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山東章邱煤田中之海成地層

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中國北部古生代煤系中時含有海相石灰岩層、其中多含海相貝類化石初經德人李希霍芬氏在山東博山縣黑山發見、經德國古生物學者弗拉世氏鑒定、謂屬下石炭紀。後三十年美國維理士氏在山東山西調查、所得化石為數不多、歸美鑒定謂皆屬上石炭紀。同時日本學者如矢部早坂諸氏、因研究奉天山東及朝鮮化石之結果、亦謂古生代煤系下部之石灰岩應屬于上石炭紀之最上部、益致疑于德人鑒定之錯誤。距維理士氏來華後二十年、即當民國十一年頃、本所葛利普博士就直隸山西等省多數化石研究之結果、復主煤系下部為下石炭紀之上部、名之曰太原系、而煤系上部則為上石炭紀之上部至二疊紀、名之曰山西系。其所論述可參閱本所出版之中國地質史。自十一年以後至此期彙報以前、本所出版品關于石炭紀煤系時代多從此說。一方面日本學者迄今表示懷疑態度、仍謂除上石炭紀上部外無更下之石炭紀地層。同時趙亞曾君對於太原系之貝類化石復詳加研究、又北京大學李四光君對于石炭紀之紡綞虫又廣為搜研、互相佐証。得以推定山西之太原系之大部應屬于上石炭紀、而本溪湖及灤州之太原系則略古、正當于中石炭紀、更名曰本溪系。如是則古生代煤系共可分為三系、即本溪系（中石炭紀）太原系（上石炭紀）及山西系（石炭二疊紀）是也。惟本溪太原二系又不必同地並存、其分布及其標準化石等具詳李趙二君著作、發表于地質學會會誌第四卷第三四期及第五卷第二期、從前上下石炭紀之爭議至此庶幾解決矣。此項詳細分層研究、關于太原臨城磁縣灤縣等煤田者、前已迭有發表。茲復繼續調查、本期彙報中所列趙君研究山東章邱及奉天本溪煤系地層、即照前述古生物學最新研究之結果以分層者、爰誌此項研究進步之始末如此。

翁文灝附誌

關于章邱煤田之地質構造及開採情形、安特生博士前已述之頗詳（見地質彙報第六期）茲不重叙。本篇所及、專就其海成層之次序及地質時代之比較詳加討論。淄博及章邱煤田雖彼此毗連、但其海成層之多寡及厚度則相差頗遠。據譚錫疇君（見地質彙報第四期）、淄川博山煤田內共有石灰岩兩層、下層厚四公尺、上層

厚一公尺有半。但在章邱煤田內、石灰岩共有五層、只最下層已厚達十公尺。就其位置觀之、淄博煤田內之下石灰岩極似相當於章邱煤田內之徐家莊石灰岩、但終鮮化石上之証明、準確之比較須俟諸異日。

章邱煤田內海成層出露最完之區首推明水車站東南十五里上高莊附近。沿河床兩岸、煤系下部之地層次序歷覽無餘、岩層走向西北東南、傾向西南、傾角通常小於二十度。自奧陶紀石灰岩之上、岩層出露之次序如左（參考柱形圖。）

一　黃色頁岩、厚薄不定……………………〇・四公尺
二　灰泥岩狀石灰岩、中含鐵質核……………〇・九
三　灰色及紫色頁岩……………………………一・五五
四　黃色砂岩及砂質頁岩、間呈礫岩狀………三・八
五　紫色頁岩……………………………………二・七
六　石灰岩中夾綠色灰質頁岩及火成岩各一層（徐家莊石灰岩……一・八
七　黃色及綠色頁岩、中夾灰質凝結物………一五・五
八　黑色頁岩……………………………………三・三
（一至八、本溪系）
九　黃色砂岩、內夾一薄黑色頁岩層…………四・七

十	深灰色頁岩、內含植物化石	一・七
十一	砂岩	二・〇
十二	灰色頁岩、中含煤層一	一・〇
十三	砂岩	三・〇
十四	黑色及灰色頁岩	二〇・六
十五	黃色砂岩	四・六五
十六	黃色頁岩、下部漸呈灰色	六・八
十七	薄層狀砂岩	八・五
十八	火泥含植物化石	二・一
十九	煤層	二・〇
二十	黃色砂岩	二・三
二一	黑色海百合莖石灰岩 (G)	一・二三
二二	灰色及黃色頁岩、上部砂質漸多	八・七
二三	黃色砂岩	一・四五
二四	黃色砂質頁岩	二・四

二五	黑色頁岩、富含植物化石如 Pecopteris, Neuropteris 等	七
二六	煤層	
二七	黃色頁岩狀砂岩	一・八
二八	石灰岩及砂岩之互層(H)	七・〇
二九	黃色頁岩狀砂岩	三〇・〇
三十	灰色頁岩、含植物化石如 Annularia 等	二・〇
三一	石灰岩(K)	一・〇
三二	火泥、上有煤層一	二・八
三三	黃色軟砂岩	三八・〇
三四	石灰岩(L)	一・〇二
三五	黃綠色頁岩	六・四

(九至三五、太原系)

自此以上皆爲砂岩頁岩及煤層之互層(山西煤系)、後者之上卽爲石英質砂岩系、一與淄川博山煤田同。

本溪系・中石灰紀

本系包有五十公尺之頁岩、砂質頁岩、砂岩及一厚石灰岩、但不含煤。該石灰岩層出露於徐家莊之南、故名之

曰徐家莊石灰岩、下距奧陶紀石灰岩約二十公尺、共厚一一・八公尺。其自下而上之次序如左。

厚層狀密緻石灰岩	五・〇公尺
淺赭色石灰岩	〇・三
灰色灰質頁岩與薄石灰岩相間成層	一・八
石灰岩	一・〇
火成岩流厚薄不定	一・二
灰色石灰岩	二・五

本層內之化石雖不甚多、而種類則幾全與產自甘肅羊虎口石灰岩內者相同。

Fusulinella sp.

Girtyina quasicylindrica Lee

Spirifer mosquensis Fischer

Productus gratiosus var. occidentalis Schellwien

Phillipsia cf. kansuensis Loczy

太原系——上石炭紀

本系共厚約一六五公尺、多為頁岩、砂質頁岩、砂岩及薄石灰岩之互層、中夾煤層。石灰岩層共有四、皆曾發現

化石。

G石灰岩。　本層下距本溪系約五五公尺、厚一・二公尺。質密性脆、風化後多呈黃色、內含海百合莖頗多。化石不富、無紡綞蟲、能鑑定者有下列數種。

Spirifer taiyuanensis Chao

Spirifer cf. strangwaysi Verneuil

Naticopsis sp.

Loxonema sp.

H石灰岩。　本層均爲薄石灰岩及砂質頁岩之互層、下與G石灰岩隔有十四公尺之頁岩及砂岩中夾植物化石及煤層。其自下而上之詳細次序如左。

灰色石灰岩	○・二二公尺
黃色頁岩、狀砂岩	○・九五
灰色石灰岩	一・○七
頁岩狀砂岩、中夾灰岩扁豆體	一・一
灰色石灰岩	○・五六
砂質頁岩	○・五五

黑色頁岩產 Productus …………………………………………二•五

採自本層內之化石已鑑定者有下列諸種。

Schellwienia richthofeni Schwager

Schellwienia longissima Möller

Lophophyllum acanthiseptum Grabau

Spirifer sp. indet. (probably sp. taiyuanensis Chao)

Spirifer fasciger Keyserling

Martinia sp.

Productus ecnidniformis Gr. em. Chao

Productus taiyuanfuensis Grabau

Loxonema sp.

K石灰岩。 本層共厚一•八四公尺、下距G石灰岩隔有約二十公尺之黃色頁岩狀砂岩及灰色頁岩一薄層內含植物化石。其自下而上之次序如左。

白色砂岩……………………………………………………○•二十公尺

褐色砂質頁岩…………………………………………………○•一四

深灰色頁岩……………………………………………○・四
灰色石灰岩……………………………………………一・○

凡此等頁岩及砂岩內皆富含化石、但岩質鬆軟頗難得完美者。能鑑定者有下列數種。

Marginifera longispinus var. orientalis Chao

Marginifera pusilla Schellwien

Chonetes sp.

Hustedia sp,

L 石灰岩。　本層厚只一公尺、下與K隔以約四十公尺之砂岩。除一 Loxonema 外、尚未得有其他之化石。

南滿石炭紀地層之研究

趙亞曾

地質調查所關于中國北部石炭紀地層之研究已漸臻精詳、而對於南滿則所知者較鮮。執此之故、作者於十四年夏奉命赴南滿調查、專研究煤田地層並採集化石以便與他省研究較詳之剖面相比較。足跡所及包有本溪湖、牛心台、及五湖嘴三煤田。

據作者調查所得之結果與日人所得者大不相同。昔早坂一郎謂烟台煤系內含有 Spirifer nikitini, 牛心台產 Spirifer wynnei, 高麗黑河煤田內則 Schwagerina princeps 與曾發現於南滿各煤田中石灰岩內之珊瑚同產於一處。執此、早坂教授斷定凡南滿煤系下部之石灰岩薄層應隸屬上石炭紀之 Schwagerina 級。但據作者之研究、牛心台及本溪湖煤系以下之石灰岩薄層恰與開平之唐山石灰岩相當、蓋以彼此均有相同之珊瑚及紡綞蟲生物群以爲之証也。唐山石灰岩內因有 Spirifer mosquensis 及產於俄國莫斯科石灰岩內紡綞蟲類化石之存在而証其屬於中石炭紀、則本溪湖及牛心台煤田內之海成層自亦屬於中石炭紀。在此二地、莫斯科級(即中石炭紀)之上直接即爲二疊石炭紀之山西煤系、屬於上石炭紀之太原系完全欠缺。昔作者在「太原系之時代」一文內(見地質學會會誌第四卷第三—四期)曾名太原系內之屬於中石炭紀者爲 Spirifer mosquensis 層、屬於上石炭紀者爲 Spirifer taiyuanensis 層。茲以 Spirifer mosquensis 層特別發達於本溪湖也、故特名之曰本溪系、而以太原系一名專限於作者所謂 Spirifer taiyuanensis 層焉。太原系雖欠缺於北部、但稍南則漸出現於山西系與本溪系之間、如在遼東半島南部之五湖嘴、太原系即已

甚發達、含有標準太原系化石多種。

一　本溪煤田

本溪煤田之構造頗爲簡單。岩層概傾向正南偏東、傾角十度以至二十度、通常十五度。在距奧陶紀石灰岩不遠之處沿走向一帶廢窰累累、土色爲黑。煤田西在新洞溝爲斷層所切、東北在明盛溝爲侵入岩所斷、產煤區域東西延長約十五里。太子河爲本區之巨流、環繞東南兩部。地形之高低專恃地下之岩層性質以爲定。煤田之北部皆爲含煤層及石灰岩薄層所作成、故山勢低緩。南部概爲鬆軟之紅砂岩、易於侵蝕、因亦組成低圓之山丘。中部則以多爲堅硬之石英岩、不易於消磨、故山勢陡增、組成高峰。

奧陶紀石灰岩以上之上部古生層共厚不下一千公尺、可分爲四系、茲分述之如下。

本溪系—中石炭紀

本系位居奧陶紀石灰岩之上、共厚約九十餘公尺、全部均爲頁岩砂岩及石灰岩薄層所作成、不含煤層。其上下之次序以出露於本溪縣治西十二里新洞溝與螞蟻村溝間者爲最完整。自奧陶紀石灰岩起由下至上地層之次序如左（參見英文第八頁第一圖。）

1 紫色頁岩漸變爲灰色頁岩……五•〇公尺

2 黃色軟砂岩中夾泥質石礫……四•〇

3 黃色頁岩中夾砂質層……四〇•〇

4 灰色石灰岩內含 Spirifer …………〇・六

5 黃色砂質頁岩…………四・三

6 石灰岩內含鐵礦小塊…………一・〇

（4—6 螞蟻石灰岩）

7 黃色頁岩…………一三・〇

8 淺灰色結晶狀石灰岩內含 Girtyina, Lithostrotion, Chaetetes, Spirifer 等化石（小峪石灰岩）…………一・八五

9 黃色及綠色砂質頁岩中夾砂岩層…………一一・〇

10 淺灰色厚層狀石灰岩、間含海百合莖顆多、內產 Girtyina, Cnaetetes, Lithostrotion. Spirifer 等化石（本溪石灰岩）…………五・五

11 淺灰色砂質頁岩…………五・〇

12 灰色粗砂岩…………七・〇

自此以上卽爲山西煤系。

（二）螞蟻石灰岩　本名用以代表上剖面中下部之二薄石灰岩層、下層厚・六公尺、上層厚一公尺、中爲厚四・三公尺之黃色砂質頁岩所分隔、下距奧陶紀石灰岩約五十公尺在本煤田內、本層只露出於螞蟻村溝剖面中。下螞蟻石灰岩略呈泥灰岩狀、除一 Spirifer 外、未得有其他之化石。上螞蟻石灰岩質密而脆上部泥灰

岩狀、間夾鐵礦結核。紡綞蟲並不甚多但極普遍、其他化石概成剖面露出岩表、頗難得完全者。所採集之化石有下列三種。

Girtyina schellwieni Staff

Spirifer mosquensis ? Fischer

Dielasma sp.

(二)小峪石灰岩　小峪石灰岩以出露於順山子小溝峪旁者爲最完美。色灰層厚、頂底泥質漸增、呈頁岩狀。海百合莖極少、但紡綞蟲化石則甚多、全部灰岩幾全爲彼等之遺殼所作成。共厚一・八五公尺、下與螞蟻石灰岩隔以十三公尺之黃色頁岩。本層復出露於螞蟻村溝剖面中及小峪溝與明盛溝間之山丘上。在此三處所採集之化石含有下列數種。(凡表內有十字者均亦曾發現於開平煤田內之唐山石灰岩)

† Neofusulinella bocki Möller

† Fusulinella sphaeroidea Möller

† Girtyina konnoi Ozawa

Girtyina pankouensis Lee

† Alveolites tangshanense Grabau

† Lithostrotion kaipingense Grabau

† Chaetetes sp.

Reticularia sp.

Productus sp.

† Spirifer mosquensis ? Fischer

(三)本溪石灰岩　本層爲本溪煤田內最厚之石灰岩。凡廢窰帶之北、本層露出之處頗多。本石灰岩之下即無煤層、故當地土人每視其爲產煤層之底。色淺灰、厚層狀、半結晶、厚五・五公尺。下與小峪石灰岩隔有十一至十五公尺之黃色及綠色砂質頁岩、上與煤系隔以一厚灰色粗砂岩層。海百合莖之多寡因地而異、普通以帶泥質層內者爲較多。紡綞蟲不甚豐富、他種化石亦頗稀少。在坑口附近、螞蟻村溝及小峪溝與明盛溝間所採集之化石含有下列諸種。

Boultonia rawi Lee

Bradyina nautiliformis Möller

† Girtyina cylindrica Fischer

Girtyina pankouensis Lee

† Girty na konnoi Ozawa

† Lithostrotion kaipingense Grabau

†*Multithecopora penchiens's* Yoh

†*Chaetetes* sp.

†*Spirifer*

山西系—石炭二疊紀

山西煤系下與本溪系交接處爲厚七公尺之灰色粗砂岩。由海相之屢浸驟變爲煤層之堆積代表當時情形顯然起變更及証以化石之研究始知兩系中間實有一大間斷。本溪系內之化石既確屬於中石炭紀、而山西系內之植物化石復久已鑒定屬于石炭二疊紀、甚至於下二疊紀、則二者之間必經侵削或未堆積可斷言也。

山西系內概爲黑色及灰色頁岩砂岩及煤層之互層、但無石灰岩、共厚約一百七十公尺。據鑽採結果、全系含煤層十八、但可供開採者皆限於其上下兩部、中間爲厚石英質砂岩所隔、含煤極有限。詳細次序可參考柱形圖。在黑色頁岩內植物化石頗多、Schenk, Zeiller, Yokoyama 及 Mathieu 等曾經研究之。據 Mathieu 詳細之鑑定、謂其時代爲石炭二疊紀、並恰與直隸唐山石灰岩以上之煤系相當。

石英質砂岩系—二疊紀

山西煤系之上爲一厚約二百五十公尺之砂岩系。砂岩多爲白色石英砂粒所作成、間呈灰及淺綠色。下部常夾有黃色及紫色頁岩薄層、上部則概爲純砂岩。以石質堅硬不易侵蝕、故多組成高山。本系在中國北部之分佈頗廣、凡山西煤系之上幾無處無之。至其時代、當屬二疊紀。

紅色頁岩及砂岩系－二疊紀？

石英質砂岩系之上爲一厚紅色頁岩砂岩系、共厚五百餘公尺。岩石以紅色輭頁岩、砂質頁岩及砂岩爲主。砂質岩石常呈雲母狀。於其底部在蔡家屯爲一節黃色及紫色輭頁岩、多破碎成碎片。於其中部在鮑家窪子及姚家屯之間見有一厚礫岩層中夾砂岩卵石。以其質甚鬆輭、故多侵蝕成低平之山丘。

紅色頁岩及砂岩系在中國北部亦分佈甚廣。關於其時代、前人多以之屬於二疊三疊紀。但三疊紀化石向未發現於中國北部、則本層仍歸之於二疊紀似亦無悖於理也。

二　牛心台煤田

牛心台位居本溪東四十里、有支路往來本溪牛心台間、日通車四次。

煤田構造恰如椅、以奧陶紀石灰岩爲其緣。岩層之次序一與本溪者同。海成層以出露於紅臉溝者較爲完備。該處小峪石灰岩仍保持其原來之性質、紡綞蟲特別衆多。本溪石灰岩與出露于本溪者頗有不同、色灰質密、含燧石結核甚多。但據李四光教授研究紡綞蟲化石之結果、則本層與出露于本溪者仍含同樣之化石也。

三　五湖嘴煤田

五湖嘴位居遼東半島之西南部、東距普蘭店車站九十里。該處三面環海、鹽沼棋佈、中有狹長之高地突出低澤約五十公尺、南北延長、至西北而分爲二支。煤田即棲息於此邱陵地之上焉。

煤田構造以二向斜層爲主、中隔以一背斜層。東向斜層即遲家屯向斜層北起東邱陵地之北端、（在遲家屯

稍北）南行漸漸減小、及至楊樹溝卽行絕跡。西向斜層卽老君廟向斜層亦北起於西邱陵之北端（在菩薩廟附近）至老君廟而發達特甚、振興公司卽在於是焉。二向斜層中間之背斜層南起於楊樹溝、向北開展漸掩埋於二邱陵地中間低澤之中。除此主要構造外、地層復受種種之拗曲、開採之困難半基於是。

下部地層只出露於三稜山麓。石炭紀地層與奧陶紀石灰岩接觸之處爲厚二公尺之紫色頁岩、富含鐵礦塊。其自下而上之次序如左（第二圖）

1 紫色頁岩富含鐵礦……二・〇公尺

2 灰色硬粘土岩……五・〇

3 雜色頁岩……十二・〇

淺灰色石灰岩間含海百合莖……一・三

5 綠色及紫色頁岩……五・〇

6 灰色厚層狀石灰岩、含燧石頗多、常沿層理排列成層、上部間夾海百合莖及 Spirifer

（三稜石灰岩）……八・〇

7 黃色頁岩……十六・〇

8 灰色泥質石灰岩……〇・九

9 灰色頁岩……七・〇

（I—9.本溪系）

10 白色石英質砂岩風化呈黃褐色……………………二·五

11 灰色頁岩上部被覆

12 厚層狀石灰岩內含燧石結核

自第十層以上、皆爲土壤所掩、無法窺探。但第六層以上諸地層復出露於丁家屯與王家屯間邱陵地之東麓、其次序如左（第三圖）。

1 黃色頁岩

2 厚層狀石灰岩含燧石結核上部產海百合莖 Spirifer, Chaetetes 等（等於三稜山剖面中第六層）……………………七·〇公尺

3 黃色頁岩中有綠色砂質層厚一·二公尺……………………一〇·〇

4 灰色石灰岩……………………〇·九

5 黃色及灰色頁岩上部被覆……………………二四·〇

6 灰色粘土……………………五·〇

（I—6.本溪系）

7 灰色砂質粘土中夾薄煤層……………………五·〇

8	暗色石灰岩含燧石結核	一・五
9	綠色砂質頁岩內含化石	〇・七五
10	灰色薄層狀石灰岩	〇・四五
11	褐色砂岩內含化石	〇・一
12	灰色頁岩上部色綠	三・三
13	深灰色泥質石灰岩	一・三
14	黃色頁岩產 Productus taiyuanfuensis. Aviculopecten, Entolium 等	〇・二
15	灰色頁岩	四・〇
16	灰色厚層狀石灰岩含燧石結核化石甚少	六・四
17	青色厚層狀灰質頁岩含化石	五・〇
18	黃色頁岩	一・二
19	淺灰色粘土	二・五
20	黑色砂質岩	四・五
21	頁岩下部色黃上部淺灰	一・〇
22	淺灰色砂岩	三・〇

23　黑色矽質岩……………………………………五・○

本溪系—中石炭紀

本系之下部只出露於三稜山麓。在丁家屯與王家屯間邱陵地之東緣、其上部之出露亦甚完整。全系概爲紫色頁岩、黃色頁岩及石灰岩薄層所作成、但不含煤、共厚約七十公尺。

三稜石灰岩　本層下距奧陶紀石灰岩約二十五公尺。色淺灰、厚層狀、含燧石結核、厚約八公尺。上部含有海百合莖及 Spirifer 之剖面。在三稜山麓曾採有 Spirifer mosquensis 及 Fusulinella 等化石。但保存太壞鑑定甚難。在丁家屯與王家屯間亦採有 Chaetetes 數塊。與得自唐山石灰岩及本溪石灰岩者完全相同。就其化石及無煤層觀之、本石灰岩層顯然屬於本溪系。三稜石灰岩上十六及下五公尺之處均有一薄石灰岩層。岩石性質大致相同、但未得可供鑑定之化石。

太原系—上石炭紀

本系厚約一百公尺、可分爲上下二部。

下部以出露於丁家屯與王家屯間者最爲完整（第三圖）。下爲灰色頁岩中夾薄煤層、中爲含燧石石灰岩與含化石泥質及砂質層相間、上爲黑色矽質岩及砂岩、共厚約四十餘公尺。

五湖嘴層　下部太原系中間之石灰岩及頁岩等統名之曰五湖嘴層。更可分爲二部。下部五湖嘴層包有石灰岩三層中夾含化石頁岩及砂岩層、共厚五・八公尺。於此等岩層中在丁家屯與王家屯間採有左列諸化

石。

Productus taiyuanfuensis Grabau,

Marginifera pusilla Schellwien

Spirifer taiyuanensis Chao

Naticopsis sp.

Aviculopecten sp.

Entolium sp.

上部五湖嘴層包有厚六・四公尺之燧石石灰岩及厚五公尺之灰質頁岩。下與下部五湖嘴層隔以四公尺之灰色頁岩中夾煤層。經長時之搜求未得有可供鑑定之化石。在楊樹溝稍北於堆積於路旁之石塊中曾採得 Marginifera pusilla Schell., Productus echidniformis Gr., Productus manchuricus Chao 頗多。就其地位觀之、該石塊頗似來於本層、但終鮮確實之證明。

上部太原系概爲頁岩砂質頁岩所作成、下有厚煤層一、中有 Schwagerina 石灰岩二。全部厚約六十餘公尺、其上爲一厚灰色粗砂岩所覆。

楊樹溝石灰岩　本層位居上部太原系之中部、以出露於楊樹溝得名。色黑質密、厚約一公尺、中含 Schwagerina 頗多、但其他化石則甚少。能鑑定者有下列二種、Schwagerina moungthensis Lee 及 Schellwienia richthofeni Schwager 在楊樹溝稍北王家屯與斐家屯之間一石灰岩層復露出。本層抑代表另一石灰岩層或卽相當於楊樹溝石灰岩無從證明、但就其所含化石觀之則以前說爲較可靠也。在本層內所採集之化石含有左列諸種。

Neofusulinella chaoi Lee

Boultonia willisi Lee

Schellwienia richthoteni Schwager

Schellwienia nobilis Lee

除上述諸化石產地外、石灰岩出露之處尚多、如在丁家屯西之路旁、斐家屯東之溝內、斐家屯北之道旁及楊樹溝附近等處。惟所採集之化石尚未加以詳細之研究茲不具述。

奉天黑山縣八道濠煤田

譚錫疇

引言

民國十四年秋、偕美國第三次亞洲調查隊隊員禪內君、同赴奉天撫順黑山各煤田採集植物化石。嗣因奉天礦務局總辦王子文君之邀請、奉翁所長派令、復於是年十月下旬、再至八道壕煤田調查。八道濠煤礦本有煤田一部詳圖、奉天礦務局又以黑山縣五萬分一之地圖見示、故地形圖得以有所根據。計在野外調查者七日、在井下觀察者一日。此煤田向少人知、惟民國十年俄國地質學者阿乜爾特 E. Ahnert 曾一至其地、於煤田地質略有敘述、但地層次序構造狀況俱未詳細研究、僅以所採植物化石交由俄國古植物學者克利世陶佛維氏 A. Kryshtofovich 爲之鑑定而已。就八道壕煤田之位置及性質而言、夙有研究之必要。蓋煤田所處東有撫順第三紀煤田而煤質近之、西有北票侏羅紀煤田而煤質不同、北爲阜新煤田屬何年代言人人殊、而煤質亦有近似之處、八道壕煤田處屬何時、久應成爲問題。當作者第一次同禪君在八道壕煤礦之時以二日觀察所得有可以佐證煤系之時代者二。一、地層系統與第三紀煤系不同而與白堊紀煤系實頗相類似。二、煤系下部近煤層處有黑灰色頁岩內含葉鰓類化石、與作者前在奉天義縣煤系所採經葛利普博士鑑定爲白堊紀之 Corbicula 者酷似。於是作者遂以八道壕煤系屬於白堊紀或無疑義。八道壕煤系生成時代之確定不但地質重要疑問可藉以解決、而於白堊紀煤系之存在、與夫白堊紀亦可爲煤之富源又多得一佐證。蓋作者近年來對於白堊紀地層雖多所發見、然地層之夾有可採煤層而可稱一煤系成一煤田者惟赤峯平泉三數處而

已、礦產區域實嫌褊小、今益以八道壕煤田、則白堊紀煤系在中國北部始確有經濟價值矣。

位置

八道壕煤田在奉天黑山縣西北境、與熱河阜新縣境毗連、東南距黑山縣城約三十里、距京奉鐵路之打虎山車站約五十里、(由打虎山車站至八道壕車站鐵路共長三十公里)距奉天省城約三百二十里。約占北緯四十一度五十五分、東經一百二十一度五十五分。

交通

煤田雖居近山地、而交通甚便、由京奉鐵路之打虎山車站至黑山縣北境之新立屯、築有支路、通過煤田。鐵路所經正煤系分佈所在、車站距採煤坑井最遠尚不及二里。由八道壕至打虎山連過磅掛車計往返約需五小時。由打虎山至奉天省城最慢貨車僅七小時。卽陸路亦平坦、大車可到處通行、鄉間轉運惟此利賴、附近無大河不能水運。

地形

醫巫閭山脈之一支盤亘於奉天北鎭黑山及熱河阜新交界、八道壕煤田一帶山嶺又爲其東南來之餘委、山勢至此已大低減、不復呈層巒嵯峨之雄態、而起伏羅佈於煤田附近者惟平漫蜿蜒之岡阜、與夫孤立之小山而已。煤田居中間地勢低平、由南而北而東北成一延長淺平之谷、南部狹、北部闊、山嶺分列左右。煤田之西北爲羅台頭台一帶小山嶺、自羅台北山迤而西北至阜新縣界桃花營子附近、與自頭台北來之嶺連。山嶺均不

高大羅台北山高出於煤田約六十公尺、頭台北山約七十公尺、在煤田之西北與頭台山嶺隔谷遙峙者爲一帶小山嶺、蜿蜒起伏二台迤而西南山勢陡起、成一巒立之山、高約一百二十公尺。自此而南而東南山勢漸低、至煤田之西南落爲原野。煤田之東地勢亦高、自台子後迤而東南過郝屯至團城子（維城子）爲一帶小嶺、最高處不逾五十公尺。又東南地勢陡起爲綱台北山、高約七十公尺、東南隔谷與綱台東南山嶺遙望。大抵煤田以西山嶺自北而南、勢漸低降、而煤田以東山嶺自北而南、勢以次而隆起也。

煤田一帶無大川巨水、不過夏秋雨期、山水驟至、河身加寬、旋即復原仍成細流、大抵均無專名、或以經流之地名之。在煤田北部有河自西北流來經頭台羅台之南轉而南流經綱台而南出本區域、其流貫於煤田南部者、發源於半仙屯之西北、東南流經東西兩嶺之間、迤而南流、其侵削西嶺者亦均由北而南順勢而下、出本區域、與前兩渠會而南流。

地層

八道壕煤田地質大致尙屬簡單、然詳細觀察與他處所見頗具殊異之點。而冲積層到處分佈、不與地層充分露出之機、亦足爲研究之障礙。地層最古者爲太古界片麻岩常與煤系地層相近、而接觸之處未嘗目擊。煤系下部常夾一種礫岩而火山熔岩及凝灰岩之上亦有之。至熔岩凝灰岩與煤系之關係又全爲冲積層所掩、無法窺悉。凡此皆足使觀察困難。煤系之上爲一種極厚之礫岩層、其礫石之大成分之雜、尤所僅見。礫岩層之上爲凝灰岩及火山岩流、與前礫岩下之岩流凝灰岩亦常相混淆也。玆將各地層分期敍述如左。

（一）泰山系（即片麻岩系）　泰山系爲中國地層之最古者、各處所見太古地層率以斯名之。其在本區域者暴露雖不甚廣而煤田邊際則常有踪跡、岩石以片麻岩爲主、片理頗粗、礦物結晶甚大、有時含有石英細脈。分佈於煤田東邊者在台子後附近露頭甚多、其西似與煤系底部成不整一之接觸。煤田之北桃花營子一帶、暴露頗廣、有時與凝石岩及熔岩成顯著之斷層接觸。煤田之西、二台西南礅台山一帶、片麻岩亦多以斷層與凝灰岩接觸。片麻岩所在大抵地勢平漫、爲低嶺或山坡、地層多暴露於溝渠中也。

（二）震旦紀石英岩層　位於泰山系之上、成不整一之接觸、惟於頭台北山及二台礅台山兩處見之。岩石爲白色及灰色石英岩間夾淺綠色片岩。分佈面積狹小惟地層所在山形多呈峻峭之觀。在中國北部白色石英岩與泰山系有時相接觸者有二。一、爲五台系內之石英岩、一、爲滹沱系（或震旦系）內之石英岩。前者常夾於片麻岩內與大理岩共生、後者自爲一層常夾砂岩及頁岩。本區域石英岩似與滹沱系石英岩相當、屬於元古代後期。

（三）綱台層（卽火山岩層）　此層大部爲火山岩、惟岩石噴出後已均成爲岩流、層次顯然、並間夾凝灰岩、雖毫無水成岩踪跡、而層向斜向常與水成地層一致。然與他層關係毫無接觸可尋、惟其右方隔冲積層爲煤系下部地層、而層向略同、故暫假定爲古於煤系之岩流、而置諸煤系之前。但他處煤系之下部緊接太古片麻岩、毫無火山岩踪跡、且煤系以上礫岩層之上亦有火山岩流及凝灰岩、與此岩流是一是二尙有疑義。玆就岩石之性質及地位、暫定爲先於煤系噴出者。此層在綱台北山最爲發育、組成顯著山嶺、在本區域外綱台東南分

佈尤廣。岩石以棕紫色火山熔岩爲主、稍夾暗綠色及紫色凝灰岩岩流就顯微鏡下觀之頗呈斑狀。斑晶爲斜長石及角閃石、但量不多、石基爲針狀長石及少量玻璃質所成。在岩石分類中屬於安山岩。此外其噴出時代似屬於侏羅紀。

(四)黑山系(卽煤系)　因八道壕煤田在黑山縣境內故煤系以黑山名、直位於泰山系之上、大抵爲不整一之接觸而接觸之點則未能目覩。就地層覆疊情形及含煤多寡而言、又可分爲上中下三部。(一)下部以泥質頁岩砂岩及礫岩爲主、不夾煤層、地層由下而上大致先爲淺綠淺黃色泥質頁岩及粗砂岩、次爲綠黃灰色泥質頁岩及細砂岩、上爲雜色礫岩、所含礫石大小極不一律、普通直經大小以數公分至數十公分計、大者有時可以公尺計。在郝屯東溝礫岩內有石英岩巨塊、初視之亦現層狀、極似石英岩原生露頭、及詳細觀察爲石英岩巨塊及石英岩質礫石結合而成、不過巨塊礫石多有稜角、又不間他質礫石、結固後頗難辨其眞質耳。礫岩所含礫石質亦龐雜、大抵以石英岩片麻岩及砂岩爲最多、火山岩間一見之、此部露頭以台子後郝屯一帶及張羅屯迤西鐵路塹道爲最清晰、分佈均在煤田之東緣、厚度未能實測、但就地層露頭寬狹及斜度大小估計、約在百公尺以上。(二)　中部位於下位之上、大抵爲不連續之接觸、以砂岩頁岩粘土及礫岩爲主、中夾重要煤層、惟地層被黃土及冲積層所覆、露頭絕少、僅就採煤開坑所知及偶露出於地面者略見其一部。在郝屯東溝與下部礫岩接觸者爲淺綠淺黃色粘土、在園城子西下部礫岩之上淺綠色泥質頁岩、八道壕煤礦開坑採煤所出多灰色砂岩黑灰色及黑色頁岩、豎坑剖面所示爲砂岩頁岩粘土及礫岩交互迭生、夾有煤層。此

外打鑽所得岩石種類性質不能分別、未可依據。此部分佈因無露頭可見、只可暫就上下兩部露頭而定大抵自八道壕煤礦起、北經曹屯之西、沿鐵路至小新立屯之西、而東北、南經鐵路之西戴屯圍城子之間、過田三家而南、至全部厚度粗事估計、約爲二百二十公尺。（三）上部繼中部而生、以泥質頁岩砂岩爲主、夾薄煤層、但與中部接觸之處全爲黃土及冲積層所掩、地層無從窺悉。就打鑽所得石末觀察、大致亦多爲砂岩頁岩之類、（十三號鑽三號鑽均似穿過上部一部）其露出部份沿西嶺東麓頗爲清晰、在陳八道壕之北地層爲（由下而上）灰色淺綠黃色泥質頁岩、夾粗砂岩及黑色泥質頁岩一層、（厚約十公尺）礫岩含片麻岩石英岩及火山岩質礫石、（厚約六公尺）灰色黃色泥質頁岩夾砂岩、（厚約五公尺）礫岩、（厚約三公尺）黃色灰色泥質頁岩及砂岩（厚約十公尺）礫岩夾砂岩、（厚約六公尺）黃色灰色粗砂岩夾礫岩及泥質頁岩、（厚約五十公尺）在戴屯附近上部夾薄煤層曾開經採、惟夾煤地層多無露頭、僅煤層上之一部在溝內可以目擊、爲淺黃淺綠灰色粘土及砂岩、（厚約五公尺）礫岩含片麻岩及石英岩質礫石、（厚約三公尺）灰色淺黃色泥質頁岩夾砂岩、（厚約六公尺）礫岩夾砂岩、（厚約四公尺）灰色淺綠淺黃色泥質頁岩及灰白色灰色砂岩、（厚約六公尺）礫岩、（厚約十公尺）灰色淺黃色砂岩、（厚約十公尺、）其他在雙井子前紅石槽等處上部亦有露頭、大致均爲灰色淺綠淺黃色粘土砂岩夾細質礫岩。此部分佈大抵由雙井子往南、經陳高八道壕、水泉、戴屯、馬三家、而南往北、經紅石槽迤而東北、經羅台之東、而東北。全部厚度、據估計所得約爲二百公尺。

煤系內化石。俄人阿也爾特氏所採植物化石、經俄人克利世陶佛維氏所鑒定者有四種。一爲 Dioonites kotoi Yokoyama 克氏謂此爲尼堪系之標準化石、而屬於烏蘇里省侏羅紀之上部者。二爲 Ginkgo digitata Brongn 與英國約克色 Yorkshire 及烏蘇里侏羅紀之產酷似、並曾見之於英國他處西比利亞及日本北滿上下侏羅紀及下白堊地層內。三爲 Phoenicopsis speciosa Heer 烏蘇里阿穆爾及東三省均產之、四爲 Pityophyllum nordenskiöldi (Heer) Nath 在烏蘇里及穆阿爾省亦曾採集。克氏括約其詞、而謂所有植物化石可証八道壕煤系屬於上侏羅紀。然作者與禪內 Chaney 君同游時曾得似 Sequoia 之植物、禪內君因疑爲第三紀。嗣作者復由八道壕煤礦坑下採集葉鰓類化石、歸京後持示葛利普博士、請其鑑定、博士謂內有 Corbicula 一種與奉天義縣所採相同。義縣葉鰓類經葛博士鑑定爲白堊紀之產、故八道壕煤系亦當屬於白堊紀。此次在坑旁石堆及戴屯附近亦採得植物化石多種、經周君贊衡鑑定大致有 Podozamites, Czekanowskia, Nageiopsis, Taxodium 數種、但均爲侏羅紀白堊紀共有之物。就上述三次研究之結果、一則以八道壕煤系爲侏羅紀之產、二則以之屬於第三紀、三則謂歸入於白堊紀。按植物繁殖有時在相近兩地質期內均占多數。如 Baiera 及 Zamites 本爲侏羅紀之化石。而在白堊紀內亦能有之。Sequoia 雖在第三紀最多、而在白堊紀生活已見其端。或阿禪兩君所得之植物化石均爲白堊紀之物、而適亦生存於侏羅第三兩紀者。且兩君所假定一爲侏羅紀、一爲第三紀、相距太遠、而以煤系歸入於白堊紀、則與兩方均不甚衝突、似爲折衷近似之說。况克君所指與八道壕煤系相當者均爲上侏羅紀、距白堊紀頗近、所含化石當有極相似處、則與白堊紀之說固爲亦不

相悖也。

就地層次序岩石性質觀察、八道壕煤田煤系亦以屬於白堊紀爲宜。中國北部侏羅白堊兩紀地層共同生存而均成爲煤系者、惟熱河北票煤田。下爲侏羅紀煤系、夾重要煤層、有淸晰之植物化石、Baiera及Zamites 占大多數、岩石以白灰色砂岩黑灰色頁岩爲主、大致均堅硬、煤均爲烟煤、可煉焦。上爲白堊紀煤系、夾薄煤層、下部含六足虫化石 Samarura 又含植物化石與葉鰓類共生、岩石以泥質頁岩及薄層砂岩爲主、大致多鬆軟、煤爲褐煤及次等烟煤、不能煉焦。今就黑山系三部綜觀、以泥質頁岩及薄層砂岩爲多、煤爲次等烟煤及褐煤、與北票白堊紀煤系頗有類似之點。並所含植物化石與北票白堊紀化石亦同、常與葉鰓類共生。且中國北部時代確定之侏羅紀煤系上多爲砂岩頁岩層、再上則有最普遍之凝灰礫岩層、北票煤田侏羅紀煤系之上爲白堊紀煤系、再上卽凝灰礫岩層、八道壕煤系之上直接一種礫岩層、一部夾凝灰礫岩及凝灰岩、與北票之凝灰礫岩層頗相類。故煤系之屬於白堊紀實較屬之於侏羅紀者爲宜。

(五)礫岩層　在煤系之上、大致成不連續之接觸、岩石以礫岩爲主、夾凝灰岩、火山岩流及砂岩。大別之可分爲上下兩部。下部多礫岩、上部則凝灰岩占重要位置。下部之底部與煤系上部接觸處除礫岩及鬆砂岩外、並常見凝灰岩及凝灰礫岩。在雙井子西北、凝灰岩質細、呈灰綠黃色、凝灰礫岩內夾紅綠色粘土及鬆砂岩。在前紅石槽西、凝灰礫岩亦夾鬆砂岩。此層下部礫岩粗細不等、大致由下而上漸次變細、先爲粗礫岩、夾淺綠灰色鬆砂岩、次粗細礫岩交互迭生、夾灰色及紅色鬆砂岩、終則細礫岩加多、夾紅色鬆砂岩含石英岩質火山岩質

礫石、在石家溝南夾紅色硬砂岩數層均不甚厚、礫岩所含礫石以石英岩片麻岩爲最多、砂石頁岩及火山岩亦常目擊、大小直經由數分至數尺不等。在朱八道壕西南溝曾見片麻岩巨塊頗似地層原生露頭、礫石或呈圓形、或有稜角、大小雜生、頗似未曾經久遠之冲移者。

上部爲綠紫棕色凝灰岩及岩流夾砂岩泥質頁岩及薄煤層。在桃花營子西約一里、有綠紫色凝灰岩及淺紫色岩流、與片麻岩接觸夾薄煤層、曾經開採、煤層厚一二尺。桃花營子東南約一里、凝灰岩內亦夾薄煤層、曾經開採。羅台北山有綠棕紫色凝灰岩及熔岩夾粗砂岩礫岩及淺綠色黑色泥質頁岩、礫岩所含礫石有時均爲石英岩質每帶稜角、凝結成層、甚堅硬、頗似石英岩層。在二台山西南敬台山東有紫綠色黑色凝灰岩及熔岩、夾灰色砂岩及石英岩質礫岩。全層分佈甚廣、本區域西部山嶺除有片麻岩石英岩少許外、大抵均爲本層組成。下部面積尤大、上部在本區域西邊及羅台北山一帶全層甚厚、約略估計下部約在一千五百公尺以上、上部受斷層之影響、其存留者不過一二百公尺而已。至其時代因化石不能確定、就地層位置岩石性質觀察或與中國北部如山東熱河等處常見之凝灰礫岩層相當、而屬於白堊紀上部。

（六）黃土及冲積層　黃土在本區域露出者頗少、大抵多埋藏於冲積層之下、溝渠中亦不常見。冲積層分佈頗廣、大抵平原低地山嶺坡麓均其發育之所、重要成分爲次生黃土冲積土及砂礫、厚度不一、平均約在二三十尺之間。八道壕煤礦開坑所經、併黃土計算、約爲七十餘尺。

構造

八道壕煤田地質構造初視之似頗簡單、然詳細觀察則費解之處尚多。實因浮表積物觸處分佈、地層暴露太少、重要之點往往掩覆不見。茲惟論其大略。

本區域自白堊紀後受造山勢力之影響、地層斷折。斷層生成之期大抵在白堊紀礫岩層沉積以後、本區域已成陸地、造山作用繼續不已、直至第三紀中葉漸新世或中新世地層不能抵抗、破壞之力遂沿弱點破裂而成斷層。但在本區域內所得事實不足證明斷層之時期。不過在第三紀中葉實爲一地殼破裂之期、中國北部大斷層多生於此時、本區域斷層或亦與各大斷層同時生成者也。斷層錯動大抵均不甚劇烈、動力以垂直運動爲著、均爲正斷層。其最大者、爲本區域西邊斷層、大致爲南北方向、一部稍偏自東南與西北。在本區域內者南自三道溝西嶺起、北經二台墩台山之東、至頭台之西北、延長約十七里。斷層面傾斜向東或東南、仰側爲泰山系及石英岩層、俯側爲礫岩層。次爲煤田北部之斷層、與前斷層是否相連末得窺悉。不過兩斷層方向不同、似可分而爲二。此斷層自桃花營子而東南、轉向東、經羅台山北部董屯盤桃山以北、而東北、延長十餘里。斷層面大致向西南或東南傾斜、仰側爲泰山系、俯側爲礫岩層。其他小斷層頗多、皆局部變動、與煤田大體構造無大關係。坑下採煤所遇小斷層亦夥、亦皆錯動不大、煤層昇降踪跡可尋、爲害不鉅。至地層褶疊在本區域發育不著、不過當地層斷折之際上下錯動遺有傾斜之跡、而地層起伏不平、傾斜每易其方向耳。本區域地層除逼近斷層一部外、大致向西南或西北傾斜、斜度平緩通常在一二十度之間、平緩可減至五度、陡峻不至三十度。在斷層附近則局部變動有時頗大、二台墩台山東斷層線東之礫岩層上部地層傾斜由四十度竟至直立、斜向

西南、而斷層西石英岩層傾斜由四十八度至七十八度、斜向東南。頭台北山石英岩層傾斜東南偏南、斜角由三十四度至六十三度。桃花營子礫岩層上部凝灰岩傾斜東北、斜角由四十度至六十度。羅台北山凝灰岩砂岩頁岩傾斜正南、斜角由五十度至七十度。盤桃山砂岩頁岩傾斜東南偏東、斜角三十四度。均係局部變動也。以上所述為本區域構造之大概。於地質方面關係雖甚重要、然於較小範圍如採礦施工所遇、則此項大構造尚無直接關係、今最當研究者為煤田本部之構造、而坑下採煤所經之情形也。八道壕煤礦坑下採煤常有煤層忽焉被阻不能進採、而阻煤之地層大致為一種礫岩、礫石麤雜大小不等、初視之似為斷層所阻、然詳加觀察實有非斷層所可解釋者。接觸處有時既不類斷層面、而按斷層尋找煤層、又不可得、且各煤層非全為所阻、往往在同一地點第一二層阻絕、第四層煤仍繼續不斷。如為斷層、各煤層應均受影響、此實為非斷層之明證。但作者初次至八道壕煤礦時、卽以斷層及煤層漸次減薄兩說解釋之、此次至礦遇坑務科長王翼臣君、王君對於坑下情形極為熟習、遂與互相研究、王君極不以斷層之說為然。謂在煤層成就之後、煤田曾一度成陸、經受侵蝕、煤層一部為水冲去、成多數溝渠、及後礫石沉積溝內、而成礫岩、溝旁未冲煤層乃與礫岩接觸。此說雖近是、然似與地質原理不合、如煤田曾經成陸煤層曾受侵蝕、則地層間必有一不整合無疑、且第四煤層既未阻絕、不與礫岩接觸、則第四層當生於煤田成陸以後、不整合當在第二層及第四層之間。作者曾詢王君、兩層間有無不整合之跡、王君謂地層煤層均甚銜接、在坑下向未見不整合之形象。當作者地面調查時、在郝屯及東井之東遇一種礫岩、與坑下煤層接觸之礫岩相似、而此礫岩確在煤層之下、當時遂假定煤層與礫岩之間

或爲一不整合、礫岩曾受侵蝕、致地面凸凹不等、及含煤地層沉積凹處、煤層爲凸處礫岩阻隔、至後湖底或湖邊積平、煤遂一致平鋪、故第一二煤層段落不接爲礫岩所隔、第四煤層連續不斷也。當以此說就正於王君、王君謂坑下礫岩阻斷煤層者大致均上狹下寬、正苦解說不妥、如將不整合移於煤層之下、不但第四煤層不爲礫岩所阻、可以解釋、卽礫岩上狹下寬本爲受侵蝕時所成自然之狀、與事實亦相符合。如是則煤層斷而不續、非受斷層之影響、而爲原來沉積所成也明矣。但小斷層亦有時錯綜其間、當坑下觀察時嘗見小斷層分隔煤層及砂岩、斷層面頗爲淸晰、不過斷層於煤層之失關係較小、如設法追尋、煤層尙可獲得。但煤層自然隔阻於礫岩者、則影響於施工頗鉅。至煤系暴露所在構造似尙簡單、褶曲既無踪跡、斷層大者亦少、地層大致平整、不過稍呈彎曲之狀。自八道壕煤礦而北煤系地層延長爲西南東北方向、自礦而南地層延長向南略偏東南、煤礦開採所在正値彎曲之處、而煤系含煤部份亦以此處地勢爲高、故煤層初卽發見於此。就地勢較高之東井與地勢較低之四號井開採情形觀察、大抵構造上無大變動、不過地層在東井一帶稍爲隆起、在四號井略爲低降耳、自四號井而東北、經曹屯之西、沿鐵路而進、地勢頗爲平坦、地層似無大變動。自礦場而南至戴屯地勢亦平、地層似無褶斷之跡、但南至藥王廟三家一帶、東爲煤系下部礫岩、西爲煤系上之礫岩層、兩層相距不甚遙遠、中間煤系含煤部份分佈所在面積頗小、似地層一部受斷層之影響而沉沒者。惟上覆冲積層毫無露頭不能得事實以證明之耳。

八道壕煤田中之煤系分爲上中下三部已如上述、煤則夾於中上兩部、最重要者均在中部、上部僅有薄煤層、至下部並薄煤層而無之。八道壕煤礦在礦塲之東、台子後村以西、曾打鑽深約三百尺（英尺凡言尺均爲英尺、）結果毫未見煤、僅有暗色頁岩及砂岩、而打鑽所在地層確屬於煤系下部、可見此下部之不含煤也。夾於上部之煤層確知者爲戴屯一帶、以前曾經開採、坑井猶存、煤渣亦可目擊、據云採時煤層二三層厚各約二三尺。此外第三號及第十三號鑽雖經過上部一部、但均鑽下三百尺左右方得煤層、就地層傾斜角度推算則所得煤層露頭距西井及現採煤層之露頭頗近、距煤系上部頂部露頭甚遠、大致不屬於上部而爲屬於中部者。煤系中部煤層萃集、卽現八道壕煤礦所採者、而較厚煤層多在中部之下部、距煤系下部之礫岩頗近、且有時煤層陷入於礫岩中也。八道壕煤系爲白堊紀、煤層沉積極不規則、煤層之數目既多、厚度亦頗不一律、往往相距不遠、而厚度增減甚大、甚有全失其踪而不能尋獲其相當層者。在西井鑿坑所見煤層厚薄共計多至十餘層、而可採者不過五層、坑下第一反秤道與西井位置相距甚近、所見煤層數亦頗多、而可採者大致爲四層、在西井所見之最上厚層在反秤道內似尚未經過。東井位置距煤層露頭較近、深度較小、鑿坑所見煤層亦少、可採煤層僅有下三層、其第三層似尚不完全。北井較東井尤淺、煤層可採者只有下兩層、且兩煤層相距甚近合爲一層、而第三層僅有一小部。四號井爲最淺之井、僅有下兩層、相距甚近合爲一層。此外可藉悉煤層概略者爲打鑽所得、然八道壕煤礦所用者爲人力搗鑽、微論岩層及煤層準確厚度不得而知、卽岩石種類亦難辨別、蓋打鑽所得均爲石末、由石末而能分別岩石之種類者、甚非易易。況打鑽事均由工人任之、無有學識者在塲

監視、一日打下若干尺、即將所得石末少許送公事房、以此而定岩石種類厚度煤層位置、其能得準確之結果者鮮矣。不過煤層之有無如詳慎爲之、或亦可得其大概、至煤層厚度絕不能得其眞像也。八道壕煤礦共計已打鑽十三處、第一鑽在礦塲之東、完全經過煤系下部、未得煤層。第二鑽在礦塲之北、八道壕車站東南、經過煤系中部、得煤一層頗厚、惟中夾岩石約二三尺、煤共約八尺餘。就鑽眼位置及得煤深度推測、似與西井最上之厚層（第五層）相當。第三鑽在朱八道壕之西南、大抵經過煤系上部及中部、見薄煤五六層、按其位置似有與西井最上之厚層相當者。第四鑽在八道壕車站東北鐵道之東、經過煤系中部、見煤兩層、上層較厚、中夾岩石、似與西井最上之厚層相當。第五第六第七三鑽均在礦塲迤南附近、大抵均經過煤系下部、無結果而罷。第八鑽在北井西北經過煤系中部、見煤兩層、下層似與西井第三層相當。第九鑽在朱八道壕東鐵路以東、大抵經過煤系下部之礫岩、未見而止。第十鑽距第二鑽甚近、而在其東見煤兩層、上層似爲西井之最上層。第十一鑽在西井之西北、相距不遙、經過煤系中部、見薄煤兩層、似爲西井最上兩煤線至深處而加厚者。第十二鑽在第八第十兩鑽之間、僅見薄煤一層。第十三鑽在雙井子村之南、第十一鑽之西、大抵經過煤系上中兩部、在三百一十尺處見煤一層、厚約五尺。按鑽眼位置煤層間距推測、似爲西井所見煤層外之一層、而爲煤系中部所夾煤層之最上層也。

就開坑打鑽所得煤層頗多、厚薄相間、隨地而異、如按層分數互相歸屬、其事殊難、往往兩煤層因相隔岩石甚薄可併爲一層、而一煤層每以岩石分隔亦可分爲數層。玆僅按煤層較厚、可以開採者、及開坑打鑽所得煤層

深淺位置其數目記其厚度、由下而上、分別叙述。第一層在煤系中部之底部、距煤系下部之礫岩甚近、往往交錯而生、煤層每爲礫岩所分隔、不相連續。現八道壕煤礦盛採之西井東井北井四號井均有此層、其露頭當在東井四號井之東、向東北延長、由礦場而南、當在第九鑽之西、鐵路附近、略向東南延長、旋轉而南、煤層厚度不甚一律、每夾岩石薄層。在西井通常所採大致厚約六尺、在第一反秤道所見除所夾岩石薄層外煤厚共約九尺半。在東井煤層厚約六尺、但所夾岩石薄層有至一尺半者。在北井第一第二兩煤層相距甚近、合爲一層、共計厚約二十尺內夾岩石薄層數層。至四號井兩煤層亦併爲一層、共計厚約十七尺餘、夾岩石薄層多層。第二層與第一層相距頗近、有時合爲一層、亦常爲礫岩分隔。在西井大致煤厚約五尺、與岩石薄層相間而生、在東井煤亦厚約五尺、爲岩石薄層數層相間。在北井與第一層併爲一層、厚約二十尺、在四井與第一層合爲一層、厚約十七尺餘、均夾岩石薄層。第三層亦有時爲礫岩分隔、不相連續、因煤層常夾於一種細礫岩中八道壕煤礦稱之爲卵石層、（卵石卽礫岩）惟在西井下曾經採掘、厚約四尺、夾岩石薄層。在第一反秤道厚約八尺、間有岩石薄層。在東井北井似只見其一部、厚約二三尺、至四號井併踪跡而未獲、蓋較淺、且近露頭、僅經過第一二兩層也。北井之西北第八鑽所見之下層、似卽第三層、惟鑽下不深卽止、未及第二層第四層。在西井下下僅採少許、聞以前曾大經開採、不受礫岩分隔之影響、西井鑿坑所見厚七尺餘、夾岩石薄層、第一反秤道內所見厚在六尺半以上、中隔岩石層、打鑽所得煤層多不與此層相當。第五層在西非鑿坑所見之煤厚約五尺、中隔岩石層、由礦場而北、至第二鑽所見之煤層、似爲此煤、層厚在八尺以上、中隔岩石一層。第十鑽所見之上層似亦爲此

層、惟僅經過其一部、厚只二尺餘。再北第四鑽所見之上層、似與此層相當、厚在五尺半以上、中隔岩石一層。由礦塌而南至第三鑽所見之下兩層、似有一層與此層相當、但煤層較薄、一厚約三尺、一僅二尺有半、中隔岩石薄層。第六層爲煤系中部所含煤層之最上層、僅爲第十三鑽所經過、按其位置不與西井所見煤層相當、且就地層斜度鑽眼地位計算、距第五層頗遠、故另名爲第六層、厚約五尺。其露頭大抵在西一帶、向北當在第四鑽之西、向南似在第三鑽附近也。

煤層之數目厚度大略既如上述、茲更宜進而考究者、爲各煤層中間之距離。然煤層厚薄斷續既不一律、而現現在開採區域狹小、又未能證明煤層各部準確相當、故各煤層間距之遠近深淺、實不易考悉、卽有所考究而結果亦未必盡是。不過就各方面考察所得、略有敘述、爲將來有所參考校正而已。第一層第二層之間距離頗近、在西井兩煤層中間隔岩石薄層不過三尺、且中間尙有薄煤層、謂其爲連續亦未始不可。但在東井兩層相距稍遠、中隔岩石十餘尺、而岩石中亦夾薄煤層。至北井四號井兩層實已併爲一層、無間距之可言。第二層第三層之間距離較遠、隨地而異、在北井兩層間距不過十四五尺、在東井兩層間距約二十六尺、至西井增至三十餘尺、但在第一反秤道所得兩層間距爲二十餘尺。就上述煤層間距遠近各地不同、可證煤層或地層有時愈近地面厚度愈減、愈深厚度愈增。而反秤道所得兩層間距少於西井所得十餘尺、又可證煤層間距、實大有變遷、未能以一律論定之也。第三層第四層之間距離愈遠、兩層關係僅在西井及反秤道可悉、大概在西井鑿坑所得兩層間距約一百十四尺、而反秤道內所得約一百數尺。至第八鑽所見之下秤雖似爲第三層、而其上

層似猶第四層、或爲第三第四兩層中間之一層。第二第四兩鑽所見第五層之下、雖鑽下甚深、然未得厚煤層、其間距至是又無從推知矣。第四層第五層之間距離遠近惟在西井鑿坑時得之、約爲五十餘尺。其第二第三第四第十四鑽、雖見第五層、然第四層踪跡未能明瞭、關係不能究悉。第五第六層之間大抵相距甚遠、其關係僅就第十三鑽第十一鑽及西井之位置大致推測。第十一鑽所見之兩薄煤層似相當於西井最上之兩煤線、而第十三鑽所見煤層之露頭尚在第十一鑽之西、未嘗爲第十一鑽所經過、故以第十一鑽見煤之深度、及西井最上煤線與第五層之間距觀之、第五第六兩層中間距離當不下三百尺。此各煤層中間距離之概略也。

煤層厚度間距表（由上而下排列）

煤層	第六層	第五層	第四層	第三層	第二層	第一層
厚度	約五尺（英尺）	五尺至八尺	六尺半至七尺	四〇尺至八尺	約五尺有時與第一層合併厚十七尺至二十尺	六尺至九尺半有時與第二層合併厚十七尺至廿尺
間距	至第五層約在三百尺以上	至第四層約五十餘尺	至第三層由一百尺至一百一十四尺	至第二層由十四尺至三十餘尺	至第一層約二三尺多至十餘尺有時併爲一層	

煤質

八道壕煤田煤質不甚佳、最上者爲一種次等烟煤、而質劣者直可謂之褐炭、色雖黑而各部明暗不等、相間而生、蓋一則多含炭質、一則多含雜質也。煤含灰分甚多、水分亦高、而固定炭質有僅在百分之三十有奇者。在八

道壕煤礦坑下曾按法採集四層煤樣、由工業試驗所化驗、據化驗結果則其水分之多過於撫順。灰分之重過於開灤、實不足以稱佳煤然燃燒頗易殆亦一長。且據化驗所示第四層煤似尚可煉焦、而發熱量亦較大頗近似中等烟煤、確否似尚待證。又阜新大新公司亦曾擇其良質者而分析之、玆將各分析結果表列如左。

八道壕煤礦煤質分析表一 農商部工業試驗所分析 民國十四年

煤層	水分	揮發物	固定炭	灰分	灰色	煤性	硫磺	發熱量
第一層	一三・〇六	二七・一六	四〇・九八	一八・八〇	紅棕	不團結		克洛利 六〇五六
第二層	一一・三八	二五・八〇	三五・八四	二六・九八	紅棕	不團結		五五〇一
第三層	一三・七四	二三・九〇	三九・〇二	二三・三四	紅棕	不團結		五五七〇
第四層	九・八三	三四・三三	四八・二二	七・六二	淡黃	團結	〇・一二	七一五一

八道壕煤礦質分析表 阜新大新公司分析 十二年（？）

煤類	水分	揮發分	炭素	灰分	灰色	硫磺	煤性	發熱量

最佳煤	一三・五一	二二・九九	四五・二七	七・一三	淡橙色	○・七二	不煉焦	克洛利 六〇四八
佳煤	一三・六五	三〇・五五	四一・六八	一四・一二	暗紫色	五・六九	不煉焦	克洛利 五七九七

煤量

礦量估計結果本卽不易準確、如煤田構造眞像未悉、煤田厚度鑽探不詳、礦量計算尤無把握、蓋煤系分佈所在煤非盡可採出、而煤層旋斷旋續忽厚忽薄、實有離乎常規者。或僅以煤田面積與煤層厚度之積乘煤之比重而爲其礦量、其法雖簡其結果恐難確實。故欲求一煤田礦量之概略、須先知煤田大概之構造及煤層近是之厚度、否則妄事推算、徒感失據而已。今八道壕煤田就上所述構造大致簡單、卽有局部斷層錯動亦頗微小、不足爲害。南自田三家一帶起、北至小新立屯之西止、煤系中部分佈所在均有可採煤層。就地表觀察旣甚平整、絕無大斷層錯綜之跡、而地層傾斜緩慢、角度大致一律、又可沿層下採甚遠、使可採煤量加多、但第一二三三煤層有時受煤系下部礫岩阻隔之影響、常斷而不續、致煤田儲量有相當之減色耳。煤層厚度在本煤田內變化頗大、卽就八道壕煤礦開採一帶及打鑽地點而言已大不規則。第一二兩層在東西兩井本分而爲二厚度不同、至北井四號井兩層併而爲一、厚度竟增至二十尺。第二第四第十三鑽地位所在本可鑽得第五層下之煤層、而下鑽頗深或見薄煤層、或未見煤層、均可證煤層厚度及位置常有變遷而不循定規。茲爲力求準確計、取各煤層最近是最低小之平均厚度、作估計煤量之標準。第一二兩層常相合併厚度可相提並論、兩層之

合已知者最小數約十一尺、最大數爲二十尺、姑取其平均以下之數十二尺爲兩層總厚度。第三層厚度已知者有八尺四尺之數、而取其小數四尺爲可採厚度。第四厚層度已知者有七尺六尺半、茲以五尺爲可採厚度。第五層厚度有五尺半八尺者、茲以五尺爲其平均厚度、第六層可採厚度暫假定爲五尺。統計六層平均總厚度爲三十一尺、而假定爲九公尺。煤層之長雖隨煤系延長而定、然第一二三三層因常爲礫岩阻絕、中斷部份頗多、假定取其半數爲可採之長。而第四五六三層仍以煤系延長所及而定、計由田三家至小新立屯約八公里、即爲煤層可採之長。煤層傾斜角度不大、平均約十五度、由地面直下三百公尺以上之煤層、儘可採掘。按度數計算、煤層之寬爲一千一百六十公尺、茲再爲減縮以一千公尺爲煤層可採之寬。煤爲次等烟煤、比重較小、假定爲一・一。如是計算則八道壕全煤田煤量約爲五千九百餘萬噸。因採煤施工手續及構造種種關係不能如數採取、假定以十之七爲可以採出之數、則全煤田可採煤量約爲四千一百五十餘萬噸。但此礦量估計係以煤層延長繼續不斷而得、若煤層時有時無段落而生、則礦量更當減少。惟欲悉煤層斷續之跡、實非地表觀察所能奏效、非賴鑽探不可、故礦量估計是否準確、須視煤層厚度延長情形而定、而煤層眞像能否確識、全以鑽探結果如何爲轉移也。

礦業紀略

八道壕煤田發見之初、聞係在民國八年、於現八道壕煤礦採煤之處掘井得見煤層、即由阜新縣人劉姓呈請試採。嗣因內部發生意見、未幾訟興、由奉天巡閱使署派委調查、遂歸巡閱使出資採辦、稱八道壕礦務局、委闞

瑞廷君督辦其事、著手探採。後改隸奉天礦務總局、以王正黼君爲總辦、置備機器、規模大具、資本二百萬元、礦區面積約三方里、總局在奉天總辦駐焉、礦場有礦長分設坑務庶務會計各科。現有坑井六處、豎井四、一爲西井深約三百八十尺見可採煤層五層、一爲東井深約一百二十尺見煤三層。一爲北井深約八十尺、見煤三層。一爲四號井頗淺、見煤二層。斜坑二、一坑在東井西井之間、斜深頗遠、下與西井通。一坑在四號井之北、頗淺、尚未採煤。機器出煤用鋼繩捲揚機、出水用唧筒、發動力爲汽力機器、由奉天及天津購製。採煤係包工、每噸小洋二元五角、通風爲自然通風法、點燈工人用油燈、職員用水月電燈、支拄用本地產楊柳木等。工人現約三百餘人、日出煤約二百五十噸。煤價在礦場塊末平均每噸奉小洋十六元、運銷京奉路沿線及奉天省城、聞近年來每年可盈餘數十萬元。

熱河朝陽煤田地質

譚錫疇

北票煤田在熱河朝陽縣東北、約九十里。由京奉鐵路錦州站有支路、約二百三十里、直至北票。民國十二年冬、承北票煤礦公司之邀、調查北票煤田地質、並順道沿錦朝鐵路觀察。該煤田地質概況曾由丁在君先生調查測有縮尺二萬四千分一之地質圖、地層次序煤系暴露均劃分明確、頗可導循。惟煤田一帶紅土頗厚、到處分佈、不但地層露頭爲其所掩、而地層起伏錯綜之跡更難究悉其端倪。此次調查擬就已知事實、推究構造狀況、但所得事實頗少不足以資考究、姑就觀察所及、述其梗概如次。

(一) 地層

北票煤田地質與中國北部他處中生代煤田地質稍異、他處煤田煤系之下或卽接二疊三疊紀地層、或與各代地層成斷層之接觸、而北票煤田煤系之下有火山岩層、煤系上下兩部均含煤層、下部煤層重要、隨煤系地層向兩方延長。上部煤層若斷若續、延長不遠、並夾昆虫及葉鰓類等動物化石。煤系之上復有火山岩層似與各處凝灰礫岩層相當。

石英岩層　新元古界卽震旦紀地層、分爲上下兩部、下部爲石英岩、上部爲矽質灰岩。石英岩在北票煤田分佈不廣、惟於東部見之。尖山子村東南均其暴露之所。岩石爲白色硬石英岩、與中國北部他處所見相似、下與他地層之接觸未能目擊。

矽質灰岩層　震旦紀之矽質灰岩沿煤田南緣暴露頗廣、組成一帶山嶺、僅目擊其一部、岩石爲灰岩、質不純、

色灰或白、往往含矽質。所見者均與他層成斷層接觸在煤田西部台吉營子東北、尖山子之東、有灰岩露出、大致亦爲本層之物。暴露面積狹小、四周環以火山岩。

以上震旦系地層、與下火山岩層之接觸似均成不整合關係。

下火山岩層　分佈於煤田南部下與石英岩層矽質灰岩層大抵均成不整合之接觸。岩石爲凝灰岩凝灰礫岩夾火山岩流、色多綠及棕赤有時火山岩流占全層重要位置、凝灰礫岩不甚發育、故未便直稱凝灰礫岩層、暫以火山岩層名之。全層厚度大抵西部較薄約三百六十米突、東部較厚約五百米突。

下煤系　位於下火山岩層之上、大抵成整合接觸。以砂岩頁岩爲主、夾礫岩及粘土、並含重要煤層、有時有火成侵入岩層沿層面而生。砂岩質有粗細硬軟之別、色分黃灰綠灰白。往往含黃鐵鑛。頁岩或爲砂質或爲泥質、色有灰黑綠藍之分。礫岩在下部較粗、上部較細、有時爲層頗厚、不下百尺。有時甚薄、厚約數寸。礫石或爲石英岩所成、或爲火成岩組成、粘土爲灰色、層均不厚。與煤層接近之黑灰色頁岩內往往含植物化石、以Baiera sp及Zamites sp. 等爲最常見。

上煤系　以砂岩及泥質頁岩爲主、間有礫岩、有時並夾煤層。砂岩多黃色及淺綠色、間有灰色、有時質粗硬頁岩多泥質、色多灰色及淺綠色、亦有呈黑色者、往往夾煤層、砂岩變粗爲礫狀、而礫石聚集多處成礫岩、色爲淺綠、及黃色淺綠黃色砂質頁岩內夾昆虫化石 Samarura, 砂岩內有葉鰓類化石 Corbiacia 及植物化石、全層頗厚、粗計之不下一千五百米突。

以上二煤系似相緊接、但下煤系煤層較厚、煤質較佳、似屬侏羅紀。上煤系昆虫類及葉鰓類化石與作者曾在山東白堊紀地層所發見者同、似屬白堊紀。

上火山岩層　位於層系之上似成整合之接觸、分佈於煤田北緣、組成西北一帶山嶺。岩石爲凝灰礫岩、凝灰岩、及火山岩流。色多綠及棕、礫石多由火山岩及石英岩所組成、全層甚厚、目擊者只下部一少部份、火山岩層有時極發育、凝灰礫岩往往不占重要位置。

由義縣至北票煤田沿途所見地層爲綠紫棕灰各色砂岩頁岩及火山岩流凝灰礫岩等。由義縣至四方台爲淺綠黃色砂岩及棕紫灰色泥質頁岩確爲義縣煤系之上部、其上卽火山岩層、分佈廣遠直至朝陽寺。由朝陽寺至北票煤田南端、除小嶺上部有時有火山岩流凝灰礫岩外、均爲綠紫棕灰砂岩頁岩時代似當與義縣煤系之上部、及北票之上煤系相當。其上之火山岩流凝灰礫岩卽屬於上火山岩層者也。

（二）　構造

北票煤田構造大致雖尚簡單、但紅土堆積頗厚、地層露頭甚少、故摺曲形狀斷層踪跡往往不易究悉。就觀察所知地層除局部偶有變動外大致均向東北正北西北三方傾斜。在煤田西部煤系地層大致傾斜西北偏北、有時偏西、傾斜較陡、斜角由五十四度至八十五度、偶有平緩至三十度者。上火山岩層大致向北傾斜、斜角約六十度、在尖山東矽質灰岩傾斜方向極不一致、或向西北偏北斜角六十六度、或向西南偏南斜角由四十二度至六十度、或向東南偏南或偏東斜角由十度至三十度、或向南斜角由三十八度至八十度。在煤田中部、下

矽質灰岩或向西北偏西傾斜、或向東北偏東傾斜、斜角有時較小約二三十度、有時頗大在八十度以上、地層間有垂直立者。下火山岩層傾斜西北稍偏西斜角至小五十六度、地層有時直立。煤系地層大致傾斜西北或偏北或偏西、斜角四十度左右者爲最常見有時平緩至十八度、有時直立。亦有傾斜向北稍偏東北者、斜角由三十度至四十五度。在煤田東部石英岩向西北偏北傾斜、斜角由四十二度至七十六度、矽質灰岩傾斜西北偏北或正北或北稍偏東北、斜角頗大由六十二度至八十二度。下火山岩層傾斜向北或偏西北或偏東北。煤系地層大致傾斜向北或偏東北或偏西北、地層傾斜較緩、通常三四十度、斜角至大五十六度小至二十度。上火山岩層傾斜向北。斜角約四十二度。總之北票煤田地層多向西北偏北傾斜、有時向東北偏北或正北傾斜、斜角由三十度至五十度者爲最常見、不過地層有時摺曲異向、局部稍有改變耳。

北票煤田紅土遍佈、露頭極少、大斷層尙可追尋、小斷層只能由所知情形推究假定、確否未可斷言也。三家子之東有一南北斷層、係由地層分佈及層向斜向推究而得。在三家子西層向大致西南東北斜向西北、在三家子東層向大致東西斜向北、其改變之處似非由摺曲而成、乃爲斷層所致。且三家子西北上火山岩層不與東北上火山岩層連絡、其間似有斷層分隔。斷層踪跡大致經過三家子村東部、向南北延長、似爲一平推斷層、地層上下錯動之跡不著。又在馬路兩邊有斷層二、互相平行、其踪跡係由馬路坑下工作所遇而得、坑下採煤東西均遇斷層、煤系一部與下火山岩層顯成斷層之接觸。且由地面觀察亦似能得其跡、馬路北山上火山岩層一部似受斷層之影響稍向南移、蓋斷層實爲平推斷層也。又岳家溝兩旁亦似有兩斷層、互相平行、據土人云

寶聚窰舊有馬路（即斜坑）四、其東馬路向東採掘約百餘尺、即見斷層、其踪跡似與岳家溝西之斷層相合、又夏家窰開採時五槽煤東見斷層、其踪跡似與岳家溝東之斷層相合大致亦爲平推斷層。又大井下東見一小斷層錯動極微白灰色砂岩與煤層接觸。

由義縣車站至北票煤田中間所經、無重大褶疊、惟地層起伏不平傾斜有差。義縣四方台一帶煤系上部地層大致傾向南稍偏西南、斜角約在三十度左右、由四方台至朝陽寺爲上火山岩層分佈之所、層向斜頗不淸晰。由朝陽寺至涼水河爲煤系上部及上火山岩層分佈所在。在張子店南嶺一帶地層傾斜向東、有時稍偏東南、斜角約十四度。在大梨樹溝一帶大致傾斜西南或稍偏南或稍偏西、斜角由十二度至三十度。在涼水河一帶層傾斜向東或向北或向東北、斜角由十五度至二十二度。落等營子南矽質灰岩大致傾斜西北偏西、斜角由二十六度至四十五度、亦有向南傾斜者、蓋局部變動也。斷層可見者惟涼水河北有一大斷層、大致成東西向仰側爲矽質灰岩層俯側爲煤系上部、且仰側之矽質灰岩即北票煤田南部之矽質灰岩。

（三） 煤層

煤田雖居山嶺之中、而煤層所在地勢大部平坦、有南北兩嶺中夾闊谷、即煤田所在。南北兩嶺山勢較高、最高峯巔高於煤田低地約三百餘公尺。煤田又可分爲東西兩部、西部爲涼水河流域、東部爲馬牛河流域。中有分水嶺由涼水河而東北、溯支流而上、至北票煤礦馬路附近、地勢高於涼水河約一百二十公尺。由馬路而東、順河渠而下、至尖山子以南、地勢低於馬路約一百二十公尺。而東馬牛河主幹、與其旁支又爲小分水嶺分隔、地

勢高於兩旁低地、不過五六十公尺而已。自凉水河而西、地勢平坦、至台吉營子附近、有小山突起、高於凉水河、約二百公尺。再西地勢以次而降抵於河岸。

（層次）　北票煤田可採煤層均夾於下煤系、下部數目厚度既各處不同、位置間距亦隨地而異。在煤田西部凉水河以西曾鑽採兩處其第十一號鑽見煤八層由上而下第一層厚十五尺、（英尺）第六層厚約四尺六寸、第八層厚約五尺六寸、尚可開採、餘均薄層不至二尺。在煤田中部凉水河以東、三家子以西、打鑽開坑所得煤層數目厚度頗不一律。在北票煤礦大井以西附近曾鑽採三處、其第一號鑽見煤五層、第三層厚約七尺、第五層約六尺、可開採、餘至厚一尺六寸。第二號鑽見煤十層、第五層厚約四尺第六層厚約五尺、第十層厚約七尺六寸、餘最厚約二尺。第八號鑽所見煤層頗多、第十二層厚約八尺、第十六層厚約四尺、可開採、餘最厚約三尺。在三家子以南曾鑽採兩處、一見煤兩層、最厚者約四尺、一見煤三層、均甚薄。北票煤礦開鑿大井見煤十層、第三層厚約五尺六寸、夾頁岩一層、第六層爲大煤層夾頁岩砂岩數層、煤共厚約十八尺十寸、有時增至二十尺以上。第九層由四尺至六尺可開採、餘最厚約三尺。在三家子大井之間鑿馬路所見煤層頗多第九層厚約七尺、（卽馬路所稱第五層）第十四層厚約六尺三寸（卽馬路所稱第八層、）第十五層夾頁岩數層、煤共厚約十尺八寸、（卽馬路所稱第九層）餘最厚約三尺六寸、有時或可開採。據土人舊日採煤所見煤層厚度數目亦隨地而異。在大井老道營子之間、寶聚窰見煤六層、由上而下第三層土人名小槽子、厚約十尺、（營造尺土窰均用此尺）第五層名五槽、厚約六七尺、爲通常開採煤層、餘最厚約三尺、寶聚窰迤東永聚窰所見小

槽子煤層厚約八尺、五槽煤層厚約五尺。再東至夏家窰亦曾見煤六層、第一層厚約八尺、第三層卽小槽子厚約八尺、第五層卽五槽厚約四五尺、第六層厚約四尺。大井西南石家窰曾採此層、其第二第三四兩層厚均約三尺。再東至陶公銘窰僅見煤兩層、一土人名爲頂骯髒槽、謂與北票煤礦大井所遇之大煤層（亦稱頂槽）同爲一層、厚約三十尺。一名爲小槽子、西部厚約四尺、東部厚約六尺。

在煤田東部三家子以東馬牛河以西曾鑽探三處、第五號鑽見煤六層、第一層夾頁岩煤共厚約四尺、第四層厚約八尺、第六層厚約六尺、餘最厚約二尺六寸。第六號鑽見煤九層、第二層厚約六尺、第四層厚約二十尺、第七層厚約四尺、第八層厚約七尺、餘最厚約三尺六寸、第七號鑽見煤六層、第四層夾砂岩一層煤共厚約十七尺、第六層厚約五尺、餘最厚約三尺。

就所述煤層厚度觀察、在煤田西部煤層可採者有三層、煤田中部可採者亦有三層、煤田東部可採者有時多至四層。但煤層數目厚度隨地而異、中間距離高低不同、故可採煤層之位置頗難比較。據土人所稱有頂槽、腰槽、底槽、爲通常開採之煤層。北票煤礦大井所見之大煤層、土人謂與頂槽相當、卽陶公銘窰所採之頂骯髒槽。但陶窰曾採煤兩層、頂骯髒槽之下卽爲小槽子、再下向未見煤層、聞曾向南開鑿三百餘尺、未嘗見煤。且就老君廟東南溝地層露頭觀察、小槽子煤層以下似不含重要煤層。此似可證明北票煤礦大井可見之大煤層非絕對爲可採煤層之頂層、而其下未必尙有兩厚煤層可以開採。據觀察所得、北票煤礦大井之大煤層似爲腰槽與陶窰所採之大槽同爲一層、陶窰與大井相距不遙、陶窰大槽之下僅有小槽子一層可採、厚由四尺至六

尺。大井大煤層之下雖見煤數層、而可採者亦只一層、厚亦由四尺至六尺、與陶窰小槽子似同爲一層、或卽爲可採煤層之底槽、而其下未必尙有可採煤層也、煤田內有可採煤層三大抵確定、大井大煤層及陶窰大槽旣同爲腰槽、而其上當復有頂槽可以開採。但聞陶窰大槽之上未嘗見可採煤層、而大井大煤層之上所見煤層較厚者約五尺、此層如爲頂槽、則頂槽腰槽底槽大井均已得之。如此層爲三層外之一層、而其上當更有所謂頂槽者、似可由大井下向北鑽探得之也。

煤層厚薄有無生成時原不一律、隨地而變、故煤層位置比較有時極不準確。今僅就打鑽開坑所得煤層間距地層特徵、互相比擬、用備參考。北票煤田可採煤層大致分爲上中下三層或以頂槽腰槽底槽名之。但有時亦不完全、一部漸次減薄、不能開採。由煤田西部至東部第十一號鑽之第一層、寶聚窰之小槽子、第一號鑽之第三層、第八號鑽之第十二層、第二號鑽之第六層、大井之第三層、似均爲可採煤層之上層或頂槽。第十一號鑽之第八層、寶聚窰之五槽、第一號鑽之第五層、第八號鑽之第十六層、第二號鑽之第十層、大井之大煤層、陶窰之頂骯髒槽、馬路之第十五層、第五號鑽之第四層、第六號鑽之第四層、第七號鑽之第四層、大約均爲可採煤層之中層或腰槽。石家窰五槽下之煤層、大井之第九層、陶窰之小槽子、第五號鑽之第六層、第六號鑽之第八層、第七號鑽之第六層、似均爲可採煤層之下層或底槽。此不過就相同之點大致比較、確否固尙難斷定也。

（煤質）　北票煤田煤系有二、一爲侏羅紀煤系、含有烟煤、一爲白堊紀煤系、含褐煤或次等烟煤。現盛採者爲侏羅紀煤、白堊紀煤停採已久、故煤質可述者爲侏羅紀煤。煤質猶多各處不同、往往同一煤層質亦有差、如北票

煤礦大井所採大煤層在民國十二年所採部份煤質頗佳、比開灤煤有過之無不及。民國十四年所採部份、則不甚純潔、層內含泥灰頗多。但均爲有烟煤可煉焦。茲將北票煤田煤質分析結果分別表列如次。

北票煤田煤質分析表一 穆勒 (W. A. Moller) 分析

地點或煤層	水分	揮發分	炭素	灰分	硫黃	發熱量
岳家溝?	四•○○	三五•五○	五二•五○	八•○○	無	一三○○○英熱量
岳家溝?	二•五○	二八•五○	六四•八○	四•二○	無	一四四○○英熱量

北票煤田煤質分析表二 農商部工業試驗所分析

地點或煤層	水分	揮發分	焦炭	灰分	灰色	硫黃	煤性	發熱量
岳家溝	一•七四	三三•二九	六四•九七	一九•七八	棕	○•三九	煉焦	六○五○

北票煤田煤質分析表三 日本中央試驗所分析 民國七年及九年

煤層或地点	水分	揮發分	炭素	灰分	灰色	硫黃	焦性	發熱量

岳家溝	一三・一九	三六・〇五	三七・九五	一二・八一	黃	〇・六七二	不粘結	五四二五克洛利
寶聚窰	一・四五	三五・四四	五五・九五	七・一六	淡紅	〇・七三	粘結	六九七五克洛利

又最近逐層分析可參閱本期內翁著中國煤質分類

（煤量）　北票煤田面積寬廣、可採煤層亦厚、統言之頗有價値。但地質構造不同、火成岩石侵衝有差、致各部優劣不等、礦量亦異。玆分部估計、俾資參考。煤田最佳部份計有三處、一爲由老君廟至凉水河中間一帶、包有北票煤礦大井第一第二第八三鑽及舊日開採各窰。東部大井及第二號鑽雖有火成岩、但踪跡頗少、似不爲害、而可採煤層較厚。西部第一號鑽及各舊窰可採煤層雖薄、但地面平坦、火成岩絕跡、斷層於煤礦工程亦無大碍。總計此部之長約爲千七百公尺、卽爲煤層可採之長。煤系地層傾斜較大、由二十八度至六十八度、平均四十八度、假定距地面直下六百公尺以上之煤可以採掘、則煤層可採之寬約爲八百公尺、煤層可採者計有二層、上層厚由五尺至十尺、平均厚約七尺（英尺。）中層由四尺至三十尺平均厚約十一尺、下層由四尺至六尺平均五尺。三層總計平均厚二十三尺、計七公尺。煤爲烟煤、比重爲一・二、則此部煤量約爲三千一百餘萬噸。二爲由凉水河至台吉營子西山中間一帶、地勢平坦、除西山有火成岩外、他處踪跡頗少、而可採煤層亦不薄。此部之長約爲四千公尺、卽爲煤層可採之長。煤系地層在台吉營子以東傾斜較緩、平均當不過四十度左右、煤層可採之厚亦以八百公尺計。據第十一號鑽所得煤層可採者三層、一厚約十五尺、一厚約四尺六寸、

一厚約五尺六寸、總計約二十五尺、合七公尺半、計此部煤量約爲二千八百餘萬噸、三爲竇家店以東札藍營子以西、包有第五第六第七三鑽鑽探之區、地勢大半平坦、惟西部第五號鑽一帶火成岩頗多、於礦區價值稍有影響。東部第七號鑽及第六號鑽之間鑛區甚佳、此部之長約三千六百公尺、卽爲煤層可採之長、煤系地層傾斜由二十六度至五十六度、平均約四十度。假定煤層可採之寬亦爲八百公尺。第五號鑽見可採煤層三層共厚十八尺、第六號鑽見可採煤層四層共厚三十七尺、第七號鑽見可採煤層二層共厚二十二尺、總計平均厚度爲二十五尺合七公尺半、卽爲煤層可採之厚。估計此部煤量約有二千五百餘萬噸。此外由老君廟至北票煤鑛馬路一段舊窰跡頗多、當有煤層可採、不過厚度未悉。在馬路兩旁有斷層、鑛區稍受影響、由馬路經三家子至竇家店一段、曾打第九號鑽、最厚煤層只四尺、就打鑽位置觀察、鑽眼稍偏南方、應於三家子村附近打鑽或得較厚煤層。不過此段亦有斷層、鑛區或不甚佳。由老君廟至竇家店共長約五千七百公尺、因有斷層有時不能開採以五千公尺爲煤層可採之長、亦以八百公尺爲煤層可採之寬。據馬路所採煤層可採者總厚約二十四尺、計合七公尺。但他處煤層厚度不詳、平均計算、假定以五公尺爲煤層可採之厚。估計此段煤量約爲二千四萬噸。煤田東部過馬牛河尚有煤系、惟至三塊石頭溝南、阻於斷層、長不過二里、據云煤層甚薄、最厚者不過四尺、僅可用土法開採。又煤田西部台吉營子西山以西、亦有煤系、惟火成岩侵衝甚烈、不能大採、亦僅可用土法掘挖。煤田東西兩端鑛區不佳、煤量頗微、故不計入。總以上所述四部、共計煤量約一萬一千餘萬噸、此審愼計算北票煤田鑛量之大略也。

（四）礦業

北票煤田久經開採、故各處舊窰踪跡甚多。在北票煤礦未開辦以前、由老道營子至老君廟一段、開採頗盛、著名者有寶聚窰、永聚窰、夏家窰、石家窰、陶公銘窰、老君廟至馬路寶家店至札籃營子西部台吉營子均有小窰。北票煤礦自民國六年開辦、歸京奉鐵路局經營礦區七十五方里五百零四畝、工程由礦師英人穆勒（W. A. Moller）佈置打鑽開坑、規模略具。民國九年有官商合辦之議、該礦邀請地質調查所丁所長赴礦調查計畫鑽探指定打鑽地點、由瑞典打鑽公司承辦。十年經交通部批准由官商合辦、定名北票煤礦公司、聘丁在君先生爲總經理、資本洋五百萬元、官股二百萬元、商股三百萬元、每股一百元。共五萬股。一面在岳家溝鐵匠營子之間開鑿大井、在池家溝以南開鑿斜坑、一面收買各土窰取消土法開採、減礦區面積爲五十一方里四百三十六畝餘、又增煤田西部台吉營子礦區九方里四百二十七畝餘、及興隆溝煤田礦區六方里二百零九畝餘、規模大具。民國十二年冬大井工程大致就緒、預備安設機器斜坑、（馬路）日出煤約一百噸。民國十四年春大井一面出煤、一面裝置電機、產額日約二百五十噸。預計將來電機安妥大井日可出煤約一千噸、有大井二、均深六百英尺、第一號大井現用汽力捲揚機、第二號大井將來用電力升降機。第一號大井經過可採煤層二層、第二號大井經過可採煤層一層。在井下已見可採煤層三層。斜坑斜深約九百六十尺、經過可採煤層三層。出煤大井用捲揚機、斜坑用捲拽機。出水用喞筒、通風現用自然通風法、點燈用安全燈、支柱用本地產各種木料。工人因工程未設人數不定、現約五六百人。運銷錦朝鐵路由京奉鐵路之錦縣車站直達北票煤礦礦場、煤進

至錦縣約半日程、銷售於京奉鐵路由山海關至奉天一段。由溝帮子轉至營口、再運往上海、滬寗滬杭鐵路沿線均有分銷廠。售價在民國十四年調查時在礦場每噸大洋七元、營口每噸大洋十元零五角。

中國石炭之分類

翁文灝

一 緒言

中國石炭之富亦既久著、惟於其種類之分別、成分之差異、則似尚少研究及之者、卽實際用途、亦復不求甚適、少加別擇、以致効用不著、損失孔多、良可惜也。

石炭分類一依分析、分析有二種、一曰元素分析、(Ultimate analysis) 詳求其元素成分是也。二曰實用分析(Proximate analysis)僅分析其水份揮發份定炭灰份等是也。中國石炭曾經爲元素分析者爲數尚少、可資以爲分類根據者惟有求之于實用分析、爲此類分析之記載者、如第十二次萬國地質學會編印之世界煤礦誌、以及日本地質調查所迭次出版之石炭分析表、皆可參考。較近如農商部工業試驗所報告類刊、中有石炭分析甚多。又如山西有礦產調查化驗報告書、開灤及福中公司對於他處煤礦、略有分析、均曾有專家報告刊行。然以採集及化驗者之不一、其人不一、其法、標本既多偶得、分析復少標準、以故所得結果、往往不易比較。茲欲藉以分類、極須慎加選擇、方可資爲根據。茲篇所取別擇衡量、頗費經營、然亦未敢以爲盡臻至當也。

現有分析中大抵揮發份及定炭比較稍爲可靠、水份多少視乎標本採集之久暫、與夫所受溫度濕度之差異、方法既少標準、得數卽較參差、而以發熱量一項尤爲難信、中國各試驗所既因缺乏儀器、所得結果崎少崎多恆越常理、卽日本分析表中、亦間有未敢盡信者。夫分析結果貴符實際、明知其謬、不如其無。然發熱量之大概數目、往往可以公式求得之、尤以顧塔爾法(Goutal's Method)最爲簡確、屢加試用其錯誤常在百分之三以下。

故以現在中國石炭分析方法之不完密、對於發熱量一項、與其援用極不可靠之試驗結果、不如用顧塔爾公式求得約數之爲愈也。

本篇第一表中共列中國石炭三十一處、每處分析皆求其比較足以代表大多數產量或主要煤層之平均成分、姑將以此爲根據而求其分類、然所得可靠分析爲數既少、錯誤之處在所不免、且同一煤礦煤質變化往往因層因地而不同、要未可一概而論、一言斷定原不可能、茲惟用佐大略比較、不可援以精密定價、特誌於此以免誤會。

第一表　中國重要石炭分析表

省區	礦地	水份	揮發份	定炭	炭份	發熱量
京兆	門頭溝	二•三	六•五〇	七五•二〇	一五•〇〇	（克洛利）七〇五七
直隷	開平	〇•六	二五•九八	五九•七八	一三•三四	七四一三
直隷	井陘	〇•五六	二〇•二〇	六九•二〇	九•二〇	七八三六
直隷	臨城	一•八九	三〇•八八	五六•六四	一〇•五〇	七五四五
直隷	柳江	〇•七〇	六•五七	七七•五七	一五•二〇	七二六二

直隸	怡立	一•六〇	一九•〇〇	六八•五〇	一〇•三〇	七六五〇
熱河	北票	三•二五	三〇•五〇	五四•二五	一一•〇〇	七三三五
熱河	新邱	二•〇〇	三五•〇〇	四二•五〇	一〇•〇〇	六〇九〇
奉天	撫順	六•七三	三九•三四	四八•一五	五•二五	六七八〇
奉天	本溪湖	〇•六八	二三•九五	六四•〇七	一一•二〇	七五〇八
奉天	烟台	一•一五	一二•〇〇	七一•二〇	一四•七〇	七一九八
奉天	八道壕	一二•六五	二〇•五五	四一•六八	一四•一二	五三六九
吉林	長春	一〇•八〇	三二•五〇	四五•一六	一一•一二	六二七〇
黑龍江	湯源	一•五〇	三二•二一	五八•一四	七•五〇	七七三一
黑龍江	札賚諾爾	二〇•九三	三六•三五	三九•〇三	三•六九	三四四三(?)
山東	中興	〇•五〇	二七•〇〇	六三•五〇	九•四〇	七八五三

山東	淄川	○•五七	一四•九○	七四•七○	一○•○○	七八二一
山東	博山	○•八五	一八•九○	六九•八○	九•八五	七八八四
山東	坊子	二•八○	三○•七○	五一•八○	一四•七○	六九四八
河南	六河溝	○•五五	一九•一六	七二•○五	八•四○	七九七七
河南	焦作	○•六五	六•七○	八四•五○	八•○○	七八六七
河南	澠池	九•六	三二•五○	四五•四○	一三•五○	六二五八
山西	大同	四•五○	三○•九九	五九•四五	五•五○	七八一九
山西	平定	○•七八	六•五五	八六•三五	五•七○	七九九八
山西	澤州	一•八○	九•三五	八○•八○	七•八○	七八四一
江西	萍鄉	一•三五	二三•七五	六二•七五	一一•八○	七五八○
江西	樂平	一•○○	四五•九○	四四•○○	九•一○	五五五○(?)

江蘇	賈汪	一·三五	二九·五四	五一·五〇	一七·六〇	七〇六四
安徽	舜耕山	〇·八五	三四·九〇	五四·七五	九·五〇	七三八五
安徽	宣城	〇·七五	二六·四七	四九·七七	二三·〇〇	六五六八
浙江	長興	〇·九四	三七·七〇	四九·八〇	一〇·九〇	六九一三

二 以純燃質爲根據之分類

石炭成分中惟揮發份及定炭二者爲可燃體、中含碳素及氫素、可燃燒而發熱、灰份係不可燃之雜質、水份雖含氧素、而已充份氧化、不可再燃、故論石炭之性質、實應以揮發份及定炭爲主體、即所謂純燃質 (Coal Substance) 是也。惟以此爲分類之標準者、又有數法、(一) 格魯納法 (Grüner) 創於法人格魯納氏、假定水份及灰份爲零、而算出純燃質中之揮發份百分數、即以作爲分類根據、此法歐洲大陸用者最多、(二) 波爾登 (Boulton) 分類法、根據相同、而類別有異、曾適用於英國南威爾斯石炭、(三) 拂雷社 (Frazer) 分類法、始適用於美國之本皆爾佛尼亞州、以定炭除揮發份而求其比例、名曰燃率 (Fuel ratio) 美國用之最廣、以此諸法施之於中國各石炭則得結果如第二表。

第二表　中國石炭純燃質分類表

次序	礦名	純揮發份	格魯納法	波爾登法	燃率	拂雷耐法	主要用途
一	平定	七•〇五	無烟炭	無烟炭	一三•二	無烟炭	家用爐灶
二	焦作	七•三四	無烟炭	無烟炭	一二•六	無烟炭	家用爐灶
三	柳江	七•八〇	無烟炭	無烟炭	一一•五	半無烟炭	家用爐灶
四	門頭溝	八•〇〇	無烟炭	無烟炭	一一•五	半無烟炭	家用爐灶
五	澤州	一〇•三八	瘠炭四分一肥	無烟炭	八•六	半無烟炭	家用爐灶
六	煙台	一四•一六	瘠炭二分一肥	多碳炭	六•二	半烟炭	蒸汽
七	淄川	一六•四四	瘠炭二分一肥	半烟炭	五•八	半烟炭	蒸汽
八	博山	二〇•二〇	短焰肥炭煉焦炭	半烟炭	三•七	烟炭	蒸汽及煉焦焦甚重
九	六河溝	二一•一三	短焰肥炭鍊焦炭	半烟炭	三•八	烟炭	蒸汽及鍊焦焦甚重
一〇	怡立	二一•七一	短焰肥炭鍊焦炭	半烟炭	三•六	烟炭	蒸汽及鍊焦焦甚重
一一	非陘	二三•五七	短焰肥炭鍊焦炭	半烟炭	三•四	烟炭	蒸汽及鍊焦焦甚重
一二	本溪湖	二六•〇七	肥炭（冶金用）	烟炭	二•七	烟炭	鍊焦焦重
一三	萍鄉	二六•二〇	肥炭（冶金用）	烟炭	二•五	烟炭	鍊焦焦重

一四	中興	二九•八四	肥炭（冶金用）	烟炭	二•四	烟炭	鍊焦焦重
一五	開平	三〇•三〇	肥炭（冶金用）	烟炭	二•一	烟炭	鍊焦焦重
一六	八道濠	三三•〇二	長焰肥炭 瓦斯炭	烟炭	二〇	烟炭	焦鬆散
一七	臨城	三四•一三	長焰肥炭 瓦斯炭	烟炭	一•八	烟炭	焦鬆散
一八	大同	三四•一五	長焰肥炭 瓦斯炭	烟炭	一•九	烟炭	焦鬆散
一九	宣城	三四•七七	長焰肥炭	烟炭	一•九	烟炭	焦鬆散
二〇	湯源	三五•六五	長焰肥炭	烟炭	一•八	烟炭	焦鬆散
二一	北票	三五•八七	長焰肥炭 瓦斯炭	烟炭	一•八	烟炭	焦鬆散
二二	賈汪	三六•四五	長焰肥炭 瓦斯炭	烟炭	一•八	烟炭	焦鬆散
二三	坊子	三七•二一	長焰肥炭 瓦斯炭	烟炭	一七	烟炭	焦鬆散
二四	舜耕山	三九•〇二	長焰肥炭 瓦斯炭	煙炭	一•五	煙炭	焦鬆散
二五	澠池	四一•七二	長焰光炭	過煙炭	一•四	亞煙炭	不粘結
二六	長春	四一•八四	長焰光炭	過煙炭	一•四	亞煙炭	不粘結
二七	長興	四三•〇五	長焰光炭	過煙炭	一•三	亞煙炭	不粘結
二八	撫順	四四•九六	長焰光炭	過煙炭	一•二	亞煙炭	不粘結

二九	新邱	四五•一六	褐炭	過煙炭	一•二	亞煙炭	不粘結
三〇	扎賚諾	四五•五五	褐炭	過煙炭	一•一	亞煙炭	不粘結
三一	樂平	五一•〇五	褐炭	過煙炭	〇•九	亞煙炭	不粘結

拂雷社分類法用者雖廣、然卽在美國已有人評爲止能應用於燃率較高之石炭、對於燃率較低者則殊嫌分別太少。其烟炭一類包含過廣、至少可將燃率二以上及二以下者、分爲二類。燃率二以上者、大抵適於鍊焦、其在二以下者、則不適鍊焦。又燃率一・五以上者與一・五以下者、亦頗不同、蓋一・五以下者、漸近於褐炭也。然凡此分別、在格魯納分類法中均已計及。故此在同一原則之諸分類法中、格氏分類不特發表最早、抑亦分配最適也。此分類在歐洲大陸用之頗廣、而在英美二國則不甚採用另創分類者、殆以格氏所用法文名詞稍嫌繁冗、不易轉譯故歟。

觀上表卽見燃率高下之次序、與純揮發份（卽純燃質中之揮發份）數目之次序實無以異。惟燃率爲數較簡、便于記憶、是其勝處。故燃率八以上者、爲無烟炭。四五至八、爲不適鍊焦之半烟炭、卽蒸汽炭 (Steam Cool)。燃率三至四・五爲焦質最佳之烟炭。然二三之間者、亦甚適製焦。燃率一・五至二者爲瓦斯炭 (Gas Coal)。復下則爲亞烟炭 (Sub-bituminous) 卽英國所稱之木生炭 (Splint Coal) 及褐炭、二者之間、界線不甚清楚、往往有以有無木理爲是否褐炭之標準者。

以上分類之結果對於中國石炭之位置、亦有不妥之點。例如以八道濠石炭與開平及臨城並列、在稍知此三

處石炭之性質者、當即知其失當。蓋開平臨城之炭質、實遠較八道濠為優也。又如澠池長春之炭、甚不優良、而分類位置反在長興之上。即置之撫順之上、恐亦有嫌其未可者。又如大同與臨城並列、而實際經驗、則大同炭殊不及臨城之較適製焦。又如樂平炭之分類位置乃反在札賚諾爾之下、頗覺出乎意外。此皆分類結果之與實際炭質不甚符合之處、而不得不謂為分類法之缺點者也。推其所以致此之由。良以上述各分類法、僅計及揮發份與定炭、而其他成分如水份及灰份則悉置不問、且假定為無、實則水份之影響炭質者、甚為重要。故近代炭質分類、已漸有並為顧及之趨勢矣、

三　兼顧水份之分類

石炭分類兼顧水份者又有多種、較為知名者、為多林(Dowling)分類法、以揮發份分作兩半、以一半與定炭之和作為分子、又一半與水份之和作為分母、名其比例曰分揮燃率 (Split volatile ratio) 意蓋以為揮發份之碳素及氫素一部分已受氧化、不全能燃、茲假定其約居半量、則炭質中真能燃燒者、與不能燃燒者二部份之比例、即為分揮燃率。此法初用於坎拿大之石炭分類、嗣後第十二次萬國地質學會又以此法與拂雷社之燃率二者參合兼用。燃率較高之石炭以燃率為分類標準、燃率低者、則以分揮燃率為分類標準、蓋燃率較低者、水份重、僅計燃率其失有如上述、故改用分揮燃率藉為救濟也。然同一分類而應用二種標準、則其間分界殊難確定、似亦非為善法。萬國地質學會之石炭分類法迄今從者殊少、殆以此也。又一法則逕以水份加入揮發份之中、以其和與定炭相除。此項比例今擬名之為加水燃率 (Moisture combined ratio) 獨立用者尚無其人、

惟亞斯來 (Ashley) 氏之實用石炭分類 (Use Classification) 中嘗以之爲其中標準之一。

美國地質調查所康倍爾 (Compbell) 氏最近所創之石炭分類實亦兼顧水份之分類法也。其法在實用分析中、將灰分假定爲零、重行計算其水分揮發份及定炭之多少。因而發見自褐炭而至無烟炭、定炭含量逐步增漲、遂卽以爲分類之標準。

今試以上列諸法、一一應用于中國石炭、則得第三表。

第三表　中國石炭兼顧水份之分類表

次序	第二表中次序	礦名	分揮燃率	多林法	加水燃率	定炭	康倍爾法
一	一	平定	二二・一	無烟炭	一一・八	九一・六	無烟炭
二	二	焦作	二一・九	無烟炭	一一・五	九一・八	無烟炭
三	三	柳江	二〇・三	無烟炭	一〇・五	九一・四	無烟炭
四	四	門頭溝	一五・九	無烟炭	八・五	八八・五	半無烟炭
五	五	澤州	一三・二	半無烟炭	七・三	八七・六	半無烟炭
六	六	烟台	一一・二	無烟性烟炭	五・三	八三・五	高級半烟炭
七	七	淄川	一〇・三	無烟性烟炭	四・九	八三・〇	高級半烟炭
八	九	六河溝	八・〇	高碳炭	三・六	七八・六	低級半烟炭

九	八	博山	七•七	高碳炭	三•八	七七•四	低級半烟炭
一〇	一一	井陘	七•六	高碳炭	三•四	七六•二	低級半烟炭
一一	一〇	怡立	七•一	高碳炭	三•三	七六•四	低級半烟炭
一二	一二	本溪湖	六•〇	高烟炭	二•六	七二•二	低級半烟炭
一三	一五	開平	五•五	烟炭	二•二	六九•〇	高級烟炭
一四	一四	中興	五•五	烟炭	二•七	七〇•一	高級烟炭
一五	一九	宜城	四•五	烟炭	一•八	六四•五	高級烟炭
一六	一七	臨城	四•四	烟炭	一•七	六四•〇	高級烟炭
一七	一三	萍鄉	四•二	烟炭	二•五	七一•一	高級烟炭
一八	二〇	湯源	四•二	烟炭	一•七	六二•八	高級烟炭
一九	二二	賈汪	四•一	烟炭	一•七	六二•四	高級烟炭
二〇	二四	舜耕山	三•九	烟炭	一•五	六〇•五	高級烟炭
二一	二一	北票	三•八	烟炭	一•六	六〇•九	高級烟炭
二二	一八	大同	三•七	烟炭	一•五	六二•九	高級烟炭
二三	二七	長興	三•五	烟炭	一•五	五五•九	中級烟炭

二四	二三	坊子	三・四	低碳炭	一・三	六〇・八	高級烟炭
二五	二五	澠池	三・〇	低碳炭	一・一	六二・五	中級烟炭
二六	二六	長春	二・八	低碳炭	一	四八・九	低級烟炭
二七	二八	撫順	二・六	低碳炭	一	五〇・六	低級烟炭
二八	三一	樂平	二・五	低碳炭	〇・九	四八・四	低級烟炭
二九	一七	八道濠	二・三	褐性烟炭	一二・五	四八・一	低級烟炭
三〇	二九	新邱	二・〇	褐性烟炭	〇・九	四七・二	低級烟炭
三一	三〇	扎賚諾爾	一・五	褐炭	〇・七	四〇・五	褐炭

以第三表與第二表相較、各石炭之次序首十二種之位置殆無甚差異、但含水份及揮發份較多之石炭則位置變更甚多、八道濠石炭在第二表中佔十七位者、在第三表中乃佔第二十九、彛耕山炭則自第二十四變爲第二十。

兼顧水份之分類視僅及純燃質之分類較爲優勝、其理由前已說明、但以上三種分類法——卽多林、亞斯來及康倍爾三法、——究竟何者爲勝、則殊覺不易判斷、因中國石炭實用研究尙不甚精、以上三法稍有出入、孰符實際頗少標準也。然就大致言之、中國石炭之性質上列分類頗足以代表、多林氏之高碳炭卽康倍爾氏之低級半烟炭爲鍊焦最佳之炭。多林氏之烟炭卽康倍爾氏之高級烟炭中一部份亦甚適鍊焦、但一部份則含氣質較多焦質頗爲疏鬆、凡此分別、中國石炭之性質、與康倍爾氏美國石炭分類所得之結果適相符合、亦可

見此項分類之確有實際意義矣。康倍爾氏中級與低級烟炭之分別似視多林氏分類法爲尤精、惟既將水份加入分類標準、復將含水較多之石炭多分種類、則石炭分析中水份多少甚關重要、不幸中國石炭之分析多不甚精密、對於水份尤多疑義、則憑此論斷、自不免或違事實、此不可不愼者也。

四 新分類法及石炭記號

平常所作之石炭分析將成分極複雜之石炭僅分爲水份揮發份定炭灰份等廖廖數種物質、實不足以充份代表石炭之各種化學的及物理的性質、是以以此爲根據之分類法亦不能希望完全盡合天然分類、不過能藉之爲實用分別、以資工業用途之別擇而已。惟然故石炭分類首當以代表其實用價值爲主要目標、上述各種分類法一律假定灰份之數如等於零、卽僅視燃質而不問雜質、而忘其雜質之多少亦大有影響於石炭之實用價值、則殆不免猶有遺憾乎。

竊以爲石炭分析中之成份可大致分爲二部份、水份揮發份定炭三者爲一部份、其相互之比例如水份燃率或加水燃率或依康倍爾法算得之定炭、其所表示大致足以代表石炭之含碳級次(Rank)。灰份爲又一部份、其含量約足以代表石炭之淨度(Grade)。更申言之、含碳級次者乃石炭含碳多少之級次、卽其在分類表中高下之位置是也。蓋地質研究証明石炭爲植物所變化、自泥炭而褐炭而烟炭而無烟炭、循次而進殆無確界、玆所謂石炭之含碳級次者、卽於此連續之變化中假分段落而已。所謂淨度者石炭所含雜質多少之結果也、

譬如金屬礦石、金屬之外有矽酸焉有炭酸焉金屬之多少卽金屬礦石等高下之所由分、含碳素及氫素物質之多少卽石炭淨度之所由分也。同一含碳級次之石炭含灰百分之五與含灰百分之二十者、其實用價值當然不可同年而語、而中國石炭灰份且有超過百分二十以上者、豈可置諸不問乎。故石炭名稱及記號必須兼能代表含碳級次與淨度者方合實用、其理蓋甚明也。

玆爲適合中國石炭分類起見、擬一新法、含碳級次之標準以加水燃率爲之、其理由有二（一）加水燃率之數目自〇·五至十二爲數較簡、分配較勻、（二）分揮燃率於無烟炭差別甚大、加水燃率則較少。烟炭分別較爲重要、而分揮燃率僅自三·五至一十、無烟炭分別關係較輕、而分揮燃率則自一十至二二以上、殊不如加水燃率之較爲均勻也。

玆卽以加水燃率爲標準而分別石炭之級次、並求其與他種分類法約略相當之關係列如第四表。

第四表　新分類法與其他分類法之關係

新類名	記號	加水燃率
高碳無烟炭	Ah	一〇—一二
中碳無烟炭	Am	八—一〇
低碳無烟炭	Al	六—八
無烟性烟炭	AB	四—六
高碳烟炭	Bh	三—四
中碳烟炭	Bm	一·七—三
低碳烟炭	Bl	一·三—一·七
褐性烟炭	BC	〇·九—一·三
褐炭	C	〇·九以下

格魯納名	無烟炭	瘠四分一肥炭	瘠二分一肥炭	製焦炭	肥炭冶金炭	製瓦斯炭	光燄炭	褐炭
拂雷社名	無烟炭	半無煙炭	半烟炭	烟炭	亞烟炭	褐炭		
多林名	無烟炭	半無煙炭	無烟性煙炭	高碳炭	烟炭	烟炭及低碳炭	低碳炭及褐性炭	褐炭
康倍爾名	無煙炭	半無煙炭	高級半煙炭	低級半煙炭	高級煙炭	中級煙炭	低級煙炭	亞煙炭或褐炭
普通英名	無煙炭	蒸汽炭	製焦炭	製瓦斯炭	木性炭	褐炭		

以上分類卽將石炭分爲無烟炭 (Anthracite) 烟炭 (Bitumite) 褐炭 (Lignite) 三大類、每一類各以英文大寫字母 A,B,C, 爲其記號、每一類中又分高中低三級、以英文小寫字母 h,m,l 代表之、每二類間各有一中介類、在無烟炭與煙炭之間者曰無烟性烟炭 (Anthracitic Bitumite)、在烟炭與褐炭之間者曰褐性烟炭 (Lignitic Bitumite)。此項分類於無烟炭及煙炭分析頗詳、似於中國石炭頗爲適用、至褐炭一類中國礦藏不多故未詳爲分別、如欲研究則現有外國分類法中、似以伊文斯 (Evans) 氏對於新西蘭之褐炭分類最爲完善、可採用也。

石炭之淨度可直接以灰份百分率定之、亞斯來氏實用分類法中嘗以灰份多少分爲五等、灰份愈多則石炭之成分愈劣、卽其淨度愈低、每等又各以記號示之、表列如下。

炭份百分率	石炭淨度	淨度記號
〇—四	極高	一
四—八	高	二
八—一二	中	三
一二—二〇	低	四
二〇以上	極低	五

含碳級次與淨度復可互相聯絡、以成石炭之完全記號、例如開平炭如以第一表分析爲標準應稱爲低淨中碳煙炭、其記號爲 Bm_4 撫順炭應稱爲高淨褐性煙炭、其記號爲 BC_2 門頭溝炭應稱爲低淨中碳無煙炭、其記號爲 Am_4 餘可類推、茲將中國重要石炭之記號刊爲第五表。

第五表　中國石炭分類記號表

石炭	記號	石炭	記號	石炭	記號
平定	Ah_2	焦作	Ah_3	柳江	Ah_4
門頭溝	Am_4	澤州	Al_3	淄川	AB_3
烟台	AB_4	博山	Bh_3	六河溝	Bh_5
井陘	Bh_3	怡立	Bh_3	中興	Bm_3
本溪湖	Bm_3	萍鄉	Bm_3	開平	Bm_4
臨城	Bm_3	湯源	Bm_2	宣城	Bm_5
大同	Bl_3	賈汪	Bl_4	北票	Bl_3

舜耕山	Bl_3	坊子	Bl_4	長興	Bl_3
撫順	BC_3	樂平	BC_3	澠池	BC_4
長春	BC_2	新邱	BC_2	八道濠	BC_4
扎賚諾爾	C_1				

以上記號如能用之稍爲熟習、則其意義不難一望而知、而於石炭之實用價值卽可得其梗概。

石炭成分中尙有硫質一項、有時亦甚關重要、故亦有歸納入石炭記號之必要、仍可分爲五等如下。

硫質百分率	〇—〇・七五	〇・七五—一・五	一・五—二・五	二・五—四	四以上
硫量稱號	甚低	低	中	高	甚高
硫量記號	一	二	三	四	五

以此加入記號、例如中淨高碳無煙炭硫量低者其記號應爲 Ah_3^{2}。字母下之指數爲灰份記號。其上之指數則硫量記號也。假如有一石炭其記號爲 Bh_2^{1} 卽知其爲高碳烟炭含灰在百分之四至八之間含硫在百分之〇、七五以下、鍊焦冶鐵最佳之炭也。

五　石炭記號之用法

茲所提議之記號非徒以矜新奇而已、於研究石炭實甚便應用。試舉數例如下。

石炭成分往往各層不同、今如以 I II III ・・・・代表炭層、每層之炭質復各以記號表示之、則可得一公

式、以代表此炭田之炭質例如

$$IAm_2^1 + IIAM_3^2 + IIIAB_2^2 + IVAB_1^2 + VBh_1^1 \cdots\cdots\cdots\cdots$$

在上列假定公式中、可見層次愈上者炭質含揮發份愈多、如此表示雖僅見大概、然視連篇累牘之分析表似簡明多矣、同一炭田內炭質變異不但各層不同、而且往往同一炭層各處不同、今如作探井三、有炭三層、則各井各層之炭質可以記號表示之如下。

	井甲	井乙	井丙
I	AB_3^2	AB_1^1	AB_2^1
II	Am_3^2	Am_2^2	Am_3^3
III	Am_2^1	Am_3^2	Am_2^3

同一炭田有炭質變異倏忽多端、表面上似屬毫無規則者、若欲詳細研究、最好多作詳細平面圖、及縱橫剖面圖、將炭層分布詳細繪出、又復多採標本、在圖上確記採集地點、精爲分析再就分析結果作爲記號、記之於圖上採集地點、如是則炭質分布及變異之規則、可以一目瞭然矣。炭質複雜如京西齋堂炭田者、誠以此法施之似當不至毫無所得也。同一炭礦所出之炭、成分不能完全一致、往往在一定範圍之內時有出入、則代表此礦炭質之記號亦可確示其變異之範圍例如有一高碳無烟炭、略如平定炭者、其含灰等差自二至四含硫自一

至三則其記號卽可作爲 Ah_{2-4}^{1-3} 又如此炭級次亦時有變化、則又可作記號如 $(AB-Bh)_{2-4}^{1-3}$ 此記號如寫作 $AB_2^1-Bh_4^3$ 則其意義與前者頗有不同、後者係確示等級之間有一定關係、而前者則不含此義也。用此方法則中國重要炭礦之炭質可以較爲概括之公式表之如下。

開平 $(\underline{Bm}-Bh)_{2-4}$

井陘 $(Bm-\underline{Bh})_{1-3}$

淄川 $(Ah-\underline{AB})_2$

烟台 $(\underline{Bh}-AB)_{2-3}$

上列公式中下加一畫者、係表示數量上較爲重要之意、如須更進一步表示某礦所採出者某類炭與某類炭間之數量比例、則可寫如左式、

$$70\%Bm_2+15\%Bm_1+5\%Bh_3$$

意卽謂該礦產出高淨中碳烟炭佔總產額百分之七十、極淨中碳烟炭佔百分之十五、而中淨高碳烟炭則僅有百分之五而已。

石炭之實用價值不但在其成分如何、而尤視其塊末比例、如欲表示某種石炭塊炭數量若干、亦可特加記號如 ⌈⌋ 作爲塊炭標誌、則可作公式如下、

$$\frac{3}{4}\ \boxed{Bm}_2 \quad 或 \quad 75\%\ \boxed{Bm}_2$$

此卽表明此項石炭可得塊炭四分之三也、由上舉數例觀之、可証玆所創擬之石炭記號於實用頗爲便利、凡石炭之大致成分、製性焦質、灰份、及硫質之多少、塊末比例等、種種有關實用價值之事項、均可以極簡明之記號表示出之。凡一炭田或一炭礦之炭質變化種類等、又可以此記號聯爲極簡明之公式或圖表、種種要點一覽可曉。誠知記號所示之成分僅及大概、並不精密、然石炭之分析結果實際上原僅可代表所分析之標本而已、苟有巨量石炭其成分勢必稍有異同非區區少數標本所能代表、卽爲平均標本、亦祇能代表其平均、而非能代表其全量、故雖有精密之分析、亦少實際之意義、卽記號所表示者實亦並無十分精密之必要而已足實際應用矣。而此項記號簡單明瞭則于比較記憶抄寫記錄均極爲便利、視彼僅抄錄化學分析表、徒佔篇幅、而不深究其意義者、似頗有優勝之處、世之研究石炭者或將有取於是乎。

六　石炭成分及其地質時代之關係

從前歐洲有人誤信石炭成分與其地質時代具有一定不易之關係、今已知其並不盡然。惟地質時代雖非成炭之唯一原因、而於炭質變化究亦不無重要影響、玆將中國石炭之地質時代及其成分列如第六表、藉以明其間之關係焉。

第六表　中國石炭地質時代表

時代	礦名	成分記號	水份百分率
第三紀	扎賚諾爾	C_1	二〇•九三

白堊紀		
撫順	BC_3	六・七三
八道濠	BC_4	一二・六五
新邱	BC_3	一二・○○
長春	BC_3	一○・八○
滬池	BC_4	九・六
侏羅紀（下侏羅紀或中侏羅紀）		
坊子	BL_4	二・八○
北票	l_3	三・二五
大同	l_3	四・五○
湯源	m_3	一・五○
萍鄉	m_3	一・三五
門頭溝	m_4	二・三
二疊紀（中部）		
樂平	C_3	一・○○
長興	l_3	○・九四
宜城	m_3	○・七五
二疊石炭紀（北部）		
舜耕山	l_3	○・八五
賈汪	l_4	一・三五
臨城	m_3	一・八九
開平	m_4	○・六
本溪湖	m_3	○・六八

中興	Bm_3	〇・五〇
怡立	Bh_4	一・六
井陘	Bh_3	〇・五六
六河溝	Bh_3	〇・五五
博山	Bh_3	〇・八七
烟台	AB_4	一・一五
淄川	AB_3	〇・五七
澤州	Ah_2	一・八〇
柳江	Ah_4	〇・七〇
焦作	Ah_3	〇・六五
平定	Ah_2	〇・七八

詳察上表可得結論如下：

（一）、第三紀以褐炭爲主要、例如扎賚諾爾、惟撫順則爲褐性烟炭、第三紀中最優良而不可多得之石炭也。

（二）、八道濠新邱長春三種石炭皆爲含水較多之褐性烟炭、如依哥里愛（Collier）氏以含水百分之十以上爲褐炭之標準、則此種石炭已可稱爲褐炭矣。八道濠之地質據地質調查所譚錫疇君之調查、並衡以譚君在山東之經驗、其時代應屬白堊紀、新邱及長春之地層日本學者或以爲侏羅紀、或以爲第三紀、意見不一、最近所得亦爲中生代化石則亦以白堊紀爲近、是三處炭質頗爲相近、在中國石炭中卓然自成一類、與時代較

新或較古之石炭逈不相同、殆可謂此時代石炭之特徵。澠池石炭據所分析與白堊紀諸石炭頗為相近而其時代則已不同、然此係據馬底幼 (Mathieu) 氏就少數植物化石鑑定之結果、是否無校正之餘地未可知也。中國北部白堊紀之石炭雖似皆為褐性烟炭、而褐性烟炭則並不專屬白堊紀。故新者有第三紀之撫順炭、而較舊者則有二疊紀之樂平炭。但較二疊紀更古者則迄從未聞有為褐性烟炭者。

（三）然吾原未敢謂石炭之複雜性盡可以簡單記號表出之也。八道濠、新邱、長春、澠池、撫順、樂平六種石炭中其記號雖皆為 BC 而含水百分率則頗不相同。觀其分別之所在則又與石炭時代顯有關係。八道濠新邱長春三種三種所含水份皆在十至十三之間、其時代似屬白堊紀、澠池炭水份近此其時代亦似相近。樂平撫順記號雖同、水份大異、其地質時代亦相懸絕。大抵古生代石炭水份從不甚高而新生代石炭則水份如撫順者已屬甚低也。

（四）侏羅紀石炭在中國極為豐富、而佔重要之位置、其成分頗為不一、其有成為無烟炭者乃顯係局部變質所致、非其本質亦非通例。且侏羅紀石炭卽使揮發份減少、而水份仍往往較多、如門頭溝是也。又侏羅紀之烟炭皆屬中碳或低碳、而高碳烟炭則在中國侏羅紀中尙迄今未見重要實例、是亦一特徵也。侏羅紀石炭水份常在百分二至七之間其有在二以下者則如為烟炭往往可以鍊焦如萍鄉卽其例也、卽同一炭田中亦然、例如大同齋堂等處炭質不一、水份低者鍊焦常較適。

（五）長江一帶二疊紀石炭多為中碳或低碳烟炭及褐性烟炭不適鍊焦、中碳烟炭中間有可鍊焦者又為

含硫太多。以故長江一帶冶鐵需焦雖殷。而鍊焦之炭極不易獲。在古生界中尤不多覯也。

（六）二疊石炭紀之石炭在中國北部炭礦中佔最要之位置、其成分自高碳無烟炭以至低碳烟炭殆各級均有。惟褐性烟炭則絕未之見。何以同一時代之石炭通常爲烟炭者、而在某種大區域內則成無烟炭。例如太行山以東炭田如臨城井陘磁縣安陽等等皆爲烟炭、而一至太行山以西卽山西東部反成爲無烟炭、至山西西部復又成爲烟炭。此其變化及分布之原因、自李希霍芬(Richthofen)氏以來卽成爲問題、最近那林(Norin)氏始以爲無烟炭與烟炭之分別、與地質時代大有關係、意謂山西省東部無烟炭似屬石炭紀、而山西省西部則屬二疊石炭紀、東部之所以不見烟炭者、因石炭紀以上之二疊石炭紀已受侵蝕之故、此種主張尙無充分証明、然據近年研究、確已發見中國北方各大炭田從前概括的屬之於二疊石炭紀者、其中含炭部分精確時代實甚不一致、此項時代之分別、是否與石炭成分具有何種確定之關係、當俟地層學與古生物學詳細証明、此項研究現方開始、循是以往或能得有重要實用的結果未可知也。

此篇先在南開礦學會出版之礦學會誌發表茲復有所修正故重列於此

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PEKING
THE GEOLOGICAL SURVEY OF CHINA
MINISTRY OF AGRICULTURE AND COMMERCE.

Succession of the Marine Beds in the Chang Chiu Coal Field of Shantung

BY Y. T. CHAO (趙亞曾)

[INTR]ODUCTION

The tectonic features and mining conditions of the Chang Chiu coal field have been already treated by Dr. J. G. Andersson* who surveyed it in 1919. In the spring vacation of the next year when the author was still a student of the Peking National University, he made a short trip to this coal field. Even at that time, he was greatly struck by the fine and complete exposures of the lower part of the coal series. Since then its completeness of succession had long been kept in the writer's mind and it was only until in the spring of 1923, that the writer accompanied by Messers. C. C. Chang & C. C. Tien visited there again and a section was carefully measured. In view of the fact that so far no detailed report on the succesion of the marine beds of the Chang Chiu coal field has yet been published, this brief account here seems to be not altogether superfluous.

One thing that seems remarkable is the marked difference in the relative number and thickness of the marine limestones between the Chang Chiu and Tsuchuan-Poshan coal field, these two forming essentially one coal field except that they are separated in the middle by a great fault. According to Mr. T'an**, in Tsu Chuan and Po Shan there are only two marine limestones, the lower one (*Fusulina* limestone) of which is 4 meters thick while the upper is 1.5 meters. In the Chang Chiu coal field, on the other hand, there are 5 marine limestones the lowest of which alone is more than 10 meters in thickness. It is quite possible that Mr. T'an's *Fusulina* limestone corresponds to my Hsuchiachuan limestone, but since no material from the former limestone is accessible to the writer at present, a positive correlation has to be postponed to a later date.

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* J. G. Andersson: Report on the Chang Chiu coal field in Shantung; Geol. Surv. China Bulletin No. 6, pp. 51-61.

** H. C. T'an: The geology of Tsuchuan-Poshan coal field, Shantung; ibidem No. 4, pp. 81-87.

DESCRIPTION OF SECTIONS

The section was measured along a small valley a little east of Shang Kao Chuan (上高莊), the latter being situated 15 li S.E.E. of the Ming Shui Station (明水車站) of the Tsingtao-Tsinan railway (膠濟路). Here the beds are very gently tilted, dipping generally less than 20 degrees towards the southwest. From the Ordovician limestone upwards, the coal series has the following succession (See Plate in Carboniferous Stratigraphy of S. Manchuria):

1.	Yellowish shale, variable in thickness	0-.4 meters
2.	Marly limestone with iron nodules	0.9
3.	Grey and purple shale	1.55
4.	Yellowish sandstone and sandy shales, conglomeratic at parts	3.8
5.	Purple shale	12.7
6.	Marine limestones with a bed of greenish calcareous shale and a sheet of igneous rock	11.8
	(Hsuchiachuan limestone)	
7.	Yellowish and greenish shale with bands of calcareous concretions	15.5
8.	Black shale	3.3
	1-8 Penchi series.	
9.	Yellow sandstone with a thin layer of black shale	4.7
10.	Dark grey shale with plant remains	1.7
11.	Sandstone	2.0
12.	Grey shale with a coal seam at middle	1.0
13.	Sandstone	3.0
14.	Black and grey shales	20.6
15.	Yellow sandstone	4.65
16.	Yellow shale, becoming greyish at lower part ...	6.8
17.	Thin bedded sandstones, shaly at parts	8.5
18.	Fireclay with plant fossils	2.1
19.	Coal seam	2.
20.	Yellow sandstone	2.3
21.	Black crinoidal limestone, weathered to a yellowish color (G)	1.23

22.	Greenish yellow shale, sandy upwards	8.7
23.	Yellow sandstone	1.45
24.	Yellowish sandy shale	2.4
25.	Black shale with abundant plant fossils such as Pecopteris, Neuropteris etc.	.7
26.	Coal seam	
27.	Yellowish shaly sandstone	1.8
28.	Alternating beds of grey marine limestones and yellowish sandstones (H)	7.0
29.	Yellowish shaly sandstone	30.0
30.	Dark grey shale with ***Annularia*** and other plant remains	2.0
31.	Grey limestone (K)	1.0
32.	Fireclay with a coal bed at top	2.8
33.	Yellow soft sandstone	38.0
34.	Black limestone (L)	1.02
35.	Yellowish green shale	6.4

9-35 Taiyuan Series.

From here upwards, the series is followed by a great sequence of alternating beds of sandstones and shales with coal seams (Shansi series), which is in turned capped by a quartzose sandstone series the same as in the Poshan-Tsuchuan coal field in the intermediate neighbourhood.

PEN CHI SERIES—MIDDLE CARBONIFERQUS

This consists ot about 50 meters of shales, sandy shales, sandstones and a thick bed of limestone but without coal.

Hsuchiachuan limestone: This limestones is well exposed a little south of Hsu Chia Chuan whence derives its name. It lies about 20 meters above the Ordovician limestone and amounts to a thickness of 11-8 meters. The detailed succession from top to base is as follows:

Yellowish dense brittle limestone	2.5	m.
Doleritic sill variable in thickness	1.2	
Yellowish limestone	1.0	
Grey calcareous shale, interfingering with limestone	1.8	

Pale ocher limestone	.3
Dense massive limestone	5.0
	11.8 m.

Fossils seem to be very rare in this limestone, but otherwise the species so far collected from it are very characteristic of the Yanghukou limestone of Kansu.

Fusulinella sp.
Girtyina quasicylindrica Lee
Spirifer mosquensis Fischer
Productus gratiosus var. *occidentalis* Schellwien
Phillipsia cf. *kansuensis* Loczy.

TAIYUAN SERIES—UPPER CARBONIFEROUS

This is composed of alternating beds of shales, sandy shales, sandstones and limestones, carrying coal seams at different horizons. The total thickness is about 165 meters. There are 4 marine limestones, each being designated a capital letter.

Limestone G: This limestone lies about 55 meters above the Penchi series and is 1.2 meters thick. It is dense and brittle, weathered to a yellowish color and carries abundant crinoidal stems. Fossils seem not to be abundant and foraminiferas are entirely absent. So far only the following species have been obtained from this bed :

Spirifer taiyuanensis Chao
Spirifer cf. *strangwaysi* de Verneuil
Naticopsis sp.
Loxonema sp.

Limestone H: This is composed of an alternating bed of thin limestones and sandy shales. It is separated from limestones G by 14 meters of shale and sandstones carrying coal seams and plant fossils. The detailed succession from top to base is as follows :

Black shale with *Productus*	2.5 m.
Sandy shale	.55 m.
Grey limestone	.65 m.
Shaly sandstone with limestone lenses	1.1 m.
Grey limestone	1.07 m.

Yellow shaly sandstone	.95 m.
Grey limestone	.22 m.
	6.95 m.

From these beds a typical Taiyuan fauna has been collected:

Schellwienia richthofeni Schwager
Schellwienia longissima Köller
Lophophyllum acanthiseptum Grabau
Spirifer sp. indet. (probably *Sp. taiyuanensis* Chao)
Spirifer fasciger Keyserling
Martinia sp.
Productus echidniformis Grabau *em* Chao
Productus taiyuanfuensis Grabau
Loxonema sp.

Limestone K: This limestone is separated from limestone G by about 30 meters of yellowish shaly sandstone and a thin bed of dark greyish shale with plant remains. In descending order, it contains the following members:

Greyish, dense limestone	1. m.
Dark grey shale	.4 m.
Brown sandy shale	.14 m.
White sand	.3 m.
	1.84 m.

All these shaly and sandy beds are richly fossiliferous but the fossils are mostly fragmentary and crushed. Among the collection the common forms are:

Marginifera longispinus var. *orientalis* Chao
Marginiferia pusilla Schellwien
Chonetes sp.
Hustodia sp.

Limestone L: This limestone is separated from horizon K by about 40 meters of sandstones and is 1 meter thick. No other reliable fossils except a small species of *Loxonema*, have so far been observed.

Carboniferous Stratigraphy of S. Manchuria.

BY Y. T. CHAO (趙亞曾)

(With 3 figures & 1 plate)

INTRODUCTION

During the recent years, the Geological Survey has untertaken a detailed and systematic study of the coal-bearing formations in N. China, but comparatively little has so far been known about the Carboniferous stratigraphy of S. Manchuria. In order to get more material of Fusulinoids for Prof. J. S. Lee and to correlate the different marine beds of the coal-bearing series in the latter province with those of other parts in N. China, Dr. W. H. Wong, director of the Survey, sent me to Manchuria in the summer of 1925 for these purposes. Because of the hot season and other inconveniences, only 3 coal fields were visited, including Pen Chi Hu (本溪湖) and Niu Hsin Tai (牛心台) not far south from Mukden, and Wu Hu Tsui (五湖嘴) in the southern part of the Liaotung peninsula.

From my study in this journey, I have arrived at conclusions somewhat different from those previously arrived at by our Japanese collegues. Based upon the occurrence of *Spirifer wynnei* Waagen in Niu Hsin Tai and of *Spirifer nikitini* Tschernyschew in Yen Tai, and the association of *Schwagerina princeps* with several characteristic corals in the Hei-jo coal field, Korea, which latter have also been found in the marine limestones of Manchuria, Prof. Hayasaka[1] concluded that all the marine limestones underlying the coal-bearing formation in this country represent the *Schwagerina* stage of the Uppermost Carboniferous. According to my study, on the other hand, the marine beds underlying the coal series in Pen Chi Hu and Niu Hsin Tai are exactly equivalent to the Tangshan limestone in the Kai Ping coal basin, both being characterized by the same coral and foraminifera fauna. Since the Tangshan limestone is Moscovian in age[2] because of the presence of *Spirifer mosquensis* and many Fusulinoids characteristic of the Miatschova limestone of Russia, there scarcely leaves any doubt about the Moscovian age of the marine beds in the Pen Chi and Niu Hsin Tai coal fields. In these two districts, the Moscovian is immediately followed by the coal-bearing Shansi series (山西系) of Permo-Carboniferous age, with the Taiyuan series

1 Hayasaka: Upper Carboniferous Brachiopoda from the Hon-Kei-Ko Coal Mines, Manchuria; Palaeozoic Brachiopoda from Japan, Korea and China, p. 135

2 Y. T. Chao: Age of the Taiyuan Series; Bull. Geol. Soc. China, Vol. IV. No. 3—4, pp. 221 249.

(太原系) of Upper Carboniferous entirely wanting. Because of the extensive development of the Moscovian division in Pen Chi Hu, we propose to call it the Penchi series (本溪系).

Towards Southern Fengtien, however, the Taiyuan series begins to appear between the Penchi and Shansi series. Such is the case in Wu Hu Tsui where the Taiyuan series is well developed with typical Taiyuan fossils.

1. PEN CHI COAL FIELD

The structure of the Pen Chi coal field is remarkably simple. The strata strike generally N. 60° E and dip towards S. S. E. The dip angle varies from 10° to 20°, commonly 15°. Along the strike not far from the outcrop of the Ordovician limestone, one can unmistakenably see a continuous zone of black dumps left by the old native pits. The field is terminated on the west by a big fault a little west of Hsin Tung Kou (新洞溝), and ended on the northeast by a large igneous intrusion at Ming Sheng Kou (明盛溝), the productive area extending for a distance of about 15 li.

The main drainage is Tai Tze Ho (太子河) which flows around the eastern and southern margins of the coal field. The general topography is mainly controlled by the lithological characters of the underlying rocks. And thus the district presents a very regular aspect along the dip direction. The northern part of the field, which is made up by the coal-bearing series and its underlying series of shales, sandy shales and limestone intercalations, marks a belt of very moderate elevations. The southern part, being occupied mainly by soft red shales and sandstones, forms a group of low hills with open valleys. The middle part between them, consisting principally of hard quartzose sandstones, on the other hand, builds up conspicuous peaks.

The Upper Palaeozoic sediments of the Pen Chi coal field above the Ordovician limestone amount to a thickness of more than 1000 meters. From the base upwards they can be divided into four series as follows:—

PENCHI SERIES—MIDDLE CARBONIFEROUS

This series lies disconformably above the Ordovician limestone. It consists mainly of shales, sandstones and limestones but there is no coal. Its thickness is estimated at about 90 meters. The succession can best be seen on a hill ridge just between Hsin Tung Kou and Ma I Tsun Kou (螞蟻村溝) about 12 li northwest of Pen Chi Hsien. From the Ordovician upward, the following strata appear in succession (fig. 1):—

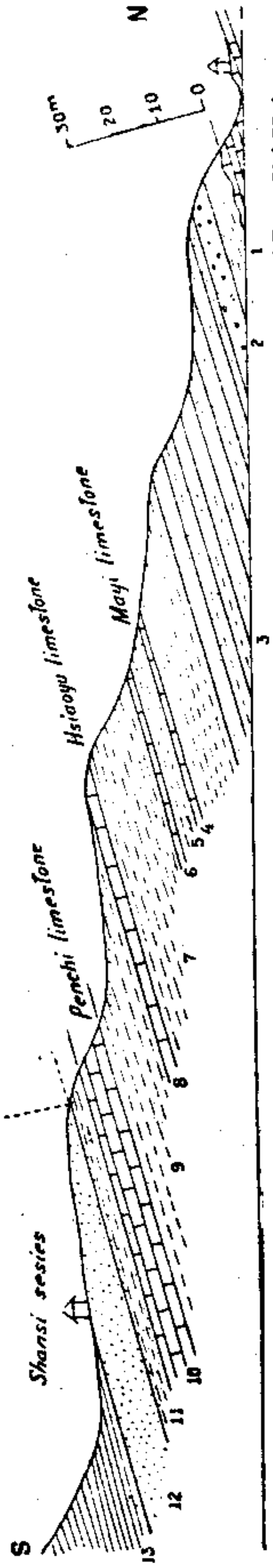

Fig. 1. Section of Penchi series between Hsin Tung Kou and Ma Yi Tsun Kou about 12 li northwest of Pen Chi Hsien

第一圖 本溪縣治西北十二里新洞溝與螞蟻村溝間本溪系剖面圖

1. Purple shale, changing gradually into light grey shale	5.0	m.
2. Yellowish coarse soft sandstone, carrying earthy pebbles	4.0	m.
3. Yellowish shales, sandy at some layers	40.0	m.
4. Grey limestone, with *Spirifer* (Loc. 1904)	.6	m.
5. Yellowish sandy shale	4.3	m.
6. Grey dense brittle limestone, upper part marly, carrying sometimes hematite nodules (Loc. 1905)	1.0	m.
(4-6 *Mayi limestone*)		
7. Yellowish shale	13.0	m.
8. Light grey semicrystalline limestone with abundant *Girtyina*, *Lithostrotion*, *Chaetetes*, *Spirifer* and others	1.85	m.
(*Hsiaoyu limestone*)		
9. Yellowish and greenish sandy shales, with intercalations of sandstones	11.0	m.
10. Light grey, massive, dense limestone, sometimes full of crinoidal stems, with *Girtyina*, *Chaetetes*, *Lithostrotion*, *Spirifer* and others	5.5	m.
(*Penchi limestone*)		
11. Light grey sandy shale....	5.0	m.
12. Grey coarse soft sandstone	7.0	m.

From here upward, it is followed by the Shansi coal series.

I. **Mayi limestone:** This name is introduced for the lower two limestones. The first bed is about .6 m. thick and the second layer is approximately 1 m., the two being separated by 4.3 meters of yellowish sandy shale. They are only exposed at Ma I Tsun Kou whence derives their name. It is separated from the Ordovician limestone by about 50 meters of shale, sandy shale, sandstone and conglomerate. The lower Mayi limestone is marly and seems to contain no other fossils except a kind of large *Spirifer* (Loc. 1904). The upper Mayi limestone is dense and brittle, marly at the upper part, and carries sometimes iron ore nodules. Foraminiferas seem to be not very abundant and other fossils mainly occur as cross-sections. From its lower part, the following species of fossils are collected (Loc. 1905):—

Girtyina schellwieni Staff
Spirifer mosquensis? Fischer
Dielasma sp.

II. **Hsiaoyu limestone:** The Hsiaoyü limestone is best exposed in a small gully at Shun Shan Tze (順山子 Loc. 1906 b) at the entrance of Hsiao Yü Kou (小峪溝) where are located the residence houses of the Pen Chi Hu Coal and Iron Mines. It is light grey and massive, becoming earthy and shaly at the upper and lower layers. Crinoidal stems are very few in number and small, but foraminiferas are extremely abundant, the whole limestone being closely crowded with their remains. The measured thickness is 1.85 m. and it is separated from the Mayi limestone by 13 meters of yellowish shale. This bed is again exposed in the Ma I Tsun Kou section (Loc. 1906) and on the hill top between Hsiao Yü Kou and Ming Sheng Kou (Loc. 1906a). In the former locality, beautifully preserved *Lithostrotion*, *Alveolites* and *Chaetetes* which are very characteristic of the Tangshan limestone in North Chihli have been collected. The fossils so far obtained from this bed at the above three localities when combined yield the following species:

†*Neofusulinella bocki* Möller
†*Fusulinella sphaeroidea* Möller
†*Girtyina konnoi* Ozawa
Girtyina pankouensis Lee
†*Alveolites tangshanense* Grabau
†*Lithostrotion kaipingense* Grabau

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†Also found in the Tangshan limestone of Chihli.

†*Chaetetes* sp.
Reticularia sp. indet.
Productus sp. indet.
†*Spirifer mosquensis?* Fischer

III. **Penchi limestone:** This is the thickest limestone bed in the Pen Chi coal field. Just below the black dumps of the old native pits, this limestone is exposed at many places. On account of its great thickness and position, it has been well known to the native miners. The limestone is light grey, massive, semicrystalline and 5.5 meters thick. It is separated from the Hsiaoyü limestone below by 11 to 15 meters of yellowish and greenish sandy shale, and from the coal series above, by a thick bed of grey coarse sandstone. Crinoidal stems are sometimes very abundant, but in other cases they appear to be rather rare. As a rule, the crinoidal stems seem to be more concentrated in the earthy layers. Foraminiferas are moderately abundant, but other fossils seem to be very rare and the limestone is too dense to yield good specimens. Collections are made at three localities, that is, at a temple just behind the tunnel of the Coal Mine (Loc. 1903) at Ma I Tsun Kou (Loc. 1907) and at a place between Hsiao Yü Kou and Ming Sheng Kou (Loc. 1907 a). These three collections are essentially alike and contain the following species of fossils:

Boultonia rawi Lee
Bradyina nautiliformis Möller
†*Girtyina cylindrica* Fischer
Girtyina pankouensis Lee
†*Girtyina konnoi* Ozawa
†*Lithostrotion kaipingense* Grabau
†*Multithecopora penchiensis* Yoh
†*Chaetetes* sp.
†*Spirifer* sp.

SHANSI SERIES—PERMO-CARBONIFEROUS

The Shansi coal series is separated from the Penchi series below by 7 meters of grey coarse sandstone. The sudden change from a condition of frequent marine invasions to that of an extensive coal accumulation seems to suggest a disconformity between the two. This idea is fully justified by a consideration of the fauna and flora which it contains respectively. Since the marine fossils from the lower series have been proved to be

Moscovian or Middle Carboniferous and the plant fossils from this coal series have long been known as Stephanian or Permo-Carboniferous, there must be an overlapping of the two above the Taiyuan series, which is so extensively developed in other parts of N. China, but entirely absent here.

The Shansi series here consists of alternating beds of black and grey shales, sandstones and coal seams, but without limestones. Its total thickness is estimated as about 170 meters. As many as 18 coal seams are reported to occur, but the productive seams are mainly confined to its lower and upper parts, the two being separated by a thick sequence of quartz sandstones and shales carrying only thin coal seams at different horizons. Its detailed succession can best be seen from the columnar section (Pl. I). In the carbonaceous layers, plant fossils are abundant which have been studied by Schenk, Zeiller, Yokoyama and more recently by Mathieu[1]. This latter author carefully analysized the flora and arrived at the conclusion, that it represents Permo-carboniferous and that it may be tentatively correlated with the coal series above the Tangshan limestone in the Kai Ping coal basin of Chihli.

QUARTZOSE SANDSTONE SERIES—PERMIAN.

The Shansi coal series is immediately followed by about 250 meters of a sandstone series. It consists mainly of grey, greenish and white quartz sandstones. In its lower part, intercalations of yellowish and purple shales are frequently met with, but towards the upper part only sandstones remain. About 60 meters above the base there is a layer of hard compact massive greenish shale, carrying ball-like concretions which have a very characteristic appearance in the field. Some of the sandstones are exceedingly coarse and carry sometimes abundant small quartz pebbles, giving rise to the formation of a local conglomerate. Only in rare cases are the sandstones earthy and micaceous. Owing to its great resistance to the agency of weathering, this sandstone series often forms high peaks.

This quartzose sandstone series is very persistant and wide-spread in N. China. It has been generally regarded as Permian in age.

RED SHALE AND SANDSTONE SERIES—PERMIAN?

Above the quartzose sandstone series lies conformably a vast sequence of red colored rocks, more than 500 meters in thickness. The dominant rock types are soft red shales, sandy shales and sandstones. The sandy rocks are mostly micaceous. In about the middle part at a hill-lock between Pao Chia

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1. F.F. Mathieu: L'age geologigue du bassin de Pen Chi Hu, Bull. Geol. Surv. China, No. 6 p.65

Wa Tze (鮑家窪子) and Yo Chia Tun (姚家屯) there is a thick layer of conglomerate containing large pebbles of sandstones. Near the base of the series at Tsai Chia Tun (蔡家屯) is seen a thick bed of yellowish and purple easily fissile shales. Owing to the porosity and softness of the rocks, the present series forms a group of low hill-locks, dissected by broad and open valleys.

This red sandstone and shale series is also rather wide-spread in N. China and has been generally regarded as belonging to the Mesozoic. But since no unquestionable Triassic fossils have so far been known in N. China, it appears more likely to belong still to the Permian.

2. NIU HSIN TAI COAL FIELD.

Niu Hsin Tai coal field is situated about 40 li east of Pen Chi Hsien. It is easily accessible by a branch railway along which the train runs four times every day.

The structure of the coal field is just like a chair. Its foreside faces to the north, while its back-side to the south, with the Ordovician limestone which surrounds it in the latter direction forming its frames. The dip angle varies greatly at different localities. As a rule, it increases rapidly towards the Ordovician limestone.

The succession of the Pen Chi coal field can be equally applied to Niu Hsin Tai, though the uppermost part, the red shale and sandstone series, seems to be here eroded away or else is preserved in the far north. A little north of Hung Lien Kou (紅臉溝), the Penchi and Hsiaoyu limestones are again exposed.

The Hsiaoyu limestone shows its normal characters and is, as was the case in every part of the Pen Chi coal field, extremely abundant in foraminifera remains. The Penchi limestone, on the other hand differs somewhat lithologically from that in the Pen Chi coal field. It is dark grey and dense, carrying abundant black chert nodules, these latter being entirely absent in Pen Chi Hsien. According to Prof. J. S. Lee, the foraminifera faunas of these two limestones are essentially the same as those found in the Pen Chi coal field.

3. WU HU TSUI COAL FIELD.

The Wu Hu Tsui (五湖嘴) coal field is situated about 90 li west of the Pu Lan Tien station (普蘭店) It is surrounded by the sea both on the south and on the east. The coal-bearing series is mainly confined to the lengthened table-land which trends in a northwest and southeast direction. This table-land branches into two towards the northwest, and rises generally about 50 meters above the salt marshes.

The structure of the coal field is controlled mainly by two synclines which are separated in the middle by an anticline. The eastern syncline or the Shihchiatun syncline begins from the northern end of the eastern table-land a little north of Shih Chia Tun (遲家屯), gradually decreases in magnitude towards the south and finally disappears in the vicinity of Yang Shu Kou (楊樹溝). The western syncline or the Laochunmiao syncline commences again from the northern end of the western table-land at Pu Sa Miao (菩薩廟) and gets its full development at Lo Chun Miao (老君廟) where the tunnels of the Chen Hsing Mine (振興公司) are located. The anticline between these two synclines makes its first appearance at Yang Shu Kou and broadens rapidly towards the north. Apart from these dominating structures, the strata are moreover very likely subject to secondary foldings which render the miner's work very difficult

The lower part of the coal series is exposed only at the foot of San Lin Shan (三稜山), the latter locality being rather famous to the natives for the production of iron ore. The iron-bearing layer is a purple shale about 2 meters thick. It forms the base of the Carboniferous coal series and is in direct contact with the Ordovician limestone. The succession from the latter upwards is as follows (fig. 2) :—

Fig. 2. Section showing the succession of the Penchi series southeast of Ting Chia Tun, Wu Hu Tsui coal field

第二圖 丁家屯東南三稜山籃本溪系剖面圖

1	Purple shale, carrying abundant hematite nodules	2.0 m
2.	Greyish hard clay-rock, with abundant foraminifera-like concretions	5.0
3.	Variagated shale	12.0
4.	Light grey massive limestone, pure and semicrystalline, with very few small crinoidal stems	1.3
5.	Greenish and purple shale	5.0

6.	Grey massive limestone, with flinty bands at the bedding plane, upper layers carrying crinoidal stems and *Spirifer*	8.0
	(*Salin limestone*)	
7.	Yellowish easily fissile shales	16.0
8.	Grey lenticular limestone (Loc. 1923)	·9
9.	Greyish shale	7.0
	(1-9, *Penchi series*)	
10.	White quartz sandstone, weathered to a brown color	2.5
11.	Lower light greyish shale, upper covered.	
12.	Massive thick limestone with flint bands (Loc. 1924)	

From bed No. 10 upward the strata are covered by debris and ploughed fields. But the strata from No. 6 upward are well exposed at a clay quarry between Ting Chia Tun (丁家屯) and Wang Chia Tun (王家屯) from where we have the following succession (fig. 3) :—

1.	Yellowish shale	
2.	Massive pure crystalline limestone, carrying sometimes hematite nodules: upper part carrying small crinoidal stems, *Spirifer, Chaetetes* etc. (Loc. 1926)	7.0 m.
	(= bed No. 6 in the foregoing section)	
3.	Yellowish fissile shale, with a greenish sandy layer about 1.2 m. thick in about the middle part. ...	10.0
4.	Greyish limestone (Loc. 1917 b)	·9
5.	Lower yellowish grey shale, upper covered by clay debris	24.0
6.	Light greyish clay	5.0
	(1-6, *Penchi series.*)	
7.	Greyish sandy clay carrying thin coal seams ...	5.0
8.	Massive dark limestone with flint nodules (Loc. 1911)	·5
9.	Greenish fossiliferous sandy shale	·75
10.	Greyish shaly limestone	·45
11.	Brown yellow sandstone, fossiliferous	.10

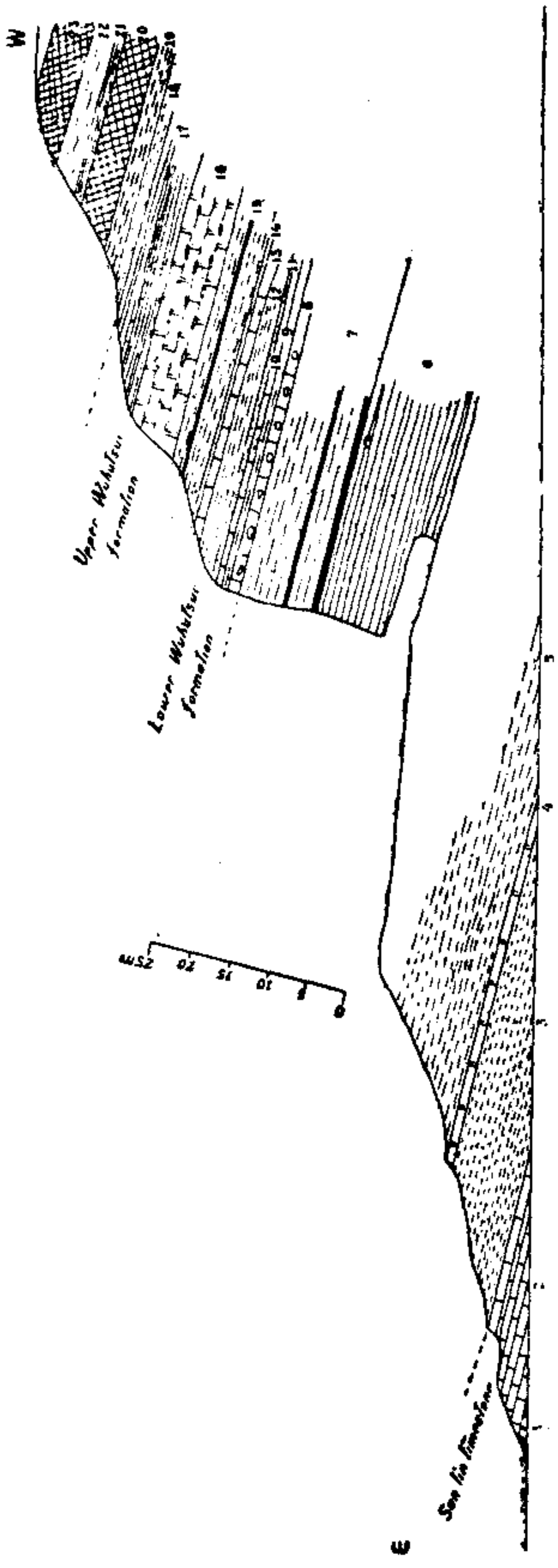


Fig. 3. Natural Brofile between Ting Chia Tun and Wang Chia Tun 第三圖 丁家屯與王家屯間剖面圖

12.	Grey shale, upper two-thirds greenish and sandy	3.30
13.	Dark brittle earthy limestone (Loc. 1912)	1.30
14.	Yellow fossiliferous shale with *Productus taiyuanfuensis, aviculopecten, Entolium* etc.	.20
15.	Grey shale becoming light grey upwards	4.0
16.	Massive grey limestone, with flint bands at the bedding planes: crinoidal stems not abundant and other fossils seem to be very rare (Loc. 1913)	6.4
17.	Massive bluish calcareous shale, fossiliferous	5.0
18.	Yellowish shale	1.2
19.	Light greyish clay....	2.5
20.	Black hornstone	4.5
21.	Shale, lower yellowish, upper light grey	1.0
22.	Light grey sandstone	3.0
23.	Dark hornstone	5.0

PENCHI SERIES—MIDDLE CARBONIFEROUS

This series consists of 70 meters of purple shale, yellownish shale and a thick bed of limestone but without coal. It is well exposed at the foot of San Lin Shan and its upper part also crops out at the eastern margin of the table land between Ting Chia Tun and Wang Chia Tun.

Sanlin limestone: The thick limestone to which the name Sanlin limestone is given is about 25 m. above the Ordovician limestone. It is light grey, massive, semicrystalline, with abundant flint bands, and about 8 m. thick. The upper layers are crinoidal and carry here and there cross-sections of Spirifers. At the foot of San Lin Shan, have been collected a brachial valve of a *Spirifer* which in every respect agrees with *Spirifer mosquensis* Fischer and several not well preserved *Fusulinella* tests; while in the section between Ting Chia Tun and Wang Chia Tun, are obtained several specimens of *Chaetetes* exactly the same as those found in the Tangshan limestone of Kai Ping and in the upper two limestones of the Pen Chi coal field. Based upon the absence of coal seams and the evidence furnished by the animal remains, it appears preferable to include this limestone to the Penchi series.

5 m. below and 16 m. above the Sanlin limestone, there are two thin limestones essentially of the same character, but so far no reliable fossils except crinoidal stems, have been detected upon them.

TAIYUAN SERIES—UPPER CARBONIFEROUS

The series amounts to a thickness of about 100 meters. It may be conveniently divided into an upper and a lower subdivision.

The lower part of the Taiyuan series is well exposed on the vertical walls of the table land between Ting Chia Tun and Wang Chia Tun (fig. 3). It consists mainly of cherty limestones intercalated with fossiliferous shales and sandy shales, being underlaid by a thick bed of greyish shale carrying thin coal seams and of fireclays, and overlaid by two beds of black hornstones with sandstones and shales between. The total thickness is 42 meters.

Wuhutsui formation: The marine limestones and shales in the middle part is collectively named as the Wuhutsui formation which may be divided into two parts. The lower Wuhutsui formation is composed of three beds of limestones with intercalated fossiliferous shales and sandy shales and is 5.8 m in thickness. From these beds (Loc. 1911, 1912) at a place between Ting Chia Tun and Wang Chia Tun, the following species of fossils are collected:

Productus taiyuanfuenis Grabau
Marginifera pusilla Schellwien
Spirifer taiyuanensis Chao
Naticopsis sp.
Aviculopecten sp.
Entolium sp.

The upper Wuhutsui formation is composed of 6.4 meters of massive grey cherty limestone and 5 meters of bluish calcareous shales. It is separated from the lower formation by 4 meters of grey shale carrying thin coal seams. Crinoidal stems are not abundant and other fossils seem to be very rare. Notwithstanding repeated thin-sectioning of the limestone specimens obtained from the thick limestone, no Fusulinoids of any kind have so far been detected.

A little north of Yang Shu Kou, several brachiopods were collected from scattered limestone blocks along the road side. The limestone is of a dark color and contains apparently no foraminiferas It appears very probable that they are derived from the Upper Wuhutsui limestone, though there is no positive evidence for such an assertion. The brachiopods are:

Marginifera pusilla Schellwien
Productus echidniformis Grabau *em.* Chao
Productus manchuricus Chao

The upper Taiyuan series consists mainly of shales and sandy shales with a thick coal seam at the lower part and one or two layers of *Schwagerina* limestone in about the middle part. This shale series amounts to a thickness of about 60 meters and is capped on top by a thick bed of soft greyish sandstone.

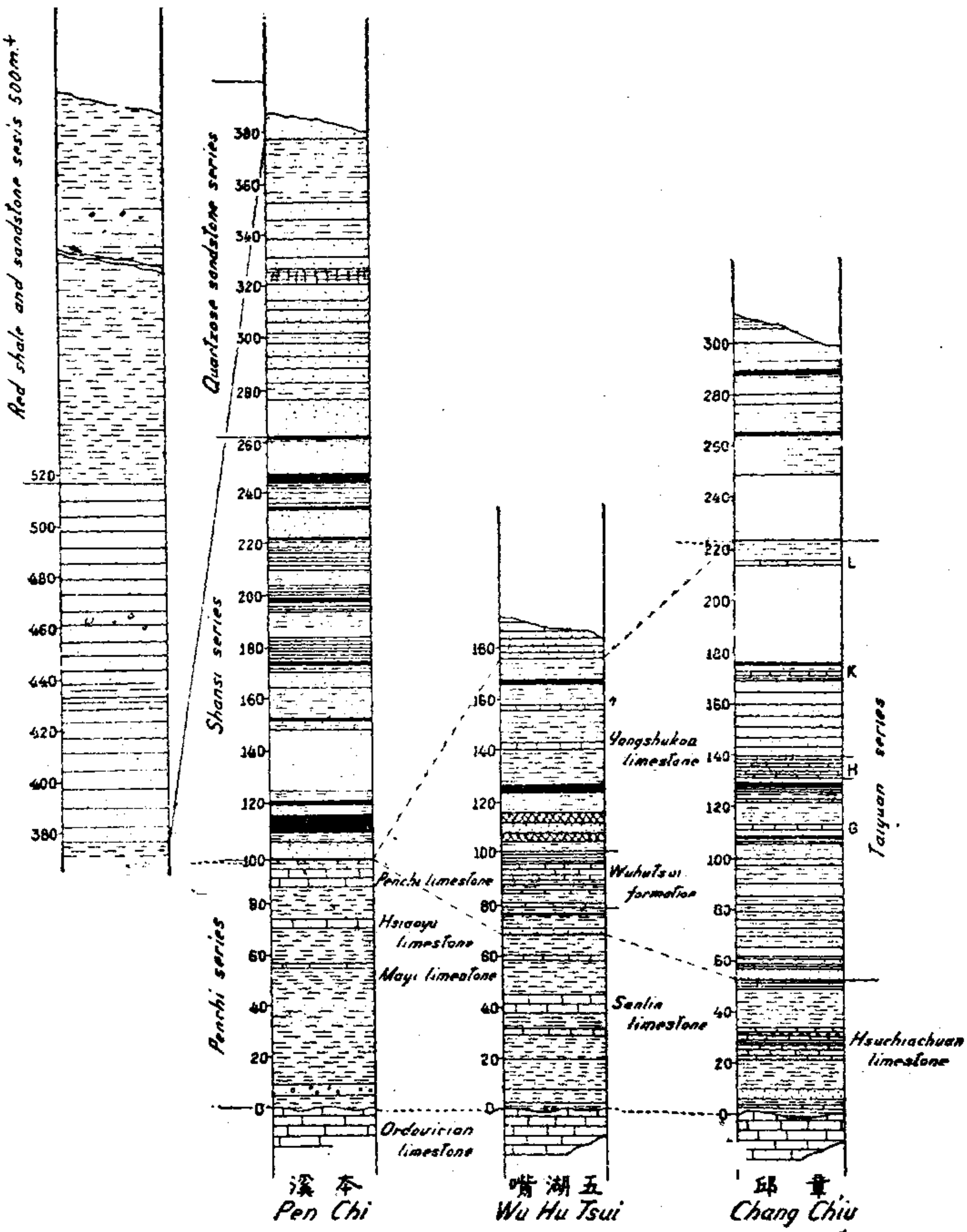
Yangshukou limestone: This lies in about the middle part of the coal series and is well exposed on top of the table land at Yang Shu Kou. It is dark, dense, massive and about 1 m. thick. Round sections of *Schwagerina* appear abundantly upon the weathered surface but other fossils appear to be very rare. So far only two species of foraminiferas have been obtained from this bed (Loc. 1919):

Schwagerina moungthensis Lee
Schellwienia richthofeni Schwager.

A little north of Yang Shu Kou between Wang Chia Tun and Pai Chia Tun (白家屯), a layer of limestone also crops out (Loc. 1921). Whether it represents another layer of limestone within the coal series or is equivalent to the Yangshukou *Schwargerina* limestone is not quite clear at present, though the former is most probably the case. It carries a rich foraminifera fauna which comprises the following species.

Neofusulinella chaoi Lee
Boultonia willisi Lee
Schellwienia richthofeni Schwager
Schellwienia nobilis Lee

Besides these fossil localities above-mentioned, scattered limestone outcrops containing Fusulinoids occur in many other places, such as, on the road side west of Ting Chia Tun (Loc. 1915), in a valley bottom east of Pai Chia Tun (Loc. 1925), on the road side north of Pai Chia Tun (Loc. 1928=? Loc. 1925) and in the vicinity of Yang Shu Kou (Loc. 1927, 1920). All the material, however, has not yet been carefully studied and hence it is not possible at present to state definitely about their position and correlations.


Red shale and sandstone series 500m.+
Quartzose sandstone series
Shansi series
Penchi series
Penchi limestone
Hsiaoyu limestone
Mayi limestone
Ordovician limestone
Yangshukou limestone
Wuhutsui formation
Senlin limestone
Taiyuan series
Hsuchiachuan limestone
L
K
H
G
溪 本
Pen Chi
嘴 湖 五
Wu Hu Tsui
邱 章
Chang Chiu

Geology of the Pa Tao Hao coal field in the Hei Shan district, W. Fengtien.

(*Summary*)

BY H. C. TAN (譚錫疇)

(*With 4 plates*)

INTRODUCTION.

The coal field in question is situated between the Hei Shan (黑山) district in Fengtien province and the Fu Hsin (阜新) district in Jehol. The main coal mine is near the Pa Tao Hao (八道濠) station of a branch-line which starts from the Ta Hu Shan (打虎山) station of the main railway between Peking and Mukden, out of the Shan Hai Kuan. The distance between Pa Tao Hao and Ta Hu Shan is about 30 kilometers. The geographical position of the coal mine is about long. E 121°55' lat. 41°55'

This coal field has not been geologically studied before except by Mr. E. Ahnert, a Russian geologist who in 1921 paid a visit to this field and made a collection of fossil-plants which have been studied by Dr. A. Kryshtofovich. The second geological observation was made by me in the autumn of 1925 in company of the American palaeobotanist Mr. Chaney. In October a detailed survey was carried on by the writer by the instruction of Dr. W. H. Wong, director of the Survey and upon the request of Mr. C. F. Wang, director of the Mukden Mining Bureau under whose auspices the coal mining is being carried on.

STRATIGRAPHY.

There are many gaps in the chronological sequence. The Archaean gneiss is often immediately overlaid by the Cretaceous beds with a marked unconformity between them. Only the Sinian (Neo-Proterozoic) quartzite formation and the supposed Jurassic volcanic lavas are sometimes found in the interval and none of the formations from the Sinian (Neo-Proterozoic) limestone up to the lower Jurassic are represented. The Cretaceous deposits are well developed in this area and play an important role in the stratigraphy of this region (see cross and columnar sections).

Taishan Complex (Archaean Gneiss): This consists chiefly of gneiss of coarse schistosity containing small quartz veins. It occurs on the border of

奉天黑山縣八道壕煤田地質圖

GEOLOGICAL MAP OF THE PATAOHAO COAL FIELD IN THE HEI SHAN DISTRICT, FENGTIEN

譚錫疇調查

SURVEYED BY H. C. TAN.

Scale 1 : 60,000 縮尺六萬分之一

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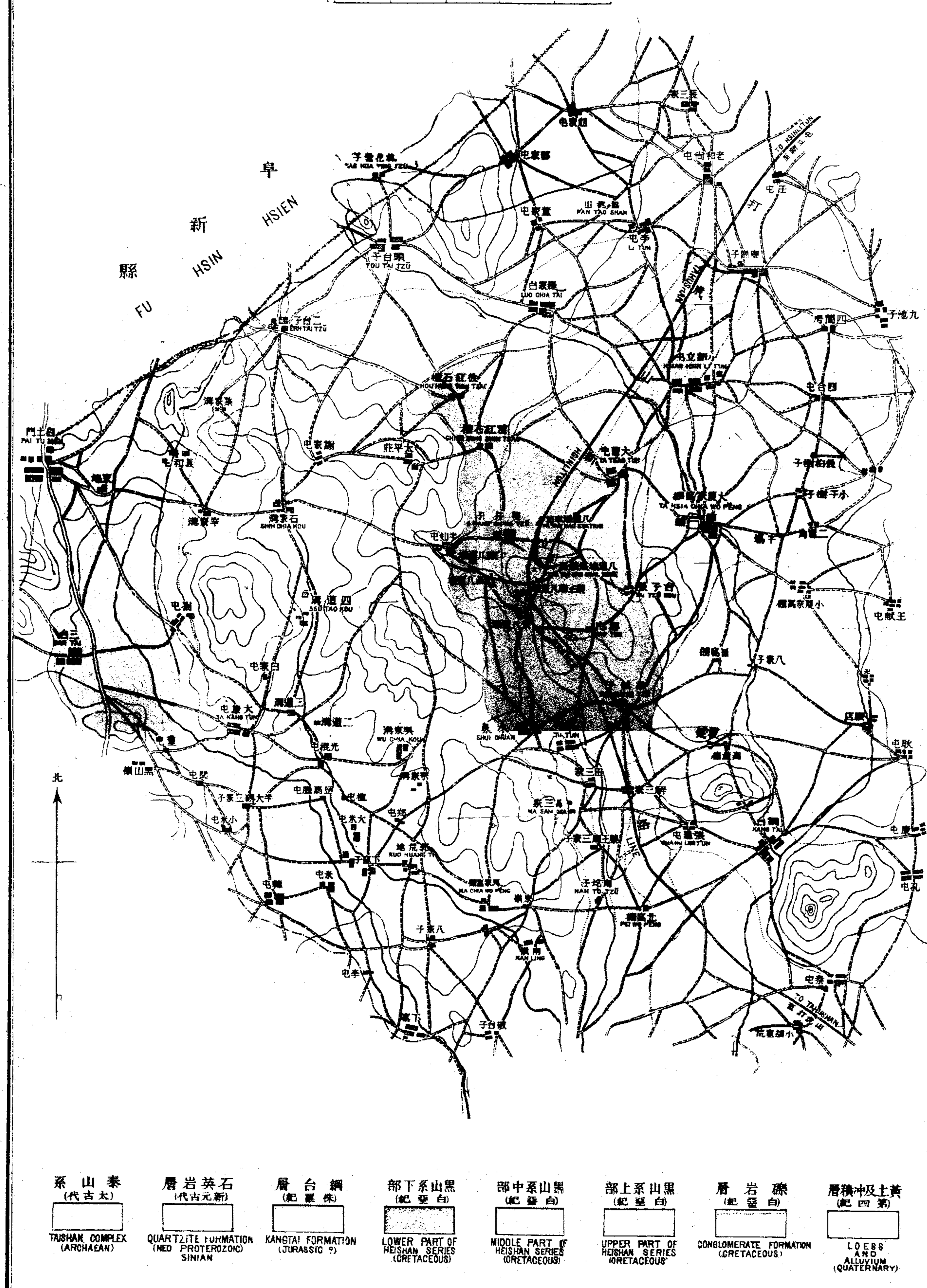


the coal basin. In the vicinity of T'ai Tzu Hou (台子楼) east of the coal mines the Archaean gneiss is widespread. North and West of the coal field in a zone passing by Tao Hua Ying Tzu (桃花營子) and Erh T'ai (二台) it is in fault contact with the tuff and lava of the Cretaceous formation. The Archean gneiss often forms low lands and low-hills and mostly crops out in ravines.

Neo-Proterozoic (Sinian): It unconformably overlies the Taishan complex and is found only at T'ou T'ai and Tun T'ai Shan (southwest of Erh T'ai), on the North West of the coal field. This formation contains white and gray quartzite with greenish schist at T'ou T'ai; white and gray quartzite and gray sandstone at Tun T'ai Shan. The quartzite often forms cliffs and conspicuous peaks, though it only occurs in small areas. The age of this white quartzite may be either Wutai (Eo-Proterozoic) or Sinian (Huto or Neo-Proterozoic). The latter correlation seems to be more likely in this area.

Kangtai Formation (volcanic Lava): This formation is well developed in the environs of Kang T'ai (鋼台) south east of Pa Tao Hao and forms conspicuous hills on the southeast of the same village. It consists chiefly of brown, purple and violet volcanic andesitic lavas and dark green and violet tuff. When examined under the microscope, the andesitic lava shows phenocrysts of idiomorphic and medium sized plagioclase and hypidiomorphic greenish horblende in a hypocrystalline ground-mass composed of feldspar microlites and subordinate glassy matter. On account of their apparent stratification the lava and tuff are grouped in one formation; no sedimentary beds are interbedded with them. In the northen part of the mapped area this formation is lacking and the Archaean gneiss is directly followed by the coal bearing Heishan series, while in the southeastern part the Heishan series is underlaid by this formation although without visible contact. According to its apparent stratigraphic position, this andesitic lava and tuff formation is provisorily considered as of Jurassic age.

Heishan Series (Coal Series): According to superposition and coal content it may be divided into three parts. (1) The lower part comprises largely clayey shale, sandstone and conglomerate without coal seams, from bottom upward the members are greenish and yellowish clayey shale and coarse sandstone, greenish and yellowish-gray clayey shale and fine sandstone and variegated conglomerate with pebbles from several contimeters to several decimeters and sometimes even to several meters in diameter. At Hao T'un (郝屯) a conglomerate of quartzite pebbles forms some hard beds which look very much like quartzite strata. Besides quartzite, pebbles of the conglomerates are also made of gneisses, sandstones and occasionally volcanic rocks. This part occurs along the eastern margin of the coal field and is exposed in the vicinities of T'ai Tzu Hou and Hao T'un and along the railway west of Chang Luo T'un (張羅屯). According to the width of the outcrop and the dipping angles of the strata this part amounts to about 100 meters in thickness. (2) The middle part overlies the lower part with a disconformity between them. It consists chiefly of sandstone, shale, clay and conglomerate with workable coal seams. The outcrops are very rare owing to extensive covering of loess and alluvium and only few strata are known in mining works and local exposures. At Hao T'un in contact with the conglomerate of the lower part is the greenish and yellowish clay, at Wei Ch'eng Tzu (維城子) above the lower part there is the greenish clayey shale; most of the rock pieces worked out from the shafts and inclines are gray sandstone and dark gray and black shale, and those shown in columnar sections through shafts are sandstone, shale clay and conglomerate with coal seams. This part is found to occur along the railway, though nearly the whole part is covered by superficial deposits, and the thickness is estimated at about 220 meters. (3) The upper part conformably overlies the middle part, but the contact is covered by superficial deposits. The essential members are clayey shale and sandstone with thin coal seams and apparently exposed along the eastern foot of the low hills on the west of the coal field. On the north of Ch'en Pa Tao Hao (陳八道濠) the strata are (from below upward) gray and greenish-yellow clayey shale with coarse sandstone and one seam of dark clayey shale (about 10 meters thick), conglomerate including pebbles of gneiss, quartzite and volcanic rocks (about 6 meters thick) gray and yellow clayey shale with sandstone (about 5 meters thick), conglomerate (about 3 meters thick) yellow and gray clayev shale and sandstone (abont 10 meters thick), conglomerate with sandstone (about 6 meters thick), and yellow and gray coarse sandstone with conglomerate and clayey shale (about 50 meters thick). In the vicinity of Tai T'un this part contains thin coal seams which have been worked, the strata exposed in ravines are yellowish, greenish and gray clay and sandstone (about 5 meters thick), conglomerate including pebbles of gneiss and quartzite (about 3 meters thick), grav and yellowish clayey shale with sandstone (about 6 merers thick), conglomerate with sandstone (about 4 meters thick), gray, greenish and yellowish clayey shale with gray-white and gray sandstone (about 6 meters thick), conglomerate (about 10 meters thick), and gray and yellowish sandstone (about 10 meters thick). In the environs of Shuang Ching Tzu and Ch'ien Hung Shih Tsao this part is represented by gray, greenish and yellowish clay and sandstone with fine conglomerate. It occurs along the western margin of the coal field, and is estimated at about 200 meters in thickness.

As to the age of the Heishan Series, Dr Krishtofovich* mentioned four species of plants fossils collected by Mr. Ahnert probably from the middle part of the series:

Dioonites kotoi Yokoyama
Ginkgo digitata Brongniart
Phoenicopsis speciosa Heer
Pityophyllum nordenskiöldi (Heer) Nathorst

On the basis of these fossiles, Dr Krishtofovich referred this formation to the Nican Series of the Russian Maritime province or to the upper division of Jurassic deposits in the Ussuri region. However, Dr. Krishtofovich himself has expressed the opinion that the age of the Nican series may well extends to the Wealden i. e. Lower Cretaceous.

The writer of this report has collected some fossil pelecypods from a dark shale below the coal seams in the middle part of the Heishan series. They were examined by Dr. A. W. Grabau, and some of them were found to be just the same *Corbicula* as that I have fommerly collected from the Yi Hsieh Cretaceous deposits and which have been already described by Dr. Grabau.** At Tai T'un in the southern part of this field some plant fossils were found; they are, according to the determination by Mr. T. C. Chow, *Czekanowskia*, *Podozamites*, *Nageiopsis* and *Taxodium*. In the Ling Yüan district, Jehol, the *Czekanowskia* occurs in association with fossil fishes***

* Kryshtofovich, A. Remains of Jurassic plants from Pa Tao Hao. Bull. Geol. Soc. China Vol. III, No. 2, pp. 105-108.

** Grabau, A. W. Cretaceous mollusca from N. China, Bull. Geol. Surv. China No. 5, pt. 2, pp. 185-191.

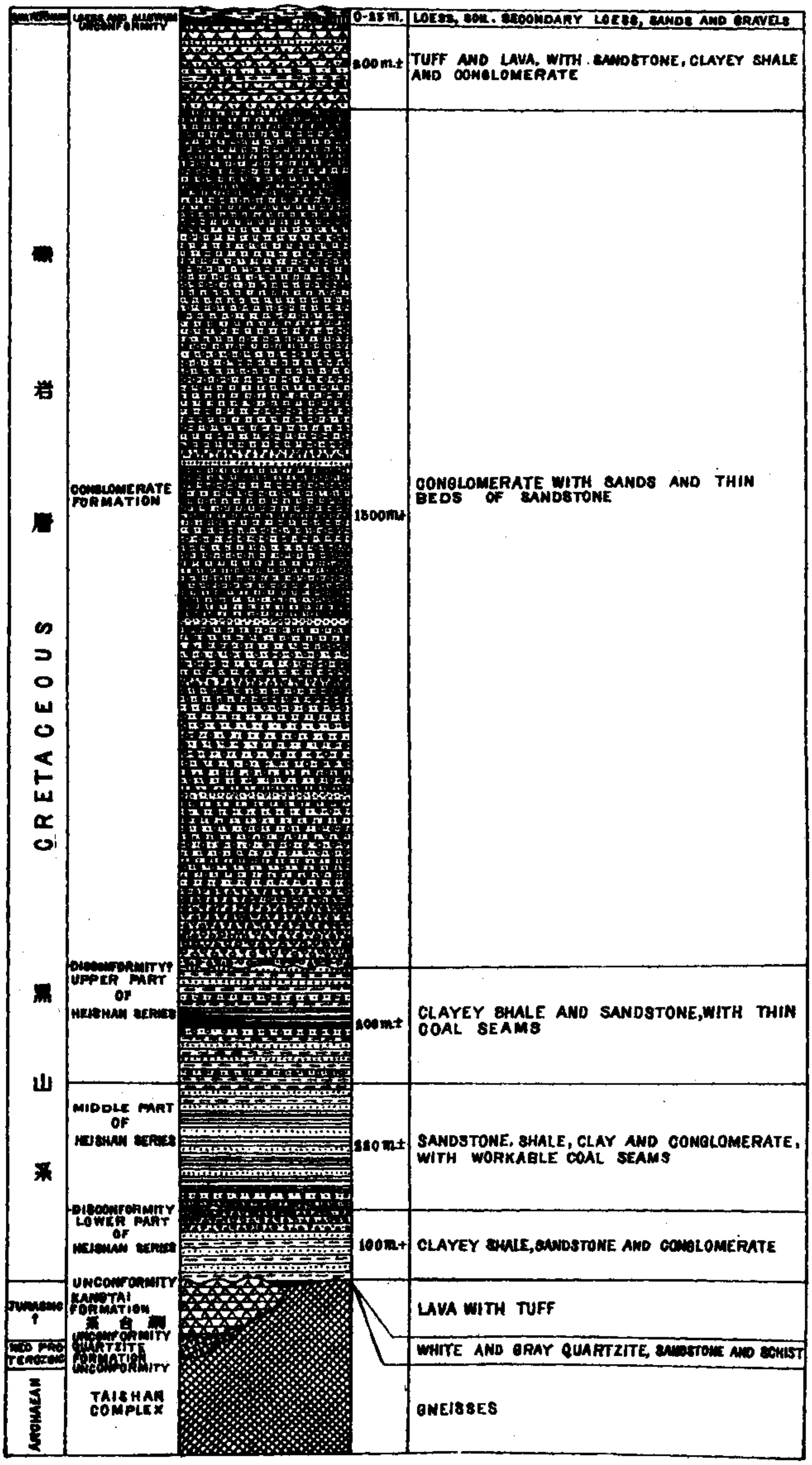
*** Grabau, A. W. Ibid. p. 184.

Lycoptera jeholensis considered as Cretaceous and the *Nageiopsis* is also of Cretaceous age. So according to fossil content the Heishan series may very probably belong to the Cretaceous. According to superposition and petrogaphical characters it is also proper to assign the Heishan series to this age. In northern China the known Cretaceous fossiliferous sedimentary deposits always lie immediately below the tuff-conglomerate,† in the Pa Tao Hao coal field the Heishan series directly underlies a conglomerate formation which contains tuff and lava in the upper part and much resembles the tuff-conglomerate of Shantung. In the Peipiao coal field in Jehol the Jurassic and Cretaceous coal series occur in association and contains different rocks from one another, the Jurassic coal series chiefly of hard-gray sandstone and dark-gray shale with coking bituminous coal, while the Cretaceous coal series comprises largely clayey shale and thin bedded sandstone with lignite or sub-bituminous coal. The Heishan series here contains clayey shale and thin bedded sandstone with sub-bitumineous coal and lignite, the latter have just the same fuel quality as those contained in the Cretaceous series in the Peipiao coal field. So the Heishan series can be well considered as Cretaceous on both the palaeontological and stratigraphical evidence.

Conglomerate Formation (Tuff-conglomerate): This formation overlies the Heishan series perhaps with a disconformity between them. It consists chiefly of conglomerate with tuff, lava and sandstone, and may be divided into two parts. The lower part contains tuff and volcanic agglomerate as well as conglomerate and loose sandstone. At Shuang Ching Tzu there are gray, green and yellow fine tuff and tuff-conglomerate with red and green clay and loose sandstone; at Chien Hung Shih Tsao the tusf-conglomerate also comprise loose sandstone. In general the conglomerate decrease in coarseness from below upward: at the base the coarse conglomerate contains greenish and gray sands, in higher horizon the finer and coarser conglomerates alternate and comprise gray and red sands, finally the finer conglomerate predominates with red sands and pebbles of quartzite and volcanic rocks. On the south of Shih Chia Kou (石家溝) the conglomerate

† Tan, H. C. New research on the Mesozoic and Early Tertiary geology in Shantung. Bull. Geol. Surv. China. No. 5, Pt. 2, p. 115.

GENERALIZED SECTION OF THE FORMATIONS IN THE ENVIRONS OF THE PA TAO HAO COAL FIELD IN THE HEISHAN DISTRICT, FENGTIEN



contains several thin seams of red hard sandstone. The pebbles of the conglomerate are mostly made of quartzite and gneiss and also often of sandstone, shale and volcanic rocks. On the southwest of Chu Pa Tao Hao (朱八道濠) large boulders ot gneiss are observed; the pebbles are either rounded or angular and the larger and smaller ones are mingled altogether. The upper part comprises green, violet purple and brown tuff and lava with sandstone, clayey shale and thin coal seam. On the west of T'ao Hua Ying Tzu the green and purple tuff and violetish lava are in fault contact with the Archaean gneiss; there are also thin coal seams which amount to 2 feet in thickness for each and were worked by natives; on the southeast of the same village the tuff also comprises thin coal seams. On the hill north of Luo T'ai (羅台) there occur green, brown and purple tuff and lava with coarse sandstone, conglomerate and greenish and dark clayey shale, the pebbles of the conglomerate are at some localities made of quartzite, mostly angular and form compact beds which look like a quartzite formation. The tuff contains fragmentary feldspar, quartz and biotite in a glassy matrix. The lava is also consequently andesitic in type; it contains phenocrysts of plagioclase with zonal structure, biotite and hornblende in a hypocrystalline matrix composed of minute crystals of feldspar and a subordinate amount of glassy matter.

Southwest of Erh T'ai (二台) there is a conspicuous hill composed of violet, green and dark tuff and lava with gray sandstone and conglomerate of quartzite pebbles. This formation is widespread in this area and has a minimum thickness of more than 1500 meters, the upper part having been partly cut away by faults.

On account of the lack of fossils the age of this formation is not exactly determinable. According to the superposition and petrographical characters, it may be correlated to the tuff-conglomerate common in Shantung and other regions in Northern China and may be of upper Cretaceous age.

Loess and Alluvium: The outcrops of the loess are very rare in this area, and most of it is covered by the alluvial deposits even in ravines. The alluvium is widespread and accumulated on the plains, low lands and slope and foot of the hills. The essential components are secondary loess, soil, sands and gravels. The thickness is irregular, from 20 to 30 ft. in average. According to the sections cut by the shafts of the Pa Tao Hao coal mine the loess and alluvium amount to about 70 ft. in thickness.

STRUCTURAL GEOLOGY.

A first and the most important igneous and diastrophic movement occurred in the Jurassic time before the deposition of the Heishan series. From this first volcanic outbreak the Kantai lava and tuff were formed. After the deposition of the Heishan series, came a second period of volcanic activity accompanied by strong erosion resulting in the formation of tuff-conglomerate. Then there was a period of faulting probably in the middle Tertiary time.

The biggest fault in the mapped area is that on the western margin of the basin striking in the south-north and northwest-southeast direction along a length of about 10 km. The upthrow side comprises the Taishan complex and the Sinian quartzite and the downthrow side the upper Cretaceous conglomerate. A second fault lies along the northern margin of this area and is about 6 km. long. Its upthrow and downthrow have the same formation as above stated. Small faults are numerous but only local.

With the exceptions of the local disturbance along the fault lines the strata are generally inclined to the west, southwest and northwest with the dipping angles varying between 5 to 30 degrees. At the conspicuous hill southwest of Erh T'ai the upper part of the Cretaceous conglomerate east of the big fault dips to southwest with angles above 40 degrees, while at the same locality the Sinian quartzite west of the fault dips to southeast with angles varying from 45 to 78 degrees. At T'ou T'ai the quartzite formation is inclined to S.S.E. at angles from 34 to 63 degrees. At T'ao Hua Ying Tzu the upper part of the conglomerate formation dips to northeast at angles from 40 to 60 degree. On the north of Luo T'ai the tuff, sandstone and shale are inclined to the south with the dipping angles between 50^0 and 70^0. At P'an Tao Shan (盤桃山) the sandstone and shale dip to S. E. E. at 34 degrees. All are local variations, and no definite folding can be detected.

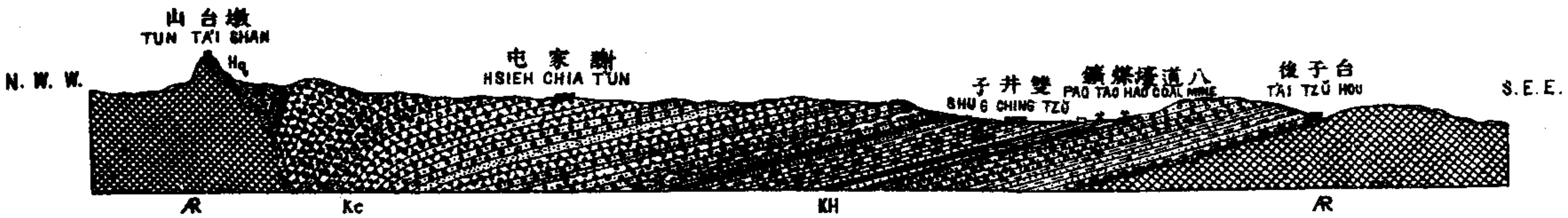
ECONOMIC GEOLOGY.

In the Pa Tao Hao coal field the coal seams are contained in the middle and upper parts of the Heishan series. The upper part comprises only thin coal seams; at Tai T'un they are two or three in number and each amount to

奉天黑山縣八道壕煤田一帶地層剖面圖

SECTION SHOWING THE DIFFERENT FORMATIONS IN THE ENVIRONS OF THE PATAO HAO COAL FIELD IN THE HEI SHAN DISTRICT, FENGTIEN

平面縮尺五萬分之一
直面縮尺一萬分之一
HORIZONTAL SCALE 1 : 50,000
VERTICAL SCALE 1 : 10,000



八道壕煤田煤系各部及可採煤層剖面圖

SECTION SHOWING THE DIFFERENT PARTS OF THE HEISHAN SERIES AND THE WORKABLE COAL SEAMS

縮尺一萬分之一
SCALE 1 : 10,000

Ar = TAISHAN COMPLEX. Hq = QUARTZITE FORMATION. KH = HEISHAN SERIES. KHl = LOWER PART OF HEISHAN SERIES. KHm = MIDDLE PART OE HEISHAN SERIES.
KHu = UPPER PART OF HEISHAN SERIES. Kc = CONGLOMERATE FORMATION.

two or three ft. in thickness. The middle part contains workable coal seams which have long been worked. According to the sections obtained by the shafts and borings there are six workable coal seams variable in thickness at different localities (see sections of shafts). The first seam occurs in the lowermost portion of the middle part of the Heishan series. It is often interrupted by the projections of the conglomerate of the lower part, and contains rock partings; its thickness is variable, about 6 ft. at west shaft; about 9.5 ft. in the 1st. crosscut excluding partings ; and about 6 ft. at east shaft including partings. In the north shaft and the 4th shaft the 1st. and 2nd seams are combined to form one seam, amounting to about 20 ft. at the former and about 17 ft. at the latter with partings. The 2nd. seam is very near from the 1st. seam, combined with it to form one seam, and also interrupted by the conglmerate, the thickness is about 5 ft. at the west and east shafts excluding partings. The 3rd. seam is contained in a fine conglomerate and sometimes interrupted by the coarse conglomerate of the lower part, the thickness is about 4 ft. at the west shaft and about 8 ft. in the 1st. crosscut excluding parting, only one part of the seam is found to occur at the east and north shafts. The 4th seam is not interrupted by the conglomerate and amounts to about 7 ft. in thickness at the west shaft and more than 6.5 ft. in the 1st. crosscut excluding partings. The 5th seam is found only at the west shaft and about 5 ft. thick. The 6th. seam is the uppermost of the workable coal seams and found at the 13th boring hole, the thickness is estimated at about 5 ft.

The thickness and the intervals between the coal seams are given in the following table:

Coal seams	1st. seam	2nd seam	3rd seam	4th seam	5th seam	6th seam
Thickness	6 ft. to 9.5 ft. (17'-20' with 2nd S.)	5 ft. (17'-19' with 1st seam)	4 ft. to 6 ft.	6.5 ft. to 7 ft.	5 ft. to 8 ft.	5 ft.
Intervals		2-3-10 ft. from 1st seam	14-30 ft. from 2nd seam	100-114 ft. from 3rd seam	50 ft. from 4th seam	300 ft. from 5th seam

The quality of the Pataohao coal is not good, and varies from subbituminous coal to lignite. But according the conclusion of the analyses of the coal by the Industrial Laboratory the coal of the 4th seam is somewhat coking. The analyses of the coal in different seams are given as follows:

Table I.

(by the Industrial Laboratory in 1925)

Coal seams	Moisture	Volatile matter	Fixed carbon	Ash	Colour of Ash	Nature of coal	Sulphur	Calorific Power
1st. seam	13.06	27.16	40.98	18.80	Red-brown	Non-coking		6056
2nd. seam	11.38	25.80	35.84	26.98	,,	,,		5501
3rd. seam	13.74	23.90	39.02	23.34	,,	,,		5570
4th. seam	9.83	28.33	48.22	7.62	Yellowish	Coking?	0.12	7151

Table II.

(by the Ta Hsin Coal Mining Co. in the Fu Hsin Coal Field 1923)

Coal	Moisture	Volatile matter	Carbon	Ash	Colour of ash	Sulphur	Nature of coke	Calorific Power
Best coal	13.51	22.99	45.27	7.13	Yellow-brownish	0.72	Non-coking	6048
Good coal	13.65	30.55	41.68	14.12	Brown	5.69	,,	5797

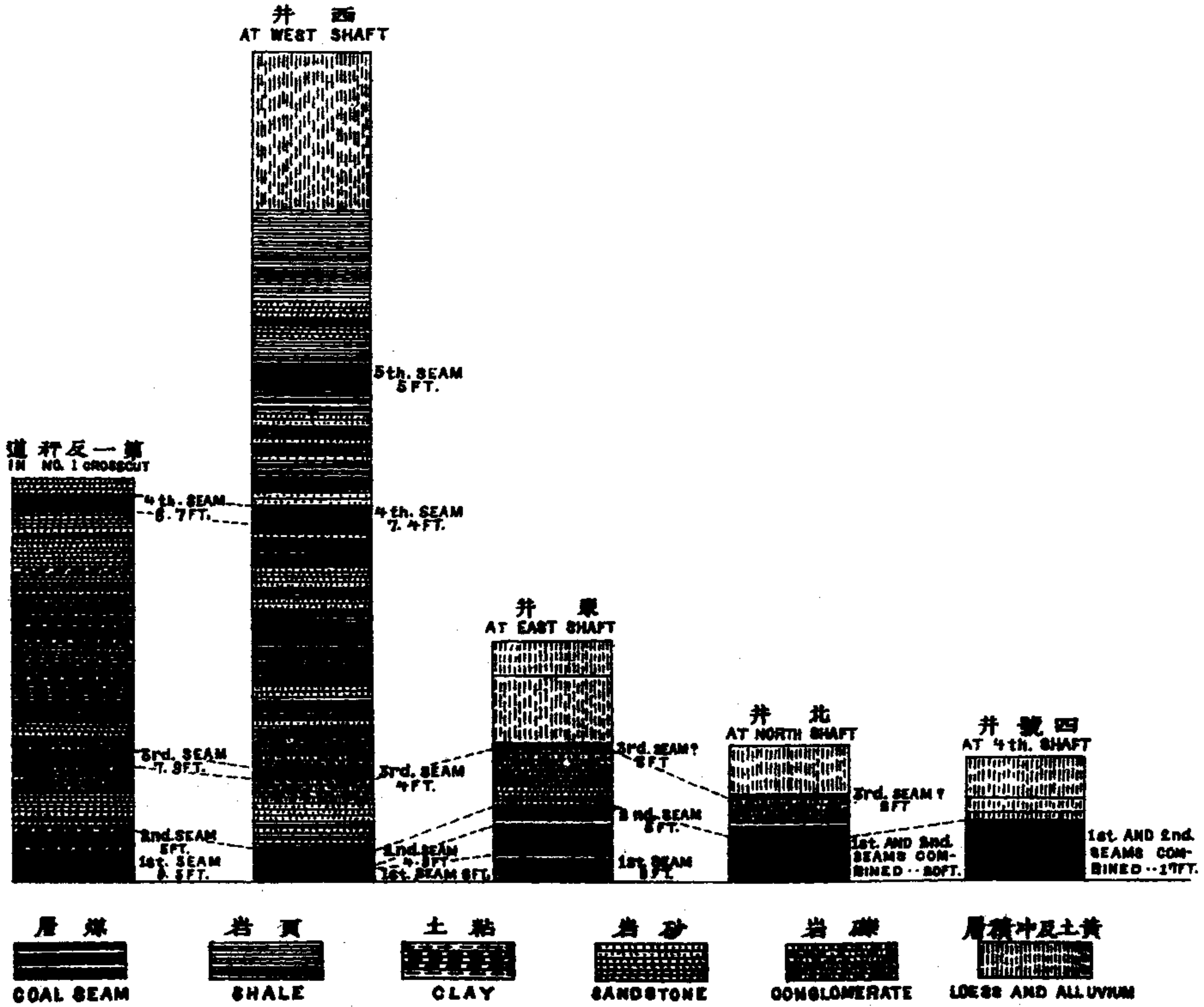
The estimate of the coal reserve of the coal field depends largely upon the geologic structure of the field and the reliable thickness of the workable coal seams. The structure of the Pa Tao Hao coal field is generallv simple, though the local faults sometimes occur to affect the coal seams. The projections of the conglomerate of the lower part of the Heishan series, however, often cause the discontinuity of the three lower coal seams, and thus reduce the coal resources. The area under which the coal seams are supposed to occur amounts to about 8 km. in length, but on account of the discontinuity caused by the projections of the conglomerate the lower three coal seams are supposed to have only one half of this figure as the total length. The inclination of the strata is gentle and the coal seams, above the depth of 300 meters from the surface are considered as workable. The width of the workable coal seams thus calculated is not less than 1,000 meters. The average total thickness of the known coal seams is about 9 meters. The specific gravity is supposed to

八道壕煤礦煤層位置比較柱狀圖

COLUMNAR SECTIONS SHOWING THE POSITION AND CORRELATION OF THE COAL SEAMS AT DIFFERENT SHAFTS IN PA TAO HAO COAL MINE

縮尺八百四十分之一

SCALE 1:840



be 1.1. The coal reserve of the Pataohaos coal field is thus estimated at about 59,400,000 tons.

It is said that Pa Tao Hao coal field was only discovered in 1919 and then immediately worked by the natives. Shortly after the authorities in Mukden sent men to establish the Pa Tao Hao Coal Mine in the field under the supervision of the Mukden Mining Bureau with a capital of two million dollars In 1925 the daily output amounts to about 250 tons. At the mine the cost of the coal (lump and dust mixed) is about 7.5 dollars per ton. The coal is transported bv the Peking Mukden Railway and sold along the line and in Mukden.

Geology of the Pei Piao Coal Field, Chao Yang distract, Jehol.

(*Summary*)

By H. C. T'AN (譚錫疇)

(With one plate)

INTRODUCTION.

This coal field was surveyed by the author in the autumn of 1923. The map is based on the more detailed one previously surveyed by Dr. V. K. Ting, but with such modifications as necessitated by my new observations. The Pei Piao (北票) coal field is situated ninety li north of the Chao Yang (朝陽) city, eastern Jehol. It is connected with the Peking Mukden railway by a branch line which joins the main line at the Ching Hsien (錦縣) station. This branch is to be continued to Chao Yang and thence to Chih Feng (赤峯) or Hata under the name of Chao-Chih railway. The distance between Pei Piao and Ching Hsien is about 230 li. The coal mine is now operated by the Pei Piao mining company with an output of over 100,000 tons per year.

STRATIGRAPHY.

The formations encountered in the mapped area are the following from below upward:

Upper volcanic series
Upper coal series (Cretaceous)
Lower coal series (Jurassic)
Lower volcanic series
Sinian quartzite and limestone.

The lower volcanic series contains chiefly tuff, agglomerate and lava. Its thickness varies from 360 to 500 meters. It seems to be unconformable with the Sinian quartzite and limestone which it directly overlies.

The coal bearing formation is chiefly composed of sandstone and shale with occasional intercalations of conglomerate and has a total thickness of over 1500 meters. It is divided into two series on the basis of the fossiles and the coal seams. The lower series contains the principal coal seams worked by the Pei-Piao coal mining company and has often yielded plant fossiles such as *Baiera* and *Zamites*. The coal is of good bituminous quality with about 2-4% moisture, 28-35% volatile matter, and about 50-64% fixed carbon. The good coal has less than 10% ash. It is similar to the coal of Ta Tung in north Shansi which is also of Jurassic age.

The upper coal series contains only thin and irregular seams of rather bad coal. The author of this report has found some *Corbicula* shells from a sandstone of this series and also some fossil insects which are identical with the *Samarura* of the Laiyang shale Shantung already described by Prof. A. W. Grabau.* On the evidence of these fossiles, Cretaceous age is asigned to the Upper coal series while the lower coal series is probably to be considered as Jurassic.

There seems to be no sign of unconformity between the upper and lower coal series although the existence of a disconformity is probable. The precise limit is yet to be determined. Owing to the wide covering of the red clay and the scarceness of rock outcrop, the detailed stratigraphy is as yet imperfectly worked out.

Above the upper coal series, comes again a very thick formation of volcanic materials. Andesitic lava is predominant; it is some times intercalated with tuff and onglomerate of green or brown color. This formation probably corresponds to the tuff-conglomerate that the author has previously studied in Shantung.**

The age determination of these formation is only provisory. It is uncommon to encounter a thick volcanic formation below the Jurassic, elsewhere in North China.

STRUCTURE.

As can be seen from the accompanying geological map, the general structure of the coal field is rather simple. The strata from the Sinian up to Cretaceous volcanic formation have a general strike NE-SW dipping to NW.

The coal field is cut by a series of transverse horizontal slips. These can be detected by the observation of the rock outcrop as well as in the underground mining work. The slip is generally not great. Five of these faults

* Grabau, A. W. Cretaceous fossils from Shantung. Bull. Geol. Surv. China, No. 5, Pt. 2. p. 177.

** T'an H. C. New research on the Mesozoic and early Tertiary in Shantung, Bull, ibid. p 114.

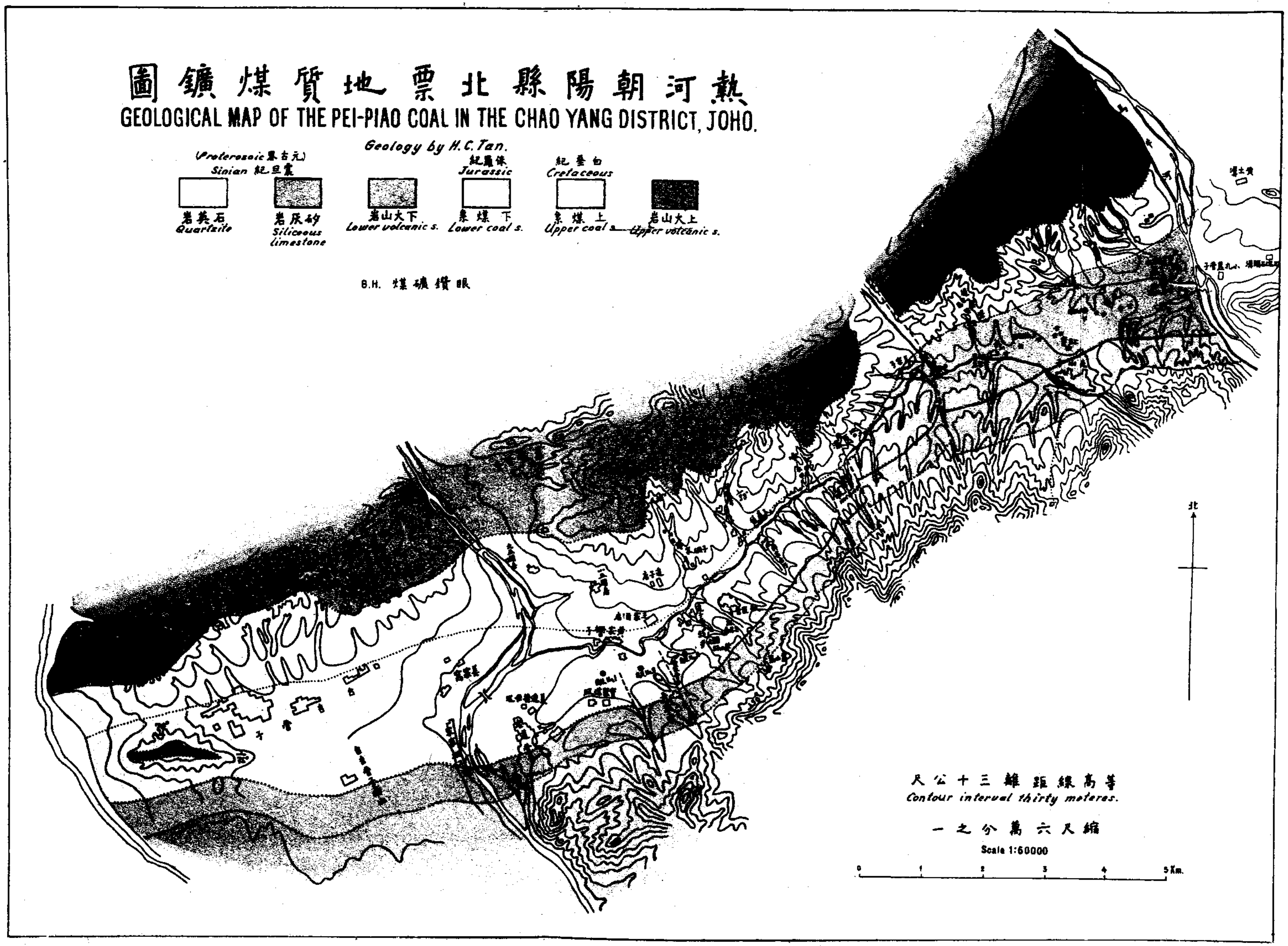
are shown on the geological map. These faults produce no effect on the topogarphy. Their age is probably rather young, at least post-Cretaceous.

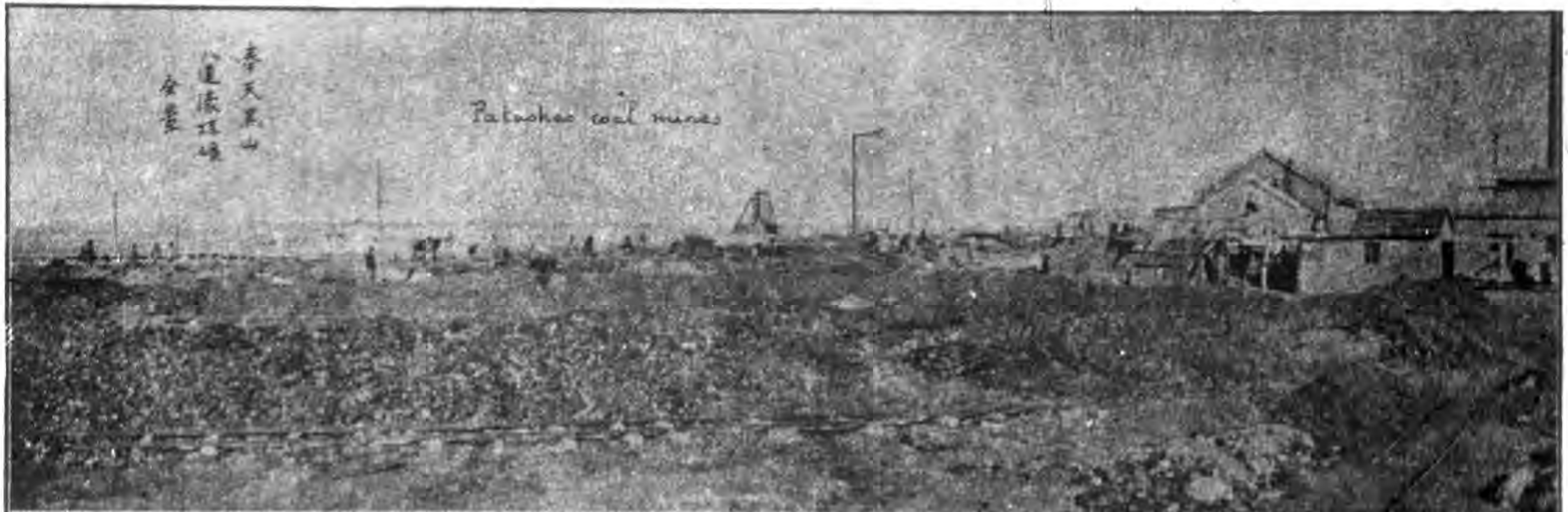
COAL SEAMS.

The special aim of the author's visit to the field was to study the position of the coal seams. Those contained in the lower series and as known by the shafts and borings of the Pei-Piao mining company are discussed in some details in the Chinese text.

As far as our actual knowledge goes, these exist in the western and central parts of the coal field three coal seams of sufficient thickness for mining. The upper seams has a thickness of 5-10 feet, the middle 4-30 feet, and the lower one 4-6 feet. There are some times a fourth worbable seam in the eastern part of the field. The number of coal seams is much increased if thin seams are included thus the boring hole No. 8 alone has encountered not less than sixteen seams the thickness of which varies · from a few inches to over eight feet. Taking only into account the three main seams and assuming their average total thickness to be 23-25 feet the authors arrived at an estimate of a little over 110,000,000 tons as the actual reserve to the depth of 600 metres.

The quality of the Pei Piao coal though not to compare favorably with the best Palaezoic coal in North China is yet the best of all the coals in the Jehol pegions which are as a rule low in carbon and high in moisture as represented by the Pa Tao Hao coal. The Pei Piao mine is rather favorably situated as it is not very far from the coast, and coal can be easily exported from Ching Wan Tao or the future port Hu Lu Tao. This is one of the important coal field recently developed in North China and which has a promising future.


熱河朝陽縣北票地質煤鑛圖
GEOLOGICAL MAP OF THE PEI-PIAO COAL IN THE CHAO YANG DISTRICT, JOHO.
Geology by H. C. Tan.
(Proterozoic 元古累)
Sinian 震旦紀
侏羅紀
Jurassic
白堊紀
Cretaceous
石英岩
Quartzite
矽灰岩
Siliceous limestone
下大山岩
Lower volcanic s.
下煤系
Lower coal s.
上煤系
Upper coal s.
上大山岩
Upper volcanic s.
北
等高線距離三十公尺
Contour interval thirty meteres.
縮尺六萬分之一
Scale 1:60000
0 1 2 3 4 5 Km.


奉天黑山
八道濠煤礦
全景
Patohao coal mines


Peipiao coal mines
熱河
朝陽
北票
煤礦
全景

Classification of Chinese Coals*

And a New Nomenclature with Notations

By W. H. WONG (翁文灝)

INTRODUCTION.

The richness of China in coal resources is well known, but so far little attention seems to have been paid to the differential quality of the various kinds of coal which are almost indifferently used. An attempt is here made to classify the principal kinds of the Chinese coal in the hope to bring out their main difference of composition.

No systematic classification based on ultimate analyses is yet possible for the Chinese coals because very few of them have been so analysed. Many proximate analyses, however, have been made and are to be found in various publications, chief among which are the special publication of the XIIth international geological Congress, and some Japanese reports.[1] More recently a number of analyses have been made by the Chinese Industrial Laboratory[2] of the Ministry of Agriculture and Commerce upon specimens collected by the members of the Geological Survey or obtained otherwise. Analyses have been also made and published by some provincial laboratories, for instance that of Shansi.[3] Reports have also been published by engineers of some mining companies.[4]

However owing to the lack of standardization of sampling and analysing, the analyses available are widely different in accuracy. A very careful selection has been necessary in order to have figures roughly comparable if not exactly representative.

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* Reproduced from "Oriental Engineer" April-May 1926 with revision.

1 Report of Japanese geological Survey No. 43. tables of coal analysis published in 1922 pp. 135-150 in 1919 pp. 1-4 and in 1924 pp. 1-22 also Journal of the Meji College of Technology in Japanese vol. II No. 7, 1922, pp. 183-187

2 Report of the Industrial Laboratory (工業試驗所報告彙刊), 1923, coal analyses pp. 1-55. See also various reports on coal fields in the bulletin of the Geological Survey.

3 Report of the Shansi analytical laboratory (山西礦產化驗成績報告書) 1915

4 See for instance F. F. Mathieu La géologie et les richesses minérales de la Chine, 1923, which contains many analyses made in the laboratory of Kailan Mining Administration. W. A. Shockley Notes on the coal and iron field of S. E. Shansi Trans. Am. Inst. M. E. Vol XXXIV. 1904, p. 843 containing analyses of Shansi anthracites etc.

For most of the coals which we are going to classify, volatile matter and fixed carbon seem to have been relatively well determined. But, except in a few cases, moisture has often been determined with less care.

The calorific values of most of the Chinese and some of the Japanese determinations are far from accurate and sometimes quite misleading. Figures calculated by Goutal's method[1] seem to be much more satisfactory and will be only used in the present study.

In the following (Table I) are tabulated analyses of thirty-one Chinese coals either better known as to their composition or actually worked in comparatively larger scales. In making selection from many analyses of a same coal field often widely different between themselves, only those representative of the principal seems actually worked are taken. When several such analyses are available, their average is given. While special effort has been made to have the figures as comparable as the available data could afford, it is however not pretended that any of the classifications thus arrived is to be considered as definite. On the contrary the exact position of any coal in any of the classifications is nothing but provisory and evidently subject to modification when better analysis is available. This preliminary character of the classifications can not be too much emphasized less there should be any misunderstanding regarding the commercial value of the coals here listed.

TABLE I ANALYSES OF PRINCIPAL CHINESE COALS.

	Province	Coal mine	Moisture	Vol. matter	Fixed Carbon	Ash	Cal. val.
1.	Metropolit:	Mentoukou	2.3	67.50	75.20	15.00	7057
2.	Chihli	Kaiping	0.6	25.90	59.78	13.34	7423
3.	,,	Chinghsing	0.56	20.20	69.20	9.20	7836
4.	,,	Lincheng	1.89	30.88	56.64	11.50	7545
5.	,,	Liukiang	0.70	6.57	77.57	15.20	7262
6.	,,	Yenli	1.6	19.00	68.50	10.30	7650
7.	Jehol	Peipiao	3.25	30.50	54.25	11.00	7335
8.	,,	Hsinchiu	12.00	35.00	42.50	10.00	6090

[1] Goutal's formula is $P = 82C + aV$ where P represents calorific value, C fixed carbon and V volatile matter, a is function of V' or volatile matter of pure coal without moisture and ash, $V' = \frac{100\,V}{V+C}$. To 5, 10, 15, 20, 25, 30, 35, 38 and 40% of V', respectively correspond 145, 130, 117, 109, 103, 98, 94, 85 and 80 of a. The intermediary values can be found by graphic method. For values of a readity calculated see E. Combeau, de la houille 1921. p. 69. The method is however not accurate for V' higher than 42%

TABLE I (Continued).

	Province	Coal mine	Moisture	Vol. matter	Fixed Carbon	Ash	Cal. val.
9.	Fengtien	Fushun	6.73	39.34	48.15	5.25	6780
10.	,,	Penchihu	0.68	23.95	64.07	11.20	7508
11.	,,	Yentai	1.15	12.00	71.20	14.70	7198
12.	,,	Pataohao	12.65	20.55	41.68	14.12	5369
13.	Kirin	Changchun	10.80	32.50	45.16	11.12	6270
14.	Heilungkiang	Tangyuan	1.50	32.21	58.14	7.50	7731
15.	,,	Zalainor	20.93	36.35	39.03	3.69	3443(?)
16.	Shantung	Chunghsing	0.50	27.00	63.50	9.40	7853
17.	,,	Tzechuan	0.57	14.90	74.70	10.00	7821
18.	,,	Poshan	0.85	18.90	69.80	9.85	7784
19.	,,	Fangtze	2.80	30.70	51.80	14.70	6948
20.	Honan	Liuhokou	0.55	19.16	72.05	8.40	7977
21.	,,	Chiaotso	0.65	6.70	84.50	8.00	7867
22.	,,	Mienchih	9.6	32.50	45.40	13.50	6258
23.	Shansi	Tatung	4.50	30.99	59.45	5.50	7819
24.	,,	Pingting	0.78	6.55	86.35	5.70	7998
25.	,,	Chechou	1.80	9.35	80.80	7.80	7841
26.	Kiangsi	Pinghsiang	1.35	23.75	62.75	11.80	7580
27.	,,	Loping	1.00	45.90	44.00	9.10	5550(?)
28.	Kiangsu	Chiawang	1.35	29.54	51.50	17.60	7064
29.	Anhoei	Shunkenshan	0.85	34.90	54.75	9.50	7385
30.	,,	Hsuancheng	0.75	26.47	49.77	22.00	6568
31.	Cheking	Changhsing	0.94	37.70	49.80	10.90	6913

On the basis of these analyses, systematic classification may be attempted. There exist however quite a number of systems of coal classification. Each of them seems to have its advantage and disadvantage. We shall now successively apply to the Chinese coals the main classifications used in Europe and America and try to draw such conclusions as they may lead to. At the end a new system of nomenclature and notation will be outlined.

CLASSIFICATIONS BASED ON THE VOLATILE MATTER OR FUEL RATIO ON MOISTURE AND ASH FREE BASIS.

Classification based on the volatile matter content is also known as the Gruner classification[1] chiefly used in France and with greater or lesser modifications in the other countries of the European continent. The volatile matter content is calculated in the theoretic value as would contain a dry

1 L. E. Gruner, Ann. des mines Vol. 4 (Ser. 5) pp. 169-207, 1873. See also Chemin et Verdier La houille et ses derivés p. 27; W. A. Bone, Coal and its scientific uses 1918 p. 64; F. Colombier et ch. Lordier, Combustibles industriels 4th edit. 1921 pp. 34-27.

ashless fuel. More recently Boulton[1] proposed a new classification for the South Wales coals chiefly based on the hydrogen and carbon contents. As there seems to be some constant relationship between the hydrogen and the volatile matter, Boulton's main divisions of coal can also be roughly established with the percentage of the latter. The Table II will show the volatile matter contents of different Chinese coals calculated on the dry and ash-less basis and the corresponding names in the Gruner and Boulton classifications.

The fuel ratio, being the ratio of the fixed carbon to the volatile matter, the most commonly used in America as coal classification basis, is based on the same principle as the Gruner classification though in a different form, for this ratio is also calculated as if the moisture and ash were non-existing. The coal classification based on this ratio is chiefly known as Frazer's classification[2] from the name of the author who first applied it to the Pensylvanian coals. The nomenclature of the Chinese coals according to this classification will be also listed in the table II. That there is no important change in the relative position of the different coals in the three classifications is easily explained by the fact that these classifications are all based on the same principle in taking account only of the pure "coal substance"

As it has been already pointed out by several authors,[3] Frazer's classification is really good only for the coals of higher ratios. His group of bituminous coals is too comprehensive and thereby loses much of its usefulness. One subdivision at least might be introduced above and below the fuel ratio 2; Coals with fuel ratio above 2 are generally well coking while others with fuel ratio below 2 are as a rule not coking so well. Another one may be added with the fuel ratio 1.5 as the dividing point; the coals below that point are rapidly approaching the lignite. These variations are all well represented by the Gruner classification which appears thus still better adaptable to practical use than any of the later ones based on the same principle. This classification is some times called the Regnault-Gruner classification as the first scheme was

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1 W. S. Boulton, Trans. South Wales Inst. Eng. Vol. XXI 1900 also Practical coal mining Vol. I pp. 87-91.

2 Persifar Frazer, Trans. Am. Inst. Min. Eng. Vol. VI 1877 pp. 430-451 Pensylvania Second Geological Survey Report MM. 1879 p. 143.

3 M. R. Campbell The classification of coal, Trans. Am. Inst. Min. Eng. Vol. XXXVI 1906 p. 326.

TABLE II CLASSIFICATIONS BASED ON THE VOLATILE MATTER OR FUEL RATIO ON MOISTURE AND ASH FREE BASIS.

Order	Coal (Prov.)	Volatile matter. †	Gruner's classific.	Boulton's Classific	Fuel ratio††	Frazer's classification	Chief uses
1.	Pingting (Shansi)	7.05	Anthracite	Anthracite	13.2	Anthracite	Domestic heating
2.	Chiaotso (Honan)	7.34	"	"	12.6	"	"
3.	Liukiang (Chihli)	7.80	"	"	11.5	Semi-anthracite	"
4.	Mentoukou (Metrop)	8.00	"	"	11.5	"	"
5.	Chechou (Shansi)	10.38	Charbon maigre, Quart-gras	"	8.6	"	"
6.	Yentai (Fengtien)	14.16	Charbon maigre, Demi-gras	Carbonaceous	6.2	Semi-bituminous	Steam raising
7.	Tzechuan (Shantung)	16.44	Charbon maigre, Semi-bituminous demi-gras	Semi-bituminous	5.8	"	"
8.	Poshan (Shantung)	20.20	Houille grasse a courte flamme, charbon a forge.	"	3.7	Bituminous	Coke making & steam raising (coke very dense)
9.	Liu Ho Kou (Honan)	21.13	"	"	3.8	"	"
10.	Yenli (Chihli)	21.71	"	"	3.6	"	"
11.	Chinghsing (Chihli)	22.59	"	"	3.4	"	"
12.	Penchihu (Fengtien)	26.07	Houile grasse proprement dite, charbon de forge	Bituminous	2.7	"	Coke making (coke dense)
13.	Pinghsiang (Kiangsi)	26.20	"	"	2.5	"	"
14.	Chunghsin (Shantung)	29.84	"	"	2.4	"	"
15.	Kaiping (Chihli)	30.33	"	"	2.3	"	"
16.	Pataohao	33.02	"	"	2.0	"	"

TABLE II (Continued)

Order	Coal (Prov.)	Volatile matter. †	Gruner's classific.	Boulton's classific.	Fuel ratio††	Frazer's classification	Chief uses
17.	Lincheng (Chihli)	34.13	Houille grasse a longue flamme charbon a gaz.	Bituminous	1.8	Bituminous	Gaz making, coke very porous.
18.	Tatung (Shansi)	34.15	,,	,,	1.9	,,	,,
19.	Hsuancheng (Anhoei)	34.77	,,	,,	1.9	,,	,,
20.	Tangyuan (Heilungkiang)	35.65	,,	,,	1.8	,,	,,
21.	Peipiao (Jehol)	35.87	,,	,,	1.8	,,	,,
22.	Chiawang (Kiangsu)	36.45	,,	,,	1.8	,,	,,
23.	Fangtze (Shantung)	37.21	,,	,,	1.7	,,	,,
24.	Shunkengshan (Anhoei	39.02	,,	,,	1.5	,,	,,
25.	Mienchih (Honan)	41.72	Houille Flambante, Houille Seche a longue flamme.	Perbituminous	1.4	(Sub-bituminous)	Residue non coherent.
26.	Changchun (Kirin)	41.84	,,	,,	1.4	,,	,,
27.	Changhsing (Chekiang)	43.05	,,	,,	1.3	,,	,,
28.	Fushun (Fengtien)	44.96	,,	,,	1.2	,,	,,
29.	Hsinchiu (Jehol)	45.16	Lignite	,,	1.2	,,	,,
30.	Zalainor (Heilungkiang)	45.55	,,	Lignitious	1.1	,,	,,
31.	Loping (Kiangsi)	51.05	,,	,,	0.9	,,	,,

† The value is calculated on the dry and ash-less basis; it is obtained by the formula $V' = \frac{100\,V}{V+C}$ where V and C are respectively the volatile matter and fixed carbon of ordinary proximate analysis.

†† This is the ratio $\frac{C}{V}$ which is the same as $\frac{C'}{V'}$

due to Regnault[1] who first pointed out that the percentage of carbon and other elements could be used to group coals in such a way as to indicate their utility for different industrial purposes. It is surprizing to see that so many classifications have been later devised based on the same principle as, but offering no distinct advantage over, the Regnault-Gruner Classification which has however an incontestable priority.

The advantage of the fuel ratio is, however, to afford numerical characteristics easy to remember. Thus fuel ratios above 8 correspond to anthracites. Those ranging from 4.5 to 8 are non-coking semi-bituminous or steam coals. The best coking coals have their ratios ranging from 3 to 4.5 although those from 3 to 2 are also good for coking. Coals of which the fuel ratio ranges from 2 to 1.5 are gaz coals. Still lower down, we arrive at the splint coals, as they are called in England, and lignites the clear division between which is not well established.

There are however some points which seem doubtful in the above classifications as applied to Chinese coals. For instance, one can not help being surprised at seeing the Pataohao coal placed side by side with the Kaiping and Lincheng coals which are certainly of a much better quality. It is also unexpected to find the Mienchih and Changchun coals classified much above the coal of Changhsing or even above that of Fushun, for they are generally known to be of rather inferior quality. The Tatung coal is shown as very close to the Lincheng and Kaiping in this classification; but it has been established[2] by careful experimentation that the former is not so well coking as the latter. The Loping coal constitute an anomaly in these classifications, its fuel ratio is even lower than the Zalainor lignite. One of the chief reasons for these disagreements of the numerical characteristics of the coals with their known properties consists of the fact that all these classifications do not take into account any thing but the volatile matter and fixed carbon; besides these elements, there are certainly others in the actual composition of the coal which have influence on its quality. The moisture especially acquires such an importance in the low-ranks coals or coals higher in volatile matter content that it can not be entirely neglected in a good classification. It is therefore the general tendency in modern classifications to take the moisture as a con-

1 V. Regnault Ann. des mines Vol. 12 (Ser. 12) 1837. 161-240.

2 C. C. Wang The cold field of Tatung, Shansi, Bull. Geol. Surv. China, 1921 Chinese text pp. 60-66

stituent part of the coal[1] on the equal footing with the volatile matter and the fixed carbon.

CLASSIFICATIONS BASED ON THE VOLATILE MATTER, THE FIXED CARBON AND THE MOISTURE CONTENTS ON ASH FREE BASIS.

There are also different ways to take into account the moisture content in the coal classification. One of the most successful attempts was that of Dowling[2] who based his classification on the "split volatile ratio". The ratio is expressed by the formula.

$$\frac{\text{Fix. Carb.} + \frac{1}{2}\ \text{Vol. Mat.}}{\text{Moist.} + \frac{1}{2}\ \text{Vol. Mat.}}$$

The volatile matter is here divided into two portions because it is presumed that only approximately half of the volatile carbon and hydrogen is available for the production of heat while the other half is inert and therefore should be placed with the moisture as anti-calorific material. This ratio has been mostly used for the classification of Canadian coals and partially adopted by the XII Session of the International Geological Congress[3] for the low carbon coals. The difficulty is then to determine satisfactorily the "change-over" point when using two different factors in one classification.

Another way to take the moisture into the fuel ratio is simply to add the moisture to the volatile matter in the calculation of the fuel ratio. This will be then represented by the following formula which we shall call here for

$$\frac{\text{Fix. Carbon}}{\text{Moist.} + \text{Vol. mat.}}$$

simplicity the "moisture combined ratio". It has been used by Ashley[4] as one of the characteristics in his "use-classification" and will also be applied here to the Chinese coals for comparison.

The classification adopted by Campbell[5] for the coals of the United States is based on the three components in proximate analyses: viz, moisture.

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1 W. T. Thom. Moisture as a component of the volatile matter of coal, Trans Am. Inst Min. Eng. Vol. LXXI 1925 p. 282.

2 D. B. Dowling, Canada Dept. Mines, Geol. Suryey Branch, Report No. 1035, 1909. pp. 43-45; Coal fields and coal resources of Canada Can. Geol. Survey, Mem. 59, 1915.

3 Coal resource of the world 1912.

4 G. H. Ashley: A use classification of coal Trans. Amer. Inst. M. M. Eng. Vol. XLIII 1920 p. 786.

5 Marius R. Campbell, The coal fields of the United States, general introduction U. S. G. S: prof. pap. 100-A 1922 pp. 8-9.

TABLE III: CLASSIFICATIONS TAKING ACCOUNT OF THE MOISTURE.

Order	Order in table II	COAL	Split volatile Ratio†	Dowling's Classif	Ash free Fixed carbon††	Campbell's classification	Moisture combined ratio†††
1.	1	Pingting	22.1	Anthracite	91.6	Anthracite	11.8
2.	2	Chiaotso	21.9	″	91.8	″	11.5
3.	3	Liukiang	20.3	″	91.4	″	10.5
4.	4	Mentoukou	15.9	″	88.5	Semi-anthracite	8.5
5.	5	Chechou	13.2	Semi-anthracite	87.6	″	7.3
6.	6	Yentai	11.2	Anthracite-coal	83.5	High rank semi-bituminous	5.3
7.	7	Tzechuan	10.3	″	83.0	″	4.9
8.	9	Liuhokou	8.0	High carbon coal	78.6	Low rank semi-bituminous	3.56
9.	8	Poshan	7.7	″	77.4	″	3.8
10.	11	Chinghsing	7.6	″	76.2	″	3.4
11.	10	Yenli	7.1	″	76.4	″	3.3
12.	12	Penchihu	6.0	″	72.2	″	2.6
13.	15	Kaiping	5.5	Bituminous coal	69.0	High rank bituminous	2.2
14.	14	Chunghsing	5.5	″	70.1	″	2.7
15.	16	Hsuancheng	4.5	″	64.5	″	1.8
16.	18	Lincheng	4.4	″	64.0	″	1.7
17.	13	Pinghsiang	4.2	″	71.1	″	2.5
18.	20	Tangyuan	4.2	″	62.8	″	1.68
19.	22	Chiawang	4.1	″	62.4	″	1.66
20.	24	Shunkengshan	3.9	″	60.5	″	1.5
21.	21	Peipiao	3.8	″	60.9	″	1.6

TABLE III: (Continued)

Order	Order in table I	COAL	Split volatile Ratio†	Dowling's Classif.	Ash free Fix. carbon ††	Campbell's classification	Moisture combined ratio†††
22.	20	Tatung	3.7	Bituminous coal	62.9	High rank bituminous	1.5
23.	27	Changhsing	3.5	,,	55.9	Medium rank bituminous	1.5
24.	23	Fantze	3.4	Low Carbon coal	60.8	High rank bituminous	1.3
25.	25	Mienchih	3.0	,,	62.5	Medium rank bituminous	1.1
26.	26	Changchun	2.8	,,	48.9	Low rank bituminous	1
27.	28	Fushun	2.6	,,	50.6	,,	1
28.	31	Loping	2.5	,,	48.4	,,	0.9
29.	17	Pataohao	2.3	Lignite-coal	48.1	,,	1.25
30.	29	Hsinchiu	2.0	,,	47.2	,,	0.9
31.	30	Zalainor	1.5	Lignite	40.5	Subbituminous or lignite	0.7

† This ratio is represented by the formula $\frac{C+\frac{1}{2}V.}{M+\frac{1}{2}V.}$

†† This is expressed by $\frac{100\ C}{C+V+A}$ and is neither the direct result of analyses nor the one in the Gruner classification.

†† This is represented by the formula $\frac{C}{M+V}$

volatile matter and fixed carbon. Coals increase in ranks from sub-bituminous to anthracite as the fixed carbon calculated on the ash free basis gradually increases.

It is remarkable that the order of the first twelve numbers or so remains unchanged in the table II, and III, but the position of the coals higher in volatile combustible and moisture varies rather widely. Especially noticeable is the position of the Pataohao coal which from No. 17 in the table II falls in the table III to No. 28. Equally remarkable is the change of the Shunkengshan coal from No. 24 to No. 20. The reason has been already pointed out to prefer the classifications which take into account the moisture content besides the volatile matter. The three classifications above mentioned all satisfying that condition, give results which offer no essential difference, and it seems difficult to decide which classification is better conform to the general proprieties of the coals in the light of our limited knowledge of the Chinese coals.

In a broad way however, the practical value of the coals is well represented by these classifications. The high carbon coals of the Dowling classification corresponding to Campbell's low rank semi-bituminous are good coking coals. Dowling's bituminous corresponding to Campbell's high rank bituminous coals comprise coals also good for coking but already gradually passing into coals rich in gas and producing very porous coke. This is the same property which Campbell has found with the United States coals as is well shown by his atlas.

Campbell's distinction of medium rank and low rank bituminous seems to afford a better division than Dowling's low carbon coal. In the absence of accurate practical tests of the Chinese coals, it is again difficult to formulate any definite opinion. Much uncertainty is also due to the lack of standardization in the determination of the moisture which is greatly variable with the condition of the specimens.

It is also to be noticed that the denomination of the Pataohao, Hsinchiu and Zalainor coals as lignites happens to be in accord with the classification of Collier who proposed the moisture content of 10% as the basis of separation between bituminous coal and lignite. Campbell made appeal to physical properties for the distinction between his sub-bituminous and lignite.

A NEW NOMENCLATURE

It is generally admitted that not all the physical and chemical properties of coals are well represented by the proximate analyses; therefore any classification based on such analyses only can not be expected to be satisfactory in all respects.

It must be expecially borne in mind that both the volatile matter and the fixed carbon in a coal analysis are but two vague terms to designate widely variable and complex components. The volatile matter, for instance, comprises gaz and tar the composition and proportion of which may have strong influence on the quality of the coal.

However the proximate analysis constitute always the most convenient way of getting the first knowledge on coal composition and should used as such to obtain a classification useful for practical distinction. This is evidently the aim of the different systems of classification above outlined and applied to the Chinese coals with unequal successful results. All of these classification try to represent the fuel only as if the ash were entirely non-existing. The figures or ratio so far used are therefore entirely theoretical because the coals which they are intended to represent are always more or less impure and sometimes very ashy.

A practical specimen of coal is composed of the "coal substance" or combustible matter which is in turn roughly distinguished as volatile matter and fixed carbon, the moisture, the ash and a few minor elements of more accidental nature, as sulphur. The practical value of the fuel depends much, of course, on the composition of the combustible substance but in a no small measure also on the content of the other components, chief among which are moisture and ash. There is always some ash present in coals and often to an important amount. The ash content of the thirty Chinese coals treated in this paper varies from 3.61 to over 20% with a majority over 10%. It is therefore clear that in order to have a practical representation of a coal, two characters at least must be taken into account: (1) the quality of the essential part of the fuel i.e. the volatile matter, the fixed carbon and the moisture of the properly air-dried specimens and (2) the relative proportion of the above mentioned components to the extraneous matter, the ash. The first character decides the *rank* to which a coal belongs and the second its *grade*. All the classifications already mentioned only refer to the rank but none to the grade.

For practical purpose therefore, a new system of nomenclature or at least representation which gives at once the rank as well as the grade of coals may be useful. The question is only how to express these characteristics. For the reason already explained the ratios taking into account the moisture together with the volatile hydrocarbon may be used with advantage to distinguish the different ranks of coal. As to the grade of coal, the ash content is the direct expression.

In comparing the three ratios used in the Table III it must be borr mind that there is no direct proportion between these ratios and the prac quality of the coals. In other words, the numerical value of these ratios no other significance but to indicate the relative order of the coals. It ha: the contrary, the inconvenience of giving much more difference to high- coals than to the low-rank ones. Thus the split volatile ratio ranges from 10 to over 22 for the anthracites and only from 3.5 to 10 for the bituminous. As for practical purpose the distinction between the different varieties of bituminous coal is far more important than between the various kinds of anthracite, it could be desired to have a contrary distribution in the classification with the ratios of bituminous coals more differentiated than those of the anthracites. At that point of view the ratio of the fixed carbon to the volatile matter and moisture combined or more simply the moisture combined ratio is better than the split volatile ratio. For this reason this ratio is here adopted for the distinction of the ranks of coals.

A special name and a corresponding symbol may be given to each of the ranks thus distinguished. The Table IV shows the suggested nomenclature and its approximate equivalency with other systems of classification.

In this table, three ranks each are distinguised from the anthracites and the bituminous coals. The latter is called *bitumite* following the example of Evans.* Anthracite and bitumite are respectively designated by the symbols A and B in capital letters. These are followed by small letters h, m or l, respectively corresponding to the high, medium or low rank. Lignite is represented by the symbol C. Two intermediary ranks are found to exist between anthracite, and bitumite and between the latter and lignite. These

* W. P. Evans. Some remarks upon coals and their classifications. New Zealand Journ. of Sc. & Tech. 1924 p. 168

TABLE IV: CORRELATION OF THE NEW CLASSIFICATION WITH THE OTHERS

New classification and symbol	Moisture combined ratio	Gruner classific.	Frazer classific.	Dowling classific.	Campbell class.	German class.	Belgian class.	English class.	Chief uses
Ah High rank anthracite	10-12	Anthracite	Anthracite	Anthracite	Anthracite	Anthracite	Anthracite	Anthra-cite	Domestic heating
Am Medium rank anthracite	8-10		Semi-anthracite		Semi-bituminous				,,
Al Low rank anthracite	6-8	Charbon maigre, ¼ gras		Semi anthracite		Mager kohle	Charbon dur. Charleroi	Steam coal	,,
AB Anthracitic bitumite	4-6	Charbon maigre, ½ gras	Semi-bituminous	Anthracite coal	High rank semibit.				Steam raising
Bh High rank bitumite	3-4	Charbon a coke	Bituminous	High carbon coal	Low rank semibit.	Fett-kohle koks-kohle		Coking coal	id & coking Coke very dense
Bm Medium rank bitumite	1.7-3	Houille grasse, ch. de forge		Bituminous coal	High rank bitum.	Fett-kohle	Flenu gras Mons		Coking, Coke dense
Bl Low rank bitumite	1.3-1.7	Charbon a gaz	Sub-bituminous	Bit. & low carbon coal		Flamm kohle		Gaz coal	Gaz making, Coke porous
BC Lignitic bitumite	0.9-1.3	Houille seche a longue flamme		Low carbon & lignite coal	Med. rank bitum. Low rank bitum.		Flenu sec	Splint coal	Reverbatory furnace, Residue non-coherent
C Lignite	< 0.9	Lignite	Lignite	Lignite	Sub-bit. or lignite	Lignite	Lignite	Lignite	Res. non-coherent.

are respectively called anthracitic bitumite and lignitic bitumite represented by AB and BC.

This classification seems to especially suit the Chinese coals as it includes and distinguishes all the principal varieties of anthractie and bituminous which constitute the most important mineral fuels in China. No subdivision of the lignite is attempted as this kind of fuel has not much practical importance in this country. Evan's classification[1] seems to be the best existing.

The grade of coal is to be indicated by the ash content; it may be roughly indicated by a simple index if a definite division is established of the varying percentage of the ash. For this purpose, Ashley's scale[2] may be used with each grade represented by a figure. Thus we shall have:

Ash percent	0-4	4-8	8-12	12-20	20
Grade index	1	2	3	4	5
Grade expression	very high	high	medium	low	very low

According to this system of classification, each coal may be represented by a notation consisting of a symbol combined with an index.

Thus if the analyses of the Table I be accepted as correct, the Kailan coal would be called low-grade medium-rank bitumite and represented by the notation Bm_4. Likewise the notation of the Fushun coal would be written as BC_2 and called high-grade lignitic bitumite while the Mentoukou coal would be low-grade medium-rank anthracite Am_4. The following table shows the corresponding notations for all the Chinese coals treated in this paper:

TABLE V:

Coal notations with grade index based on ash

Coal	Notation	Coal	Notation	Coal	Notation
Pingting	Ah_2	Yenli	Bh_2	Peipiao	Bl_3
Chiaotso	Ah_3	Chunghsing	Bm_3	Shunkengshan	Bl_3
Liukiang	Ah_4	Penchihu	Bm_3	Fangtze	Bl_4
Mentoukou	Am_4	Pinghsiang	Bm_3	Changhsing	Bl_3
Chechou	Al_2	Kaiping	Bm_4	Fushun	BC_2
Chechou	Al_2	Kaiping	Bm_4	Loping	BC_3
Tzechuan	AB_3	Lincheng	Bm_3	Mienchih	BC_4
Yentai	AB_4	Tangyuan	Bm_3	Changchun	BC_3
Poshan	Bh_3	Hsuancheng	Bm_5	Hsinchiu	BC_3
Liuhokou	Bh_3	Tatung	Bl_2	Pataohao	BC_4
Chinghsing	Bh_3	Chiawang	Bl_4	Zalainor	C_1

1 W. P. Evans op. cit. pp. 200-214.

2 Ashley loc. cit. p. 794

With a little familarity, it will be easy to get a rough but practically clear enough idea of the general quality of a coal by a glance at its notation.

Another element in the coal composition which has not been yet taken into account is the sulphur content. As this is often of not negligible importance, it may be desirable to have it represented in some way in the coal notation. For this purpose Ashley's division† can be again followed which calls very low a sulphur content between 0-0.75%; low 0.75-1.5%; medium 1.5-2.5; high 2.5-4; and very high 4 upwards. These five grades of sulphur content may be again respectively designated by figures from 1 to 5 and indicated on the upper side of the coal symbol. Thus a high rank anthracite and medium-grade coal low in sulphur will be represented by the notation Ah_3^2. It will be Ah_3^4 if it is high in sulphur content.

APPLICATIONS OF THE COAL NOTATION

The coal notations as above outlined may be useful for various purposes. They can be used for instance to indicate the different composition of the successive coal seams of a same basin. If we call I II.. these seams of which the proximate analyses are known, they may be represented by some formula like the following:

$$\text{I } Am_2^1 \; + \; \text{II } Am_3^2 \; + \; \text{III } AB_2^2 \; + \; \text{IV } AB_1^2 \; + \; \text{V } Bh_1^1 \; \ldots\ldots\ldots\ldots$$

Such formulae will be more easily remembered than lengthy tables of analyses and also make the comparison clearer and easier.

It often happens that in a same coal field, the coal composition is not only variable from seam to seam but also from place to place for a same seam. The question is then to represent such variation by different sections. In such case, the coal notation may be again of much use. Thus we may write for instance:

Seam	Section A	Section B	Section C
III	AB_3^2	AB_1^1	AB_2^1
II	Am_3^2	Am_2^2	Am_2^3
I	Am_2^1	Am_2^2	Am_2^2

† Ashley op. cit. p. 794

In a similar way, the notations can be conveniently used for showing the variation of the coal composition in a plan where coal seams are indicated. The notations of each seam can be simply added on the plan at the exact point from where specimens have been collected and analysed in the same manner as the symbols of stratigraphic divisions or strike and dip are added to a geological map.

In the coal fields where the coal composition varies in a complicated way, such use of notations may greatly aid to the clear understanding of the rules governing the variation. In a case like the Chai-tang coal field, west of Peking, where a great number of varieties exist from purest anthracite to bituminous coal rich in volatile matter in most puzzling relation one to another, it is highly desirable that systematic sampling be made and results of analyses be represented by the notations both in plan and in section so that the variation may be clearly and concretely grasped at a glance, and conclusions may be eventually drawn.

Sometimes the coal composition varies within certain limits even for a same seam and in a same section, such variation may be again easily shown by the notation. Thus if a high rank anthracite varies from second to fourth grade and from very low to medium sulphuric, we shall nave the notation: $Ah^{1\text{-}3}_{2\text{-}4}$.

If a coal varies from anthracitic bitumite to high grade bitumite with the same variation as to the grade and sulphur content as mentioned above, the notation will be: $(AB\text{-}Bh)^{1\text{-}3}_{2\text{-}4}$. The latter notation may be given different significance from $A^{1}_{2}\text{-}Bh^{3}_{4}$ which imply some definite relation between the variation of grade and sulphur content and that of the "coal substance."

The same kind of notations may be used also to indicate in a general and more rough way the variation of coals worked in a given mine. We may say for instance:

Kailan coal............$(B\underline{m}\text{-}Bh)_{2\text{-}4}$

Chinghsing coal........$(Bm\text{-}\underline{Bh})_{1\text{-}3}$

Tzechuan coal..........$(Ah\text{-}\underline{AB})_{2}$

Yentai coal............$(\underline{Bh}\text{-}AB)_{2\text{-}3}$

The underlining in the above formulae may be intended to indicate the predominant or common variety of coal produced from the respective mine.

If it be needed to express the more or less exact proportion between different varieties of coal produced by a given mine, their respective notation may be then preceded by a proper coefficient. Thus the following formula

$$70\%Bm_3 + 15\%Bm_4 + 5\%Bh_2$$

means that the mine produces 70% of high grade and 15% of very high grade medium-rank bitumites with only 5% of medium-grade high-rank bitumite.

Coals often greatly differ in practical value by their proportion in lumps. To express this relation, the lump coal may be represented by a special sign such as $|\overline{\underline{Bm}}|_3$ and its relative proportion by a percentage coefficient. Thus the formula

$$3/4\ |\overline{\underline{Bm}}|_3 \text{ or } \frac{75}{100}\ |\overline{\underline{Bm}}|_3$$

is to indicate a high-grade medium-rank bitumite with three quarters of lumps.

The new system of coal notations is therefore adaptable to many purposes. General composition, coking quality, ash percent, sulphur content and lump proportion,. all can be easily grasped by a rapid glance at these notations. They have admittedly no pretension to any great accuracy which is beyond the proximate analyses, and even of the latter the notations give only a general idea. But accurate analyses can be only representative of a small quantity or a definite sample of coal while the fuel practically extracted or used in any serious amount is always variable within more or less elastic limits; for practical purpose therefore notations as suggested in this paper will give a sufficient idea of the general quality of the fuels which they are to represent. And they have certainly the advantge of simplicity and clearness by which they can be easily written, compared and remembered.

RELATION BETWEEN THE COMPOSITION OF COALS AND THEIR GEOLOGICAL AGE

Although it is now well established that time is not the only factor in the complex phenomena of coalification, yet the geological age is certainly not without clear relation with the coal composition. The Table VII will show the age of the principal Chinese coals as far as our present knowledge goes.

TABLE VII

The geological age of the principal Chinese coals

Age	Coal	Notation	Moisture%
Tertiary	Zalainor	C_1	20.93
	Fushun	BC_3	6.73
Cretaceous	Pataohao	BC_4	12.65
	Hsinchiu	BC_2	12.00
	Changchun	BC_3	10.80
Jurassic (Lower or middle)	Mienchih	BC_4	9.60
	Fangtze	Bl_4	2 80
	Peipiao	Bl_2	3.25
	Tatung	Bl_3	4.50
	Tangyuan	Bm_3	1.50
	Penghsiang	Bm_2	1.35
	Mentoukow	Am_4	2.30
Permian (of Central China)	Changhsing	Bl_3	0.94
	Shunkengshan	Bi^3	0.85
	Loping	BC_5	1.00
Permo-Carboniferous (North China)	Hsuancheng	Bm_5	0.75
	Chiawang	Bl_4	1.35
	Lincheng	Bm_2	1.89
	Kaiping	Bm_4	0.60
	Penchihu	Bm_3	0.68
	Chunghsing	Bm_3	0.50
	Yenli	Bh_3	1.60
	Chinghsing	Bh_2	0.56
	Liuhokou	Bh_2	0.55
	Poshan	Bh_2	0.87
	Yentai	AB_4	1.15
	Tzechuan	AB_2	0.57
	Chechou	Al_2	1.80
	Liukiang	Ah_4	0.70
	Chiaotso	Ah_2	0.65
	Pingting	Ah_3	0.78

From this table the following conclusions can be inferred:

1. Lignite (C) is confined to the Tertiary although the exact age of the Zalainor formation has not yet been established.

2. Three lignitic bitumites (BC)—Pataohao, Hsinchiu and Changchun—belong very probably to the Cretaceous. H. C. Tan was the first to assign the Cretaceous age to the Pataohao coal series in comparison with the similar

formations which he identified in Shangtung.[1] It is quite probable that Hsinchiu and Changchun are of the same age. The Mienchih coal is not well known and assigned to Jurassic according to the paleobotanical determination of Mattieu[2] which is of preliminary nature and seems not to absolutely exclude the possibility of younger age. We have thus an homogeneous group of lignitic bitumites all of younger Mesozoic age. The case with the Fushun coal is rather exceptional in that it is younger in age but higher in rank and grade. This constitutes really an exceptionally favorable case as to the industrial value of the fuel.

While all the known Cretaceous coals in North China belong to the class of lignitic bitumite BC, all the lignitic bitumites do not belong to the Cretaceous. Thus we have the Fushun and Loping coals both represented by the symbol BC but respectively Tertiary and Permian in age. We know however no case of BC older than Permian in China.

3. Of course not all properties are represented by the simple symbol. Thus the above mentioned six coals, Pataohao, Hsinchiu, Changchun, Mienchieh, Fushun and Loping, although similar in their moisture combined fuel ratio, shows great difference in their moisture content. The three first mentioned, Pataohao, Hsinchiu and Changchun form an homogenous group with 10 to 13% moisture. They all are Cretaceous. The Mienchih coal closely approaches them and may be therefore likely of the same age. The Loping and Fushun constitute two cases different between themselves and from all the others. The Loping coal although very low in carbon like the younger coals is remarkable by its low moisture content, a feature which seem to be special to the Paleaozoic coals. The Fushun coal is younger in age but higher in rank than the Cretaceous coals and therefore constitutes an exceptionally favorable case as far as its industrial value is concerned.

4. The Jurassic coals in China are quite important in reserve and comprise different ranks varying widely from medium-rank anthracite to low-rank bitumite. Anthracite due to metamorphism is of course of only local occurrence; the prevalent types of the Jurassic coal are medium-rank and low-rank bitumites (Bm, Bl.). High rank bitumite of this age is very rare, if not totally absent.

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1 H. C. Tan New research in the Mesozoic and early Territary geology in Shangtung, Bull. Geol. Sury. China No. 4 part II 1923 pp. 111-115. See also his reports on Pataohao and Peipiao coal fields in this same bulletin.

2 F. F. Mattieu, op. cit. p. 389.

Another characteristic of the Jurassic coals is their moisture content. It is seldom higher than 7% and usually above 2%. Even in the coals so metamorphosed as to become anthracite, for instance the Mentoukou coal, the moisture is still near or above 2%. Only in rather exceptional cases such as in the Pinghsiang and the Tangyuan coals is the moisture percent below 2%, and then the coal is good for coking. The rule usually holds good for the different varieties of coal in a same field. Thus in the Tatung and the Chaitang basins where occur coals of different qualities, those lower in moisture are always better coking.

5. There is as a rule, a distinct difference between the Permian coals in the Yangtze valley and the Permo-Carboniferous coals of North China. The former are usually low-carbon coals including low and medium rank bitumite (Bl, Bm) and lignitic bitumite (BC.). The low rank bitumite and the lignitic bitumite are generally not good for coke making, and when medium rank bitumite it is often spoiled by too high sulphur content. This explains the difficulty of finding coking coals in the Yangtze valley where it is however so badly needed for the iron smelting.

6. All ranks from high-rank anthracite to low-rank bitumite are to be found among the Permo-Carboniferous coals in North China. Among the bitumites, high rank (Bh) and medium rank (Bm) ones are predominating. The question has been asked, ever since Richthofen's time, how the Permo-Carboniferous coal normally bituminous became anthracite in some provinces in North China over wide area without apparent indication of metamorphic action. The variation is especially remarkable and difficult to explain on the two slopes of the Taihangshan range; on the east all the fields—Chinghsing, Lincheng, Tzechou (Yenli), Liuhokou—contain bituminous coals while the vast fields on the west in eastern Shansi extending from Pinting down to Chechou are distinctly anthracitic. Within the province of Shansi there are also distinct areas of anthracite and bituminous. Suggestion has been made by Norin* that this variation may be simply due to the geological age, the anthracite of Shansi belonging to Carboniferous and the bituminous to Permo-Carboniferous. This explanation is still to be confirmed by paleontological studies. Although recent stratigraphical researches** have revealed rather important difference

* E. Norin The lithological character of the Permian sediments of the Angara series in Central Shansi N. China, Contr. Nyst. Inst. No. 8, 1924, P. 20.

** Several papers published in Bull. Geol. Surv. China No. 2, 3, 4 6, and 7 of horizons of the workable coal seams in the so-called Permo-Carboniferous fields in North China, there has been established yet no definite relation between such difference and the variation of the coal composition. The idea is however interesting and worth while of further investigation. It may be hoped that with the progress of the detailed stratigraphic work and better and more extensive coal analyses, some definite relation between the age and the quality of the coal seams will gradually be brought out.

Lignitic bitumite is definitely excluded from the Permo-Carboniferous coals.

APPENDIX.

In order to show the variation of the coal composition in a same mine or field, analyses of the principal workable seams of some coal mines are given in the following table.

Coal	Seam	Moisture	Vol. mat.	Fix. carb.	Ash	M.C. ratio	Notation
Liukiang	(2nd seam)	0.70	8.86	68.24	28.16	7.0	Al_4
,,	(3rd seam)	0.60	7.52	77.72	12.50	9.4	Am_4
,,	(6th seam)	0.62	2.75	79.99	16.86	23.9	Ah_4
Kailan	Tangshan (5th S.)	0.62	29.49	65.10	4.78	2.2	Bm_2
,,	,, (11th S.)	0.90	22.60	58.60	18.00	2.5	Bm_4
,,	Machiakou (9th S.)	1.13	22.49	66.69	9.69	2.8	Bm_3
,,	Dust No. 1	0.50	26.00	53.40	20.30	2.0	Bm_5
Chinshing	(2nd seam)	—	24.60	65.10	7.90	2.6	Bm_2
,,	(4th seam)	0.87	17.82	72.60	5.80	3.8	Bh_2
,,	(5th seam)	0.26	18.10	67.20	10.40	3.7	Bh_3
Lincheng	(1st seam)	1.90	37.10	54.20	6.80	1.4	Bl_3
,,	(6th seam)	1.60	30.60	55.60	12.30	1.7	Bm_4
,,	(3rd seam)	1.40	28.80	50.20	19.60	1.7	Bm_4

Chunhsing	Mid. Tayao	1.20	31.50	59.79	14.50	1.7	Bm_4
,,	Lower Tayao	0.50	35.00	54.58	9.92	1.5	Bl_2
,,	Market Spec.	0.10	26.80	63.28	9.82	2.3	Bm_3
,,	,,	0.08	29.48	62.18	7.34	2.1	Bm_2
Tzechuan	(8th seam)	0.97	13.75	77.97	7.31	5.3	AB_2
,,	(9th seam)	0.79	13 96	80.03	3.98	5.4	AB_1
,,	(10th seam)	0.68	13.21	81.18	4.93	5.8	AB_2
Peipiao	(3rd seam)	4.00	30.00	48.00	16.00	1.4	Bl_4
,,	(4th seam)	2.50	30.50	48.80	18.20	1.5	Bl_4
,,	(5th seam)	1.50	31.00	51.00	16.50	1.6	Bl_4
,,	(6th seam)	1.50	26.50	52.00	20.00	1.9	Bm_4

Errata

Page	34	line	23	read	6.50	instead	of	67.50
,,	41	,,	17	,,	19	,,	,,	16
,,	,,	column	2	,,	17	,,	,,	18
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,,	43	line	7	,,	29	,,	,,	28
,,	51 Shunkengshan and Hsuancheng should interchange their position							