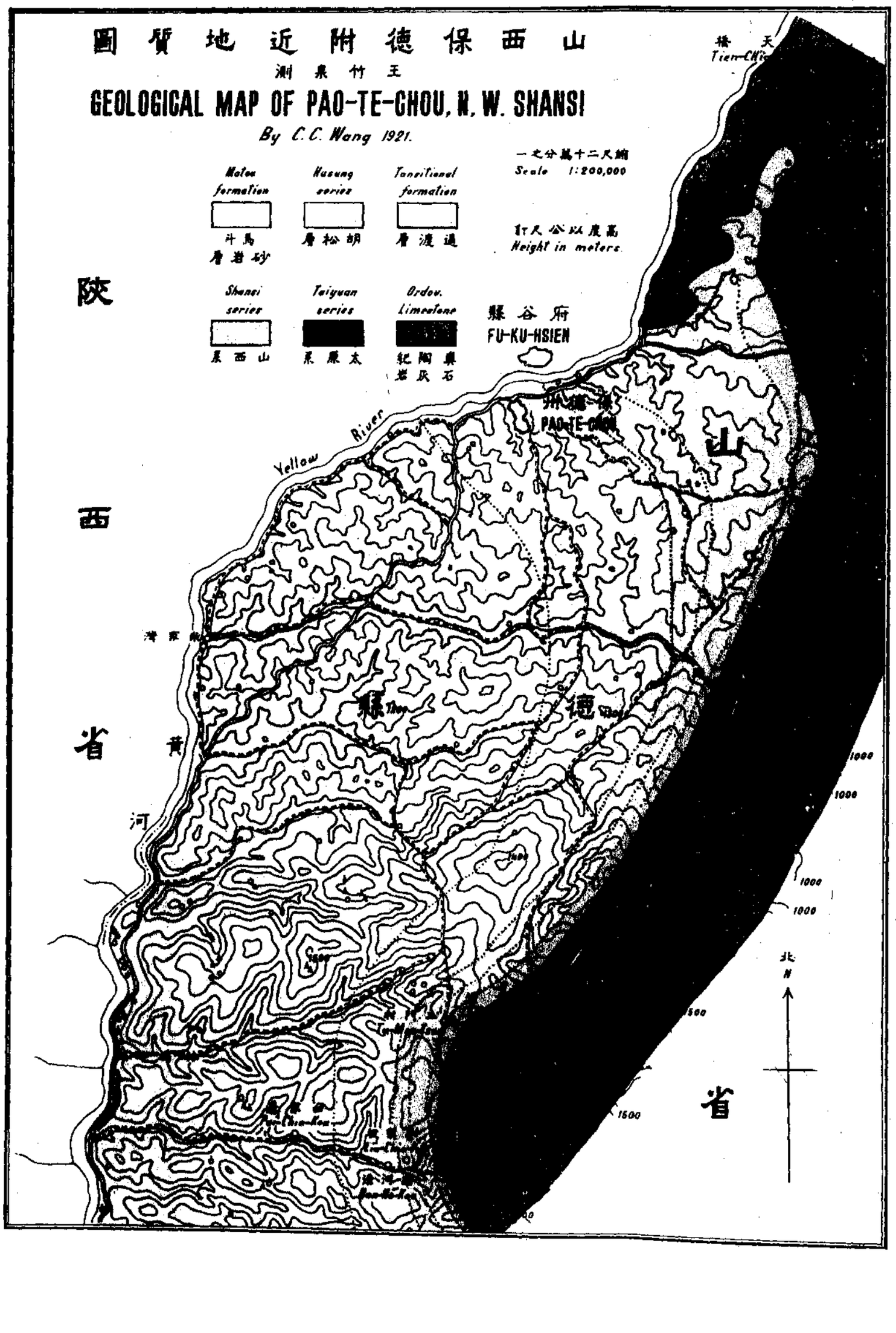
1 Ordovician limestone.
2 Iron-bearing red shale.
3 Blue compact calcareous shale, sometimes bearing iron
4 Blue and black shale (with plant prints).
5 White sandstone.
6 Bluish shale (plant prints).
7 White brown coarse sandstone.
8 Black shale and coal.
9 Grey sandstone.
10 Black and blue shales with coal.
11 Black limestone (Chanchiakou limestone).
12 Black, bluish shale with plant prints, and coal at its upper part.
13 Grey to black limestone (P'aloukou limestone).
14 Black shale with plant prints.
15 Bluish calcareous shale with plant prints.
16 Bituminous coal with intercalations of thin black shales.
17 Shaly limestone rich in marine fauna and with black shale in its lower part (Paotéchou limestone).
18 Black shale with plant prints.
19 Coal seam.
20 Calcareous black shale containing numerous limestone nodules, interbedded with a thin layer of massive limestone; all rich in fossils (T'umen shale) with traces of coal in its uppermost part.
21 White conglomeratic sandstone.
22 Black shale containing limestone nodules with a thin intercalation of grey sandstone and with a coal seam at its uppermost part.
23 White sandstone.
24 Black shale.
25 White grey sandstone.

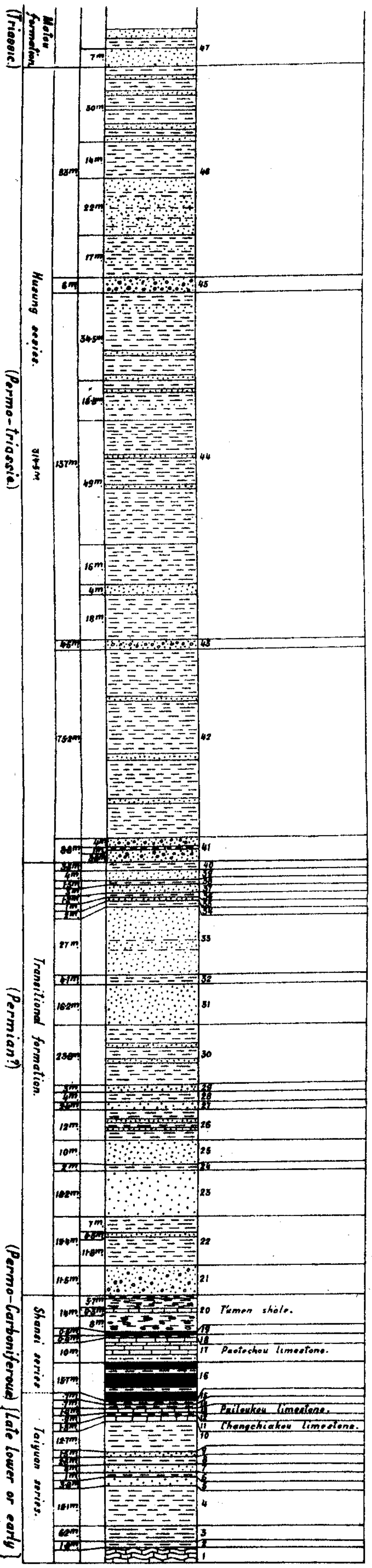
山西保德附近地質圖

王竹泉測

GEOLOGICAL MAP OF PAO-TE-CHOU, N. W. SHANSI

By C. C. Wang 1921.





Late Palæozoic and Early Mesozoic strata of Pao-tê-chou

圖全面剖層地德保西山

26 Black shale and calcareous greenish shale interbedded by layers of green sandstone, rich in plant fossils

27 White sandstone.

28 Green shale.

29 Greenish sandstone.

30 Greenish sandy plant-bearing shale containing a few limestone nodules, with green sandstones.

31 Green sandstone.

32 Green shale varied by a little spotted red shale.

33 Green sandstone with traces of argillaceous material.

34 Red and green shale.

35 Green sandstone.

36 Red and green shale.

38 White green and grey sandstone.

37 Green shale.

39 Grey sandstone.

40 Red and green shale.

41 Green conglomeratic sandstone interbedded by a green, red shale containing poor plant fossils.

42 Red shale interbedded by thin layers of green sandstone. Plant fossils found in its uppermost part.

43 White green conglomeratic sandstone.

44 A. red, yellow, and black shales.

B. yellow greenish weathered sandstone.

C. yellow, red, green, and black shales with a plant-bearing bed in the upper part.

D. red shale and red sandy shale interbedded with thin green red sandstones.

E. green shale bearing plant fossils in its lower part and interbedded with thin green sandstone.

F. red shale and sandstone with green or grey shales.

45 Green to white conglomeratic sandstone.

46 A. red shale with thin layers of red sandstone.

B. green weathered sandstone parted with thin red shales.

C. red shale.

D. white sandstone, alternately red shale, sandstone, containing a very thin layer of plant-bearing black shale in the middle part.

47 White to red sandstone (sometimes crossbedded) and red shale.

LACUSTRINE MOLLUSCA FROM EOCENE DEPOSITS IN CHINA.

BY

NILS HJ. ODHNER

During one of his scientific expeditions in the service of the Geological Survey of China, Dr. J. G. Andersson detected at Yuan-Chü Hsien, S. Shansi, a deposit with lacustrine shells beneath the Loess. As the identification of the shells was of great interest both from a palæontological point of view, and for the purpose of determining the age of the layer, Dr. Andersson sent a collection of specimens from the locality in question to the Geological Survey of Sweden for the purpose of having them identified.

Prof. Grönwall turned the material over to me, with the request that I undertake the preparation of the fossils. By washing the red "clay" in water it was dissociated into an impalpable powder and the fossils were all broken up into small fragments, impossible of identification. This method therefore did not give any practical results, and the only way of preparing the fossils seemed to be by means of mechanical treatment with instruments, a labour which was performed at the Bureau of the Geological Survey. This preparation accomplished, the collection was returned to me for description by the Director, Dr. Gavelin.

The collections consisted of samples from strata of two different types, one being a grayish marly limestone, the other a hardened clay of a chocolate colour. On first inspection, they seemed to contain somewhat different faunas, for in the gray limestone there occurred a great many specimens of *Planorbis* and several of *Physa*. The latter were not found in the red clay, which on the contrary offered a quantity of mussels, seemingly small Unionids, but no Physae and a scanty representation of *Planorbis*.

Nearly all of the fossils were in a rather bad state of preservation since they had been subject to pressure and hence were distorted and fragmentary. In considering this fact I feared there was but little chance to identify the Mollusca, the more so as they had a rather old appearance and one quite different from that of the recent fauna or that described from the latest geological deposits of Pliocene and Post-Pliocene age.

Some of the more satisfactorily preserved specimens of *Planorbis*, which appeared to be of an unusual size, suggested a method of procedure which proved successful in the other cases as well.

The large *Planorbis* referred to seemed to be most like the polygyrous species which today are restricted to the neotropical region. A comparison with the fossil species described and illustrated by Sandberger (1870-75) showed that the species in question was very similar to *P. pseudammonius* from the upper Eocene of France and western Germany, where this form is one of the leading index fossils of the limnic deposits of the "Lutetian"

The identification was verified by a comparison with two specimens of the typical species in the collections of the Zoöpaleontological department of the Swedish State Museum which were kindly placed at my disposal by Prof. G. Holm.

Among the remaining forms were found several specimens of a *Physa*, which were relatively well preserved though compressed and which seemed to agree with *Ph. lamberti* described from the Lower Eocene of France as figured by Sandberger.

As a result of these determinations the gray marly limestone was assumed to be of Eocene age. Another possibility had however to be reckoned with, namely that the formation in question is younger and that its fossils might be the relicts of an Eocene fauna which had presisted in China some time after its extinction in Europe.

The question as to which of these interpretations is the most reasonable, becomes of great importance for the solution of the problem, and on this account it appears necessary to take into consideration the youngest geological deposits known from China.

It is a well established fact that there are no marine deposits younger than Triassic in China, while terrestrial deposit fill the gap to the base of the Cretaceous, after which there is an unrepresented interval until we come to the Pliocene. It was during this interval that the extensive erosion which has produced the present rock topography of the region took place, and the rock-disintegration which furnished the material, of which the Pleistocene loess and river deposits consist. It is generally held that the climate of

eastern Asia was mild and moist during the Tertiary, and this was probably more marked in the early Tertiary, when the seas had their greatest extent.

From a geological point of view thus nothing speaks against the assumption that the present layers represent an Eocene horizon.

Nothing more is, however, known about the stratigraphy of these deposits than that they lie underneath the Loess. The age of this latter formation is well determined by the fossil mollusks found in it, which, according to the investigations of Hilber, Andreæ, Sturany and Schlosser (cf. the latter author 1906) scarcely differ from the recent mollusks of China. In this respect the Loess presents the same problem as the Loess of Europe, and like that it must be regarded as of Pleistocene age.

In the strata benearth the Loess, which contain land mollusks, v. Loczy, has determined a fauna similar to that of the Siwalik formation, the similarity being indicated by the occurence of *Steganodon insignis*. In association with this form there were found fresh-water shells (*Bithynia, Limnæa, Planorbis, Succinea, Cyclophorus?*, Loczy 1893, p. 823; 1899, p. 17, 213) "of recent character" (p. 823). The Mollusca of the Siwalik fauna are for the most part also identical with recent forms (cf. Falconer, 1868, p. 383) and in the opinon of Falconer indicate an age "of the older Pliocene—at latest".

In 1906 Schlosser described in detail the mollusks collected and previously noted by v. Loczy, and found them to belong to the following genera and species: *Limnæa merzbacheri* n. sp., *L.* aff. *ovatus* Müll., *L.* aff. *pereger* Müll., *Planorbis* (*Gyraulus*) *keideli* n. sp., *P.* (*G.*) *karkaraënsis* n. sp., *Valvata piscinalis* Müll., *Bythinia* (?) *cholnokyi* n. sp. *Vivipara* (*Paludina*) *angularis* Müll., together with some specimens of undetermined *Helix* and *Pupa*. Schlosser considers the Mollusca mentioned to be of Middle or Upper Pliocene age.

In addition to the Mollusca described by Schlosser, others have been referred to at various times in the literature, and these references have all been summed up by that author. From his list it appears that the Pliocene and Post-Pliocene land-and fresh-water Mollusca are all nearly related to, and in some cases identical with the present fauna of China.

The Mollusca which are described in this paper are on the contrary very different from the living forms of China, a circumstance which favours the assumption that they are of Eocene age.

As before noted, older Tertiary deposits have not previously been known with certainty from China, but there are indications of their occurrences elsewhere. Thus Abendanon (1907) who has described the stratigraphy of the so-called Red Basin ("Roter Becken") of Szechuan recognizes seven stages. Of these the fifth from below is referred to the Rhætic. The sixth stage is a shell marl ("Muschel Mergel") and above it follows the 7th and uppermost horizon which he describes as, "eine Formation von rund 2000 M. Mächtigkeit, bestehend aus wechsellagernden Bänken und Schichten von rotbraunen eisenschüssigen Tonsteinen und hellfarbigen Sandsteinen, welch letztere grösstenteils äolischen Bildungen angehören". He further adds:

"Diese ganze, mehr als 5000 M mächtige Sedimentdecke ist sehr arm an Fossilien und die welche ich gefunden habe, waren meist sehr schlecht erhalten".

With reference to the age of these formations, the author says: "Fest steht nur das rhätische Alter der Sandsteinformation". And further: "Die Etage 6 scheint zu der Kreideformation zu gehören, und endlich ist 7 zur Kreide, eventuell zum Tertiär zu rechnen"

According to Frech (1911) horizon 6 is to be correlated with the Wealden, and thus the red series should be referred to the upper Cretaceous or the older Tertiary (p. 225).

Taken all together it seems that the stratigraphic conditions of China are quite in harmony with the view here maintained namely that the new fossiliferous formation discovered by Dr. Andersson is of Eocene age

The question, however, now arises, whether the occurence of a west-European Eocene mollusk fauna in China is in agreement with our knowledge of the faunistical relation between the two districts so far remote from each other.

In considering this question it may first be remembered that the recent palæarctic fauna contains species which have a continuous distribution throughout the region, thus being circumpolar; among the mollusks, illustrations are offered by *Conulus fulvus*, *Margaritana*, *Acanthinula harpa* and

others. Of the European Helicid groups, *Trichia*, *Gonostoma* and *Fruticicola* are represented in the recent fauna of China. A similar distribution in Pre-Quaternary time therefore might not be unlikely.

To this may be added the fact that the present Chinese fauna contains elements which show relationship to other distant parts of the world. With respect to the Mollusca it is *inter alia* characterized by the presence of a genus of river mussel, *Mycetopoda* d'Orbigny, with twelve endemic species (cf. Cooke 1895, p. 317). Besides these the genus comprises one species from Siam and one from Assam (cf. Simpson 1900, *Solenaia*). This genus is also at home in S. America from where v. Ihering (1910) records fifteen species. With reference to its remarkable distribution v. Ihering (p. 117) says: "Simpson hat meines Erachtens einen schweren Fehler begangen, indem er die ostindischen Arten der Gattung nicht nur in ein anderes Genus, *Solenaia* Conr. versetzt, sondern dieses auch noch in einer ganz anderen Familie, der der Unioniden, unterbringt, statt sie bei den Muteliden zu belassen, zu denen sie offenbar gehören. Ebenso wie Fischer kann ich der ausführlichen Darstellung der indochinesischen Arten von Heude keinerlei konchologische Charactere entnehmen, welche eine Trennung in zwei Gattungen oder auch nur in Untergattungen rechtfertigen könnten. Sichere Entscheidung kann nur das Studium des Tieres und seiner Larve bringen. Letztere ist unbekannt, sowohl für die südamerikanischen, als für die südasiatischen Arten. Das Tier aber stimmt nach Heudes Beschreibung mit jenem der südamerikanischen Arten überein. Wenn daher auch die Frage zunächst noch als eine offene gelten muss, so sind wir doch bis dahin genötigt, *Solenaia* mit *Mycetopoda* zu vereinigen".

Furthermore, there exists in China a genus of the family Helicinidæ, *Heudeia*, which, according to Cooke (1895, p. 316) is "a remarkable and quite peculiar form of Helicina with internal plicæ, perhaps akin to the Central American *Ceres*".

In addition to the pecularities of the modern Chinese fauna mentioned, we find not only an Indian element, especially observable in southern China, but also indications of direct relationship to European Tertiary forms. Thus Neumayr (cf. Loczy 1899, p. 215) states that the mollusk fauna in the

fresh waters of China is closely related to that of the younger Tertiary of Europe. In the conchylia of Tali-fu Lake, he says, "liegt uns eine ganz normale Fauna der Paludinen Schichten vor, ja man kann sagen, dass der See von Tali-fu das letzte jener Süsswasserbecken der Pliocænzeit darstellt, das sich und seine Bevölkerung wunderbar in die heutige Periode herübergerettet hat". *

If there still exists a real European Tertiary relict fauna in China, this circumstance offers undoubtedly the best proof of a former continuous distribution throughout the Eurasian continent, and suggests that such connection may have existed in Eocene time too.

A uniform character of the Tertiary fauna of the Eurasian area has been assumed also by many other authors; I restrict myself to a citation of the statement by v. Ihering (1910, p. 426): "Das europäisch-asiatische Faunengebiet hatte in gewissem Sinne während des älteren Tertiärs einen einheitlichen Character, aber es bestanden offenbar auch damals schon zoögeographische Provinzen". And further: "Leider wissen wir zur Zeit fast nichts von der tertiären Geschichte der Landschnecken von Asien, und doch können wir nicht daran zweifeln, dass Asien die Wiege der Heliciden wie auch der Clausilien war. Europa bildete im Eocän einen Teil dieses Entwicklungsgebietes, aber auch nach Zentralamerika hin verbreiteten sich schon damals asiatische Typen von Pulmonaten nnd Deckelschnecken, wie das aus den Befunden von Dall bezüglich des Oligocäns von Jamaika hervorgeht"

The survey given above supports our view as to the Eocene age of the Mollusca sent by Prof. Andersson, and the following study of the material will give the complete verificatian of this assumption and furnish occasion to enter into discussions of some questions of interest not only from the viewpoint to Palæontology, but alsc of our knowledge of the recent faunas and their relations and origin

*The possibility that this represents a case of faunal parallelism, developed under similar physical conditions must not be overlooked. (Editor)

ERRATA: According to the usage of the Survey, the specific names shall be written with small letters. By an oversight the specific names in the headlines in this paper are printed with large capitals, whereas it shoud be uniformally in small capitals. Other minor errors also occur for which the author is not responsible, because he has not the opportunity of proof-reading himself.—Editor.

NOTES ON THE SPECIES.

GASTROPODA

PLANORBIS PSEUDAMMONIUS Schlotheim.

INCL. VAR. LEYMERIEI DESHAYES.

Plate I, figs. 1-4, textfigure 1.

Among the rather abundant fragments of this species found in the gray as well as in the red formation there were two specimens with a comparatively well-preserved shell which allowed of identification by comparison with two European Tertiary specimens from the collections of the Zoöpalæontological department of the Swedish State Museum. One of these (Plate I, fig. 1) shows a nearly perfect upper surface, while the other (ibid fig. 2) shows the under side. Both are in perfect agreement with the Chinese specimens. The latter (Plate I, figs. 3, 4) were exposed in a similar manner and thus made

Figure 1. Apical whorls of *Planorbis pseudammonius* Schlot × 7.

possible a comparison in all respects. The specimens showing the upper side exhibited a close agreement with regard to the slowly widening whorls, and the stronger dilatation of the ultimate one as well as the apical depression; besides that, the lines of growth run in a similar manner and are similarly marked. The large Chinese specimen, which, if complete, would measure 28 mm. in diameter and have 7 whorls, is much depressed and crushed, and thus does not show the details so distinctly, but some other smaller specimens exhibit them here and there, and they are in a full agreement with the French examples.

As to the specimens in which the under side is exposed, they also show a marked similarity with the European forms in their coiling and in the character of their whorls the breadth of which as well as the sculpture with fine lines of growth, is very similar, so that here too the identity of the Chinese and European form is easily established.

In a few specimens of the Chinese form, fine and regular spiral striæ were seen in the apical whorls, but they did not appear more distally, and the last whorl was quite smooth. In quite a similar manner this sculpture may occasionally be present also in the French specimens. This has been noted by Sandberger, who considers those forms described as *P. leymerici* Deshayes, a variety of *P. pseudammonius*. This corresponding sculpture of the shells in the two districts so remote from each other, is further evidence of the similarity of these faunas and strengthens the identification of the species.

Planorbis Sparnacensis Deshayes.

(Plate I, figs. 7, 7a),

One specimen rather well preserved and measuring 5 mm. in diameter was obtained from the gray marly limestone. It agrees very well with the figure given by Sandberger (Pl. IX, fig. 11) in being but little concave above and presenting distinct spiral lines of irregular strength. This sculpture is represented in our Pl. I. fig. 7a. The whorls are 4 in number.

Planorbis Chertieri Deshayes

(Plate 1, fig. 8, text-fig. 2)

Figure 2. Apical whorls of *P. chertieri* Desh. × 7.

Two specimens of this species are present in the collection. They are easily distinguished from the other by the depressed whols, recalling the recent *P. fontanus*, and because they have an obtuse keel in the periphery as well as a relatively small embryonic shell. The shell is of a grayish colour with a greasy gleam and in all respects agrees with the description and figures in Sandberger (Pl. XIII, fig. 9). The largest specimen measures only 3 mm. in diameter and consists of 4 whorls, and is probably a juvenile example.

Planorbis Sinensis sp. nov.

(Plate I, figs. 12-15. text fig. 3)

Shell depressed, planorboid with the spire depressed in such a manner that it appears on the umbilical side, giving the shell a sinistral aspect. Apex papilliform, consisting of 3 whorls, the subsequent ones again projecting beyond the apex and rapidly increasing. Whorls of the complete shell at least 6, the last one projecting beyond the others especially on the upper side, this side of the shell thus being more excavated. Sculpture consisting only of lines of growth irregularly arranged and visible only in the last whorls.

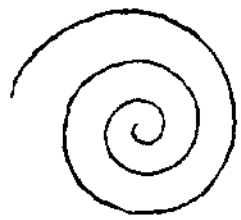


Figure 3. Apical whorls of *P. sinensis* n. sp. × 7.

The species belongs to the group of *Planorbis indicus* and *P. exastus*.

Of this species a great many shell fragments occur in both the gray limestone and the red clay. Most of them consist merely of the apical whorls, but in a few cases also the fourth whorl or a part of the last whorl remains, which makes possible the identification.

No traces of opercula of this species were found, apparently in consequence of the delicate structure of these objects.

Physa cf. Lamberti Deshayes.

(Plate I. figs. 5, 6.)

Two specimens were prepared from the gray marly limestone, the largest of which measured 13 mm. in height. Unfortunately the spire was deficient in both specimens, so that the relation between spire and body whorl, so important for the taxonomy in this very critical genus, could not be determined. The remaining part of the shell had a produced ovate shape, and

it appeared as though only the penultimate whorl was left of the upper ones. Judging from this, the shell in a complete state would show a turrited spire and on account of its very shallow sutures, would recall that of *Ph.* cf. *lamberti* Deshayes (Sandberger Pl. IX, fig. 8), from the Lower Eocene of France. In any case the shells belong to the narrow forms of Physæ and seem to be most similar to such species as the American *Ph. sowerbyana* from Jamaica and S. America (cf. Reeve, Conch. Icon. 19; and Clessin, in Martini & Chemnitz, Conchylien Cab., Limnæiden).

It is of interest that in the Upper Eocene deposits of France no Physæ are known except one mentioned by Sandberger (p. 228) as resembling the small *Ph. mediana* Fer. from Peru. This is however too small to enter into consideration in the present case (cf. Clessin, l. c. pl. 54, fig. 10).

Euchilus Deschiensianum Deshayes.

(Plate I, figs. 9-11)

Opercula of a *Bithynia*-like shell were present in the gray limetone and these showed a close resemblance to those of this form as reproduced by Sandberger (pl. XIII, fig. 8b). Their structure also agreed with the description given by this author (p. 225), in being calcareous and formed "aus zahlreichen, einen nahezu in der Mitte gelegenen Kern ringförmig umgebenen Lagen", which was clearly shown in an example completely prepared.

For a shell exhibiting the characteristics of this species, I sought however in vain, until I remembered a small *Limnæa*-like shell, not previously fully prepared, and appearing to be peculiarly characterized as to its aperture. This specimen when fully exposed showed an apertural margin which was broadly expanded and reflected just after the manner characteristic of *E. deschiensianum*, a feature of so marked a nature that no mistake as to the identity was possible The specimen in question was found in the red clay, which thus shows such a pronounced faunal similarity to the limestone that they may be assumed to represent only different facies of the same formation, an opinion verified also by other species.

The shell, the last whorl of which together with the aperture is the only specimen found, measures 5.5 mm. in height, the aperture occupying

3.2 mm.. There is no sculpture except fine lines of growth which become coarser within the umbilicus. The largest of the opercula measured also 3.2 mm. in its greatest dimension.

PELECYPODA

EUPERA SINENSIS sp. nov.

(Plate X, figs. 16-22.)

Shell somewhat quadrangularly ovate, with the umbones prominent and situated at about one fourth of the body length from the front end. Anterior end narrower than the posterior one, which exceeds a little the height of the shell at the umbones. Dorsal margin behind the umbones rather straight, passing into the posterior one by means of a more or less distinct angle; posterior margin but slightly curved and forming an obtuse angle with the inferior margin, which is evenly though slightly convex. Surface of the shell sculptured only by fine lines of growth and showing traces of colour blotches in the shape of small dots rounded or elongated as stripes and arranged in a radiating direction.

The denticulation is imperfectly shown in the specimens: in the right valve two parallel lateral teeth were observed in front of the umbones as well as behind them.

Length of the largest specimen: 4 mm.; height: 3.5; of another specimen resp. 6.4 and 4.3 mm. These differences are chiefly due to variation in the state of preservation.

Though the specimens of this species in the collection are only fragmentary there is no doubt that they belong to a species of *Eupera*. I have compared all the specimens with samples of *E. parasitica* from Egypt, stored in the collections of the Swedish State Museum, and the similarity is so striking, that it is very difficult to trace any points of distinction. The fossil species as well as the recent one seem to vary considerably, and the single difference between them seems to be that the fossil one has its frontal end somewhat shorter than has the Egyptian form.

The presence of a species of the genus *Eupera* (*Limosina*) in the deposits in question, where it occurs only in the red clay formation, is a

remarkable fact, and is of interest from a stratigraphical as well as from a palæontological and a zoögeographical point of view. According to Sandberger, forms of this genus are met with only in Upper Cretaceous and Lower Eocene deposits in France (cf. l. c. p. 208, 141, 165), and these species are all referable to the South American recent *Cyclas bahiensis* Spix of Brazil or to *Pisidium modioliforme* Anton from Brazil and Venezuela (p 184). That we find a new species in China consequently proves that the deposits containing it are in all probability of Eocene age, as the remaining fossil Mollusca indicate, and leads us to enquire into the distribution of the genus in recent times. This as we shall see supports our view as to the origin of the African genus *Lanistes*.

There exist no statements regarding the occurrence of the genus *Eupera* in a fossil state in America, but it is not unlikely that it is hidden under other names. White (1883) reproduces some forms of *Sphærium* which are very like *Eupera*, namely *S. recticardinale* and *S. formosum*, both described by Meek & Hayden. These were found in the Laramie Group of the Upper Missouri River region, but as no description or figures are given of their hinge or coloration, their reference to one or the other genus is wholly questionable.

Eupera has about the same recent geographical distribution as *Lanistes*. It has been recorded from South America (Brazil and Venezuela), from Central America and the West Indies; in all 12 species are mentioned by Clessin (1907) from these regions, one of which, *E. cubensis* Prime, has also been found in Florida (Sterki 1916). Another North American form, *E. singleyi*, was described by Pilsbry in 1889, and occurs in Texas and Louisiana; it is nearly related to *E. cubensis* (Sterki 1916). Thus both North American species show relation to the fauna of the West Indies and of Central and South America. (In 1900 v. Martens described another new species from Central America, *E. pittieri*.) Outside of the Neotropical region the genus has representatives in Africa: *E. parasitica* of Egypt, *E. ferruginea* Krauss in S. Africa (Clessin 1879) and in Madagascar (Smith 1882); *E. landeroini* Germain (1909) occurs in the French Sudan and *E. bequarti* Dautzenberg & Germain (1914) in the Belgian Congo.

The fossil Chinese species seems to occupy a position between the elongated Egyptian form *E. parasitica* and the Central American *E. cubensis* or *E. pittieri* with its shorter form and more elevated posterior portion.

It is probable that the immigration of the genus *Eupera* into Africa has proceeded from Syria, as we have assumed was the case with *Lanistes*. In Eocene time, there existed a more direct connection, it is true, via India and Madagascar, but this way does not seem to have been followed either by *Lanistes* nor by *Eupera*, because no species of these genera exist at present in India. In Madagascar occurs the same species of *Eupera* which is found in S. Africa, and this is certainly due to a relatively recent importation of this species in Madagascar, probably through transportation by water birds or otherwise. That its occurrence in Madagascar is of a secondary nature is apparent from the statements made regarding *Lanistes* (cf. above) as well as from the fact that another water mollusk of Ethiopian origin has been recorded from the island, namely *Aetheria elliptica*. Of this species Germain says (1907 p. 227): "Le fait de retrouver l'*Aetheria elliptica* dans les régions tropicales de Madagascar, si pauvre en Acéphales fluviatiles montre qu'il existe quelques points de contact entre la fauna de cette île et celle de l'Afrique équatoriale". The species referred to was found at a height of 200 m. above the sea and 150 km. from the coast, and it was quite similar to specimens from the Nile, Niger and Congo.

As there is no evidence of a land bridge in Post-Pliocene time which could explain these occurrences in Madagascar, I think they may be explained as due to importation, probably by birds, a method of dispersion which is known to be rather common among the lacustrine Mollusca.

GENERAL PALÆOGEOGRAPHIC SUMMARY

The study of these few fossils at present known from the Eocene deposits of China, has given us an idea of an intimate relation of the fauna of this region and epoch not only to that of Europe but also to the Ethiopian and Neotropical fauna. We have tried to give some explanations of the former relations, and these assumptions are well supported by numerous facts showing a close interconnection of these several parts of the world.

In order to explain the similarity of the fauna in China and South America v. Ihering (1910) adduces a theory of a direct connection across the Pacific. He says (p. 426): "Nachdem ich in früherer Zeit namentlich die Beziehungen Südamerikas zur alttertiären antarktischen Landmasse, der *Archinotis*, sowie zum afrikanischen Kontinent, der *Archhelenis*, verfolgt habe, bin ich neuerdings darauf aufmerksam geworden, dass eine weitere alttertiäre Wanderstrasse von Ostasien nach Zentralamerika führte, meine *Archigalenis*, welche nicht in Beziehung stand zu Nordamerika. Im Miocän wurde diese Landbrücke zerstört, während andererseits Süd-und Zentralamerika miteinander in Verbindung traten, sodass die ostasiatischen Einwanderer nach Südamerika gelangen konnten, während umgekehrt der südamerikanischen Fauna der Zugang nach Ostasien verschlossen blieb".

Jehring gives some further examples as proof of his view, and finds that "wir sind heute nicht mehr berechtigt, eine europäisch-westindische Landbrücke im Sinne Heer's anzunehmen, denn dem widerspricht, die Geschichte der marinen Küstenkonchylien".

The theory of a land bridge across the Pacific seems, however, to be quite superfluous for the explanation of the peculiar occurrences of related forms in China and S. America as well as in Europe. The existence of an Archigalenis seems hardly well founded, since it must be admitted that a migration from Asia to America or vice versa is easily made possidle by means of the land bridge over Bering Strait. If this way has been followed, we must, however, expect to find the same or allied forms in a fossil state in N. America, but there seems to be no evidence of this occurrence. In his "Review of the Non-Marine Mollusca" White (1883) certainly mentions a lot of Eocene fossils, and the fauna as a whole seems to show a similar composition to that of Europe on the one hand and that of China on the other, inasmuch as *Planorbis* is common, together with species of *Physa*, and there are even very similar though not identical species. Thus *P. pseudammonius* is replaced by *B. utahensis*, and *P. sparnacensis* by *P. cirratus*. The "*Pupa incolasa*" mentioned by White, which possesses an expanded edge of the outer and columellar margin and lacks teeth and folds in the aperture is perhaps akin to *Euchilus*. There are, however, no specimens of the Lamellibranch *Eupera* in the Eocene

deposits of N. America, but very probably such have existed; in the Laramie Group dealt with by White, some species of *Sphærium* have been described, the shape of which recalls strongly that of *Eupera* (cf. above). On the other hand large Unionids are present in the American series in question, which still remain to be detected in the Eocene of China.

Facts thus seem to support the view that the Eocene fauna has spread from North America to Europe on the continents which still exist though these were certainly of different outline and topography, and that we do not need the supposition of a direct land connection.

Since the European and Asiatic continents certainly had a similar fauna, it seems necessary to assume that, in Eocene time, they formed part of a climatic region with a circumpolar extent, thus including also North America. The fact that in the Laramie series, the species described differ from the Asiatic, is apparently due on the one hand to the absence of a comparative study of the North American and the European Eocene Mollusca, and on the other to the differentiation in various directions which the faunas of these areas have undergone, just as they have in later Tertiary and in recent times.

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EXPLANATION OF THE FIGURES.

PLATE I.

Fig. 1. *Planorbis pseudammonius* Schlotheim. "terrain palustre, Alsace" (Palæozoöl. Dep. of Swed. State Mus.). Slightly magnified.

Fig. 2. The same, another specimen from the under side. Same locality and magnification. (Palæozoöl. Mus).

Fig. 3. The same, marly limestone, Yuan ku, China, Same magnification.

Fig. 4. The same, another specimen from below. Locality and magnification as fig. 3.

Fig. 5. *Physa* cf. *lamberti* Deshayes. Yuan kü, limestone. About 1¾ times magnified.

Fig. 6. The same, another specimen. Same locality and magnification.

Fig. 7. *Planorbis sparnacensis* Deshayes. Same locality and magnification.

Fig. 7a. Sculpture of the preceding. × 25.

Fig. 8. *Planorbis chertieri* Deshayes Same locality and magnification.

Fig. 9. *Euchilus deschiensianum* Deshayes. Impression of operculum. Gray limestone. × 1¾.

Fig. 10. The same, operculum. Same locality and magnification.

Fig. 11. The same, last whorl of shell, with aperture. Red clay. × 1¾.

Fig. 12. *Planorbis sinensis* n. sp. Apex and fragment of sequent whorl, gray limestone. × 1¾.

Fig. 13. The same, a more perfect small specimen. Gray limestone. × 2¼.

Figs. 14, 15. The same, fragment of the last whorl of a large specimen, from exterior (fig. 14) and interior (fig. 15). Red clay. × 1¾.

Figs. 16-22. *Eupera sinensis* n. sp. compressd specimens and casts, all from red clay. × 2¼.


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REPORT ON THE GEOLOGY AND MINERAL RESOURCES OF I, TANG, YÜ OF WESTERN CHIHLI.

(Summary)

By C. Li

In April 1919, the writer was ordered by the Ministry to make a general survey on the geology and mineral resources of the western part of Chihli. The work was started from Lai Hsui Hsien (淶 水 縣) and I Hsien (易 縣), and continued further on in succession to Yü Hsien (蔚 縣), Fu Ping (阜 平), Chü Yang (曲 陽), T'ang Hsien (唐 縣), Wan Hsien (完 縣), and Man Chêng (滿 城). The area covered has been estimated about over 300 li north and south, and over 160 li from east to west.

The geological formations encountered in the field are classified as follows:—

1. Granite
2. Red sandstone
3. Carboniferous coal series
4. Ordovician limestone
5. Cambrian formation
6. Pre-cambrian formation
7. Archæan gneiss

1. The granite with the execption of one or two small bodies occurs in an extensive area at the S.E. of Shih Meng T'sun (石 門 村). Wherever the siliceous limestones are in contact with the granite, they are so much altered into marble that sometimes abundant asbestus is found attached to them.

2. The red sandstone is the youngest formation in this district. At Ta Ch'i Chü (大 七 車) a small outcrop of this sandstone is very much weathered and easily to be crushed.

3. The Carboniferous coal series occurs in two areas; the larger one is seen at Lung Ch'üan Chen (龍 泉 鎮), and the other at T'an Hui P'u (炭 灰 舖) extended about two square li. In this series the rocks commonly found are gray sandstone, gray and black shales, sandy shale and fire clay. The coal in this series is all anthracite, as descrided on page 138.

4. The Ordovician limestone occurs at Ling Shan (靈 山), Chai Tzu (寨 子) and Shen Shih Chuang (神 石 莊) etc. It is situated conformable above the King Lung group. The whole series is about 300 meters in thickness.

5. The Cambrian formation occurring at the south of Fan Tai (樊 台) lies uncomformably above the gneiss. It is composed of red shale and reddish sandstone, the composition of which contains a little mica and iron. Besides these, thin bedded limestones, oölitic limestones, and wurmkalk exist in clearly defined layers. The total thickness is about 500 meters or more; as they are found at Sung Tzu Ling (孫 子 嶺), Hei Shih Ling (黑 石 嶺), Tang Hū (塘 湖), and Tai Yü (台 魚) etc.

6. The pre-Cambrian formation consists of the siliceous limestone and black slate, corresponding to the Nan-k'ou series, but the quartzite is wanting when the slate lies comformably on the siliceous limestone as it is shown in the region between Lai Shui and I Hsien. The siliceous limestone has the thickness of 700-1,000 meters at Chi Feng Ling (奇 峯 嶺), Pei K'ou Pu (北 口 堡), but near Fu Ping and Kong Tzu Tai (康 子 台) the limeston, is estimated to be more than 50 meters in thickness. In this limestone, flint often occurs in lenticular or nodular shapes.

7. The gneiss is the oldest formation in this district, the geological age being the same as that of the Tai Shan complex. Its outcrops may be divided into two areas, the one is scattered from the east of Hsia K'on Tzu (下 口 子) passing through the Shang Cheng Yi (上 乘 驛), Chin P'o (金 坡), and Chiao Chia Ho (喬 家 河) etc.; and the other from Nan Cheng Ssu (南 城 司) over the area of Ho Ling (賀 嶺), and Nan T'o Ling (南 沱 嶺) etc. It is very much weathered and soft. Its composition is of quartz, felspar and mica. Pegmatite veins frequently occur in the gneiss.

The mineral resources noticed in this survey are summarized as following:—

1. The asbestus mines situated in I Hsien and Lai Yuan Hsien (涞 源 縣).

The asbestus forms stock-like veins, 1″ or 2″ to 2′ wide in marble and occurs in general at the contact zone between the siliceous limestone and

granite. The mining has not been continuously carried on, owing to the inconvenience of communication. The only mine in operation belongs Yü-jung Company (裕榮公司), which is located at Shui Chuan Kou (水泉溝), Lai Yuan Hsien.

The ores mined have to be crushed in order to extract the mineral from the impurities.

Daily output is about 600 catties maximum and 200 catties minimum. The transportation for a distance of 150-190 li from the mine to the I-hsien railway station, amounts to 2 cents per catty. The destinations are Peking and Tientsin.

2. The Ling Shan coal field.

The Ling Shan coal field is situated 40 li N.E. of the city of Chü Yang Hsien. The strata of the coal series form a synclinewith its axis towards the E.E.S. and a gentle dip on the both sides of the fold, with dip angles of about 30° or 40°. In the northern part of Yen Wo (燕窩), the dip direction observed is generally to S S.E.; and at Yeh Pei (夜北) the dip forms angles of 20° or 25° towards the S.S.W.

The area including the above places from north of Ling Shan Chen (靈山鎮) to south of Kwan Chuang (官莊), is often covered by loess. The coal seams are seven in number according to the experience of the native miners. The first seam has a thickness of one foot, the second three feet, the third and fourth are so thin that they cannot supply the mining, the fifth is five feet, the sixth 2.5 feet and the seventh 5-9 feet. The average of the above seams may be 4 feet in thickness. The quantity of coal is estimated at 30,000,000 tons. Many native pits are being worked now, but some have been given up because of the water trouble. The daily output for the largest pits is about 15-20 tons and that for the other ones can not be over 30 tons in total. The coal is anthracite.

3. The T'an Hui Pu coal field.

This coal field is situated 60 li N.E. of Fu Ping Hsien. The total thickness of the coal series is about 220 meters. It lies nearly vertical and the dip angle is 80° towards N. W. The western part of the field is marked by a normal fault bringing the coal into contact with the Ordovician forma-

tion. From the native pits we recognise the four coal seams shown as follows: The first and the thickest seam is about 4 feet, and has the best quality of anthracite. The second is 2.5 feet and the third four feet; they contain much sulphur. The fourth is very thin, nearly 1.5 feet, and, being vertical, can not be easily worked. On account of its small area, which is less than two square li on the whole, the coal field can not be worked on large scale, and has no great prospect in store for the future.

直隸易唐蔚等縣地質圖

GEOLOGICAL MAP OF I HSIEN, TANG HSIEN, YÜ HSIEN, ECT. WESTERN CHIHLI.

Surveyed by Li Chieh 1919

測 捷 李

一北分萬十五大縣

Scale 1:500.000

0 5 10 15 20 25 30 35 40 45 50 Km.

Loess

Porphyry

Granite

Red Sandstone
Post Carboniferous

Coal Series
Carboniferous

Limestone
Ordovician

Limestone
Cambrian
(Hia Lung group)

Siliceous Limestone
Pre-Cambrian

Gneiss
Archæan

北

直隸易縣八里坡上新生界地層斜面圖

直隸易縣柏鄉村上新生界地層斜面圖

倒馬關附近之地層斜面圖