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四川石油概論

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油田之位置

四川油田，在四川省中部，而稍偏南境，產油地點，散在各處，著名者，爲自流井貢井河洱坎油井坡羅泉井蓬萊鎮煤油溝中壩井等處，自流井屬富順縣，在縣城之西北約九十里，素以產鹽著稱，鹽井內時有石油，知名最早，油井均在產鹽區內，凉高山大坟包郭家㘭一帶，舊日即有出油鹽井，但時出時息，迄今存者，不過數井，即四福井同昌井東順井振川井積富井富龍井，其餘鹽水內稍浮油泡者，井頗多，鑿井時曾見油質者有之，昔日曾經出油而今廢棄者亦有之，玆將各種油井名目位置表列如左。

井名	地點	產油情形	備考
四福井	大坟包區桂花山	現出油煎賣	附近曾有油井十餘處，今均廢棄，黃水井
同昌井	凉高山區甕塘	現出油煎賣	黃水井
東順井	凉高山區老林冲	現出油煎賣	黃水井
振川井	凉高山區石灰窰	出油少許	黃水井
積富井	郭家㘭區白家灣	現出油煎賣	前爲黑水井，現出黃水帶油，
富龍井	郭家㘭區江家坡	現出油煎賣	前出腰脈水，現出黃水帶油，附近曾有出油井數處，均已廢棄
福深井	凉高山區泡通崖	鹽水上稍浮油泡	黑水井
利生井	凉高山區蔣家溝	開在深數十丈處，曾出油泡	黑水井
天福井	凉高山區牛角冲	前曾出油少許，今已無	黑水井
四通井	凉高山區甕塘	前曾出油，今已廢棄	前出假黑水及黃水，黃水帶油

金鴻井	大坟包區芈邊山	前曾見油泡	現爲火井(深火井)
三元井	大坟包區桂花山	前曾出油，今已廢棄，聞有油三處	前爲火井
炎泰井	大坟包區大坟包	曾見石油	岩鹽井，前在二十五丈處曾見油
裕隆井	大坟包區大坟包	見油泡	岩鹽井
建豐井	豆芽灣區王家山	曾見石油	黃水井
雙全井	郭家垻區溝壩	出石油量不多	黑水井
廣龍井	郭家垻區田壩	曾出石油	黃水井
雙發井	豆芽灣區蘆蓄冲	曾出石油	黑水井，在二百五十餘丈出油
天寶井	郭家垻區白家灣	曾出石油	黑水井，前在一百餘丈曾出油
廢油井	涼高山區老林冲	曾出石油	現已廢棄，踪跡全無，只有井眼地點，井名亦已不傳
大源井	大坟包區久安寨	見油泡	黑水井

貢井屬榮縣，在縣城之東南約九十里，亦以產鹽著，區域與自流井相連，相距只十五里，扇子嘴一帶，有產油鹽井，缸龍井最著，現尚出油未息，其曾經出油而廢棄者，在扇子嘴爲三興井，在黃石坎區爲夔龍井海潮井德心井永盛井，在苟氏坡區只富華井而已。河洱坎屬樂山縣，在犍爲樂山產鹽區內，距樂山縣城約四十里，而在其東，產油井最著者爲薛家井，昔日產油尚多，今已漸衰，只出微量，又有宋家井，亦曾見油，全區產油者，有六七處，今所知者，只此二井，其他地點屬於犍樂區者，在楊柳灣叢草灘曾各有二井產油，油井坡順河街鹽井出油者，聞亦曾有多處，美人勞德伯克略有記載，今已全廢，未悉眞像。羅泉井屬資中縣，在縣城之西北約一百一十里，亦爲產鹽區域，鹽井曾出石油者數處，在羅泉井之北三星橋一帶，今所存者爲富源井潮源井洪源井，尚出油，餘均廢息枯渴，聞前出油井深淺不一，有淺在五十餘丈出油者，今已廢棄。蓬萊鎭在蓬溪縣之西南，約一百八

十里，而距遂寧縣較近，約一百十里，產油地點在蓬萊鎮西北八里火井溝一帶，曾鑿井五六十處，出油者有十餘井，均距胡姓住宅不遠，東北二里崩山溝附近，尚有火井未息，油井則均掩沒矣。

煤油溝中壩井兩處產油地點，未能親往觀察，詳情未悉，據云煤油溝屬巴縣，在縣城之南約九十里，距煙坡數里，而在其東，石油流露地表，溝中可見，地質構造適於石油聚集，或有試探之價值。中壩井屬仁壽縣，在縣城東北偏北約一百里，亦爲產鹽區域，舊日曾出油，現已廢息，無採取者，產區情形，鹽井深淺，或與羅泉井無大差異，惟產量不及羅泉井之多耳。在仁壽縣城鹽井鹽水上有時見黃皮，似有油質，向未出油。又威遠北硯台壩天保煤礦鑿豎坑時，曾見石油一層，油甚少。威遠白龍池，雅安附近，屏山王溝，地層露頭，均有石油臭味甚著，可作產油之佐證也。

油田之區域

四川產油地點已知者，既如上述，其或已經發見，有因交通不便，消息阻塞，而未甚傳述者，當亦在所不免，如四川東北部達縣所屬，聞曾經發見煤油，東南部江津境內，亦似有石油暴露地表，諸如此類，所傳雖未必盡實，然亦足證明有類似有機物由地下淺出，經人發覺，或可爲探索石油之導線也。就已知產油地點位置而言，有時相距頗遠，散在各地，不能劃歸一區，如自流井貢井油區，西距樂山犍爲油區，約二百五十里，北距羅泉井油區，約二百里，再北至中壩井曾經出油地點，約三百五十里，東北距蓬萊鎮油區，約六百里，東距巴縣煤油溝油區，約六百五十里，據此計算，產油地點所在區域，東西長約九百里，南北廣約五百里，面積（里數係按路程而言，不足作爲計算面積之根據，俟詳圖製就，尚須校正，）之大，可以概見，惟產油區域中間，山嶺阻隔，地層不同，未必觸處可以產油，茲就考察所及，依據地質關係，劃分四川產油區域，將來有試探之價值者，計有下列各區。(圖見第一版)。

富順樂山區

此區雖名爲富順樂山區，然分佈所暨，範圍甚廣，大江以北，岷江以東，井研威遠以南，沱江以西，悉屬之，包有富順榮縣

樂山犍爲宜賓屬境，及內江威遠井研南溪江安瀘縣之一部，東西長約四百里，南北廣約三百里，區域內除已知產油地點，將來可作試探，或藉資參攷比較外，就地質構造及地層分佈情形觀察，可以試探之處頗多，自貢犍樂油區，因有鹽井，得機發見，其向未經開鑿深井，而地腹應有石油存在者，面積甚廣，已知油區，不過一小部份而已。如將來爲試探四川油田計，應詳測區內地形地質圖，一方作爲研究油田之參攷，一方可藉以計算產油區域之面積也。

地形　就地理方面而言，四川中部，向稱盆地，言其四周俱繞高山大嶺，而中部地勢較低，恰如盆之有邊，而具平緩之底也。擴觀之，四川北部自灌縣彭縣綿陽閬中達縣以北，爲岷山大巴山之脈，西部自印崍雅安峨眉峨邊馬邊屏山雷波以西，爲大雪山脈，及其支脈，南部自大江以南漸入高山區域，東部自嘉陵江以東，逾華鎣山嶺，入巫山山脈分佈之區，四周山嶺高度，由千餘公尺至五千餘公尺，最高之峰，可達七千五百公尺。然實地觀察盆地區域，山嶺起伏，狀如邱陵，最高山峰，高出海面除東部華鎣山高約一千五百六十公尺外，均不過一千公尺，高於附近河谷低處，不過四五百公尺，簡陽龍泉驛山向西南延長，至仁壽境內之山嶺，及威遠榮縣北部山嶺，其最著者也。富順樂山區，卽在威遠榮縣山嶺之南，北與資仁油田隔阻，南西兩方，均傍江河，逾河地勢漸次隆起，東與榮永油田區域相連，區內山嶺，均不高大，較高山頂，高出海面不過七百公尺，高於附近低處只一百餘公尺而已。樂山之高約三百八十公尺，自此而東，地勢漸次隆起，至自流井，約三百餘里，高低之差，不過三十公尺，中間小山嶺，雖常有起伏，但均不高大，犍樂油田，緊傍岷江，地勢愈低。宜賓之高約三百二十公尺，由此而北，至自流井，約二百五十里，高低之差，約九十公尺，中間亦無高大山嶺。瀘縣之高約三百公尺，向西北至富順縣，約二百里，高低之差，約五十公尺，又一百里，至自流井，相差約一百公尺，富順縣在沱江岸，附近一帶，無高山大嶺，富順自流井之間，地勢亦多平緩，自流井貢井一帶，最高山嶺，高於附近低處，不過一百餘公尺。總之富順樂山油田區域，爲一帶低山嶺組成，平均高度，高出海面在四百五百公尺之間，最高處，約七百公尺，成一低平之山地也。

地質　擴觀之，四川地質，除北部西部邊地區域地質情形較爲複雜外，內部盆地附近，地層暴露淸晰，地質構造亦有蹤跡可

尋，火成岩在盆地邊緣，有時侵衝至地層內，或一部暴露，但在盆地內部，絕未見其露出地表，就地層而言，露頭完全之區而與
油田地質有關係者，厥有四處，一為峨眉，一為犍為屏山，一為威遠榮縣，一為巴縣合川，或位於油田附近，或分隔油田而為二
區，均可藉以證明油田地腹地質之情形。峨眉一帶，地層露出較多，犍為屏山，地層暴露不全，最下地層僅見三疊紀地層之下部
，威遠榮縣最下地層，僅見三疊紀地層之上部，巴縣合川地層，三疊紀之下，二疊紀一部暴露。（圖見第二版） 油田地質可分
地表地腹兩部，地表地質，顯而易見，考察不難，地腹地質，須與附近地層暴露清晰者，對照比較，藉以知其底蘊 自流井貢井
一帶，地表地質頗簡單，地層均為自流井層之一部，因研究石油鹽產地下情形之需要，曾詳分暴露地層為七組，由下而上，一，
珍珠冲粘土，為暴露地層之最底部，露出者，以淺棕紅紫色粘土為主，夾淺綠色粘土，厚約二十公尺 二，東岳廟灰岩，以灰色
灰岩為主，夾灰棕色泥灰岩，淺綠黃色粘土及砂岩，厚五公尺餘。三，大坟色粘土，以紅紫色粘土為主，夾淺綠黃色粘土；底部
有綠灰色頁岩，夾極薄煤層及矽化木，厚四十六公尺餘。四，郭家坳砂岩，有淺綠黃灰色砂岩，及淺綠黃灰紫紅色粘土，厚約三
公尺。五，馬鞍山粘土，為紅紫色粘土，厚約五十公尺。六，大安寨灰岩，以白灰帶淺紫黃色灰岩為主，夾灰紫黃紅色泥灰岩粘
土，及淺綠暗灰色頁岩，厚約二十四公尺。七，涼高山砂岩，為淺黃灰色粗砂岩，分佈於油田內者，只一部，厚度不全。七層之
中，大安寨灰岩分佈普遍，易於辨識，藉以比較油井深淺及油層位置，不但同區油田，常用為標準地層，即油田相距遠者，油層
位置比較，亦每以此為衡，此自流井貢井油田地表地層之大概也。（圖見第三版）。

含油地層，深在地腹，在油田內毫不露出地表，考知之法，惟與地層暴露多處，對照比較，及由鑿井所得，觀察推測，就峨
眉犍為屏山威遠榮縣合川巴縣考察所知，白堊紀自流井層之下，即侏羅紀煤系，再下當為三疊紀地層，由大安寨灰岩以下，約一
百八十公尺，即可見侏羅紀煤系，而煤系厚度，各處增減無多，頗為一律，大約以五百五十公尺為平均可據之數 三疊紀地層，
上部為灰岩層，西自峨眉山，東抵嘉陵江，厚度由三百八十公尺至六百五十公尺，在富樂油區，假定平均為五百公尺，下部為砂
岩層，厚由一百五十公尺至二百四十公尺，據此以與鑿井所得，對照比較，油層位置，或可推悉梗概。富樂油區鑿井記錄詳細保

存完全者，在自流井貢井油田，曾覓得數井，玆取貢井灯龍井，及自流井炎泰井鑿井所得，略分述之，以示富樂油區地腹地層大概之情形。灯龍井在涼高山砂岩鑿下，上三十餘公尺，記錄不存，岩石先見者，爲大安寨灰岩，厚約二十六公尺，與地表所見，相差不多，下爲粘土，夾砂岩，厚約五十七公尺，當與馬鞍山粘土相當，但厚度稍大，再下有砂岩，夾粘土，厚約十六公尺，當爲郭家𡐓砂岩，惟厚度較大，再下爲紅紫色粘土，夾白灰色砂岩，厚約四十五公尺，當相當於大坟包粘土，而厚度相差不多，自此而下，有灰岩泥灰岩，夾粘土砂岩，厚約七公尺，爲東岳廟灰岩，下爲紅紫色粘土，厚約四十一公尺，與珍珠冲粘土相當，而厚度大遜，再下岩石色變，侏羅紀煤系開始，先爲灰色砂岩頁岩，至二十餘公尺下，爲黑灰色頁岩，夾薄煤層，又下頁岩相間而生，夾煤十層，最厚者達一公尺半，由煤系之頂而下，在約三百二十公尺處，稍有石油，在約三百三十五公尺處，又稍見油質，煤系共厚約五百四十公尺，下即三疊紀灰岩，鑿入者二百六十六公尺餘，由上而下，在十餘公尺至四十公尺之間，常有火氣石油發見，在由二百〇八公尺至二百三十一公尺之間，亦常見火氣，至二百六十公尺以下，火氣石油並生，兼出鹽水，灰岩多呈灰色及黑灰色，有時爲黃色及白灰色。炎泰井鑿井記錄，岩石可記者，自大坟包粘土起，爲紅紫色砂岩粘土，下爲東岳廟灰岩，與地面所見，可以對照，厚約六公尺，再下爲珍珠冲粘土，以紅紫色粘土爲主，時夾灰色及白灰色砂岩，下部稍含石油，厚約六十五公尺餘，自此而下，岩石色性變異，白堊紀以紅紫色著者，而此則爲灰黑色，岩石亦較爲堅實，砂岩頁岩居多，泥質岩石頗少，由頂而下，約二十四公尺處，有煤一層，爲已入侏羅紀煤系之証，再下砂岩頁岩相間而生，含煤七八層，因煤層質軟，厚度不能確悉，按其所記有厚三十六公分者，煤系厚約五百四十八公尺，在煤系之頂下約二百公尺處，有鹽水，在井深約六百五十公尺處，岩石變爲灰岩，已至三疊紀地層內，岩石色澤，以灰色爲多，時淺時深，黃色次之，綠色亦偶見，性質有時稍粗，在井深約九百三十餘公尺處，有岩鹽，分上下兩層，中介岩石，上層色白，厚約二公尺三，下層色紅，厚約二公尺，井深約九百四十四公尺，三疊紀灰岩被鑽入者，厚約二百九十三公尺，此富樂油區地腹地層之可參攷者。(圖見第四版第五版)。玆爲簡約計，特分述(一)含油地層之位置及時代。(二)含油地層岩石之種類。(三)油田之地質構造。

（一）含油地層之位置及時代　就產油地點地表露出地層而言，均屬白堊紀，不過有下部中部上部之分。在自流井貢井一帶，白堊紀下部地層，到處發育，區域之外，有時有中部地層。樂山河洱坎附近，白堊紀中部暴露較廣，向西南至犍為鹽區，下部亦發育，有時有侏羅紀煤系地層，向西北至樂山一帶，中部地層所在亦多。就此推論，石油所在，似與白堊紀地層有關，然一考各地產油實在狀況，石油均由開鑿鹽井得機發見，鹽井深淺不同，石油所在上下位置有差，而含油地層時代，亦當隨之而異，自流井貢井，兩處產油地點，按地質構造當合為一區，鹽井甚多，出油者已表列於上，共數十處，油層位置深淺不等，最深者，為貢井缸龍井，約二千八百七十尺，合一千〇三十四公尺，井自白堊紀下部大安寨灰岩之上鑿下，經過白堊紀地層二百二十八公尺，侏羅紀煤系地層約五百四十公尺，再下進入三疊紀上部灰岩二百六十六公尺，此井所見石油計有三處，一在五百四十八公尺至五百六十三公尺處，曾見油，量不多，一在七百九十三公尺處，有石油，量亦少，一在一千〇三十二公尺處，出石油，即現所產之石油，就地層位置而論，第一含油層，在侏羅紀煤系之下部，第二含油層，在三疊紀灰岩之上部，第三含油層，在三疊紀灰岩之下部。次為自流井富龍井，現出油之處，深約一千七百六十尺，合六百三十四公尺，井自白堊紀下部東岳廟灰岩之上鑿下，經過侏羅紀煤系，原深已進入三疊紀甚深，現石油所在地層，為煤系之下部，與富龍井大約同層者，為自流井東順四通振川三井石油，就鑿井所在地層地位及井之深淺觀察，三井含油地層，均在侏羅紀煤系下部。再次為自流井積富四福同昌三井，積富井所鑿地位較四福同昌二井稍低，故在深四百八十六公尺處見油，而四福井在四百六十八公尺處出油，同昌井在四百五十公尺處出油，三井含油地層位置，大致相當，均在侏羅紀煤系之下部，但較富龍四通振川東順四井含油地層位置稍高，相差約八十公尺，而與貢井缸龍井侏羅紀煤系含油層位置略相等。其他自流井炎泰井在白堊紀地層之底部，曾見油少許。鹽水之帶有油泡及曾經出油之井，所有油層，均不外與上列四層相當，而分在侏羅紀煤系下部及三疊紀上部灰岩層內也。樂山河洱坎石油，均隨鹽水而出，舊日鹽井之產油者，多已掩沒不傳，詳情迄未查悉，僅就河洱坎高山舖產油鹽井而言，深約一千一百餘尺，合四百四十餘公尺，井自白堊紀嘉定層之下部鑿下，進入白堊紀自流井層約三百餘公尺，此實白堊紀之含油層也。（圖見第六版）。

（二）含油岩石之種類其及蓋層　富順樂山區石油，含於三疊侏羅白堊三紀地層，已如上述，然三紀地層岩石種類不同，而石油蘊藏所在，亦不一律，三疊紀地層與石油有關係者，爲灰岩，厚約五百公尺，虹龍井油層，卽在此灰岩層之下部，據虹龍井鑿井記錄岩石所載，青黃砂岩及青黃廣子，含有石油，砂岩卽岩石之較粗者，井戶所稱之廣子，卽灰岩，但鑿井所得石屑，向不保存，未能見其原物，如灰岩內可含石油，須具多孔性質，否則不易儲存，故虹龍井油層，或爲灰岩之多孔而質較粗者，虹龍井上層油，向未採取，但其所在，爲一種黃砂岩，就威遠犍爲等處所見三疊紀灰岩上部，常有石油臭味頗強，灰岩多孔呈灰白色，又有黃色泥灰質者，含油之黃砂岩，或卽黃色泥灰質之一種疎鬆多孔灰岩。石油蓋層，當爲一種細質灰岩而不易滲透者。侏羅紀煤系以砂岩頁岩爲主，夾有煤層，侏羅紀所含之油層，均爲砂岩，俗稱草白沙，卽灰白色砂岩，含有石油，自流井淺井油，均含於砂岩層內。如石油富集時，則蓋層似爲頁岩。白堊紀地層以砂岩粘土爲主，色多紫赤，下部淺綠色及灰綠色砂岩粘土有時亦頗發育，白堊紀石油或生於淺綠色砂岩內，而粘土爲其最適宜之蓋層，河洱坎石油，雖未能確悉其含油岩層似亦生於此砂岩中也。

（三）油田之地質構造　就地形而論，四川中部成一大盆地，油田卽在盆地之中，四周山嶺高聳隆起，而盆地爲一帶岡阜小山區域。以地質而言，盆地四周地層暴露較多，構造亦頗複雜，而盆地內部地層大部埋藏地腹，構造亦較簡單。攬觀盆地全區，地層多成平鋪，或略現起伏之狀，往往數百里內，地層種類不甚改變，在此平鋪起伏構造之中，常有背斜層向斜層或背斜穹窿層爲盆地內最顯著之地質構造，亦卽油田最重要之地質情形也。在威遠榮縣北部爲一大背斜穹窿層，向東北西南延長，東北至資中縣境，西南至井研縣境，中間凸起頗高，上部已大被剝蝕，白堊紀地層大半侵冲而去，侏羅紀煤系分佈廣遠，爲四川煤鐵產區之一，三疊紀灰岩露出者約二百餘公尺，暴露於大穹窿層之中央，而在深谷溝渠附近，由此大背斜穹窿層分向四方，地勢漸次而低，而地層傾斜亦依次而緩，或另有其他背斜層向斜層穹窿層等構造，並有油田分佈各處，富順樂山區油田，卽在此大穹窿層南西南方，兩處油田雖劃爲一區，然其地質構造各不相同，富順屬之自流井，榮縣屬之貢井，成一背斜穹窿層，而產油地點，卽在穹窿層範圍以內，背斜穹窿層大致向東北西南延長約四十里，寬處五六里，四周地層傾向四方，中部平緩，南翼地層傾斜較陡，大

致傾向東南，或稍偏南，或稍偏東，斜度近中部層脊者頗緩，不過數度，愈近邊際，斜角漸次增大，由一二十度可至五十餘度，北翼地層傾斜較緩，大致向西北偏北傾斜，斜角由數度至十餘度，穹窿層東端地層，大致傾向東北偏東，斜角不逾十度，西端地層，大致向西南偏西傾斜，斜角約六七度，穹窿層中部，已經剝蝕破缺，惟尚未破至侏羅紀煤系耳（圖見第七版）。在貢井鹽區有兩層灰岩，就地表觀察，似上下重疊而生，不相連續，但就岩石色性厚度及上下層次而言，兩層灰岩極相類似，似為一層而經斷折所致者，惟斷層在地表不易察出，只可就鹽井深度，鑿井所得岩石，及各地層厚度，比較推測而知，在自流井區南部黃葛坡附近，兩層灰岩相距頗近，中間錯動微小，在貢井之北榮縣河邊，灰岩露出，似為東岳廟灰岩，而天池寺上亦有灰岩暴露，如此灰岩為大安寨灰岩，則斷層俯側大安寨灰岩未能露出地表，二者上下相差，約一百公尺左右，此處斷層錯動較大，而中間一帶地層露出不多，傾斜整齊一致，實不能目擊斷層之踪跡也。樂山屬之河洱坎，在威遠榮縣大背斜穹窿層向西南延長之端，而附近地層除大致向西北傾斜外，無特別構造之觀，西南至竹根灘以南，地層又稍隆起，而成一低平不對稱之背斜層，略成東西方向，南翼地層傾斜緩，北翼地層傾斜陡，鹽井均在北翼，最旺油井坡楊柳灣順河街等處出油之井，與此背斜層有關。（見鹽產論第二插圖）自貢井河洱坎產油地點之外，此區內背斜層向斜層頗多，就目擊者而言，由樂山沿岷江而下，至宜賓，中間所經最顯著之背斜層，為犍為縣屬麻柳場北之背斜層，向西南東北延長，北翼地層向西北偏北傾斜，斜角在二三十度之間，南翼地層向東南偏南傾斜，斜角有大至四十餘度者，成一不對稱之背斜層，惟此背斜層兩端盡於何處，或是否與其他背斜層相連，尚未跟踪追尋，不悉究竟。自此而下，直抵宜賓，地層雖屢現凸凹起伏之狀，而背斜向斜構造，不甚顯著。在宜賓附近，有一背斜層，白堊紀地層之下，侏羅紀煤系上部，已經露出，南翼地層向東南傾斜，斜角由三十餘度至五十餘度，北翼地層向西北傾斜，斜度較緩，在二十度左右，亦成不對稱之背斜層，至其延長所暨，亦未追尋　宜賓瀘縣之間，背斜層向斜層屢經目擊，最顯著者為南廣背斜層，侏羅紀煤系已經露出，北翼地層傾斜較陡，約四十餘度，南翼地層傾斜較緩，約二十餘度，此背斜層與宜賓背斜層中間為一向斜層，而連兩背斜層之兩翼。南溪江安瀘縣附近，均有背斜向斜層踪跡，惟構造多不甚顯著。由瀘縣至富順縣中間有背斜層五處，向

斜層四處，但多淺平寬廣，不甚顯著，最明晰者，爲富順屬青山嶺背斜層，侏羅紀煤系露出地表，亦向西南東北延長，南翼地層大致傾向東南，斜角有陡至五十度者，北翼地層傾向西北，斜角約四十度左右，略成一對稱之背斜層，次爲富順縣背斜層，亦向東北西南延長，南翼地層向東南傾斜，斜度較陡，至五十度，北翼地層向西北傾斜，斜角較緩約在十度左右，成一不對稱之背斜層。由富順至自流井，又復經過淺平背斜層向斜層三處，直至自流井貢井一帶，爲一背斜穹窿層。榮縣河洱坎之間，自流井宜賓之間，亦有背斜向斜層踪跡，惟多不甚顯著，僅現凸凹起伏之觀。此僅就足跡所及，曾經目擊者而得其大概情形，如將來詳細測量，地質構造，當益明顯，地層褶皺之跡，亦當全部暴露矣。(圖見第一版)。

礦業　四川石油發見於何時，言人人殊，地各有異，且年遠代淹，傳聞不實，更難信而有徵，惟四川石油多與鹽水火氣有關，火氣所在，每有石油，鹽水尤常與之共生，考鹽水火氣之發見，再參以當地所聞，或可知其概略。據鹽務載籍信而可考者，四川鹽產，始自秦代，秦孝文王以李氷爲蜀守，在廣都縣(成都雙流等地)開鑿鹽井，又據漢代經志，臨印縣有火井鹽水，臨印今之印𠦑縣，火井即火氣出而可燃者，是爲鹽水火氣發見之始，然石油之產生無所聞也。及後鹽井漸次推廣，遂及於川南川北各處，富樂區鹽產，開發最著，火井尤多，推石油發見之初，當在富樂鹽區之一井，而準確時代，實在地點，則已不可考矣。富順鹽產，開自漢代，歷晉隋唐而饒鹽利，但地點在今之鄧井關，井少而淺，無火井，且不出石油，自宋初始移至自流井一帶。榮縣鹽產著自唐代，地在貢井，自流井貢井相距甚近，故常併爲一區，昔日鹽井開鑿較淺，出火較微，據李榕自流井記云，道光初年，見微火，至咸豐七八年而盛，至同治初年而大盛。據井商面述，深鹽井開辦，約在數十年間，較老者不過七八十年，可見至清代末葉，始開鑿深井，按現在自貢油井，有深淺之別，淺井油發見或較深井油稍久，最古當在宋代以後，深井油發見當在深井開鑿以後，約在清代咸同間。在一八二七年，法國恩伯提Imbert教士，觀察自流井鹽產，僅報告有鹽水火氣，未述石油，至一八九一年，法國教士寇德瑞，L. Coldré併曾述及石油，據此自流井石油發見，或在十九世紀中期，亦即清代中葉以後也。自石油發見後，無專商經營之，石油隨鹽水而出，而浮於其上，量多時，鹽商利其價，取而蒸煎之，售於附近人戶，用以點燈，或覓取原油用之

，偶亦作藥劑，量少時，僅現油泡，出油甚少，棄而不取，猶有因惡其質濁，有損鹽水之潔淨，設法阻其來源者。出油之井，歷年變更，數目不同，地點亦異，以前產油最盛之井，今已掩沒，踪跡全無，井名亦無從探悉，在四十年前，寇德瑞（Coldré）報告，有出石油之井三四十個，其後法人杜蘭（Durand）及馬特（Marteau）報告自流井石油，呈綠色及黃色，質甚佳，含燈油頗多，燃時發烟，土人煉之，一公斤售價〇・三三至〇・四一法郎，有十五井曾獲利，初起數月內，日可出油四五千里特，及後漸減，日產四五百里特，有油井日出一千二百至一千五百公斤者，一年以後尚可出二百五十公斤，此時油井之深，約在一千二百至一千五百英尺之間，相當於現在之淺井也。在三十年前，在龍洞溝有泰豐井深約二千一百六十英尺，出油最多，日產約三千斤，幾年後，產量漸減，日約一百斤，在自流井西北一英里半金源井，深約二千五百英尺，在一月內日產約一千斤，及後減盡。民國四年，美人勞德伯克報告，自貢井鹽井帶石油痕跡者數十個，而產油者不過十餘井，無人專採之，僅由鹽水上漂浮之泡沫取集而得，油井之深，率在一千七百至二千九百英尺之間。在自流井之西約二英里華龍井，產油最多，在二千九百英尺處見油，在四十日內，日產二三百斤，及後驟減，每月共出六十斤。自流井之西北約二英里半有富江井，深約二千英尺，初時日產約一百斤，及後減至十五斤，其時泰豐井猶出油，日產約一百斤，他如四通井深一千九百〇六英尺，日產二十斤，天成井一千九百十二英尺，日產一二斤，富發井日產十斤，雙興井深二千八百英尺，日產一斤，積富井深一千九百十二英尺日產七八斤，玉龍井深二千四百四十英尺，日產二三斤，紅水井深一千七百九十英尺，日產五六斤，榮號井深一千七百九十英尺，日產約一斤，統計十一井日產總額一百六十餘斤。數年前貢井黃石坎德心井曾日產油二千斤，二三年後方盡。現自貢井一帶鹽水含油者共計二十餘井，已表列於上，可資參攷，就中稍現油泡者居多，正式產油之井，在自流井惟四福井同昌井東順井積富井富龍井，在貢井惟灯龍井而已，無專商經營之，僅鹽商就鹽水井取煎售賣，灯龍井出油最多，日產十餘斤，去年日出油七八十斤，積富井日出油數兩，富龍井每月出油六七斤，四福井日產二三斤，同昌井東順井日出油不過一二斤而已。取生油而洗煎之，去其雜質及泡沫，成帶色稀汁，售價每斤兩吊，約合洋一角五分，土人用以點燈，所採石油，曾經本所化學試驗室分析，已刊載地質彙報第十九號，自貢井石油

拉雜情形如此，毫無石油礦業之可言。犍爲樂山鹽區五通橋順河街油井坡叢草灘河洱坎一帶，亦爲產油區域，石油發見之初，據紀錄所傳在明代中葉，惟自秦代已產鹽，至明季鹽務稍盛，至清初始置專官，而鹽政載籍，無石油之敘述。至民國初年美人勞德伯克曾至其他，專重考查石油，據其報告，在楊柳灣附近一井深一千七百一十公尺，出火氣，並有油跡，又一井深一千五百五十英尺，鹽水上有油泡，在油井坡一帶鹽井深在七百英尺以上者，曾出石油數斤，彼時猶有一井深約二百五十英尺，鹽水上浮油膜，日出油不及一斤，他井亦有出火氣臭味或帶油跡者，在叢草灘附近有一井名油井兒，深一千七百四十英尺，鹽水上浮油泡，取泡熱煎，雜質下沉，而得淺棕粘液，用以點燈，通常日可出已煎之油由十五斤至二十斤，據云在此油層之上約九十尺，尚有油跡，彼時油井兒日產油約十二斤，爲此區出油最多之井，又一井深約一千六百五十英尺，鹽水上浮有綠棕色油泡，日可出油五斤，在灰山井一帶，一井深約一千四百二十五英尺，鹽水上浮油膜，出油少許，在順河街附近一井深約一千七百二十五英尺，稍有火氣，鹽水上浮油泡，又一井深約一千六百七十五英尺，稍有火氣，而日出已煎之油數斤，順河街東尙有二井，一深約一千八百英尺，出少量火氣，鹽水上浮油泡，一深約一千七百八十五英尺，稍出火氣，日產油一二斤，在岷江之西兩河口一帶有鹽井，一井日出黑綠色油數兩，用以點燈，此十五年前樂山犍爲鹽區產油之情形也

據川南鹽務稽核所民國十九年調查，在樂山河洱坎有井四眼，鹽水上浮油質一層，色淡黃，以小瓢淘起，布袋濾清，用以點燈，與洋油同，惟煙氣甚大，想係未經製煉之故，入冬卽凝結成膏，點燈則黯然無光，每日每井約出十餘斤，每年約產一萬五千斤，因由汲鹽水附帶而出，並無成本，每斤售價錢二千文左右（合洋一角五分），惜出產甚微，僅供當地之需耳。今年順河街金山寺之間，先家溝鹽井時可得油少許，福裕廠之井昔曾出油，現鹽水上仍浮油泡，日出二三兩，以其量甚微，未嘗取用，河洱坎高山舖一帶，有鹽井數十眼，而產油者僅六七眼，深一千三百餘尺至一千七百餘尺，現每日出油多者三四斤，少者數兩，有薛家井曾日出油八九十斤，採數年而減少，現日出油二三斤，所出石油曾經分析，結果刊載彙報，又有宋家井曾日出油二十斤，今則不產油矣。聞當地鹽商有開鑿深井試探石油火氣及深處鹽水之計畫，地點擬定在五通橋油井坡一帶，正請求四川軍政當局補助，未悉已成爲事實否。

資中仁壽區

此區在富順樂山區之北，中介威遠榮縣一帶山嶺，占資中仁壽兩縣屬境，及井研資陽簡陽之一部，北逾仁壽簡陽山嶺而達成都平原，區域面積，不甚廣大，東西長約三百里，南北廣稱之，產油地點已知者爲資中羅泉井，仁壽中壩井，仁壽城鹽井內似亦有油質，就地質造構而言，尙有數處可以試探，地層分佈至此當無變遷，亦爲一較有希望之區域也。（圖見第一版及第八版）。

、地形　威遠榮縣山嶺以北，簡陽仁壽山嶺以南，爲資中仁壽區，西爲岷江，東爲沱江，中爲低平岡陵分佈所在，羅泉井仁壽城相距約一百四十里，高低相差只約五十公尺，中間幾成平原，平均高度高出海面約四百八十公尺，向南入山地，山勢隆起，至約一千公尺，向北山勢漸高，至八百餘公尺，向西至岷江低處四百餘公尺，向東至沱江低處四百餘公尺，略成一中間稍凸東西漸低之岡阜小山區域也。

地質　資中羅泉井附近，地層與自流井貢井類似，大部爲白堊紀自流井層，大安寨灰岩暴露顯著，向西北至仁壽縣境，白堊紀嘉定層紅色粘土砂岩頗發育，至仁壽縣城鹽區附近，爲自流井層，有紫紅棕色粘土砂岩，至城北中壩井鹽區，當亦爲自流井層嘉定層暴露之所，玆分述含油地層之位置種類及地質構造如下。

（一）含油地層之位置及時代　資中羅泉井石油，亦自鹽井發見，曩日出油者十餘井，中有一井頗淺，約五百餘尺，合一百〇六公尺，即見石油，井自白堊紀自流井層大安寨灰岩及東岳廟灰岩之間鑿下，計其深淺及自流井層厚度，已進入侏羅紀煤系之頂部，現出油者爲開源寵富源潮源洪源鹽井，深均五百二十餘公尺，井自自流井層大安寨灰岩之底鑿下，經自流井層已進入侏羅紀煤系甚深，含油層當在侏羅紀煤系下部，察其位置頗與自貢井侏羅紀煤系下部之一含油層相當，或即富龍井東順井之含油層。仁壽城鹽井之帶油泡者及中壩井曾經出油者，位置較羅泉井淺油層猶淺，計鹽井地位及其深度，尙未至侏羅紀煤系，而爲夾於自流井層中之一層，或與樂山河洱坎油層相當。（圖見第六版）。

（二）含油岩石之種類及其蓋層　侏羅紀煤系以砂岩頁岩爲主，夾有煤層，含油地層，均爲砂岩，羅泉井深井油舍於白亮沙

內，卽灰白色砂岩，羅泉井淺井油所在岩層，因井已廢棄，未悉底蘊，當亦爲一種砂岩。至其蓋層，當均爲一種頁岩。白堊紀自流井層以砂岩粘土爲主，色多紫赤，下部淺綠色及灰綠色砂岩粘土，有時亦頗發育，白堊紀石油多生於淺綠色砂岩內，中壩井油層，或爲此砂岩也

(三)油田之地質構造　威遠榮縣大背斜穹窿層以北，爲資中仁壽區，地層傾斜由穹窿層北翼及東端向資仁區漸次而緩，至羅泉井產油地點一帶，傾斜大致向北，或稍偏西北，或稍偏東北，斜角頗小，普通三四度，有時地層成平層。由羅泉井至仁壽縣城，中間地層大致向西北偏北傾斜，斜度頗緩，約五度左右。在仁壽縣城東白堊紀嘉定層與自流井層之間，有一斷層，向東北西南延長，爲正斷層，錯動不大，產鹽帶油之井，在斷層之西，鑿入自流井層。斷層延長向東北或至簡陽，向西南至井研縣境，地層傾斜方向斜度無大變改。在內江資中之間銀山鎮附近，有背斜穹窿層，向西南延長頗遠，或與威遠榮縣大背斜穹窿層有關，向東北不遠，卽至盡端。資仁區背斜向斜層構造不多，而有一顯著斷層，或與石油聚集有關係也。(圖見第九版)。

礦業　資中仁壽自古產鹽，仁壽始於漢，資中盛於唐，至清初設官管理，今之羅泉井，卽資中鹽區之一，仁壽中壩井均併入於井研。仁壽鹽區，鹽務記載，均於石油不詳，推石油發見之初，或後於自貢犍樂等處，蓋羅泉井現採鹽井，歷史最久者，創辦於清乾隆年間，向未出油，只稍有火氣，而出油之井，開鑿甫三十年，鑿井記錄猶在，尚可稽考。油井有深淺之別，淺井深約二百〇六公尺，曾出油二百斤，今已掩沒不見。深井只有四井出油，均屬開源竈，有名者爲富源潮源洪源等井。富源井在深一千四百二十四尺(每尺合三五，五公分)，見火氣，在一千四百五十六尺見石油，再下十六尺，油量增加，日出四五斤，再下十六尺，日出油二十餘斤，又下二尺八寸，日出油由三十斤至一百二十斤。潮源井在深一千四百五十五尺見油，由二十餘斤至一百四十餘斤，再下至一千四百七十三尺有油味，下見煤一層。洪源井在深一千四百七十六尺出油。聞以前油井出油多者日出一百五十餘斤，只出數日，量卽減少，富源井日曾出一百斤，出油年餘。現出油之井，每井只日產三四斤而已，井戶取生油熱煎，用以點燈，毫無石油鑛業可言。仁壽城一鹽井深約六十丈(每尺合營造尺一尺二寸)，鹽水上浮有黃膜，似油質，稍有火氣，均未取用。中

場井鹽井前曾出油，今已廢息，情形未詳。

蓬溪遂寧區

此區在沱江之東，嘉陵江上游兩岸，產油地點，在嘉陵江支流涪江之西蓬萊鎭附近，區域不廣，然擴觀四周，多爲鹽產所在，北至蓬溪射洪三台中江，更北至鹽亭綿陽閬中，西至遂甯樂至各縣境內，均有鹽井，出水煎鹽，爲川北鹽區重要部份，惟鹽井多淺，普通深度數百尺，有淺至百尺左右者，除蓬萊鎭因鑿火井得機見油外，他處未嘗出油，聞出火之井，中江蓬溪均見之，量少火微，不足供大宗燒鹽之用。就地質構造而言，地層大致平緩，雖有上下起伏，不多見褶皺之狀，惟中江射洪之間，稍有背斜向斜層構造，如就產鹽區域擇其構造較適者而深探之，或亦可發見油層，故此區面積如將產鹽所在統計在內，包有蓬溪遂甯安岳樂至射洪三台鹽亭中江綿陽閬中屬境，南北長約六百里，東西廣約四百里，皆爲可以試探之區域也。(圖見第一版)。

地形　此區地形，純爲邱陵小山分佈所在，既無高山大嶺，又鮮平原低地，除河渠岸邊附近，偶有冲積較低之區外，均爲低緩小山，多成孤立，不相連屬，平均高度約爲五百公尺左右，登高遠矚，則見山巔排列一望無垠，溝渠四散分佈，狀頗蜿蜒，低山區域，原爲低原，或近似平原，後經溝渠侵蝕分割，而成今日小山棋佈之狀，嘉陵江之支流，爲本區主要幹水，涪江直貫境內，東北南三方均漸入高山區域，西接成都平原，一部與資仁油田相連，不隔山嶺，全區實一低平之岡阜小山地也。

地質　全區內嘉定層最發育，以紅色粘土砂岩爲主，間夾淺綠色砂岩粘土，北部或有蒙山層，爲白堊紀地層之上部，在蓬萊鎭火井溝產油地點，石油曩日由開鑿火井而得，曾鑿數十井，出油處均在深二百二十五尺，合七十餘公尺，井均自白堊紀嘉定層之下部紅色砂岩鑿下，(圖見第十版)，或已進入自流井層之上部，此爲四川已知含油地層之最淺者，(圖見第六版)。白堊紀石油多生於淺綠色砂岩內，蓬萊鎭火井溝鑿井採油，據云如見綠色岩石，即到出油所在，可知亦產於此淺綠色砂岩內。至區內地質構造頗簡單，由成都經遂甯至重慶，中間地層多成平鋪狀，前已言之，蓬遂區所屬，即此等地帶，地層褶皺之跡，頗不顯著，蓬萊鎭火井溝一帶出油所在，亦未見完全背斜層或向斜層，不過地層稍有彎曲起伏不成平層而已，(圖見第十一版)。據日人報告，此

區北部低平背斜層尚多，中江綿陽射洪鹽亭南充所屬均曾見之，惟地層傾斜頗緩，通常四五度，多至十度左右，至究竟有無關於石油之重要構造，尚須詳細測量，逐地觀察，未可舉一以例其餘也。

礦業　出油地點，惟蓬溪縣蓬萊鎮火井溝一帶胡廖二姓田地內，據云前清同治年間，即有火井（火氣上昇而燃），光緒二十六年，有胡姓購地打火井，至十四轉深處（鑿井用轉車繫竹索每轉索長約五公尺半），出石油，初尚不知其為油，有人偶燃之，發火，始知為油質，由蓬萊鎮熊姓購去若干，用以點燈，油色青白，與酒略同，質甚佳，置於筒中，下視可見筒底，其純潔如此，出油初多後少，終至於盡，多時一月曾出油數百斤。嗣有吳姓告知重慶順昌公錢莊，由順昌公典地採辦，先典胡姓周姓地，價五百吊，期四十年，後典廖姓地，價一千餘吊，至光緒二十七年開辦，鑿井五六十眼，深約四百五十尺（營造尺），在二百二十五尺處見油，油井出油多者共千餘斤，少者數斤數十斤不等，共產油萬餘斤，油曾出售，價每斤六七十文，採辦四年，共用資本二萬數千吊，此三十年前之情形也。自順昌公停辦後，無人再採，至民國十九年二月，由謝德堪試採，開鑿二井，一深約四百五十尺，在二百二十五尺處出油二十二斤，一深約四百五十尺，未見油，鑿井用工人四人，包工，材料由井戶供給，工價每深一轉，錢十三吊，井口徑長上部四五寸，下部二寸餘，每日多時可鑿下深一轉，少時二三方（即十分之二三轉），二井共鑿五個月，工程用費約二百餘元，至同年七月間停辦，迄今棄置，無人開採，僅在崩山溝尚有火井一眼，深三百六十尺，出火，可燒鍋二口，此蓬萊鎮火井溝石油礦最近之情形也。

榮昌永川區

此區包有榮昌隆昌永川瀘縣大足屬境，向未產油，只大足境內有鹽井，地質構造背斜層尚多，適於石油聚集，就地層分佈情形而言，東有三疊紀侏羅紀地層，與自貢產油層相當，發育甚厚，此區地腹埋藏之地層，應為白堊紀下部，及三疊侏羅兩紀全部，如原生油質與兩紀地層有關，即有石油聚集之可能，而有試採之價值，故亦列入產油區域，但面積不甚廣大，東至永川東部，地層隆起，露出太多，三疊紀地層有時亦均暴露地表，石油不易保存，區域之長，南北約為三百餘里，東西之寬，不過二百里而

已。(圖見第一版)。

地形　榮永區西與富樂區相連，地形大致相同，惟東方地勢漸高，與璧山永川山嶺相接，向南漸次低減，至大江而止，遙江山勢又復隆起，不屬油區範圍，北與蓬遂區無顯著之分界，本區地形雖屬低小山嶺，然因地層褶皺頗多，小嶺形勢較為顯著，大致成東北西南方向，平均高度仍在五百六百公尺之間，無特別突起之山嶺也。

地質　此區地層，以白堊紀自流井層為最發育，山嶺起處，侏羅紀煤系暴露，區域之東尚有三疊紀灰岩層，向未開採石油，含油地層不詳，但地質構造頗適於石油聚集，由隆昌至永川中間經過背斜層向斜層六七處，有時白堊紀自流井層之下侏羅紀煤系露出，背斜向斜層大致向東北西南延長，至其盡端，又成背斜穹窿層，傾斜大致在十度二十度之間，有時由四十度至七十餘度，自永川以東，地層褶皺愈甚，隆起愈高，三疊紀地層大部暴露，有時二疊紀灰岩亦露出地表，但已出油田區域範圍，為榮昌永川區及巴縣江津區中間之山地，由榮昌至瀘縣，背斜層延長頗遠，永川以南至大江岸，亦有背斜層踪跡，凡此皆可作試探石油之引線，而為重要之地質構造也。

巴縣江津區

此區在大江之南，巴縣江津綦江境內，巴縣之南約百里煤油溝，為石油流露著名地點，江津之南，亦似有石油流露痕跡，地質構造在煤油溝亦見背斜層，可作試探之區域，惟面積不廣，南北約為二百里，東西約一百餘里。(圖見第一版)

地形　巴縣江津，均在大江沿岸，高在二百三百公尺之間，大江以南，地勢隆起，至煤油溝一帶，平均高度約在五百公尺左右，山嶺雖不甚高大，而稍有高低起伏，山嶺大致成東北西南方向，地形不與四川盆地各油田區域相同，位於較高山地之中，而成山嶺錯綜聳起之狀也。

地質　此區為白堊紀自流井層及嘉定層發育之所，在背斜層起處，侏羅紀煤系及三疊紀灰岩暴露，巴縣煙坡煤油溝一帶，地層露出者為淺紅綠色砂岩，棕紫色粘土，或屬於自流井層之上部，石油流露地表，由淺紅色砂岩而出，但砂岩並非含油地層，來

源當在深處，至油層位置，亦未考悉，或屬於白堊紀，或相當於河洱坎油層及火井溝油層，或在二油層之上。據日人報告，巴縣煤油溝產油所在，爲一背斜層，地層傾斜不大，通常約十餘度，大致淺平。又據瑞士人漢讀報告，巴縣煙坡一帶，有向斜層背斜層之跡，煙坡位於向斜層與背斜層之間，地層傾斜大致向西，斜角五六十度，自煙坡以西，地層驟平，而成煙坡向斜層，煙坡以東，爲一完整不對稱之背斜層，煤油溝適近其層脊，西翼地層傾斜向西較陡，抵層脊漸緩，東翼地層向東傾斜，斜角初緩，由五度至十度，繼增至十八度，在大江煙坡之間，有一大背斜層，向東北偏北西南偏南延長，三疊紀灰岩居其層脊，兩翼爲侏羅紀煤系及白堊紀地層，西翼地層向西北偏西傾斜，斜角由六七十度至五度，東翼地層向東南偏東傾斜，斜角由六十度可至平層，此巴縣江津區構造之大概也。

礦業　煙坡煤油溝，爲此區產油地點，石油流露地表，爲人察知，究出現於何年，尙未考悉，惟據土人云，六十年前曾鑿兩井，一井深約八十丈，約合二百五十公尺，均見鹽水，未出石油。今有一淺坑，在一小溝內，深約五尺，有水上浮石油，油黑色重而粘，比重在五十五度爲·八八九，凝固點零度，在反光視之，呈淺綠黑色，在半透明光視之，呈棕色，現每月可產油約三百斤，在重慶售賣，每百斤十六元至十八元，用以點燈，聞去年曾有重慶紳商提議集資開採巴縣石油，登載報端，迄未再得消息，現仍無專商採辦，惟最近聘德國人用物理地學探鑛法試探，尙未得結果也。

石油富集與地質構造之關係

石油流質也，而比重較小，自生成以後，常向各處移動，而移動之方位，恆視環境情形而定，趨其所易趨，集其所當集，故移動而後，常由散漫而聚集，聚集多者，成爲富礦，石油富集，雖需要種種適宜之條件及機會，然地質構造之是否適宜，關係最大，石油之在地腹，常與潛水(地下水)共生，有時火氣存在，三者之移動儲積，密切相關，但比重大小，各不相同，水之比重大於石油火氣，而火氣最小，故存積所在，水常在下，石油次之，火氣在上，此研究石油者之通論也。如石油產地地層平緩，石油與水或火氣，可向任何方位移動，勢成散漫，不易富集，反之如地層彎曲起伏，或上下褶皺，石油及水常循地層移動而至彎曲

或褶皺之上部，石油輕而上浮，富集一處，下爲水，如有火氣，當聚集於褶皺之頂巔，若移動至褶皺之下部，水常沉於褶皺之底，石油當在其上，而居褶皺之兩翼，此褶皺之上部，即背斜層，下部即向斜層，故石油富集之處，爲背斜層發育所在，惟背斜層構造，以較爲淺平而寬廣者適於多量富集，地層傾斜由十度至三十度者爲最適，如背斜層兩翼地層傾斜陡峻，而中部窄狹，則石油聚集之面積較小，常不若寬廣者聚集之多也。穹窿層爲最重要石油富集之地質構造，地層中央隆起，而四面所含石油，均可向中央移動，而聚集於其上部，如有火氣，當在穹窿層之頂巔，水在石油之下，由上窺下，石油聚集之平面，常如環形，然穹窿層有時狀不規則，常與背斜層共生，而合成背斜穹窿層，狀成橢圓或長橢圓，並有時延長頗遠，如僅觀察其一部，似即背斜層，實則兩端環繞封閉，而又呈穹窿層之狀，在背斜穹窿層中，石油聚集所在，常成長橢圓環形，而中間爲火氣充塞之處也。斷層之關係於石油富集亦甚重要，如含油地層斷折，而上下錯移，斷折之部，如不成平層，而向斷層偏斜高起，所含石油，即沿地層移動，至斷層所在，被阻而聚集，亦常成富礦，其他如單翼背斜層不整一層階段層，均爲適於石油富集之地質構造，有時頗關重要，惟在四川此等構造與石油聚集無甚關係，故不贅述，而最重要者，即背斜層背斜穹窿層，有時斷層亦或成重要構造。富順樂山區及榮昌永川區，背斜層及背斜穹窿層特別發育，顯著者不下十餘處，兩翼地層傾斜或成對稱，或不成對稱，然大致淺平廣大者多，適於多量石油富集，自流井貢井一帶，即一背斜穹窿層所在，而他處較佳較大之背斜穹窿層尚多，皆可希望有較豐之油量蘊藏其下也。資中仁壽區背斜穹窿層雖不甚多，而仁壽縣城附近有斷層一道，向東北西南延長，未盡其端，仁壽鹽井鹽水帶有油泡，中壩井亦曾出油，均距斷層不遙，惟是否有富集關係，尚未明瞭，只可作試探之依據耳。蓬萊遂寗區地層平鋪者多，彎曲者少，構造不甚適於石油富集，如本區北部果有背斜層踪跡，尚不失爲油田區域，否則當遠遜於富樂榮永資仁區之價值。巴縣江津區有背斜層構造，當有富集希望，如其他關係條件不爲阻害，亦爲一可試探之區域也

石油與鹽水及火氣之共生關係

四川石油多因開鑿鹽井而得，故除巴縣煤油溝石油流露地表，及蓬萊鎮火井溝採取石油未出鹽水外，石油均與鹽水共生，自

流井貢井之石油其最著者。四川火氣產生最盛處，亦爲自貢井，有時與石油共生，同出一井。樂山河洱坎油井內，現出少量火氣，聞以前所採，亦有石油火氣同出一井者。羅泉井中壩井油井內無火氣，蓬萊鎭火井溝石油火氣並生，而常不出一井。巴縣煤油溝有石油，無火氣。威遠老場臭水河有火氣而無石油。相互關係，頗爲參差。茲按產地略分述之 一・自流井貢井石油鹽水火氣三者共生，但未必常出一井，有時火氣甚多，燃火極旺，而毫無石油踪跡，併鹽水亦質淡量少，有時鹽水火氣並生，而無石油，有鹽水含有石油而無火氣，情形複雜，亟待研究。屬於三疊紀之红龍井下油層，石油鹽水火氣三者共生，鹽水較淡，火氣可分五十餘火焰，石油每日可出十餘斤，上油層曾見火氣，頗微，石油量亦不多，而無鹽水。屬於侏羅紀下部之富龍井，石油鹽水火氣共生，鹽水較淡，火氣只一火焰，石油日出六七斤，東順井三者並生，鹽水較深，質淡，火氣次之，出一火焰，石油較淺，日出油數斤，四通井石油鹽水並生，而無火氣，鹽水質淡，石油曾日出數斤至數百斤，振川井三者並生，石油火氣均甚少，鹽水質淡。屬於較高油層之積富井，三者並生，鹽水淡，火氣少，石油日出數兩，聞深處火氣頗旺，鹽水亦濃，而無石油，四福井鹽水石油並生，鹽水質淡，石油日出二斤餘，聞深處曾出多量火氣，油層尚多，同昌井三者並生，鹽水質淡，火氣出二焰，石油量不多。統觀自貢井石油層，位置不一，鹽水深淺有差，而火氣所在，上下又極不規則，鹽水由淺而深，濃度漸次增高，頗似因鹽水淡水比重不同，受自然分濾，而鹽水下沉愈變愈濃者，火氣深處量多，而淺處微少，層位亦不一致，又似因質輕上浮，一部沿縫隙分侵於上部地層者，石油亦或由移積作用，分存於各層，深淺不等，三者相互位置，無顯著一定之關係，以比重而言，鹽水當常在下，石油次之，火氣在上，但同在一井，有時先見鹽水，後出石油，而石油漸次加多，亦有火氣在鹽水之下，須打出鹽水，而火氣方能上昇者，更有火氣在石油之下向下火氣量愈增者，三者生成如斯，而同在一域，無怪乎情形複雜，而須待試探詳加研究討論也。二・樂山犍爲產鹽區，順河街灰山井鰲草灘油井坡等處鹽井，前曾有鹽水石油火氣共生者，推其層位，似在侏羅紀煤系上部，但年代久遠，詳不可考，現樂山河洱坎高山舖鹽井，鹽水石油之外，有時亦有火氣，鹽水質淡，火氣微少，石油日出約二三斤，鹽水石油同出一層，而火氣在其上。三・資中羅泉井富源井，石油與鹽水共生，極少火氣，鹽水質淡，石油日出約三四斤

，淺井有石油與鹽水，而無火氣，鹽水質淡，石油日曾出一二百斤。仁壽城鹽井稍有火氣，亦可燃，量不多。四，蓬萊鎮火井溝，石油火氣均經採取，現尚有火氣燃燒，而石油則已涸竭，二者雖同出一域，而同一井內石油火氣並見者不多，較其層位，石油淺於火氣，全區內無鹽水，雖稍見味鹹之水，而無人用以煮鹽，此處石油火氣之層位，在四川已知石油產地中為最淺者，而火氣則深於石油，向下當尚有火氣之源，研究四川石油火氣之成因者，不可不注意也

油田之交通及人工

鑛產之開發，鑛業之進展，與運輸難易遲速，有密切關係，而運輸難易，又視交通便阻而定，故考察一地之鑛產，常須注意一地之交通，凡鑛皆然，不獨石油。然石油為鑛物中具有特別性質者，性質流動，而價值低廉，裝運有時頗感不便，須力籌適當之運輸方法，而補濟之，於是管運方法，大受採用，運輸方法，既具特殊形式，交通方面，應有相當便利，此敘述討論四川油田交通之由來也。人工問題，往往為鑛業中最繁雜而最切要者，鑛工能工一日，工作停頓，因而損失鉅數者有之，鑛工缺少，不敷分配，鑛業不能盡量擴充者有之，工價昂貴，成本增高，鑛業不能發達者有之，工作時間縮短，產量減少，因而營業失敗者有之，凡此諸端，亦當計及，故油田區人工之多寡，工價之低昂，與夫工作時間，操作情形，又似為觀察油田所不可忽略之要件也。

交通之便阻，視地形之高低緩峻而定，四川油田區域，在四川盆地內，地形低緩，已如上述，除一部較為隆起外，無高山大嶺，故交通稱便，運輸匪艱，就油田區域而言，富順樂山區西傍岷江，東有沱江，南倚大江，水運頗便。大江由重慶至宜賓，終年有汽船往來，上行三日，下駛二日，水漲大船可行，水落亦有小船。岷江木船由宜賓可至成都，樂山宜賓之間，夏秋水盛時，可通汽船，春冬水涸，只行木船。沱江由瀘縣上至簡陽，木船通行，惟自富順以上，河淺水少，大船不能暢行，載運不重，自富順以下，水量較多，然猶不足汽船所需，故沱江中尚無汽船行駛，轉運惟賴木船而已。此外三江支流，有時亦可航行小船，最著名者為沱江一支，亦名鹽井河，經鄧井關至自流井貢井之水，為自貢鹽產運輸要路，河淺水涸，然逐段置閘築堰，按時駛行，亦

可直達沱江正流，而至瀘縣大江。岷江小支，導入犍爲五通橋而上者，爲四望溪，亦爲運輸鹽產之需。其他支流之可航行不在此區者，暫不述及。水運如此，陸路交通，較爲不便，運輸率用人工挑抬，及馬匹馱負，近來四川修築馬路，進行雖速，但此區完成者尚少，自流井鄧井關富順一段，現已通汽車，他處路基猶未竣工，不能利用。就地形而言，區域之北爲威遠榮縣一帶山嶺，由中部起向東西南三方，地勢逐漸而低，斜度較緩，約爲千分之一，中間不經陡峻山嶺，不過岡阜小山，時須上下而已。就石油運輸需要情形而言，此區地形頗利於管運方法，由區域內任何地點起，向三江邊岸，安置運輸鐵管，均無阻礙，斜度適宜，中間不必多設唧筒，司其上下，或運原油，或運精油，皆可由產地直導流至儲廠或煉廠，如將來在此區內能發見豐富油田，交通運輸，毫無困難問題也。資中仁壽區，交通雖不及富樂區之便，然猶在岷江沱江之間，亦有舟楫之利，資中內江簡陽有木船往來，惟載運不重，不能暢駛，稍形不便，陸路運輸，率用人工擔負，馬路修築較多，簡陽內江之間，現已通汽車，由仁壽至成都，已有興工之議，石油管運方法，亦可通行無阻，惟由東部沱江流域導運而下，轉達大江，較爲便利，地形斜度不大，不過千分之一，路途雖較遙遠，但中間不必多設唧筒，卽先運至沱江岸，再轉由水運亦可，要須斟酌情形，因地制宜，方不僨事，如由區域西部用管運方法至岷江，較爲困難，中隔山嶺或繞道而行，或多設唧筒站，司其上下，導流轉運，手續不及東部之簡，但岷江水量較大，船隻載運較重，且水盛時汽船可達樂山，由仁壽至井研再轉至樂山，中間路途平坦，如將來石油發見，由管外運，此亦一重要路綫也。榮昌永川區，南濱大江，西臨沱江，交通之便，與富樂區相埒，水運較爲便利，除大江沱江正流可通汽船木船外，支流亦多可航行小木船，瀘縣榮昌永川煤產，多由河流運往各處，陸路有東大路經過區內，率用人工挑抬，近來馬路已逐段興修告竣，內江榮昌間已通行汽車，再東經永川至重慶，現已築就，將來運輸，當不困難，就地形而言，由區內南向大江，西向沱江，地勢漸次減低，而傾斜頗緩，卽有小山嶺，而山嶺延長方向，大致爲東北西南或南北，均向大江沱江漸次而低，極適宜於管運方法，順山勢敷設鐵管導運而下，頗爲便利。蓬溪遂寧區，大部爲嘉陵江之支流涪江流域，西部則臨沱江，水運稱便，嘉陵江由合川分支，上溯，經潼南遂寧射洪三台，而至綿陽，遂寧合川一段可行汽船，遂寧以上，可通較大木船，載運亦重，川北鹽區煎鹽

所用燃料，煤占大部，除安縣之煤運至綿陽外，其餘均爲合川巴縣江北璧山所屬煤田之煤，由船運而來，可見水運之利，安岳樂至中江一帶，距沱江較近，當利賴之，惟簡陽以上，只行小木船，載運不多，陸運多由人工抬挑，較爲遲緩，馬路已成者，爲由簡陽經樂至遂寧，由遂寧至潼南一段，早已通行汽車，由三台綿陽至成都，均通汽車，地形多爲岡阜小山，斜度平緩，利於管運方法，惟距大江較遠，煉廠儲廠須近嘉陵江岸，再由船運下行。巴縣江津區，離大江較近，運輸當便，惟地形稍爲高聳，山嶺延長方向，約與大江平行，由區內至大江岸，有時須橫越山嶺，不甚便利，如多設唧筒站，管運方法，亦可採用，陸運無馬路，不通汽車，大江支流之近此區者，不行船隻，倘將來發見較佳油田，只可利用管運而已。

四川省之人口，在我國各省中爲最多者，據以前各種估計，全省人口由五千萬至七千萬，平均約爲五千萬，而四川各部人口最多之處，卽四川盆地，除成都平原外，油田區域卽四川人口最多之部份也。人口稠密，百業繁興，取給較爲便利，而工價低廉，尤與鑛業發展莫大之助，四川油田區域，人工工價，以普通勞工爲根據，工作時間，由十小時至十二小時，每日每人平均大洋五角，如工作較爲精細或含有技術性質如木工鐵工瓦匠之類，平均八角，至多不過一元，工食在內，與吾國各省工價比較，爲最低之一，人口旣多，勞工亦夥，僱用選擇，不感困難，四川勞工吸食鴉片者最多，操作能力稍遜，然川人尙堅苦耐勞，如嚴格選擇淘汰，駕馭管理得法，亦可訓練而成有用之勞工，各處煤鐵鑛中，鑛工多能勞苦操作，終日不倦，惟在選擇訓練而已。川人性雖敏捷浮動，而罷工罷市之舉尙少，鑛廠工廠工人，率多循規蹈矩，只每日可得工資，卽無格外希望，工作時間之長短，工資增加之苛求，似不計較注意，故四川油田區域勞工問題，無普通工人之流弊，如管理妥善，可表現其所長，此又於鑛業進展有相當之利益焉。

油田前途發展之希望

四川石油，著名已久，學者至其地而考察之者，屢聞不鮮，然以注重所在不同，而詳略亦判，就中惟勞德伯克及漢讃觀察時間旣久，所經地點亦多，結果所得，尙可參考。關於油田之價値，及將來之希望，二人各有主張、勞氏曾至自貢井及犍樂鹽區，

詳細考察，謂犍樂鹽區內，有一背斜層，在竹根灘附近，可名爲竹根灘背斜層，向東西延長，南翼地層傾斜較緩，北翼地層傾斜較峻，成一不對稱之背斜層，鹽水火氣石油等井均在其北翼，就所觀察之油井而言，現在產油甚少，即以前之產量，亦無可以証明此處油田有實業之價值者，但少數之井，未出石油，未必即爲油田無發展之希望，就經驗所知，有一油田曾鑽七深井，以未得石油而廢棄，而後反成油產頗佳之區，試探結果未能得悉油田之底蘊者，有種種原因。一，試探之井未鑿於地質構造適當之處。二，井未達至需要之深度。三，因局部地質構造之變改，而井或鑽於無油之處。四，因執事人之無經驗，不愼重，石油在井內被水排去，致未現出。就第一原因而言，此處鹽井散佈於背斜層之各處，頗有遇觸石油富集處之機會。第二鹽井深至灰山井灰岩層之下約達千餘英尺，距地面有時逾二千英尺，此種深度尙未足探得油田眞像，如再下一千英尺，鹽水火氣石油當有增加之希望。第三數百鹽井散在各處，未必均鑿在無油之處。第四關於石油爲水排去一節，開鑿鹽井，原爲取得鹽水，對於石油之保存提用，未嘗特別注意，在某一鹽井產出石油，而在同一深度或同一層位之臨近鹽井，無石油痕跡，但多數鹽井散在褶皺構造之各部，如在低部之井，石油爲水排去，必現露於上部之井，惟在背斜層之頂部，鹽水盡後，鹽井乾而廢棄，既未嘗變爲油井，原來更未產油，故無多量石油由低部之井爲水壓浮而上。總之此區石油之產生，在鹽井內極不規則，而散漫，出油之井，爲數頗少，而排列又無相關統系，即已出油之井，產量極少，日產僅由數兩至十二斤，而充其量僅可達十五斤，無論露出於背斜層附近之地層，或由井下鑿出者，均未表現含有石油之証，有時僅示有石油之可能而已。由上述情形觀之，在此區出油之地層中，無出多量石油之希望，鹽井內實出之油，爲量極少，已出石油之量，與鹽水相較，量尤低微，毫無實業上之價值，但油之產於鹽井中者，或由深處移棲而來，或可開鑿深井，達其富源，惟就地層之性狀，石油之分佈，及與鹽水之關係觀察，石油與斷層絕不相關，鹽水封閉於原來之地層中，向未經地層而移棲，地表之水，又未灌入鹽水層內，鹽水或石油層中間之地層內，無石油或石油產物遺跡，故石油未嘗移棲，可知石油原生於含之之地層內，而原生之量本不多也。勞氏於自貢井石油，亦曾作簡略討論，其言曰，在自貢井一帶，較古地層，未嘗目擊，只於距離遙遠之區，有其露頭，自流井背斜層地層，僅有在煤系上數百英尺之砂岩層，較古地層，在自

貢井下，眞像如何，尙待研究，現只能就已有根據，而得一種結果，就目擊所知，探訪所聞，四川石油層位，均在自流井黑鹽水層之上，即在白雲岩層下部之上，此種地層，在自流井竹根灘各背斜層，均未露出，在此區之北及西北約八十餘英里外，不現產生石油或石油聚集，或石油產物之証，故吾人研究所根據者，僅鹽井供給之材料而已。據鹽井所得較古地層之性質層位厚度，與盆地北緣西北緣之露出地層，極相類似，當可互相比較，以資考証，在油田內常有石油產生於一帶；而鹽水則在臨近之一帶，其或有未經鑽鑿之區，而具石油聚集之情形者，然就觀察所知，可以產生石油之區，均經多數鹽井鑿探，未得有油池或油帶之証，有石油之處，在特別之鹽井中，或可不表現石油之存在，前曾言之矣，四川鹽井特爲鹽水而鑿，非爲石油，石油或可爲較重之鹽水換去，但全區經多數鹽井鑽鑿，此處之油被排而出，不見於他處，甚非通論，背斜層兩翼之油，被排而至層軸，則層軸一帶之井，當出多量石油，但常不出石油，即有之，而量亦不多，有多數鹽井採辦甚久，上部鹽水已採取殆盡，須向下深鑿，而取深鹽水，以增產量，如油被排而上，浮於鹽水之上，則須出現於鹽水層面較低之鹽井中，但此種情形未嘗聞知，如上所述，自貢井一帶，在地面下三千英尺之淺地層內，當無多量石油存在，就現在所知，在自貢井黑鹽水層下之深地層中，有時雖現油跡，但向未出產石油，黑鹽水產於背斜層軸，而產量甚豐，層內如有石油，必能出現，火氣層之深者，探訪未詳，火氣之產於層軸一帶者，向兩翼均常有石油，但自流井背斜層之兩翼，向無鹽井下鑿如斯之深，火氣生於較深地層之中者，在全區最低處之下，約爲三千四百或三千五百英尺，含火氣之地層，在此區若干英里，未見露頭，他處所見地層，有時爲瀝青質，當適於石油火氣生成，但未露含油之跡，將來如詳加探察，在此層位或可發見石油，就現在情形而言，較深地層，未現產生石油，或石油聚集之證，鹽井向未出多量石油，深層可否產生石油，實未能證明，最深之井，有鑿下至棕赤色頁岩層者，此種地層，雖在峨眉雅州等處見之，但深度若干，殊難估計，大約在此區最低處之下四千英尺，再深地層，更難假定，上古生代含矽質之瀝青灰岩，當在此區深處，惟是否在四千五百英尺或五千英尺，尙難斷定，因由此至其最近區域，露頭所在可有變遷也。至其與石油之關係，在所見瀝青地層之處，向未見聞有石油存在或石油聚集之證，深層火氣，亦應與之有關，總之此種較深地層，雖有含油之可能，然無石油存

在之明證，如將來再無確實證據，進行鑽採，似無把握也。

漢謨於自貢井油田之價值，亦嘗有簡略之評論，謂自流井背斜層，實爲油田之標準構造，面積至少爲五百方公里，與世界油田之具有極佳短小背斜層者相似，惟產油量少，其原因或由於鑿井之錯誤，或由於井內充滿之水，如井內水滿，壓力排油，在二千公尺之下，須爲一百氣壓力，但情形則非如斯，井內通常鹽水深不過十公尺至三十公尺，如有石油，必流至井內，故惟一問題，卽爲有無發見再深油層之希望，勞德伯克有言，在黑鹽水層下之地層，未嘗取出石油，但就實地訪問所得，福明井在深鹽井之下，約距地面三千〇十餘尺處，曾遇火氣，附有少量石油，不過最深之井，實無更得油層之希望，並三疊紀地層露出地表者，亦無產石油之觀，西在峨眉山，東在嘉陵江，厚層灰岩之下，爲紫棕色頁岩，無多孔岩石之跡而可爲石油之儲藏所也。故於一千一百公尺之下，用新式鑽探方法，而可得多量石油者，希望甚微，而在此深度之下，發見多量石油之可能，當更少矣。漢氏曾考察巴縣烟坡煤油溝及蓬溪蓬萊鎮火井溝，謂煤油溝一帶，爲一背斜層，石油露頭，在其層軸，最適於試探。火井溝石油雖來源未詳，然試探亦非無希望也。

勞漢二氏考察時間不同，目的不同，而結果所得，主見所趨，則頗相一致，咸謂四川最著名之富順樂山油田，現在無實業上之價值，將來更無發展之希望，二氏持論最要根據，爲四川產油區域，產量向不豐富，地質構造，雖有時頗適於石油富集，而開鑿鹽井所見石油，量常甚微，足証原生之量本不豐多，採取所得，自當有限，試採工作，尚須愼審。惟二氏亦嘗主張四川油田須再詳細考察研究，方能知其底蘊，蓋現在所得事實証據尚少，互相關係猶未完全明瞭，有時實難據以推論也。此次考察，亦甚忽促，時間不及勞氏所需之久，地點不及漢氏所到之多，地質方面，僅就地表觀察所及，能力推測所知，鑛產情形，只就開鑿鹽井工人，採油井商，詢問過去現在油產概況，而得爲結論。據現在初步簡略之考察，雖未敢遽斷油田價值之大小，然亦非若二氏如斯之不抱樂觀也。據石油地質鑛床原則，油田之價值，當由種種適宜之條件而定，俱具者上也，缺者少，或可發達，或不可發達，俱無者當絕望矣。今就公認之原則，推論四川油田之價值，及將來之希望如左。

(一)石油原生量之多寡　石油之生成原因不一，學者主張紛紜，莫衷一是，學理研究，茲不具論，無論來源如何，石油生成之後，數量多寡，實爲油田之第一要件，原生之量多，如其他情形適宜，當成豐富油田，即缺其一項，或不甚減其價値，反之原生之量少，即有極適於富集保存之要件，而結果所儲，量亦不至甚豐，油田價値可想而知，誠如勞漢二氏所慮，歷來產額甚少，原生之量，想不甚多，油田發展，無大希望，此理甚明，不必詳論。惟四川已知出油地點，實爲油田區域之一小部份，計全區面積不下四十萬方里，而產油之區不過二千方里，約爲全區二百分之一，其間何處有油，何處無油，何地量多，何地量少，非經試探，莫能斷定。四川已知之石油，因開鑿鹽井得機而出，其有向未取鹽之區，面積甚廣，石油無機而現，地質情形相同，地層分佈連續，均有含油之可能，，而油量多寡，實不能遽加評定，世界著名油田，鑽孔緊接，油井毗連，足証同一油田，各部含油多寡不一，時須鑽探，常有因鑽探未得結果而廢棄之油田，而後復成豐美之區，更有舊油田中繼續發見新區產量甚豐者，一地之情形，未必能代表全區之優劣，一鑽之失敗，未必即証明全區之無望。勞漢二氏之觀察，僅限於自貢井犍樂鹽區蓬溪火井溝巴縣煤油溝等處，而油層深者，又只爲自貢井一區，就所得事實，以論當地油田之優劣則可，如舉一以例其餘，未免失之無據，現在所知產油之區，安知非石油量少之處，而其他區域尚有油池油袋存在，不經鑽探，不敢斷定，觀四川油田區域幅員之廣大，油田發展之希望正多，似未可過於悲觀也。

(二)含油地層之多少　油田之價値，視油量之多寡而定，油量之多寡，常與油層之多少有關，雖豐量石油，儘可出自一層，多層石油，量亦未必盡豐，然層數多，則聚集之機，聚集之處亦多，終勝於少數之油層也。四川含油地層不止一層，地層更非屬於一紀，與石油產生有關係者，爲三疊紀侏羅紀白堊紀地層，而各紀之中，又分上下層位。三疊紀灰岩中有上下兩油層，下層實際出油。侏羅紀有上下三油層，均出油，而下二油層出油地點頗多。白堊紀下部有二油層，均曾開採。統計實際出油者已有六層，數不爲少，如原生油量不甚低微，六層聚集所儲，當較一二油層爲多，聚集機會，又多倍蓰，況原生油量在六層之中，多寡未必一律，如有一層原生量多，即有成優美油田之可能，即此而論，四川油田頗有發展之希望也。

(三)油田之地質構造　石油原生量既豐矣，含油層既多矣，然因無機聚集成池成帶，或偶流聚一處，而又分散，則石油分佈各處，終成散漫之狀，雖石油總量常不爲少，而在一處者，實量不多，甚難成爲豐美油田，故石油生成之後，又須有聚集之機，環境所在，適於造成石油富集之體如油池油袋等，此種適於石油聚集之條件不一，而地質構造其最重要者也。石油聚集與地質構造之關係，前已言之矣，勿庸再贅。據觀四川油田區域，除蓬溪遂寧區大部不甚明瞭外，地質構造多適於石油富集，地層率多褶皺彎曲，背斜層背斜穹窿層屢經目擊，富順樂山區榮昌永川區，發育尤著，背斜層兩翼地層傾斜緩急適中，洵屬油田標準構造，爲試探石油最佳之處，如果石油原生之量不少，定當聚集而成豐富油池，四川油田中斷層不著，較大者惟資仁區域仁壽城附近，路露踪跡，分向東北西南延長，現雖與石油產生無甚關係，然如石油蘊藏於下，斷層附近，當有特別富集之處，亦可作試探石油之引線也。

(四)含油層及其蓋層之性質　石油原生之量雖多，須移積方可成富鑛，然移積須得其儲蓄所在，故含油層多孔性之大小，與蓄油量之多寡，有密切關係，通常粗疏砂岩，爲含油層之最佳者，灰岩之多孔者及礫岩次之，四川含油層雖尚未能俱得其詳狀，然就已知者而言，各上油層均爲粗鬆砂岩，適於石油存蓄聚集，下油層在三疊紀灰岩中，在貢井灯龍井出深層油之處，未能考悉其含油層性狀，惟含油層確爲一種灰岩，在威遠山王場白龍池溝，三疊紀灰岩多帶石油臭味，常現多孔狀，在犍爲之西屏山縣屬王溝一帶，三疊紀灰岩呈多孔狀，孔之形狀不同，大小不一，通常二三公釐，有時頗密佈，內有方解石細微晶粒，以錘擊之，發石油臭味甚強，此不但爲含有石油之證，而石油移積蘊蓄於孔內，亦最普通之事實也。在貴州貴陽泡木冲有灰岩(或屬三疊紀)，常含晶洞，內有方解石針狀結晶，並有褐色原油，晶洞大者，徑二十公釐以上，小者二三公釐，含油多者約二兩左右，以錘擊之，晶洞破處，石油流出，與四川三疊紀灰岩含油情形近似，故四川深油層已知者，當爲三疊紀灰岩之多孔者，而儲油情形，與上述地表所見相同，不失爲最佳之含油層也。石油既得其所而移積，既得其機而富集矣，然移積富集以後，因環境不適，不易保存，復散漫流去，亦不能成爲富礦，故含油層之上，須有岩石緻密之蓋層，防阻石油滲透而出，而常保持其聚集之狀，此種蓋層，以

細密頁岩粘土或泥質頁岩爲最佳，泥灰岩灰岩次之，蓋潛水可由細密頁岩粘土排換石油而出，而至粗疎砂岩或多孔灰岩內，然不能由粗鬆岩石而再排入細密岩石中也。四川含油層上之蓋層，多未考悉究竟，僅就鑿井時岩石記錄所知，灯龍井深油層之上，爲灰岩，質不甚細密，羅泉井深油層之上，爲一種灰砂岩或黑砂岩，灰岩尙可防止石油滲透而散，而砂岩爲最不適宜之蓋層，不能助石油長時保存，四川已知產油地點，產量向不豐富，蓋層不良，或其一因。然擴觀四川油田區域地層，白堊紀下部粘土較多，砂岩次之，石油之含於砂岩者，如遇粘土爲之蓋層，卽可不至滲散。侏羅紀砂岩最多，頁岩次之，石油在較粗砂岩中，如有較細砂岩爲其蓋層，自不免一部散去，如遇頁岩爲之蓋層，卽可保存，不過頁岩較少得機不易耳。三疊紀幾全爲灰岩，存石油者當爲多孔或粗鬆之部，蓋層亦當爲灰岩而質較細密者，石油聚集之後，可不生變動，故深油層可不慮蓋層之不良。總之四川含油層上之蓋層，就現在可知者而言，優劣參半，將來於油田之發展或不至有絕大之影響，在未試驗考察確實以前，似未可過於悲觀也。

(五)石油聚集與潛水及火氣之關係　石油生成以後，非移積保存不易成爲富鑛，然移積自有適宜之條件，保存當有相當之機會，地質之構造，含油層之多少，及蓋層之性質，件件與石油豐瘠有關，前已詳言之矣。玆所論者，移積保存，尙有其他可注意之要件，石油聚集以後，或因環境變遷，復散漫流去，以致採取所獲，產量不豐，四川各處產油情形，頗類乎此，雖貧產原因未必盡同，而相互關係當可研究，此可注意之要件，卽潛水與火氣是也。按石油地質鑛床原則，石油聚集最大原因，爲比重不同，物質分異，趨適宜之構造，而上下聚集，然此種作用，在石油聚集程序中，力常不足，須藉潛水火氣之力而爲之助，潛水在地下占重要位置，而作用影響所及，往往關係於礦床者甚大，範圍寬廣，情形複雜，不能詳敘，僅就關於石油聚集者略分述之，潛水在地下之作用，爲靜水壓力毛細管作用及緩慢移動等，當石油原生於細密岩石之內，常定而不動，如有潛水流至，則由細密岩石將石油排出，而至粗鬆岩石內，排油之法，係因毛細管作用影響於潛水之力，約三倍於石油，潛水進入細孔較石油爲易，故水常向細孔侵入，而油則由細孔向附近之粗孔移積，卽石油由原生之頁岩或粘土，移積於砂岩或多孔岩石內，而潛水一部進頁岩或粘土中，此時砂岩內水與油混合，如地層傾斜，水油分異，向上移動，至適當之處，聚集停滯，如地層平緩，則由潛水緩流作用，

帶油移動，石油常因流動被阻而緩，遺留於砂岩中，而水則已流去，經時旣久，亦可成油池，在平緩地層可得多量石油者，潛水緩流作用之力也。石油聚集成池後，四周常賴靜水壓力，封閉撑持之，不使其散漫流去，而常保存其聚集之狀，此種現象在已採盡石油井內，常有潛水侵入，可以證明，其有油盡後而不現潛水侵入之觀者，或因靜水壓力已上昇至油池平面，而得平衡之狀矣。火氣常與石油共生，無論其來源如何，當經過石油存在之處，壓力所及，使油聚集，並可使油成泡，而分出移積，故火氣所在，常助其他條件，而促石油富集。然物之作用，常在適當環境之下，顯其功能，歷久不渝，如環境變遷，則作用可以失效，在靜水壓力保其平衡之際，石油聚集，可呈常態，已成油池，不致散漫，如一方壓力減小，不成平衡，潛水流動，則油池變形，石油可向各處流動分散，結果或不聚集，而成無價値之油田，今觀四川自貢井產油所在，地質構造適於石油聚集，而產量不豐，如原生之量本少，自不必論，否則當有所以致此之由，據情推之，或爲靜水壓力失其平衡，油池破壞，石油散漫所致，四川石油向由開鑿鹽井得機出現，鹽井提取鹽水，已將潛水平衡破壞，鹽水一部提出，其在地下者，當生流動，影響所及，聚集較豐之處，可以變遷破壞，石油隨水流散，自貢鹽井出油者散在各處，產油多寡不等，或爲石油隨鹽水流散之證，若然，則四川油田區域內，向未開鑿鹽井之處尙多，當有石油聚集後未受破壞之希望，四川油田之價値，正未可厚非也。此雖理論之談，然如再多集事實，詳加微詢，於試探新區，未始無參考互證之助。總之，四川產油地點，產量不豐，如原生之量不少，必有其他原因防止石油聚集，或破壞已成油池，研究四川石油者，不可不特別注意也。

油田試探之擬議

綜攬上述各種情形，四川油田，實有注意之價値，地質構造旣具特別適宜之點，含油地層數目亦多，如原生石油稍有數量，卽可得機富集，惟躊躇未取斷言者，卽事實甚少，採訪難確，結果所得，不能證明，如石油原生之量本極重要，以現在產油地點觀察推論所覩，不能舉一反三，含油層之性質如何，蓋層之種類如何，又多未能考悉，至石油是否已經聚集成池，成池以後，是否又被破壞，在在需要事實，推論考證，然僅就地表觀察研究，有時不能解決，須待試探以爲之助，故一面作詳細之地質調查，

一面作地下情形之測探，二者分頭並進，相得益彰，結果所得，用以斷定油田之價值，當不至完全乖誤，否則根據甚少，理論叢生，終莫能知其底蘊也。

（一）地質調查　在實行試探以前，油田地質情形，須特別詳細研究，往往地質關係不甚明瞭，一鑽之差，動輒浪費鉅數，各種問題在地表不能解決者，方訴之於試探，而試探進行，尤須以地質為根據，故詳細調查地質，實為試探油田之第一步工作，調查之初，須測量準確油田區域地形地質總圖，各油田詳細地形地質分圖，油田區域圖，以面積甚廣，未便過詳，縮尺以五萬分或十萬分之一為宜，高等線距二十五公尺或五十公尺，以足以表示油田地形及地質構造為度，油田地形大致為岡阜小山，高低相差不多，等高線距無妨稍小，全區高低最大之差，約為四百公尺，臨近高低之差，約為二百公尺，如等高線距定為二十五公尺，等高線數至十六，亦足表示地形大概，地質構造可以顯露，區域內地層露出者，均應詳細劃分，實量厚度層向斜向傾斜度數，逐一填註，背斜向斜穹窿等層構造，尋其端倪，觀察區內水系，以求構造分佈之關係，研究地表狀態，以明地腹深藏之情形，凡此皆當於各區域地形地質總圖內研究清晰，具體標明，以作試探之根據。各油田地形地質分圖，應較詳細，縮尺以五千分或一萬分之一為宜，等高線距由五公尺至十公尺，除關於地形高低方位力求準確顯示外，地層傾斜方向角度之變遷，觸處實量標註，地層之次序性質厚度色澤，詳細分辨記錄，一面作各地地層層位之比較，推斷下至油層之深淺，一面追踪地層彎曲傾斜之所趨，而確定試探地點之位置，平面地形地質圖之外，尤應多作剖面圖，以明各部地質構造之關係，柱狀圖表示地層遠近厚薄之變遷　地質調查工作愈詳，試探所費愈減，而結果亦愈準確，此試探之初不可稍有忽略者也。地質工作除測量油田區域地形地質圖，考察露出地層外，於臨近油田區域地層暴露較多之處，亦須注意，如自貢井油田之北，威遠境內，白堊紀下部侏羅紀全部三疊紀上部地層，均露出地表，可以實地觀察計量，應擇地層暴露完全清晰者，逐層觀察，記錄岩石次序種類厚度色性，有無石油露頭踪跡，以與自貢井含油層位置比較，或可得準確含油層及其蓋層，由地面詳細研究含油層疎密程度如何，蓋層是否適於防止石油散逸。地表地腹情形，互相證明，自易得其真像。又如犍樂鹽區之西，侏羅紀煤系全部三疊紀地層大部暴露，亦當詳細考察，以與犍樂

礦區地下情形比較互證，於試探工作，可得他山之助。凡此種種關係，皆可證明舉行地下試探之前，地質詳細調查爲最當注意者也。

(二)鑽探　地質調查工作告竣，卽可進行地下試探，試探之法不一，而最通行最可據者，爲鑽探，然施行鑽探之前，須愼審選擇鑽探地點，而鑽探位置，須完全根據地質調查結果，如油田地質構造已經考察明瞭，鑽探當尋背斜層所在，而在其平緩之一翼施工，如油田地層次序厚度調查確實，鑽探下至之深度，及鑽下若干尺可遇何種地層或油層，皆可預計而得，浮表地層之厚薄，標準地層之辨識，均與鑽探位置有關，然非經地質調查，不能確定。鑽探與地質有密切關係，久成定論，無庸多贅。鑽探位置選定之後，卽可從事鑽探，惟鑽探之法，鑽探之具，種類不同，如何採用，須視油田區域地質交通供給各種情形，及試探計畫規模大小而異。文明愈進，機械愈繁，鑽探法具，時有改良，昔之認爲利器者，而今已多廢棄不復用矣。然世界各國文化程度不同，工業發達不同，經濟狀況，地方環境，各有殊異，物之利於此者，未必卽適於彼，廢於彼者，未必不適於此，要在適合本國本地情形而已，吾國現在物質文明，不及列強，無庸諱言，器械採用，有時須特別斟酌，是否適於吾國情形，如物理地學探鑛法，昔現時最稱新式，各國爭相研究試用，無論結果準確程度如何，以吾國現狀而言，可否盡量採用，尙成問題。又如衝擊鑽探法，昔盛行時，各國視爲標準方法，今已多廢棄不用，但衡以吾國情形，此法猶有可取，此最新已舊二法之間，尙有現正通用之旋轉鑽探法，較衝擊鑽探法敏捷，而結果淸晰，較物理地學探鑛法簡單，而準確可據，各國試探油田，多採用之，美國東部，風行一時，四川油田將來如須試探，方法器具，如何選用，須詳加討論。玆先將歷來所用石油鑽探法，分述於此，以資參考。

(一)衝擊鑽探法　此法探鑛採用最早，而經時已久，油田試探，率多用之，在十餘年前，美國探油之井，什九利用此法，世界最深油井在七千英尺以上者，亦曾用以開鑿，方法旣廣被採用，而種類因之亦多，由簡易之人工粗具，進而至複雜之汽力機器，中間經過程序，屢經改進變易，方法雖多，簡括之，要不外繩索及棒桿兩種，卽連接地面裝置及鑽頭者或用索或用桿不同，其他均在地面建築高車架，安置起重機，在地下繩索或棒桿之端，連繫鑽挺及鑽頭，原則無異。鑽頭鋼製，藉重力上下衝動，擊

鑿岩石，岩石鑿碎，或用筒提取，或用水冲上，以驗其質。纜索又分竹索鐵索二種，竹索衝擊法，吾國日本用之，現四川鹽井均用此法開鑿，法極簡單，而用費低廉，用鋼鐵製成扁鑿，柄長丈許，是爲鑽頭，粗重形式不等，索用竹篾連接製成，以聯鑽頭，地面上有木高架，旁有木輪，輪爲捲竹索而起出鑽頭之用，架爲提竹筒出水及驗岩石碎屑之用，鑽頭下鑿，岩石破碎，由竹筒攝吸取出，法雖簡陋，而具有至理，可下鑿至三四千尺，惟純用人力，進行甚緩，往往鑿一深井，動輙數年，緩不濟急，爲一缺點。鐵索衝擊法，現仍通用，美國加州油田，用之特著，索徑二寸餘，下端接鑽挺鑽頭，上端繫於桿輪衝機，設立木製高車架，附鐵索弔筒，用以取井下石屑泥水，動力用蒸汽，有時用循環流動之水，冲上石屑，鑿下深者可至七千餘英尺。棒桿衝擊法，亦分數種，桿有木製鐵製，木桿衝擊法，坎拿大油田多用之，以長約十八英尺徑約二寸餘之六方或圓形木桿，連接成約三十六英尺之長桿，其他裝置設備，與鐵索法略同，鐵桿衝擊法，俄國用之，以一寸餘方長二十一英尺之方鐵桿，連成四十二英尺之長鐵桿，下連鑽挺鑽頭，在七十英尺以上，率用二十一英尺之單桿，亦爲汽力衝機，在二千英尺井內，每日下鑿平均不過五六英尺。其他衝擊鑽探法，不過此二種方法之變相，或參照多法原理而合成者也。

（二）旋轉鑽探法　此法爲鑽探法之進步者，試行成功於三十年前，美國首採用之，法與衝擊法異者，係須用鑽桿連接轉動，磨取岩石，下用特別堅硬鑽頭，以便磨切，上用旋轉壓力機器，轉動鑽桿，以水環流鑽孔，藉消磨擦之熱，用鑽挺取出石心，以驗其質，按其鑽頭形式裝置，可分數種，常見者爲泥水轉鑽，金鋼石轉鑽，鐵彈轉鑽。泥水轉鑽用厚約半寸之空心鐵鑽桿，長二十四英尺徑四寸六寸不等，鑽頭多鋼製，魚尾式，以泥水灌流鑽孔下，而利用其壓力，泥質補膏孔壁，并促石屑上昇，唧筒轉機在所必需，高車架亦須設立。金鋼石轉鑽爲轉鑽中最常用者，用鐵製空心鑽桿，連接旋轉，下附鑽挺，爲提裝石心之用，末有鑽頭，以黑色鑽石嵌鑲其上，用磨岩石成細棒狀，上入鑽挺中，提出察驗，用環流之水，由地上唧筒排入鑽桿，下至鑽頭磨石處，復沿鑽桿之外，套管之內而上，岩石鬆處，須用套管，上有轉動機連昇降機，動力多用汽力，有時用電力或汽油，高車架鐵製木製均可，隨當地情形而定。鐵彈轉鑽發動起重旋轉，與金鋼石轉鑽相同，惟鑽頭不用鑽石，而用鐵彈，鑽挺上安一圓蓋狀之管

，鑽頭爲鋼製圓狀，擠壓鐵彈，磨切岩石，鐵彈爲硬鋼製，大小如普通鐵沙彈隨地面壓下之水至鑽孔底，由鑽頭缺口至鑽頭下，受鑽頭旋力壓力，卽鑽入岩石，其鑽挺上圓莖狀之管，用以接盛石屑，亦可得所鑽地層大概。其他轉鑽原理大略相同，不過裝置構造稍異耳。

(三)物理地學探鑛法　科學進步，方法日精，學者爭相根據科學原理，用諸實驗，探鑛法亦其一端，由簡單之人力衝擊法，幾經改良，至機力取石之旋轉法，現更進而至用物理地學探鑛之時期矣。試探石油，亦多採用，徵論現在試探結果準確如何，如繼續研究改進，將來或有成功之一日。物理地學探鑛方法多種，而可施諸試探石油者，爲重力探鑛法，震力探鑛法，電力探鑛法，磁力探鑛法，其他尙在研究中，而未臻利用之時期也。

一，重力探鑛法　此法原理係利用物質密度之大小、吸引力之不同，而影響於他物顯有差異，以定鑛產所在。惟影響之差甚微，非用精細儀器，不能察知。儀器可分數種，有擺有秤，擺分普通擺倒動擺，秤分愛氏扭動秤釋氏乙式秤，就中愛氏扭動秤爲最常用者，秤之重要部份，爲一白金細絲，吊懸鋁製橫桿，桿一端下以細絲懸一細金圓柱，他端直安一同樣金柱，試探時如地下有鑛產，因密度不同，感應二金柱之引力亦異，而白金絲卽生扭動，察扭動之大小，而詳計之，可得地下物質吸引力之差，作引力之等線，而推知鑛產所在，世界油田用此法探者頗多，美國最著。

二，震力探鑛法　此法原理係根據因震動或爆炸發生之音波或震波，通過彈性不同之物質，而異其速度，以定鑛產所在。震波經過空氣，速度小於經過地層，在鬆散地層小於在堅實地層，接受顯示震波遲速之儀器，爲地震儀，如埋置炸藥於地下而燃之，震波經地層而至地震儀，顯示其遲速，作曲線以表之，而定地下埋藏之鑛產。試探油田用此法者，先定岩鹽穹窿層之所在，以尋石油，美國東部最常用之。

三，電力探鑛法　此法原理係利用物質傳電性大小之不同，通電後或發電後電流經過物質現像有差，以定鑛產所在。如一種物質通電後，電流經過物質，呈平行或規則狀態，如有傳電性不同之二種物質，通電後，電流經過或接近較良導體時，則向之

彎曲，經過或接近非良導體時，則背之彎曲，試驗電流不規則之狀態，則用等電位線以表之，定等電位線，則用各種測電計，方法繁多，試用不同，原理不外乎此，石油爲非良導體，世界油田常用電力法以探之。

四，磁力探鑛法　此法原理係根據物質磁性大小之不同，而影響他磁性物質之強弱有差，以定鑛產所在。磁性鐵鑛以此法測之最便，方法不同，不外量直立及平面磁性吸力之差，儀器不一，則有磁性計，精微磁力秤，及地球誘電計等，石油本無磁性，惟利用磁鐵鑛常散佈於岩鹽鑛內，以測探岩鹽穹窿層，有時間接亦可推定石油所在也。

（四）探鑛法之比較及利用　爲提議試探四川石油，不避煩瑣，列舉各種探鑛方法，特於關係試探石油者，悉表出之，惟方法新舊不等，繁簡有差，用于吾國，用于四川，究以何種爲宜，在實行試探之前，須特別愼審選擇，前已言之矣。玆所論者，爲就四川油田當地情形，比較各種方法，作將來採用之參考。上述竹索衝擊鑽，爲最初步探鑛法，但四川鹽井，均用此法開鑿，鑿下之深，可至四千餘尺，法簡易舉，只鋼鐵製鑽頭一條，竹吊筒一個，竹篾數百斤，木輪數個，工人四五名，即可開工，用費低廉，有在白堊紀地層開井探油每打下約十八尺，包工費僅用一元一角者，惟舊日工作進行甚緩，一井之成，動輒數年。若試探白堊紀侏羅紀油層，再加換用鋼鑽，改良工作手續，未始不可參酌用之，去歲四川第二十四軍建設設計委員會，曾用此法鑽探威遠縣煤田，進行情形尚佳，近有人提議試探犍爲樂山深鹽水及火氣石油，亦擬用此法，似未可以其簡陋而全廢棄之，不過須注意改良耳。鐵索衝擊法探油，昔曾盛行，迄今通用不衰，普通轉鑽雖與之競爭，然互有長短，未能獨專，轉鑽利在工作速，套管少，但機價貴，工價昂，起鑽費時，水易進孔，鑽孔易於彎曲，水油不易提驗，多有不利之處。鐵索衝擊鑽，弊在多用套管，工作緩慢，而鑽孔常垂直，深度準確，可鑽大孔，套管防水進孔，孔壁地層常露，可以探驗，是其所長。轉鑽利于鑽探粘土頁岩散沙，而鑽砂岩礫石甚慢，索鑽利于鑽探砂岩，而不利于鑽散沙粘土頁岩，此普通轉鑽與鐵索衝鑽比較之大略。然轉鑽又有金鋼石鑽及鐵彈鑽，爲轉鑽之最進步者，近來試探石油，有改用金鋼石鑽之趨向。而鐵彈鑽亦有種種利處。金鋼石鑽較普通轉鑽快至三倍，快而能使鑽孔垂直，且可彌補孔壁，用水壓力控制鑽桿，薄層可以保存，惟有時因鑽桿較細，不易裝置特別桿結，鑽桿銜接之處，

易於破裂，且須用鑽石頗多，價甚昂，不易置備，黑色粗鑽石，在歐戰時，每一開拉約值美金四十元，在十年前，較佳鑽石每一開拉約值美金一百十五元至一百三十五元，現在價又增加，需用鑽石之數，隨鑽頭大小而異，通常鑽探油田，每鑽約用六粒至十六粒，鑽石大小，因所鑽鑛產種類而定，鑽探油田，鑽石有時重六開拉以上至十開拉，普通平均如以五開拉一粒計，備置二十粒，每開拉值美金一百二十元，共計鑽石費須美金一萬二千元，以現在美金價計約合幣五萬元。併機器鑽桿套管鍋爐唧筒而統計之，至少十萬元，不得為非鉅數。鐵彈鑽功用似金鋼石鑽，而無鑽石之費，且具易於控制長粗鑽桿不易丟失鑽頭之長，本可採用，然不利鑽探軟硬相間之地層，且開辦費需用頗多，如鑽八英寸徑之鑽孔，機器全部約需美金二萬元，而金鋼石鑽八英寸鑽頭所用鑽石，價[illegible]五千至八千元，統計用費無大差異，此進步轉鑽利弊比較之情形也。近來探鑛方法最新式者，為物理地學探鑛法，然其應用於[illegible]探石油，學者尚多懷疑，其最通行者，為重力震力電力磁力等法，前已言之，磁力探鑛係利用物質磁性，但石油不具磁性，須先試探有無適於石油存在之地質構造，如岩鹽穹窿層等，間接推測石油，結果是否可據，可想而知。電力探鑛係根據物質傳電性，用探金屬鑛產，功能甚著，石油為非良導體，而常與其共生之鹽水為良導體，以電力法探油田，而能推定石油有無開採之價值者，迄今尚未聞也。震力重力二法，試探油田，最多用之，而效力亦著，震力法詳探略測均可，而較敏捷，重力法只可作詳測，而較緩慢，往往二者並用，相得益彰，現震力法採用尤廣，美國南部各油田，多用之，嘗發見多數產油地點，但所探之深，均不過一千五百英尺，此法所探最大深度，為二千五百英尺，再深效力如何，尚難斷言。總之，物理地學探鑛法，試探石油，至為緩慢，而用費極昂，每探得一岩鹽穹窿層，計其探費，動輒數百萬元，得失廉昂，何不詳計。就吾國情形而言，物理地學探鑛法試探油田，為時尚早，最近不必採用。如將來試探四川石油，只可於下列四法選擇施用。一·舊式竹索衝擊法，即現在四川開鑿鹽井通用者。二·新式鐵索衝擊法，即現在美國加州油田通用者。三·金鋼石轉鑽法，即現在鑛產鑽探通用者。四·鐵彈轉鑽法，即現在尚在試用而未通行者。就四川油田地質而言，上油層在白堊紀侏羅紀者，地層多粘土砂岩頁岩，有時軟硬相間，試探油田多利用泥水，易於沖去鐵彈，均不利於鐵彈轉鑽。鐵索衝擊法利在鑽孔準直，鑽大孔，防止水，可鑽硬岩石，但工

作進行緩慢，不利鑽頁岩粘土，且最大缺點，不能取出整齊地層石樣，以供檢驗油層之性質，四川油田含油地層性質種類厚度，多未明瞭，得取石心，爲最重要，故鐵索法不甚適宜。金鋼石轉鑽試探油田，初不甚採用，嗣經改進，去此法之所短，取他法之所長，近年來世界油田，大有通用之勢，美國東部油田用之最著，任何地層均能鑽探，岩石愈硬，工作愈適，前之不利鑽鬆軟地層，不易取鬆軟岩石標本者，今已設法補葺，添置特別機件，可得完全繼續石心，以供考察，此最利於鑽探新知油田，試探四川石油用之較宜，惟開辦置備價昂，有時損失亦重，須愼審將事耳。四川油田區域廣大，須探之處甚多，時間所需亦久，純用金鋼石鑽，用費浩大，舉辦匪易，如參用舊式竹索衝擊鑽，設法改良，於試探經濟，不無補益，以金鋼石鑽探地質構造重要所在，藉悉其含油層之詳細準確情形，以竹索鑽遍探構造一帶，藉定油池位置及其面積。四川油田油層位置，上下所差甚多，不下一千餘公尺，上五層在侏羅紀內，地層較軟，用竹索衝擊鑽不至甚感緩慢困難之弊，深油層在三疊紀灰岩中者，可用金鋼石鑽下探，並可再深至下層火氣之下，或可更有發見也。

(五)餘論　鑛產價值有所未知，地腹底蘊有所未明，故須試探，然試探結果，成敗兩可，成則裕國福民，利莫大焉，固可以喜，敗則眞像已明，再作別圖，亦復何害。石油關係于吾國者極大，無論實業，經濟，交通，軍事，直接間接，需之利之，將來石油需要，日重一日，若僅仰給于外品，漏巵綦鉅，且有供不應求之虞，非設法自給，無以圖存，如國內原產已開，須盡力擴充之，構造適宜，應設法試探之，擴充之無大希望，試探之結果失敗，爲供給重要需要計，亦當別求其源。德國產油極少，供不應求，現正盡力研究由煤製油，日本患石油之不足，特別採製撫順頁岩之油。吾國油田確知者，爲陝西四川，陝油已開，而鑛業迄今不振，出產無多，利用未廣，川油未探，而鑛產價值不悉，亟待試探，以定取捨。四川油田如試探成功，國勢攸關，利益自不待言，即試探失敗，亦可藉以確知吾國油田，多不可恃，設法別尋石油來源，或由烟煤取油，或由含油頁岩取油，皆可早定計畫，注意採探試驗，設廠製造存儲，以備國用，以禦外侮，未有不知已知彼，而可勝人者，未有不知己之所有，而可不仰給于人者。四川石油試探，爲謀國不可緩之圖，成敗固未可過慮也。

石油參考書目

勞德伯克　四川石油調查報告　未出版　民國四年
瀧讀(哈安姆)　四川自流井地質構造　兩廣地質調查所特刊第六號　民國十九年
　四川重慶附近地質構造及石油　兩廣地質調查所特刊第八號　民國二十年
趙亞曾黃汲清　秦嶺山及四川之地質研究　實業部地質調查所地質專報甲種第九號　民國二十年
寇德瑞　四川之鹽水火井　法國鑛業年報第八卷第十九期　一八九一
林振翰　川鹽紀要　民國八年
小林儀一郎　支那地學調查報告第二卷附圖　日本東京地學協會　一九一七
譚錫疇李春昱　四川峨眉山地質　實業部地質調查所地質彙報第二十號　民國二十二年
樂森璕　貴陽泡木冲石油鑛地質　實業部地質調查所地質彙報第十二號　民國十八年
金開英　中國石油之成分　實業部地質調查所地質彙報第十九號　民國二十一年

達縣油田

李春昱

引言　前年調查四川地質，多在西部，達縣油田，雖曾略有所聞，但未往踏勘。今夏春昱再奉命入蜀，歷時兩月，行將東歸，便道由萬縣前往視察，然後取道梁山仍返萬縣。往返費時凡十二日，而在油田區內，僅有一日，故調查頗略。比及歸來，適值四川油田概論一篇，方始付印，因將達縣油田，略述簡報，附錄於後。

地位　本區因無鹽井，故石油之發現甚鮮，然以其有露頭滲出，是可知其地下之蘊有石油也無疑。滲露地點在縣治西區橋灣河塲，西北十五六里之稅家槽，距城約百二十餘里，在小溝之旁，由砂岩內徐徐滲出，混於泉水，鄉人掘一小池，長寬尺許，常於水面浮油一層，地點狹小，產量亦微。據云每日可產斤餘，冬季更減，爲時頗久，不紀其年，但知者甚少，故未注視。然若就地質構造觀之，則可出石油地點而無露頭者，固甚廣袤，東起於趙家塲及九嶺塲，西迄於橋灣河與石梯坎之西，東西延長達四十里，南北寬約二十五六里，苟能詳爲試探，誠有希望，作者因包括是區，統稱之爲達縣油田（圖見第十八版）。

地形　達縣西區有主河二流，一爲巴河，來自巴中經橋灣河而南流，一爲州河，來自宣漢，流向西南，二者匯於渠縣之三匯，注於渠河。其他之小溪細流，率皆納之。河面平均高度約爲四百三十公尺，低窪地面約高河面三十公尺，邱阜頂點之平均高度約爲六百餘公尺。而油田東隅之鐵山，因成背斜層之關係組成長嶺，北起於兩路口與橫山子之北，南伸於申家灘與渡市街之南，呈北微偏東與南微偏西之走向，橫阻達縣至橋灣河之孔道，山嶺脊背高達一千公尺。在油田之北緣，沿地層走向亦成高嶺，但遠遜於鐵山，九嶺塲與渡市街之西南，另有背斜層隆起，大致平行於鐵山，高亦相若，惟北端沉沒於油田之南，故可擯諸本區之外。總觀是區，可稱山地，而油田所在，則以地層平緩，故崗谿之差，不爲過甚，更兼以巴河橫貫，將來石油如能開採，則其運輸，實可利賴。

地質　僅就石油之露頭附近及表面地質觀之，誠屬簡單，岩層露頭皆爲白堊紀下部之紅色黃灰色砂岩與紫紅色粘土或頁岩，

石油即於其中之一層黃灰色砂岩內徐徐滲出。然此石油決非生於此層砂岩，必由於較深地層，遇罅隙而上升者也。故欲知石油生成之層位，必先研究表面下之各紀地層，欲知石油之富集地點，必明瞭本區之地質構造：茲分別述之。

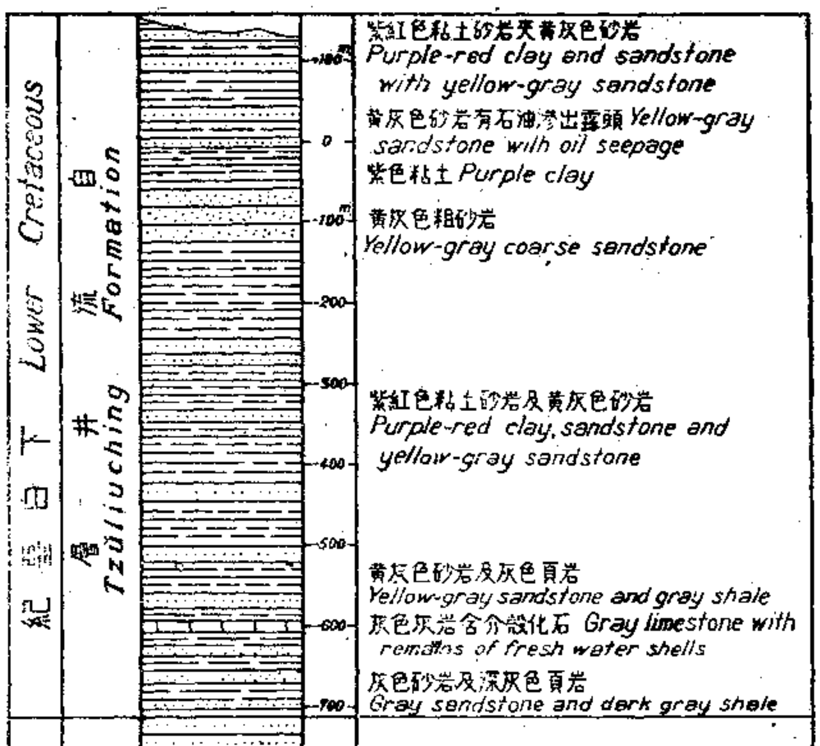
地層　本區因無鹽井，故研究其地層，必須借鏡他山，今以其西接重慶合川，東鄰奉節萬縣，就兩方之地層及其附近渡市街與中家灘間之峽谷與蒲苞山背斜層兩處露頭，合併參證，亦自三疊紀地層約略述之。三疊紀下部地層，在合川一帶爲飛仙關層之紫色砂岩頁岩，今以其蘊藏較深，姑不敘及，三疊紀上部在合川重慶之間爲灰色薄層灰岩，厚達六百餘公尺，其在奉節萬縣則在灰岩之上尚有二百餘公尺之紫紅色與灰綠色之灰質頁岩，頁岩及砂岩，前人稱之爲巴東系，漸向西北，厚度漸減，灰質漸富，紅色漸少。故在蒲苞山，介於侏羅紀砂岩與三疊紀灰岩之間者，有灰色灰質頁岩三十餘公尺，而在中家灘之峽谷內則灰岩直與侏羅紀之砂岩相接觸。遵此推之，則本區油田之下當無巴東系也。侏羅紀仍以深灰色砂岩爲主，夾含頁岩及薄煤層，厚約四百七八十公尺。其上直覆以黃黑灰色之細砂岩與頁岩，時見不完整之植物化石，或即屬於白堊紀，其厚度不過百餘公尺即覆以大安寨灰岩，亦含介殼化石。惟此層灰岩厚薄不一，在渡市街之東厚僅八九公尺，而在蒲苞山背斜層之東翼，厚達四十餘公尺，且分作兩層，此處以油田在西，當亦較薄。灰岩之上即爲黃灰色砂岩紫紅色砂岩與粘土，其至石油露頭之層位約六百餘公尺，然在石油露頭層位之上尚有紫紅色砂岩粘土甚厚，未見其極頂，蓋均屬自流井層也（見第一圖）。

地質構造　油田東側之鐵山，爲一大背斜層，軸向呈北稍偏東與南稍偏西之方向。在其北端，兩翼之傾角相若，四十餘度以至七十度，近頂之處，地層稍平，兩側山麓，傾角亦小。南端則西翼傾角稍急，約八十度，東翼較緩，五十度或三十餘度。陳家坪與渡市街之西，另有背斜層與前者大致平行，北端傾落於陳家坪之西，其兩翼傾斜狀況，以距離尚遠，未便憶度。此二背斜層對於石油之儲存固不無可能，而以其傾斜過急，延長甚遠，暴露低下地層較多，故皆擯而不述。至此油田之本身構造，則爲一大穹窿層，略呈橢圓形，東起於趙家場，西迄於橋灣河與石梯坎之西，東西稍長，南北稍狹。向四周傾斜頗緩，其在趙家場，傾向北偏東，傾角十五度，橋灣河一帶，向北傾斜，傾角十度至十二度，稅家槽之北，傾向西北，傾角十三度，石梯坎之南，向西傾

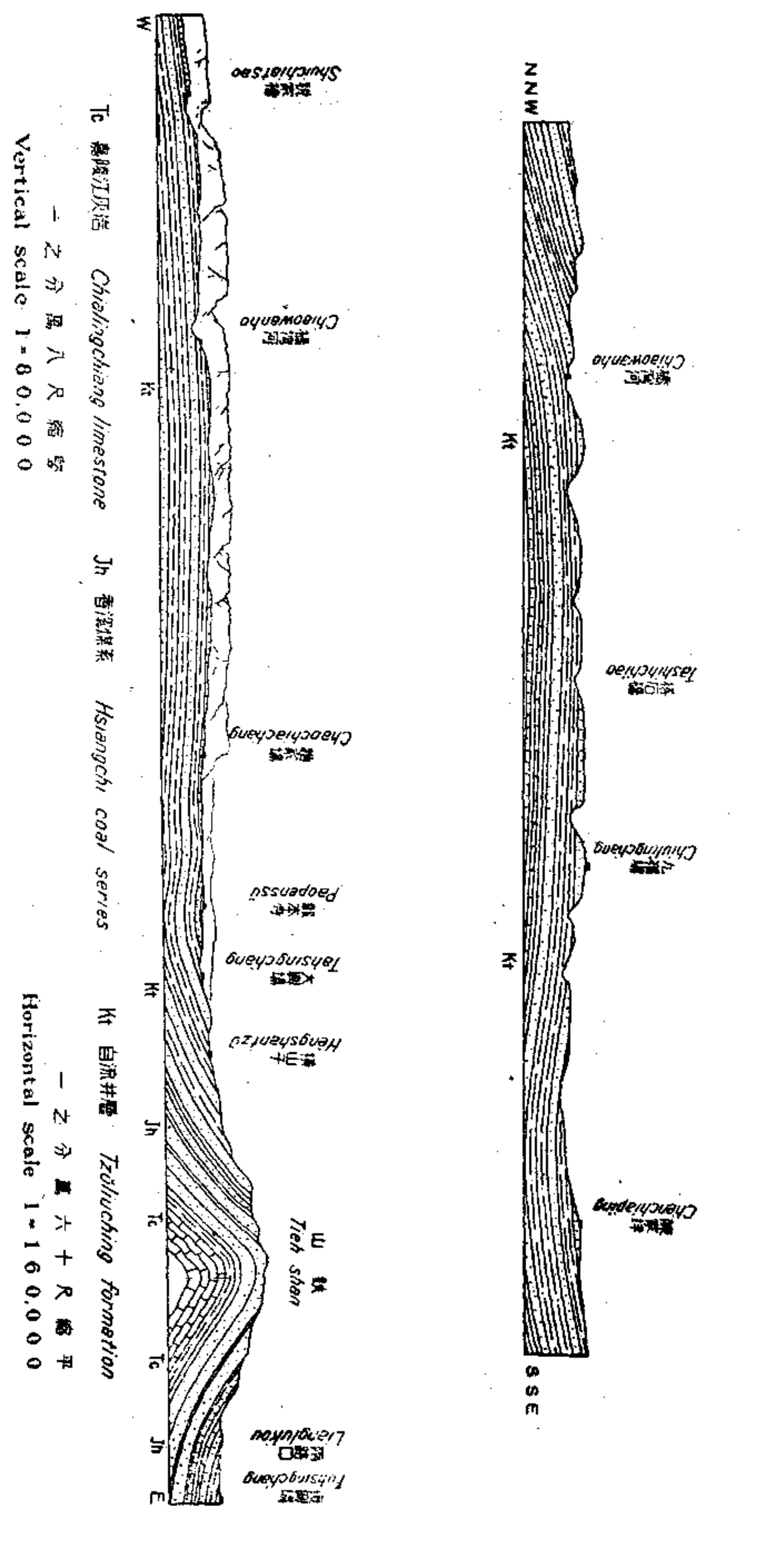
斜，傾角六度，其東傾向西南，傾角八度，搭石橋及九嶺場則傾向東南，故就傾斜之情形觀之，確爲一穹窿層，與自流井之構造，頗爲近似，且範圍較大，惟傾角稍緩，中央更平，或不宜於石油之集中。但就其本身論之，北翼之傾斜，較南翼稍陡，若能擇地試探，頗有成一巨大油田之希望也（見第二圖）。

原油性質及其層位　原油由砂岩中滲出後，甚爲稀薄，呈深棕黃色，浮於水面，鄉人採取時，以手摸之，著於指掌，然後刮

第一圖　四川達縣油田地層柱狀圖



第二圖　蓬溪縣油田地質剖面圖



下，盛以器皿，嘗用以燃燈，易燃多煙。其滲出之層位，為一層黃灰色砂岩，其下約六百尺，始遇大安寨灰岩，在此六百公尺內皆紫紅色之砂岩粘土與黃灰色砂岩，似無生油之可能，故生油地層，當在大安寨灰岩之下。若參證以四川他處各油層之層位，在

三疊紀灰岩內有一，侏羅紀岩層有三，白堊紀下部有二，今此處之油層，雖無從確斷，而按其岩石之性質相似，或其層位，亦應相當。惟其爲由岩內滲出，必係沿罅隙上升，若論機遇，上層較多，故謂之生於白堊紀底部或侏羅紀上部者，應近是也。既略知其大概層位，當再審含油層與蓋覆層，以定其是否宜於含蓄或易否逸散。試觀白堊紀底部與侏羅紀上部之露頭，所含岩石，大抵爲砂岩與頁岩或粘土，相間生成，是砂岩宜於含油，而頁岩與粘土均爲極佳之蓋覆層也。

按地質構造及地形擬俱試探地點數處：既有石油之露頭，則其存在，自無問題，復有適宜之構造與含油岩層及蓋覆岩層，又宜其蓄積，是所未知者，惟油量耳。不經試探，無由推斷。爰就地質構造，當地層由傾斜漸變至平緩處，視爲石油之停集地點；就地形狀況：在崖下稍低窪之處，以節省試探深度，擬就試探地點七處如下：稅家槽石油之露頭附近一處，搭石橋西北一處，固嘉河北崖下兩處，九嶺場之西北與西南各一處，報本寺之南一處，此不過暫擬數處，藉資試探，而非本區油田只在以上之七處。試探之深度，就地層推之，最少當亦在六百公尺以下，以如此始達大安寨灰岩之下也。

四川鹽產概論

譚錫疇
李春昱

鹽產之分佈

四川鹽產，分佈甚廣，以散在各處之鹽場言，可占全省之半，中部盆地內，特別發育，東部亦成一區，至東南之彭水，西南之鹽源，僻在邊陲，猶以產鹽稱，可供一方之食，然與四川內地鹽場較，產銷多寡，相去遠矣。計其大者，富榮鹽場當首屈一指，犍爲樂山鹽場次之，南閬射蓬雲陽三台又次之，大寧，蓬中，樂至，綿陽，蓬遂，井仁，射洪，簡陽，鹽源，奉節，中江，開縣，彭水，資中，西鹽，各場爲中等，大足，鄧關，忠縣，萬縣，鹽場其最小者也。茲爲節省敘述，便於觀察計，按照四川鹽產分場法，列表填註，記其位置，約略面積，及重要區劃，並附四川鹽產分佈圖，藉供參攷。

四川鹽產分佈表

鹽場	縣屬	方位	面積	分區	附注
富榮場	富順榮縣	富順縣西北自流井榮縣東南貢井	約四百方里	分東西二場東場分五區西場分三區	面積係按產區長寬約略估計
犍爲場	犍爲	犍爲縣北東北五通橋灰山井馬踏井金石井一帶	約一千方里	分七區	產區散在各處面積估計不易準確
樂山場	樂山	樂山縣東南牛華溪河洱坎西南順河場太平寺一帶	約一千方里	分六區內二大區四小區	
南閬場	南部閬中	南部縣中部閬中縣南境	約二千方里	產地甚多約三十餘處有廠無區	民國十六年分出一部歸南鹽場
射蓬場	射洪蓬溪	射洪縣東南太和鎮洋溪鎮青堤渡蓬溪縣西南吉祥寺小高岩一帶	約一千餘方里	有廠無區	
雲陽場	雲陽	雲陽縣西北雲安鎮	約四方里	產區小未再分	
三台場	三台	三台縣東北馬康橋槐樹場興隆場南境河嘴下觀音橋西北黃泥井一帶	約一千方里	有廠無區	
大寧場	巫溪	巫溪縣北大寧鎮	約二方里	未分區	

蓬中場	蓬溪	蓬溪縣中部北部	約五百方里	有廠無區	
樂至場	樂至	樂至縣中部香泉舖童家壩石佛場臨江鎮放生舖寶林場一帶	約五百方里	有廠無區	
綿陽場	綿陽	綿陽縣東南五里梁白池口左家岩豐谷井一帶	約三百方里	有廠無區	
蓬遂場	蓬溪 遂寧	蓬溪縣西南玉峯場觀音寺地風井河邊場遂寧縣西白馬場攔江河一帶	約七百方里	有廠無區	
井仁場	井研 仁壽	井研縣中部城區大水灣門坎山北部烏拋灣仁壽縣楊泗井城區中壩井一帶	約三百方里	分為七區井研四區仁壽三區	
射洪場	射洪	射洪縣東南部由縣城至太和鎮一帶	約八百方里	有廠無區	
簡陽場	簡陽	簡陽縣西北石橋井老君井一帶	約六十方里	有廠無區	
鹽源場	鹽源	鹽源縣西約四十里白鹽井及西約二百〇五里黑鹽塘等處	約三十方里	分二廠黑廠及白廠	白廠東西四里南北五里黑廠東西三里南北二里
奉節場	奉節	奉節縣東七里磧壩一帶大江兩岸	約一二方里	分南廠北廠在大江南北	
中江場	中江	中江縣東南胖子鎮新場一帶	約八百方里	有廠無區	
開縣場	開縣	開縣東北六十里溫湯井	約一二方里	分河東河西二區	
彭水場	彭水	彭水縣東北郁山鎮一帶	約五十方里	分後井中井老井三區	
資中場	資中	資中縣西五十五里金李井及西一百一十里羅泉井等處	約二百方里	羅泉井分第一第二兩區	
西鹽場	西充 鹽亭	西充縣西北境義興場會龍場一帶東境忠和場及鹽亭東南境	約五百方里	有廠無區	民國十六年分出一部歸南鹽場
大足場	大足	大足縣南王家場一帶	約一百方里	有廠無區	
鄧關場	富順	富順縣西北鄧井關一帶	以前產鹽區約九百方里現只數十方里	以前分詹壋王壋太壋宋壋徐壋五區現只王壋一區產鹽	
忠縣場	忠縣	忠縣北區三十里㽏鄉東北區七十里汝溪鄉	約十方里	分㽏井塗井兩區	
萬縣場	萬縣	萬縣南區九十里長灘井	約一方里	未分區	

南鹽場	南部鹽亭	南部縣富村驛一帶鹽亭縣三元場毛公場一帶	未詳	有廠無區	民國十六年由南閬西兩鹽場分出

就各鹽場實際產鹽所在，計其面積，約爲一萬數千方里，其鑿日出鹽久經廢棄者，概未計入。就中最大區域，爲南閬鹽場，約二千方里，產地甚多。最小區域，爲萬縣鹽場，約一方里。而大寧鹽出一池，不能以面積計也。其他鹽場面積數百方里者，爲最普通。但面積大小，不關產鹽之多寡，產量最多者，爲富榮鹽場，計其面積，不過四百方里，雲陽大寧兩鹽場，面積雖小，而產量則列入上等，中江西鹽兩鹽場，產額尙不及奉節鹽場產量之多，故鹽場面積之大小，不足定鹽產價値之優劣也。

鹽產之區域

四川鹽產區域，按鹽務行政，舊分二十六場，分屬川南川北川東川西四區，後併爲川南川北兩區，分鹽場爲二十八場，屬於川南者十六場，爲富榮，犍爲樂山，井仁，資中，鄧關，大寧，開縣，雲陽，奉節，忠縣，彭水，萬縣，鹽源，大足，富榮分爲東西兩場。屬於川北者十二場，爲射蓬，簡陽，南閬，蓬中，射洪，樂至，綿陽，西鹽，中江，蓬遂，三台，南鹽，南鹽場爲新由南閬西鹽兩場分出者。此種分區，或爲鹽務統轄之便，或與運銷稅收有關，而於鹽產所在地域遠近，未甚注意，如鹽源彭水僻在邊陲，遠隔數千里，歸爲一區，富榮東西鹽場，原本連接，而竟劃爲兩場。本篇劃分區域，擬以鹽產所在地形爲根據，彙亦參照地質情形，爲鹽產地理上之自然區劃，計分四川鹽產爲八區。一，富順榮縣區，富榮之東西兩場，鄧關場屬之，富榮兩場相連，鄧井關相距不遙，富順鹽場，原在鄧井關一帶，宋代移至自流井，歸爲一區，較爲適宜。二，犍爲樂山區，犍爲樂山兩鹽場屬之，犍樂兩場，原本相連，樂場西區，亦只一河之隔。三，井研仁壽資中區，井仁場資中場屬之，此區鹽產分佈散漫，但地形相連，均在威遠榮縣山嶺及仁壽簡陽山嶺之間，亦卽威遠榮縣大背斜層以北之區域也。四，川北區，南部閬中射洪蓬溪三台綿陽鹽亭中江西充樂至遂寧簡陽鹽場屬之，各場相距雖遙，但均在平緩地層區域內，旣無山嶺阻隔，地層又相連接，成一自然之分區。五，川東區，忠縣開縣萬縣奉節雲陽大寧鹽場屬之，均在川東，距大江不遙，觀各鹽場所在，似與川東大向斜層有關，忠縣萬縣

雲陽奉節四場，均在大向斜層內，而開縣大寧兩場，則在其北，或在與此向斜層相關之另一向斜層內，地域相連，可作一區。六，大足區，大足縣境內之鹽場屬之，西北兩方爲富榮資仁簡樂等場而相距均遠，中間無產鹽地點爲之聯絡，形成獨立，故另分爲一區。七，彭水區，彭水縣境之鹽場屬之，在四川東南部，僻在山叢，不與四川各鹽區連接，爲獨立之一區。八，鹽源區，鹽源縣境之鹽場屬之，在四川西南部，僻在邊地，與各鹽區山嶺阻隔，相距甚遠，地理地質上，均無連帶關係，成自然孤立之鹽區。八區之中，前五區面積較大，產量亦豐，後三區面區狹小，產額不多。茲按所分區域，敍述鹽產情形，依據事實，簡要論列如左。（圖見第十一版）。

富順榮縣鹽產

富榮鹽產，向稱豐富，開採甚盛，就產區而觀察之，則見井架林立，鍋竈櫛比，自流井貢井兩處依鹽產爲生活者，稱數十萬，工作之忙碌，街市之繁囂，儼然一工業中心。川南鹽務稽核所，設於自流井，鹽政官署分設於自流井貢井鄧井關。年產鹽三百餘萬担，占全川產額十分之六，稅收約八百萬元，爲國稅重要之收入。惟年來時局不靖，產銷減少，鹽業頗露不振之象，不急起而考察整理之，將不免日趨於衰敗也。

位置　在富順縣西境鄧井關自流井及榮縣東南貢井一帶，以自流井爲中心，向西約十五里，爲貢井，向東南約九十里，爲鄧井關。產鹽地域可分爲兩部，一爲自流井貢井一帶，一爲鄧井關王壋一帶，中隔四十餘里，未經採鹽。自貢一帶產鹽地點最著者，爲大坟包，黃石坎，凉高山，郭家坳，東岳廟，苟氏坡，豆芽灣，艾葉灘等處，東北由凉高山起西南至黃石坎止，中間所經，幾無一處不見鹽井，最多者爲大坟包黃石坎兩處。鄧井關王壋一帶產鹽地點，舊日稱下五壋，卽詹王太宋徐壋，各壋先後廢棄，現只王壋有二井產鹽，此次調查時，惟五福井一井工作而已。（圖見第十二版）。

地形　在四川盆地內，極少高山大嶺，西部惟威遠榮縣山嶺，高約一千公尺，東部惟華鎣山嶺，高約一千五百餘公尺，餘均小嶺及山邱而已。富榮鹽產區域，在威遠榮縣山嶺之南，由山嶺而南，逐漸而低，至威遠縣城一帶，已入低山邱陵區域，再南至

自流井貢井一帶，地勢稍形突起，成一帶小山嶺，山頂高者，北爲馬鞍山天池寺山，中爲大安寨山太平山，南爲富台山。產鹽地點，多在中北二小山嶺之間，低處與小嶺高頂約有百餘公尺之差。由凉高山西向經大坟包郭家坰至白家灣一帶、大致成淺平槽狀，適爲一背斜穹窿層之脊受剝蝕侵創而凹陷者。再西爲太平山，下山卽貢井，地勢又低降，經艾葉灘向西，未再隆起，惟至黃石坎一帶，地勢稍高，隱然爲太平山向西延長之一部，再西地勢較平坦，無小山嶺突起之狀，自流井位於中南兩小嶺之間，地勢較貢井又低，自流井至貢井，必經太平山南部，無低凹之路，蓋中南二小嶺至兩井之間，地勢一部相連，至貢井之南，始再分爲二支，向西南而沒。自自貢鹽區而東南，地勢漸低，經詹壋徐壋王壋太壋宋壋至鄧井關，均較平坦，無山嶺突起。鄧井關低於自流井者約六十公尺。自威遠榮縣大山嶺而南，經自貢鹽區，再東南至鄧關王壋鹽區，地勢既逐漸而低，而河渠亦當順流而下，故榮溪河（亦稱榮縣河）自榮縣東南流，入自貢鹽區，繞經其中，過貢井納中溪河，迤而東流，有龍會河自威遠南流來會（龍會河亦稱威遠河），南流迤東，經自流井，東南流，入鄧關王壋鹽區，納鐵錢溪後，入沱江。自貢鄧王兩鹽區引鹽轉運，端賴此水，惟河淺灘多，載運不重，須築堰積水，定時而行，鹽產下運入沱江，再轉入大江，亦鹽區重要水運也。

地質　四川地質以繁簡而言，大概可分爲兩部，曰山地，曰盆地，山地地質複雜，盆地地質簡單。四川鹽產除彭水鹽源兩區外，均在盆地，故地質率多簡單，盆地向稱赤色盆地，以其地層岩石多呈赤色，而鹽產所在，每與赤色地層有關，此赤色地層除一部爲三疊紀之下層外，均屬白堊紀，故就地表觀察，鹽區地層，率爲白堊紀之一部，不過層位上下，各處不同。然就採鹽鑿井深度及各紀地層通常厚薄所知，一考地腹情形，產鹽區域，殊不一律，富榮鹽區地腹地質，既與其他區域有別，而本區各處，亦不全相一致。玆擬就地表地腹兩部，分述其地質概況如左。

富榮鹽區地表地質情形，尙屬簡單，如一言以蔽之，只白堊紀下部之地層而已，惟四川白堊紀地層甚厚，不下二千五百公尺，統名爲四川系，分爲下中上三部，下部名自流井層，厚度頗不一律，由二百公尺至一千二百公尺，中部名嘉定層，厚約五百公尺，上部名蒙山層，厚約八百公尺。分佈於富榮鹽區者，爲自流井層之一部，厚不過三百公尺。因研究鹽水層位之需要，曾詳分

地層爲七組，由地表可見之底部起，(一)珍珠冲粘土，以淺棕紅紫色粘土爲主，而更夾淺綠色粘土，可見者厚不過二十公尺。(二)東岳廟灰岩，以灰色灰岩爲主，夾灰棕色泥灰岩淺綠黃色粘土及砂岩，厚五公尺餘。(三)大坟包粘土，以紅紫色粘土爲主，夾淺綠黃色粘土，底部有綠灰色頁岩，夾極薄煤層及矽化木，厚四十六公尺餘。(四)郭家坳砂岩，有淺綠黃灰色砂岩，及淺綠黃灰紫紅色粘土，厚約三公尺。(五)馬鞍山粘土，爲紅紫色粘土，厚約五十公尺。(六)大安寨灰岩，以白灰帶淺紫黃色灰岩爲主，夾灰紫黃紅色泥灰岩及粘土，及淺綠暗灰色頁岩，厚約二十四公尺。(七)涼高山砂岩，爲淺黃灰色粗砂岩，一部分佈於鹽區內。上述七層，以大安寨灰岩爲鹽區地表標準地層，鹽井位置比較深淺，以此爲衡，灰岩分佈普遍，自貢鄧王鹽區均有露頭，惟在貢井鹽區，大安寨灰岩，曾經斷折，似爲兩層，此地表地層之大略也。(圖見第二版)。

就地表觀察，地質構造，不甚複雜，惟有一斷層，在地面不易察出，地層褶皺，有背斜穹窿層及淺平起伏之狀，自流井貢井鹽區，即在一背斜穹窿層範圍內，鹽井多在其中部。背斜層自大山鋪起，初向南延長，經涼高山大坟包郭家坳至太平山東端，迤而西經貢井至艾葉灘之南，自流井在其南翼。兩端地層，分向東北西南偏西傾斜，斜角頗緩，不過十度，而兩翼地層，分向東南西北傾斜，南翼陡峻，在大安寨下，斜角可至五十餘度，北翼傾斜較緩，斜角大者至十餘度而已。地層向四方傾斜，中部凸出，成平層，如長橢圓狀，爲一最完全之背斜穹窿層。惟生成之後，久經剝蝕，頂部多已破壞凹陷，深達一百餘公尺。鹽井雖觸處開鑿，但以凹陷之部爲多，兩翼之外無鹽井，觀鹽井之所在，即可定背斜穹窿層之廣闊也。在貢井鹽區，有兩層灰岩，就地表觀察，似上下重疊而生，不相連續，但就岩石色性厚度及上下層次而言，兩層灰岩極相類似，似爲一層而經斷折所致者，惟斷層在地表不易察出，只可就鹽井深度，鑿井所得岩石及各地層厚度比較推測而知。在自流井區南部黃葛坡附近，兩層灰岩相距頗近，中間錯動微小。在貢井之北榮縣河西岸，有灰岩露出，似東岳廟灰岩，而在天池寺山上亦有灰岩，如此層灰岩爲大安寨灰岩，則斷層俯側大安寨灰岩未能露出，二者上下相差，約一百公尺左右，此處斷層錯動較大。中間一帶地層露出不多，傾斜整齊一致，實不能目覩斷層之踪跡也。自自流井東南行，經五墻至鄧井關，地層小有彎曲，屢現淺平背斜向斜層之觀。王墻一帶，地層傾斜平

綫，斜向北至西北偏西，斜角不過七八度。鄧井關附近地層傾斜方向，大致西北，而斜角較大，陡者可至四十度。此富榮鹽區地質構造之概況也（圖見第七版，及第九版）。

富榮鹽產，非生於地表，而在地腹深處，鹽井由地面鑿下，往往深至一千數百公尺，與地表所見地層相較，地腹地層，當厚至數倍，如僅詳察地表地層，而不明地腹情形，則鹽產所在，及地質關係，終難考悉底蘊。惟地表地腹，互相關連，欲確知地腹情形，當由地表着手。鹽區地表地層，均為白堊紀下部，其下究有何種地層，厚薄關係如何，須由種種方法，參照證明。第一當用開鑿鹽井所得資料，第二當與接近地域地質比較，地層露出地表，觀察比較較易，而徵詢所得，難免不實不盡之弊。擴觀四川地質，白堊紀赤紫地層以下，即接侏羅紀煤系，情形普遍，幾於觸處皆然，鹽產區域常與煤田臨近，足以證明。侏羅紀煤系之下，常接三疊紀地層，初為灰岩，下卽砂岩，此種情形，在四川西部北部山地，未必如斯，而在內部盆地，初無二致。富榮鹽區之北，為威遠榮縣山嶺，地層露出較多，白堊侏羅三疊三紀關係明瞭，侏羅紀煤系發育完全，三疊紀灰岩露出者，約二百餘公尺，白堊紀接於侏羅紀者為下部，與富榮鹽區完全相同，大安寨灰岩為一確證。各紀地層厚度，有時稍不一致，但接近地域，無甚增減。侏羅紀煤系厚度，頗有規則，西自盆地西邊峨眉山起，東經威遠煤田至嘉陵江合川巴縣峽區止，由五百公尺至五百五十公尺，迭經計量，以五百五十公尺為最可據之數。三疊紀可分二部，由峨眉山嘉陵江兩處計量結果比較，厚度均有差異，在峨眉山，上部厚度由三百八十公尺至四百四十公尺，下部厚度由一百五十公尺至二百公尺，在嘉陵江，下部厚度二百四十公尺，上部則厚度加大，約六百五十公尺。中間威遠榮縣露出不全，觀察所及，除上部稍有泥灰岩外，均為灰岩，確為上部之一部。白堊紀下部厚度，各處相差，有時甚鉅，前已述及，惟在富順榮縣威遠一帶，厚度較為一律，露出者已經計量，厚度確知。由珍珠冲粘土以下，至侏羅紀煤系，尚有若干公尺，就威遠兩紀地層接觸處觀察比較，由大安寨灰岩至侏羅紀煤系，厚約一百八十公尺，自貢鹽區大安寨灰岩至珍珠冲粘土可見者，厚約一百二十五公尺，由珍珠冲粘土而下，約五十餘公尺，卽當為侏羅紀地層。就白堊侏羅三疊三紀地層而論，性質色澤，劃然不同，白堊紀下部地層，粘土居多，砂岩次之，色呈赤紫，間帶黃綠。侏羅紀煤系砂岩最多

，頁岩次之，中夾煤層，色以灰灰白灰黑爲主。三疊紀上部爲灰色灰岩，間夾黃灰泥灰岩及棕紫黃綠色頁岩砂岩，下部爲紫色或棕紫色砂岩及粘土，夾有薄層灰色灰岩。三紀地層，如上下依次重疊，界限顯然，毫不混淆，以此與鑿井所得，比較互證，則鹽產所在，或可無大誤矣。(圖見第二版)。

今取自流井大坟包炎泰井及貢井扇子嘴灶龍井兩井鑿井記錄，表示富榮鹽區地下地質情形。炎泰井鑿井記錄，岩石可記者，自大坟包粘土起，爲紅紫色砂岩粘土，下爲東岳廟灰岩，與地面所見，可以對照，惟厚度略有出入，再下卽珍珠冲粘土，以紅紫色粘土爲主，時夾灰色及白灰色砂岩，下部稍含石油，厚度約六十五公尺餘，此白堊紀地層之最下部也。自此而下，岩石色澤大變，性質亦異，白堊紀以紅紫色著者，而此則爲灰黑色，岩石亦較爲堅實，砂岩頁岩居多，泥質岩石頗少，由頂而下，約二十四公尺，有煤一層，爲已入侏羅紀煤系之證，再下砂岩頁岩相間而生，含煤七八層，因煤層質軟，厚度不能確悉，按其所記，有厚三十六公分者，在約二百公尺處，見鹽水，鹹量一兩四，卽含鹽約百分之十三，煤系厚度，約五百四十八公尺。在井深約六百五十公尺處，岩石變爲灰岩，已至三疊紀地層，色澤以灰色爲多，時淺時深，黃色次之，綠色亦偶見，性質有時稍粗。在井深約九百三十餘公尺處，有岩鹽，分上下兩層，中介岩石，上層色白，厚約二公尺三，下層色紅，厚約二公尺。井深約九百四十四公尺，三疊紀灰岩被鑽入者，厚約二百九十三公尺。(圖見第五版)。灶龍井所在地面位置雖不高，而地層層位則較高，鑿井而下，先見者，爲大安寨灰岩，厚約二十六公尺，與地表所見，相差不多，下爲粘土夾砂岩，厚約五十七公尺，與馬鞍山粘土相當，惟厚度稍差，再下有砂岩夾粘土，厚約十六公尺，當爲郭家坳砂岩，惟較自流井一帶者加厚，自此以下爲紅紫色粘土夾白灰色砂岩，厚約四十五公尺，當相當于大坟包粘土，而厚度相差不多，再下又有灰岩泥灰岩夾粘土砂岩，厚約七公尺，爲東岳廟灰岩，下爲紅紫色粘土，厚四十一公尺，與珍珠冲粘土相當，惟厚度大遜。自此以下，岩石色變，侏羅紀煤系開始，先爲灰色砂岩頁岩，至二十餘公尺下，爲黑灰色頁岩，夾薄煤層，再下頁岩砂岩相間而生，夾煤十層，最厚者達一公尺半，煤系共厚五百四十公尺，由煤系之頂而下，在約三百二十公尺處，稍有石油，在約三百三十五公尺處，又稍見油質。煤系而下爲三疊紀灰岩，鑿入者爲二百

六十六公尺餘，由上而下，在十餘公尺至四十公尺之間，常有火氣石油發現，又在由二百〇八公尺至二百三十一公尺之間，亦常見火氣，至二百六十公尺以下，火氣石油並生，兼出鹽水，灰岩多呈灰色及黑灰色，有時爲黃色及白灰色。此自流井貢井地下地層大概之情形也。（圖見第四版）。

礦床　富榮鹽產按礦床種類，可分爲岩鹽及鹽水，而鹽水又常別爲黑水及黃水，其他如假黑水姑淡水鹽乾水，不過因含鹽量之不同，深淺位置之有差，而異其名稱，無特別分出之必要也。岩鹽生存，只限于自流井大坟包一帶，就鹽井鑿井所得岩石，及鹽井位置深度觀察計算，岩鹽生於三疊紀灰岩層之下部，成不規則之層形，或爲二層，或爲三層，中夾岩石。各鹽井所見鹽層，厚度性質色澤狀況雖不盡同，然大致均屬同一層位。在楊家冲鹹海井，鹽層分爲三層，上層厚約三尺，下有灰色岩石四寸，中層厚約四寸，下有灰色灰岩約一尺二寸，下層厚約二尺二寸，共厚七尺二寸，合二・五九二公尺，而岩鹽則二公尺有奇。至裕海井，據云岩鹽厚一丈二三，內夾灰岩，共厚四公尺餘。在周家冲聚源井，鹽層可分二層，而下層色澤不同，上層白色，厚約二尺，下有白色及灰色泥質岩石，厚約三尺八寸，下層上部爲白色，厚約一尺，下部爲灰色，厚四尺二寸，共厚十一尺，計爲三・九六公尺，而岩鹽則爲二・五九二公尺。匯源井先見白岩鹽六寸，繼爲灰岩鹽，厚約七尺，合二・七三六公尺，與聚源井相差不多。至來龍灣三泰井，據云僅見岩鹽四尺六寸。在來龍灣炎泰井，鹽層爲二層，上層色白，厚六尺四寸，下層色紅，厚五尺六寸餘，中夾灰色泥質岩石，厚約二尺，共厚不及五公尺，而岩鹽則爲四公尺有奇。在大坟包雙福井，鹽層爲二層，上層色白，厚約三尺，下層色紅，厚約五尺，中夾泥砂岩石三尺七寸，岩鹽共厚八尺，計爲二・八八公尺。多福井鹽層亦分二層，上層白色，厚三尺二寸，下層紅色，厚四尺八寸，中夾灰色岩石，厚一尺四寸，岩鹽共厚八尺，與雙福井同。至裕隆井，據云岩鹽厚約七尺。龍湧井鹽層分爲三層，上層白色，厚四尺三四寸，下有泥質岩石尺許，中層淺紅色，厚二尺餘，下有泥質岩石，厚尺許，下層灰色，厚約七尺，如此岩鹽總厚幾至五公尺。就鹽井位置及岩鹽厚度觀察比較，則見鹽層分佈所在，西部薄而東部厚，大致總厚由二公尺至五公尺，而所夾岩石不計也。鹽層分佈面積不廣，東西長約八百公尺，而南北廣稱之，但不成有規則之方形，大抵北部寬，

而向東南漸狹，至釣魚台之南而盡，出此區域，雖鑿井深逾岩鹽井之深度，而向未見岩鹽，鹽井林立，相距不遠，而鹽水岩鹽有別，其界限固可確定也。大坟包一帶岩鹽井，因位置高下不等，深度亦各處不同，大抵西部南部地勢較低，鹽井亦淺，由二百四十七丈至二百五十七丈可見岩鹽，東部北部地勢較高，鹽井亦深，由二百五十七丈至二百六十三丈可見岩鹽，卽由八百八十餘公尺至九百四十餘公尺，爲由地面至鹽層之深度。鹽井下鑿，大抵均自大坟包粘土起首，下經東岳廟灰岩及珍珠冲粘土，而至侏羅紀煤系，計經過白堊紀地層者，由七十餘公尺至九十餘公尺，侏羅紀煤系平均五百五十公尺，下始抵三疊紀灰岩，由井深公尺之數，除去經過二紀地層公尺之數，尚餘二百七十餘公尺至三百公尺，當爲經過三疊紀灰岩層者。在四川盆地邊緣，三疊紀灰岩露出者，厚度西在峨眉山約爲四百四十公尺，東至嘉陵江約爲六百五十公尺。據此鹽層當在三疊紀灰岩層之下部，而尚未至其下之紅棕砂岩層中。自流井鹽井最深者三百餘丈，有時確曾見紅色岩石，按鹽井位置深度比較，灰岩層厚度，亦約五百公尺。大坟包一帶岩鹽井，實尚未至可達紅棕岩層之深度，而仍止於灰岩層內者，當無疑義也。(圖見第十三版)。

鹽水產狀，較爲複雜，黑水黃水，雖爲表示深淺之差，而可分爲上下兩層位，然就鹽井深淺鹽水所在觀察，深淺變異，却無一定層位，黃水爲鹽水含鹽量小而位置淺者，黑水爲鹽水含鹽量大而位置深者，但含黃水地層，非止一層，上下錯綜，變遷甚大，黑水又非出自一源，深淺不等，不過鹽水自上而下，含鹽量逐漸而增，而顏色亦由淡而濃，強爲黃黑之分耳。據實地所觀察之五十黃水鹽井而圖表之，則見黃水層位除一二井已至三疊紀灰岩之最上部外，均在侏羅紀煤系內，而在中下兩部爲多（圖見第十四版）。在四十黑水鹽井中所見黑水，均出自三疊紀灰岩層內，而在中部爲多。(圖見第十五版) 在三十餘假黑水或雜鹽水井中，除三數井鹽水層位在侏羅紀煤系下部及一二井鹽水或至三疊紀紅棕砂岩層外，均散在三疊紀灰岩層之各部（圖見第十六版）。由此可見鹽水由上而下，含鹽量漸次增加，而以在三疊紀灰岩層之中部鹽水，含鹽成數最大，與岩鹽層位參照比較，頗有相當之處。但自此而下，含鹽量又以次而減，至最深之鹽井如龍雲井所出之水，竟爲白水，含鹽甚少，察其層位，已至三疊紀紅棕砂岩層矣。

鄧井關王墻一帶，有數鹽井，採白水，均甚淺，普通三十餘丈，深者六十四五丈，出鹽之井有王墻五福井，鹽水深在三十餘丈，察鹽井所在位置，係在大安寨灰岩之上，而在涼高山砂岩上部鑿下者，計其鹽水層位，當在大安寨灰岩下部五十公尺，而適當郭家墹砂岩之位置，尙在白堊紀自流井層之下部，而未至侏羅紀煤系也(圖見第十四版)

岩鹽生於三疊紀灰岩內，夾鹽之層，當爲灰岩。鹽水在各紀地層均有生存，含水之層，自不一律，在三疊紀下部砂岩層內者，含於二種砂岩內，在三疊紀上部灰岩層內者，含於多孔或多洞之灰岩內，在侏羅紀煤系內者，含於白灰或灰色砂岩內，在白堊紀地層內者，含於淺綠灰色及灰色砂岩內。砂岩疎鬆多隙，宜於存水，自易爲鹽水之儲藏所也。

礦質　富榮鹽產，生成複雜，種類繁多，故其礦質之優劣，鹽分之多寡，頗有差異。鹽分岩鹽鹽水兩種，而鹽水又分爲黃水黑水白水及各種雜水等等，既如上述，土人鹽水之分，雖以黃黑別之，然根據之點，却在鹹度(土人名爲鹹頭)，按其深淺，黃水在上，黑水在下，均有一定，如下鑿若干丈爲黃水，再深至若干丈當爲黑水，然亦有鑿至黑水深度而所得鹽水鹹度不足者，名之爲假黑水或枯淡水等。土人計算鹹度，以錢兩爲單位，即以一木椀所盛之鹽水，可煎出鹽若干兩錢，而爲此鹽水之鹹頭，所用木椀盛水之量，各處各井不同，有十七兩十六兩十五兩九錢十五兩十四兩十二兩十一兩種種之差，故鹹度須根據同一鹽井所用木椀盛水之量，與其所出之鹽量，而比較之，方無大錯。惟岩鹽水爲由地面灌下之水溶解岩鹽而成，鹹度較大，含鹽由百分之二三・二至百分之二五・七。黑鹽水鹹度，頗有差異，含鹽由百分之二七・一至百分之二六・六，以百分之二一・六，爲普通平均之數。黃鹽水鹹度較小，含鹽由百分之八至百分之一一・六。至王墻之白鹽水，鹹度愈小，含鹽僅百分之三・五。此以鹹度大小之差，而定鹽水之優劣也。至所出之鹽，種類不同，質亦有差，通常有花鹽巴鹽之別。而花鹽因燃料不同，又分火花鹽炭花鹽及火青花鹽種種，因鹽粒大小不同，又分頭粗二粗三粗大市細鹽及面子鹽種種，近且有設廠製造精鹽者，色白粒細，爲花鹽之冠。巴鹽因燃料顏色不同，亦分火白巴鹽火黑巴鹽草白巴鹽炭白巴鹽炭黑巴鹽改良炭巴鹽等等。無論花鹽巴鹽，煎出時均可成白色，其黑色者，係煎製時加入松柴烟或草柴烟而成，因各種鹽銷岸不同，而購戶嗜好亦異，有特選購黑鹽不用白鹽者。論其質，精鹽面子

鹽最佳，色白質淨，頭粗花鹽次之，二粗三粗花鹽又次之，大市細鹽在花鹽中質較劣，火青花鹽爲最劣，巴鹽以色白質細者爲最佳，改良炭巴鹽次之，炭黑巴鹽質最劣。富榮鹽產，開採最盛，鹽水成鹽，歷經分析，質各不同。茲將各處分析結果，分別表列，以資比較考證。

農商部工業試驗所富榮鹽水分析表（潘樹烜送驗）

鹽水種類	岩鹽水	黑水	鹹黃水	淡黃水	假黑水
全固形物	三二·一四	二五·七九	二九·〇〇	一〇·五四	一七·五〇
綠氣	一八·六七	一四·八〇	一〇·六三五	六·五七	九·八七
硫養四	〇·三三	〇·二五	微量	微量	微量
鎂	〇·〇六	〇·〇九	〇·〇二七	〇·四三	〇·〇二
鉀	二·七四	一·九七	四·一	〇·四五	五·〇九
鈉	一〇·三八	七·八三	三·七二七	二·三四	二·四八
鈣	〇·二三	〇·四八	〇·〇五七	〇·四三	〇·〇八
錳				〇·一三	
綠化鈉	二六·二二	九·九〇	九·四九	五·八九	六·二九
綠化鉀	五·三三	三·七六	七·八七	〇·八五	九·七一
綠化鈣	〇·二五	一·〇五	一·一五	一·一八	一·四七
綠化鎂	〇·二四	〇·三六	〇·〇七	一·七三	一·〇七
綠化鋁				〇·六九	

硫酸鈣	○·四七	○·三五			
合計	三二·三一	二五·四二	一八·五八	一○·三五	一七·五四

農商部工業試驗所自流井鹽水分析表（楊維楨送驗）

鹽水種類	黃水	黑水	岩鹽水
全固形物	一三·六四	二五·六六	三○·四○
綠化鉀	三·四五	四·二三八	一·三○
綠化鉀	二五·五六	一六·五一六	一四·二八
綠化鈉	六·七○	一五·八三	二七·六五

備考 第一項綠化鉀為全鹽水百分率
第二項綠化鉀為全固形物百分率

英國薩爾曼皮卡德公司自流井鹽水分析表

鹽水種類	岩鹽水	黑水	黃水	白水（次黑水）
不溶解物	○·三○	○·○二八	○·○三五	○·○三
鐵及鋁	○·○五	微量	微量	○·○一七
綠化鈣（帶鎴少許）	一·六○	一·九○	一·○一	一·○五六
綠化鎂	○·六○四	○·三○三	○·四三三	○·四一三
綠化鉀	一·○三	三·○二	○·七○	一·一三
綠化鈉	一二·六○	一六·九○	一三·三○	一○·六七
綠化鋇	○·四二○		○·七一	

硫酸鈉				〇·四四四				〇·五九九
全固形物		一六·六〇四		二一·七六		一六·一八八		一四·一二四
綠化鉀		六·二〇		一三·九〇		四·三〇		九·四〇
純鉀質		三·二四		七·二六		二·二五		四·九一

備考　末項綠化鉀及純鉀質爲全固形物百分率

本所化學試驗室富榮鹽水分析表（本所採取）

鹽水種類	岩鹽水	黑鹽水				黃鹽水		
鹽井名稱	炎泰井	寧山井	厚福井	洪順井	積富井	銓湧井	鼎生井	同昌井
鈉	九·八五	九·五一	七·三二	六·六九	三·六八	五·七四	四·七三	三·三四
鉀	〇·八六	〇·五三	〇·七八	〇·七八	〇·五〇	〇·三九	〇·一九	〇·三五
鈣	〇·一〇	〇·三四	〇·三一	〇·八七	〇·八九	〇·五二	一·〇九	〇·八三
鎂	〇·一一	〇·一五	〇·一二	〇·一六	〇·一一	〇·一九	〇·二四	〇·一五
綠	一六·七〇	一六·三三	一二·六〇	一三·四六	八·三三	一一·六三	九·六三	七·三五
綠化鈉	二五·〇二	二四·一六	一八·六〇	一七·〇一	九·三六	一四·六〇	一二·〇一	八·四八
綠化鉀	一·六四	一·〇一	一·四九	一·五〇	〇·九六	〇·七四	〇·三七	〇·六七
綠化鈣	〇·二七	〇·九四	〇·八六	二·四二	二·四六	一·四三	三·〇三	二·二七
綠化鎂	〇·四四	〇·五九	〇·四七	〇·六三	〇·八四	〇·七三	〇·九四	〇·六〇

財政部鹽務署自流井鹽水分析表

鹽水種類	黑鹽水	岩鹽水	鹹水

綠化鈉	一五·〇三五一	二五·〇六三	一八·六七
綠化鉀	三·六九五七	四·七七五	一三·二六
硫酸鈣	〇·二九七五	〇·四〇〇	〇·九五
綠化鎂	〇·九一三二	〇·五八二	三一·四五
綠化鈣	一·一一四五	一·二五	
水份等	七九·四〇四	六九·〇五五	三四·八〇

英國薩爾曼皮卡德公司自流井成鹽分析表

成鹽種類	黑巴鹽	灰巴鹽	白巴鹽(一)	白巴鹽(二)	白粗花鹽	白花鹽
綠化鈉	九七·九〇	九八·八六	九七·六九	九八·七〇	九八·八六	九九·〇〇
不溶物	〇·六六	〇·三〇	〇·〇八	〇·四〇	〇·一〇	〇·一五
養化鈣	〇·五〇	〇·四〇	〇·五三	〇·六六	〇·二〇	〇·二〇
養化鎂	〇·〇四	〇·〇六	〇·〇五	〇·〇二	〇·〇六	〇·〇三
硫養三	〇·五一	〇·二五	〇·二二	〇·三三	〇·一八	〇·一七
合計	九九·六一	九八·八七	九八·六七	一〇〇·一一	九九·四〇	九九·五五

川南鹽務稽核所富榮成鹽分析表

成鹽種類	巴鹽	精鹽
綠化鈉	九七·七四	九五·五〇
綠化鎂	〇·〇六	〇·〇二

綠化鉀	〇・二三	〇・一三
綠化鈣	〇・二一	〇・〇七
硫酸鈣	〇・七七	一・五三
不溶解物	〇・一〇	〇・〇二
水份	〇・九六	二・七一
合計	一〇〇・〇七	九九・九八

採製　富榮鹽產，生於地下，富源所在，往往深達千餘公尺，欲取而用之，非掘地及泉不爲功，故開鑿鹽井，爲採礦之第一步，其鑿井之法既笨拙，鑿井之器亦簡陋，工作費時，進行緩慢，以與機械新法相較，眞不可同日而語，然器物價廉，工費低減，事輕而易舉，亦有足多者，故人迄今沿用之而未改。鑿井法，先選地點，破土，開大口，深淺不等，通常約數丈，再用石料作成方塊，中穿圓孔，徑大尺餘，石塊數目不等，視見硬石深淺而定，取石塊累置，由石底至地面，名曰安圈子，石中圓孔，卽爲井口，工畢，卽在地面立井架，吊銼　土人稱鑿井曰銼井，所用之鑿鑽頭，曰銼，用木作架，以竹蔑(竹劈)作繩。銼爲鐵製，種類不一。曰魚尾銼，長約一丈，銼頭寬尺餘，重一百二十斤至一百八十斤，爲銼大井口之用。曰銀錠銼，長一丈二尺，銼頭寬數寸，重百餘斤，爲銼小井口之用。曰財神銼，寬三寸餘，中曲扯，旁有齒，重一百二十斤，如開大口後井內遺竹物泥沙，則用此搗碎之。曰馬蹄銼，形似馬蹄，如井中遺石，用此碎之。鑿井工人，以山匠爲首，下有筒匠三人，雜工三五人，如有夜工，人數加倍。井上架下，置一木板，長十餘尺，架以鐵軸，以便轉動，一端裹鐵皮，連竹篾，下掛銼，一端用人力踐踏板端上下，銼頭起落，用此重力，搗碎岩石，另用一人轉板端之鐵環，銼頭在下亦隨之而轉，井眼可成圓形。起銼時，將竹篾掛於轉車上，用牛推轉，提出銼頭，如銼頭磨鈍，再加鋼燒打，此時另用砂筒入井，撮取搗碎石塊石屑。砂筒用長約丈餘圓徑適合之竹筒爲之，筒底按置活塞，名皮錢，可以張合，砂筒入井後，以手按竹篾，使筒升降，筒降則活塞張開，氣壓碎石上升入筒，筒升則活塞閉

合，將碎石閉在筒內，提筒取出，再下銼搗鑿。如斯遞嬗進行不已，搗至岩石堅硬之處，於是停銼，是爲大口。卽用青杠木兩片，各中挖空，兩片相合，作成長木筒，徑與大口相同，約八九寸不等，空心徑以鑽眼大小而定，用桐油石灰蔴布蔴繩，將木筒纏結嚴密包裹，木筒一端單木片凸出，以便與他一木筒單出木片相合，用木架起重輪，吊下木筒，兩木筒相接之處，亦用油灰蔴布繩包裹嚴密，逐一下降至底，上至井口，此與打鑽套管作用相同，所以防閉白水泥沙也。另換小銼，銼小眼，名曰子眼，進行工作，一如大銼，至出鹽水爲止。小井眼大小不等，通常徑由二寸餘至五寸，岩鹽井較大，徑由六寸至八寸餘。銼井費用時間，各不相同，視井之大小深淺而定，如鑿岩鹽井深二百五六十丈，有費時五六年費款六七萬元者，此鑿井手續之大概。如井壁出水損壞，修補繁瑣，茲不再贅。

鑿井出鹽水或見鹽後，卽豎立天車，按置地車，以便汲取鹽水。天車爲四柱或六柱綑縛而成之木架，高由八九丈至十一二丈不等，每柱用徑數寸之木數十條而成，豎立須要穩固。地車以木爲之，徑約二丈。兩車相距約六七丈，中間置一小木輪，名地滾子，徑約二三尺，高與地車相等。在天車最高處，另置一輪，名天滾子。汲水繩索之一端，接汲水筒，搭於天滾子上，再經地滾子，圍繞於地車身上。繩索以竹篾或鐵絲爲之。地車用牛挽拽，牛數不同，視井之深淺而定，通常用四五牛。汲水筒以竹桿連接爲之，長短不等，視天車高低井之深淺而定，由四五丈至十一丈，徑小於小井眼，通常三寸餘，但岩鹽井所用汲水筒，多以洋鐵爲之，徑較大，普通五六寸，長五六丈，取其容量大，可多汲鹽水也。汲水筒均嚴密接合包縛，不使漏水，筒底置活塞，以皮或布爲之，名皮錢，以司張合，筒入井至底，壓水上湧，皮錢開張，水灌入筒，筒提上時，水下壓，皮錢閉合，水留於筒。（圖見第十九版第二十版第二十二版）。汲水筒繩索天滾子地滾子地車互相聯絡畢，地車倒轉，繩索放鬆，汲水筒入井，下降至底汲水，地車正轉，繩索圍繞於車身，汲水筒上升出井，及筒底至井口，一人持鐵鈎推皮錢使開，水卽漏下，入盛水大筒，（圖見第二十一版）。如斯進行，汲取鹽水，此爲舊式牛車汲取鹽水方法。自民國初年，大鹽井多換用機器取水，天車大致相同，而較堅固，繩索改用鐵絲繩，易地車爲捲揚機，（圖見第二十二版），牛力爲汽力，與小煤礦所用提煤裝置，大致相同，不過天車較高，易

罐籠爲汲水筒耳。汲水筒大小長短不同，盛水量亦不一律，竹筒大者，可汲水四五百斤，洋鐵筒大者，可汲水一千二百餘斤。鹽水出筒，放於盛水大筒後，再以竹管洩入一貯水池內，池木製，名梘桶，由此賣出燒製，貯水賣水方法，各種鹽井，均不一律，小井貯水梘桶，方式圓形，大小深淺不同，大井又與小井有別，就出水較多之岩鹽井而言，貯水梘桶爲圓形，徑約二十尺，兩桶相連，均深約十尺，（圖見第二十三版），可容水數千担，有提水轆轤式水車一具，斜置桶內，由此提水而上，以管儲入另一小水池內，池圓形，徑四五尺，深稱之，旁通竹梘，上有號碼，爲售賣量水之用，（圖見第二十三版），此汲水儲水大概之情形也。

富榮鹽區，鹽水火氣並生，鹽戶利用火氣以煎鹽，然水火未必同出一井，水井火井，往往相距頗遠，且井戶未必兼營竈業，於是井戶賣水，竈戶買水，交易以生，而轉運遂之。在井竈相距近者用水少者，可用人力挑担，馬力駝負，盛水之器，不外木桶，但鹽竈須近火井，而水則可由遠處購來，往往一竈可燒鍋數百口，用水甚多，轉運之法，須有組織。在自流井貢井，凡談及鹽商內容，則別爲井竈梘號四大勢力，井商銼井汲水，竈商煎製成鹽，梘商轉運鹽水，號商販運成鹽。轉運鹽水，既有專商經營之，則方法事務，繁雜可知，自貢鹽區，到處可見竹管縱橫樓架樹立者，皆轉運鹽水所需也。梘以竹管爲之，取斑竹或南竹，通其節，互相連接，外用細蔴桐油石灰包裹，使不透水，觀察地勢高低，定其安置所在，或埋藏地下，或露出地表，鹽水就高下之勢，可流注甚遠，如高低相差，不能相通，或修造水樓，上置水車，下置水池，運水而上，或用木將竹梘架起，再洩於低處，如須轉彎，則設一木桶或石缸，以爲樞紐，名爲梘窩，水之多者，一窩三梘，分注各處，竈戶如井臨水者，則用船運，由河抵岸，再用水車挽運而上，由梘達竈，如梘遇河，則於河底挖溝通梘，鑿石爲槽，覆於其上，如此安梘，越山渡水，鹽水到處可達，自流井鹽常由黃水黑水岩鹽水三種合煎而成，但岩鹽水只於大坟包一帶產之，而可以流通各處者，梘運之功也。（圖見第二十四版第二十五版）。

煎鹽所在曰竈，覆竈之屋曰竈房，竈上置鍋，鍋之大者，曰千斤鍋，徑四五尺，厚約四寸，深約二寸，（圖見第二十七版），因厚重不能鑄深，用時周圍再加鐵瓦十二塊，塗以灰泥，名曰圈子或濾邊，高不等，花鹽鍋圈子約三寸，巴鹽鍋約五寸，此外有

温鍋牛頭鍋等，皆較小。竈分火竈炭竈，燃料不同，火竈用火氣，由火井用竹管引氣至竈，出鐵管燃之，花鹽竈深約一尺半，巴鹽竈深不及尺，炭竈用煤，自貢鹽區煤由威遠購來，竈較深，煤由竈旁竈口裝入。自貢鹽區炭竈甚少，多停工歇業。鄧井關區王壋五福井及分班井有炭竈，燒鍋六口，煤由石灰溪懷德鎮運來，鹽水爲五福井分班井所出之白水，每鍋每次用水一百二十餘担，煎鹽一餅。製法先以鹽水下鍋，煎爲渣鹽，即爲渣本，再加鹽水煎熬，取出鹼質，每三晝夜加鹽水六次，始煎成餅，每次成鹽，需時三晝夜，用煤二十包，每包重二百二十斤。一竈房有竈數個數十個數百個不等，視燃料之多少而定，(圖見第二十六版)，自流井火竈現有燒四百餘鍋者。製鹽之法，花鹽與巴鹽不同，而所用鹽水亦不一定，有黃水百分之二十及岩鹽水百分之八十合煎者，有黃水百分之七十與黑水百分之三十合煎者，亦有三種鹽水相混，或單煎一種鹽水者。如燒花鹽，以鹽水注入鍋內，燃火，俟其沸騰，加豆漿以澄清之，煎移時，即有黑水泡沫附雜質浮出水面，將泡沫取出，再入豆漿數次，令其十分澄清，另加母子渣鹽少許。母子渣鹽者，爲用温鍋另煎之鹽，加豆漿後，即減小火力，用微火温之，使鹽結成片如雪花。至大鍋之水煎濃澄清後，加此鹽煎至水竭，而鹽結成粒，遂鏟入竹簸簍中，俟其鹼汁濾盡時，再以煎沸之清潔鹽水，向竹簍淋下，鹽晶遂凝結，而鹽色亦漂白矣。火力足者，一晝夜可成花鹽一百三四十斤，火力不足者，不過八九十斤而已。如燒巴鹽，先將細鹽渣鋪於鍋內，俟火將鍋燒至透紅時，再徐徐注入鹽水，漸漸結成巴鹽一餅，厚五六寸，徑大約四尺，重約七百斤。成鹽時間四五日或七八日，視火力之大小而定，此製鹽大概之方法也。

礦業　富榮鹽產開發，考自載籍，始於漢代，初在鄧井關一帶，井數不過六七，深不過二十餘丈，及後北展至自流井等處。榮縣貢井，至唐代始著。宋代富順鹽業，甲於蜀中，明代稍衰，至淸代而大盛，因地勢遼闊，分爲兩場，鄧井關一帶爲一場，自流井貢井爲一場，開採迄今，爲吾國重要鹽產之一。近因產不濟銷，頗露衰落之象，須設法整理補救也。鹽商經營鹽業，在富榮鹽區，最爲複雜，井竈梘號，業務不同，故分商經營，井商於呈報鹽務官署開業後，先擇地鑿井，如係租地，當與地主合股，地主作股五分之一，或獨資經營，或集股合辦，因鹽井深淺不等，資本無定，黃水井較淺，而資本亦少，開辦用費不大，只購備鑿

井器具，開銷工人薪資卽可，數百元亦可開辦，但及後下鑿愈深，工料增加，費款亦多，至見水汲取，井上設備如天車地車牛馬等，費成鉅數，聞一井之成，至少須數千金，黑水井較深，鑿井費時，資本須增加數倍，如爲牛拽地車，用牛有至七十頭者，每牛價約七十餘元，卽此一項，須五千元，如爲機器井，只機器一項，普通一萬數千元，經營一黑水井，資本亦需數萬，岩鹽井徑大，亦深，聞開辦一鹽井，資本約十萬元，以什之七爲鑿井之用，一井之成，由五年至十年不等，工料所需，可累至鉅數，天車建築約需八九千元，機器一萬餘元，其他設備費一萬餘元，但鑿井費時甚長，費款可陸續籌備，較輕而易舉。現富榮鹽區有鹽井井共四百五六十眼，新鑿者甚少，正鑿者，只貢井飛龍井一處，猶爲就淺井向下深鑿者，餘均爲舊井。現在井商，未必卽爲鑿井井戶，或典或租，或合股或分利，辦法不同，甚有轉租轉典數次者，故由井商而欲詢悉鑿井情形者，往往甚難。鹽井深淺不等，營業大小有差，就井上設備而言，由二牛地車數丈天車三寸汲水筒之小黃水井，至高車捲揚機八寸汲水筒之岩鹽井，規模相差甚遠。就產量而言，黃水井少者日只出數担，岩鹽井普通日可出八百担（担有大小之分小担約二百餘斤大担約四百餘斤岩鹽水均用大担）多少相差如斯。小鹽井工人三數名卽可將事，大鹽井工人須四五十人。工價，機器匠每月多者至四十元，少者十餘元，井工每月約三元，小工約一元五角，均由井戶給食，工作時間，晝日爲多，亦有晝夜兩班者。此次調查時，因產多銷少，限制產額，岩鹽井共四十餘井，不能同時出水，公定按次輪推，每七井同時工作，十日爲期。富榮鹽區一帶，物價不甚昂貴，惟機器運自遠地，價值較大，或購自上海中國工廠，或購自漢陽機器廠，捲揚機鍋爐唧筒一套，共約一萬一二千元，鋼絲繩每捲長約一千四百五十英尺，價由四百餘元至七百餘元，運費稅捐在內，每月須換一二次。機器以煤爲燃料，來自威遠，價每千斤約四元七角，如爲牛車鹽井，物料均出自本境，以買牛費款爲大宗，每頭由三四十元至九十餘元，普通約七十元。繩用竹篾，長約四丈，重約七斤，價約四角，須時常更換。種種工作，爲取鹽水，但井戶多不兼營竈業，鹽水賣於竈戶或梘商，價不一律，視鹽水鹹度大小井竈距離遠近而定，如自流井連海井黑水鹹度三兩二，賣於郭家坳，每担約三百斤，可出鹽五十餘斤，價五角五分，海龍井黃水鹹度一兩八，賣於附近海心井，每担重二百餘斤，可出鹽二十斤，價約二角，大坟包楊家冲鹹海井岩鹽水鹹度三兩五，賣於附近竈戶

，每担重四百餘斤，可出鹽約九十斤，價六角九分。鹽水大部須由梘運至竈，經營運鹽水者，爲梘商，資本無定，以梘之長短爲準，由數千元至十餘萬元，物料以竹蔴油灰水樓水車爲大宗，越山渡水各種建築工人牛馬所費亦多，此汲水運水營業之情形也。

竈商營製鹽業，先向鹽場公署註册立案，領取門牌，塡明產額，始能開業，資本無定數，視竈數多寡爲準，又火竈炭竈不同，用費亦異，大約火竈每座四五百元，炭竈約二百餘元，只千斤鍋一口，價須一百四五十元，再重如雙七百鍋價至二百二十元。富榮鹽區，共有火竈八千餘口，炭竈二百餘口，竈商大小相差殊甚，有燒一二口鍋日出鹽一百餘斤者，有燒四百餘口鍋日出鹽一百四十餘包重二萬餘斤者。燃料所費，爲燒鹽大宗，火竈用火氣，與火井往往同屬一商，鑿火井爲開鹽竈，鑿井手續，與鹽井同，惟見火氣之後，在井口下丈許挖設空洞，蓄火氣，上覆蓋，由此以竹管引氣入竈，竹管多數埋置地下，分火氣爲若干頭，每頭燒鍋一口，火焰燒處，爲鐵管，下接竹管，外敷泥灰，上距鍋底尺餘，如竈戶無火井，亦可租典火氣，租典辦法不同，如自流井雙全井每口火典價一百七十五元，三年爲期，同發井每口火典價約八百元，十年爲期，貢井龍源井每口火每月租價十五元五角，六年爲限，三輿井每口火典價一千元，十年爲期。炭竈用煤，威遠煤，價每千斤四元七角，或每包四百二十斤，價由二元五角至三元。自貢炭竈甚少，此次調查時，均停工。鄧井關區王壋炭竈，有鍋六口，煤來自石灰溪懷德鎮等處，價每包重二百二十斤，值洋六角。燃料費外，爲鹽水買價，鹽水種類不同，價值亦異，前已敘述。燒鹽工人多少，視竈業大小而定，由一二人至一百餘人，專管燒鹽者，爲燒鹽匠，通常每人管燒五口大鍋，有時附帶五口小鍋，工資常以鍋數計算，每月每鍋由九吊至十一吊，合洋七角至八角五分，五口鍋月得四元左右，由竈戶供食，挑水工人每月二十吊，合洋一元五六角。每鍋每日出鹽多少，以火力大小鹽水濃淡爲準，竈戶出鹽多少，通常均以包計，如每日出鹽若干包，但所用竹包大小各竈不等，裝鹽數目亦均不同，有一百六十斤爲一包者，有二百斤二百四十斤二百五十斤二百七十斤等等爲一包者，故計每鍋出鹽之數，須先知每包輕重大小，如以斤計，每鍋每日出花鹽由七八十斤至一百二三十斤，平均一百斤左右，巴鹽一餅約六七百斤六七日始成，亦平均一百斤左右，鄧井關區巴鹽一餅，重二百五十斤，三晝夜即成，每日出鹽八十餘斤。鹽之種類不同，票鹽引鹽銷售亦異，故鹽價不甚一律，每月由鹽場

場長按類定價，民國二十年一二月間，票火花鹽頭粗每百斤四十吊，合洋三元，二粗每百斤三十九吊，合洋約二元九角三分，三粗每百斤三十八吊，合洋約二元八角五分，濟楚引火花鹽每張(卽每引)角洋二百九十元，計岸引火花鹽每張角洋二百八十二元，邊岸引火巴鹽及炭巴鹽每張角洋二百三十六元，改良炭巴鹽每張角洋二百四十八元，其他青花鹽黑巴鹽價稍低。花鹽每張五十包，每包二百斤，合一萬斤，巴鹽每張五十觔，每觔一百六十斤，計八千斤。角洋十二角折合大洋一元，如角洋二百九十元，僅合大洋二百四十一元有奇。煎鹽成本，當不一律，營業盈虧，亦均不同，成本數目，不能確定，大約每百斤成本一元七角至一元八角，惟自流井福明井鹽價每張二百七十五元，有四十元之盈餘，卽每百斤成本二元三角五，約合大洋一元九角六分，鄧井關區五福井巴鹽每百斤價洋四元八角，成本四元，此竈商營業之情形也。

竈戶煎妥成鹽後，爲免除私漏偸盜計，限定時間，移入官倉公倉或官垣，水運引鹽，統歸官倉或公倉，按戶存儲。(圖見第二十八版)。陸運票鹽於成鹽後，限四十八小時內，運存鹽垣，不得私存，倉垣均由場署派員管理。凡鹽商販運引鹽，須先將應納稅款，交由中國銀行代收，領取繳稅聯單，限一個月內，赴鹽務稽核分所，換取運鹽准單，限三個月內，與竈商將鹽配就，赴鹽倉秤放處，會同秤放員驗照准單，在該竈商鹽內如數秤放。鹽販販運票鹽，可直赴鹽垣收稅處，完納鹽稅，領取運票，限一日內運鹽出卡。鹽稅分正稅附加稅種種，引票不同，岸各有異。引鹽正稅除濟楚岸爲三元五角外，每担(一百斤)均爲二元五角，附加稅岸各不同。自貢區票鹽正稅，每担爲二元二角。鄧井關區票鹽正稅，每百斤一元五角。放鹽秤爲司碼秤，較天平秤每斤約重八錢。引鹽於秤放後，花鹽用雙層篾包包裝，行銷計岸者，每包毛重二百〇八斤，淨重二百斤，行銷楚岸者，因運道較遠，不免損耗，故照計岸外加滷耗鹽十二斤，毛重二百二十斤。巴鹽用竹篾觔子裝盛，每觔毛重一百六十六斤，淨重一百六十斤。花鹽每載九引(張)，每引五十包，每包二百斤，全載九萬斤。巴鹽每載十二引，每引五十觔，每觔一百六十斤，全載九萬六千斤。票鹽皮重，以挑計算。花鹽一挑，皮重三斤。巴鹽一挑，皮重一斤半。引鹽裝載後，由稽核分所將准單送交駐自流井鹽運使行署委員照塡部頒運鹽執照，復連同准單送還分所，發給鹽商。自給照之日起，限於六個月內到岸，逾限失效。票鹽秤放成挑後，由駐垣

兵役查明鹽票相符，始准出垣，並限本日運出鹽區。引鹽由富榮鹽區至瀘州重慶，概用木船。楚岸自重慶改裝輪船下運。計岸至較遠山地，改用人力負挑，或騾馬馱運。票鹽多爲人力挑運，偶有牛馬馱運者。(圖見第二十九版)。鹽出區後沿途須受鹽務關卡查驗。在瀘縣合江江北涪陵萬縣及湖北恩施等地，均設有驗卡，查驗引鹽。在鹽區附近，設有驗卡，查驗票鹽。引鹽運銷以岸計，有計岸，邊岸，楚岸之分，計岸，行計引之縣曰計岸，計引爲計口授食之義，計岸即四川境內各縣是也。邊岸，行邊引之縣曰邊岸，即雲南貴州行銷川鹽各縣是也。楚岸，行楚引之縣曰楚岸，即湖北湖南行銷川鹽各縣是也。票鹽銷票岸，即鹽區附近之地也。楚岸銷花鹽，銷湖北舊荆州襄陽鄖陽安陸宜昌五府及荆門州，即現襄陽京山天門潛江監利以西五峯建始以北三十二縣，及湖南舊澧州，即現澧縣臨澧安鄉等縣。邊岸又分綦邊，銷巴鹽，銷四川之綦江南川二縣，及貴州舊遵義貴陽都勻三府及平越州，即現北部中部桐梓遵義貴陽定番羅斛等二十餘縣。仁邊，銷巴鹽，銷貴州舊仁懷廳及遵義大定貴陽三府屬縣，即現西北部鰼水赤水仁懷大定等數縣。永邊，銷巴鹽，銷四川古宋叙永古藺等縣，及貴州舊大定安順興義三府及普安廳，即現西部畢節威寧安順南籠普安等十餘縣。涪邊，銷巴鹽，銷四川酉陽秀山黔江彭水四縣，及貴州舊思南思州鎮遠石阡銅仁五府及松桃廳，即現東部鎮遠銅仁思縣思南松桃石阡等二十餘縣。涪萬，銷花鹽巴鹽，銷四川涪陵萬縣石柱酆都忠縣，及湖北宣恩恩施利川建始鶴峯五峯咸豐來鳳等縣。瀘南，銷花鹽巴鹽，銷四川瀘縣合江江北江津巴縣長壽墊江鄰水等縣。渠河，銷花鹽，銷四川廣安岳池大竹渠縣宣漢達縣萬源等縣。自貢區票鹽，銷花鹽巴鹽，銷富順榮縣隆昌榮昌永川銅梁璧山大足內江威遠資中等縣。又瀘縣宜賓南溪三縣亦間銷票鹽。票巴鹽僅貢井區銷售，票花鹽自流井貢井均售。鄧井關區票鹽，銷富順縣屬鄧井關石灰溪趙化鎮懷德鎮長灘壩等處。運費多寡，隨時隨地而異，據最近調查，自貢區票鹽，每挑平均八十斤，運行一百里，約需挑費一元二角。鄧井關票鹽多水運，由竈運至鹽垣水運每担洋七分，由鹽垣至銷地運費洋九分。引鹽岸各不同，如瀘南花鹽，每載運費，由自流井至鄧井關約需洋四百元，由鄧井關至重慶，約需洋四百〇八元，共八百〇八元。仁邊巴鹽，每載運費，由自流井至鄧井關，約需洋四百三十元，由鄧井關至合江約三百元，共七百三十元。綦邊巴鹽，由自流井至鄧井關四百三十元，由鄧井關至江津約三百七十元，共八百元。涪

邊巴鹽，由自流井至鄧井關四百三十元，由鄧井關至重慶約四百一十元，共八百四十元。楚岸花鹽，每載運費，由自流井至鄧井關約四百五十五元，由鄧井關至重慶約四百五十五元，共九百一十元。此爲木船水運運費。邊岸陸運運費，各處不同，不能確定，楚岸鹽自重慶以下改裝輪船，運費未詳。四川鹽產行銷，各有定岸，不能侵銷，而各岸所銷鹽斤，亦有定額，無得超越，如楚岸在清季每月定爲六百引，民國四年每年定爲九千九百引，六年財政部鹽務署規定川鹽行銷楚岸，每年不得超過一百二十五萬担，但歷來運銷，均未銷足九千九百引之數，民國十四年楚岸僅銷三千六百三十六引，近來愈見減少。綦邊定額，每年三千二百三十一引。仁邊每年三千二百四十五引。涪邊一千七百四十二引。永邊一百四十四引。瀘南花鹽二千三百九十五引，巴鹽九百八十九引。涪萬花鹽一千六百二十一引，巴鹽八百〇四引。渠河花鹽二千五百七十四引。但涪邊永邊渠河三岸，亦銷犍鹽，民國十九年鹽務署將永邊劃歸犍區專銷。涪邊則專銷富鹽。此富榮鹽產運銷情形也。

富榮鹽區，因受時局之影響，鹽價之漲落，每年產銷情形不同，而稅收亦當有增減，茲將自民國九年以來產銷稅收總額，表列如左，以資參考。

自流井貢井區及鄧井關王壋區產額表

年別	自貢區每年產鹽担數	鄧王區每年產鹽担數
民國九年	三、三一八、一九三·八〇担	二、八二三·七〇担
十年	三、四二〇、八一三·〇〇	一、六三七·六九
十一年	三、七三四、一四七·二九	二、六四五·一八
十二年	三、七四五、八七七·七〇	二、五六八·九二
十三年	三、六七〇、四〇八·六五	一、四七五·一二
十四年	二、六七三、七六六·一七	一、四三三·四八

十五年	三、七四七、五五一・三六	二、一二二・九六
十六年	三、七二四、六一二・三七	二、一〇六・三二
十七年	三、五四一、七六九・七六	一、七五二・六四
十八年	三、五七四、〇一七・六四	一、六五〇・五三
十九年	二、九二三、一三八・三七	一、六〇八・四七

自流井貢井區及鄧井關王壋區銷額表

年別	自貢井區每年銷鹽担數	鄧王區每年銷鹽担數
民國九年	三、三一八、一九三・八〇担	三、〇二一・〇〇担
十年	三、四二〇、八一三・〇〇	一、五六〇・〇〇
十一年	三、四九二、〇九八・六〇	二、七〇三・〇〇
十二年	三、一一七、〇〇八・二〇	二、三一一・〇〇
十三年	三、五六五、二一九・五三	一、五九八・〇〇
十四年	二、七七一、一三四・八〇	一、四七一・七〇
十五年	三、四八〇、四一一・〇三	二、一一〇・〇〇
十六年	三、六二六、二七六・六〇	二、一七八・〇〇
十七年	三、五九一、五一二・一〇	一、七〇四・〇〇
十八年	三、六八二、四八九・九〇	一、六六八・〇〇
十九年	二、六一六、八四五・五一	一、六四六・〇〇

自流井貢井區及鄧井關王墻區稅收表

年別	自貢井區每年稅收數目（元）	鄧王區每年稅收數目（元）
民國九年	七、八五四、三七八・〇四	四、五七二・七〇
十年	六、六五七、〇七七・二三	二、三四〇・〇〇
十一年	七、七四一、一四一・四〇	四、〇五四・五〇
十二年	七、一八一、八九四・三九	三、四六六・五〇
十三年	七、八六三、八七九・〇八	二、三九七・〇〇
十四年	六、二九二、九二二・七四	二、二〇七・五五
十五年	七、五三五、九三一・四〇	三、一六五・〇〇
十六年	九、八四二、九八一・八二	三、二六七・〇〇
十七年	七、七八〇、二六二・七九	二、五五六・〇〇
十八年	七、九〇〇、二六八・七五	二、五〇二・〇〇
十九年	四、七六二、九二九・三一	二、四六九・〇〇

富榮鹽務管理較爲繁雜，統分行政稽核緝私三部。四川鹽務行政最高機關爲鹽運使署，設於重慶，有鹽運使駐節，又運副一員，駐瀘川，管理川北鹽場。富榮鹽區設運使行署，有委員一員，督辦運務事宜，另有場長二員，一駐自流井，稱東場場長，一駐貢井，稱西場場長，管理行政事宜。又在鄧井關駐有監運兼鹽井委員一員，管理鄧井關王墻鹽場鹽務行政事宜。稽核方面，有川南稽核分所，設於自流井，在自貢鹽場八區，各設收稅處秤放處，貢井官倉放鹽處，及關外稽查處等。在鄧井關設有鹽務局。緝私方面，四川鹽務緝私，設有緝私營統部，統轄緝私營七營，分駐各鹽場。自流井設有緝私第一營第四營營部，貢井設有緝私

第五營營部，各有營長一員。鄧井關駐有緝私第四營緝私兵一排。此富榮鹽區管理之情形也。

犍爲樂山鹽產

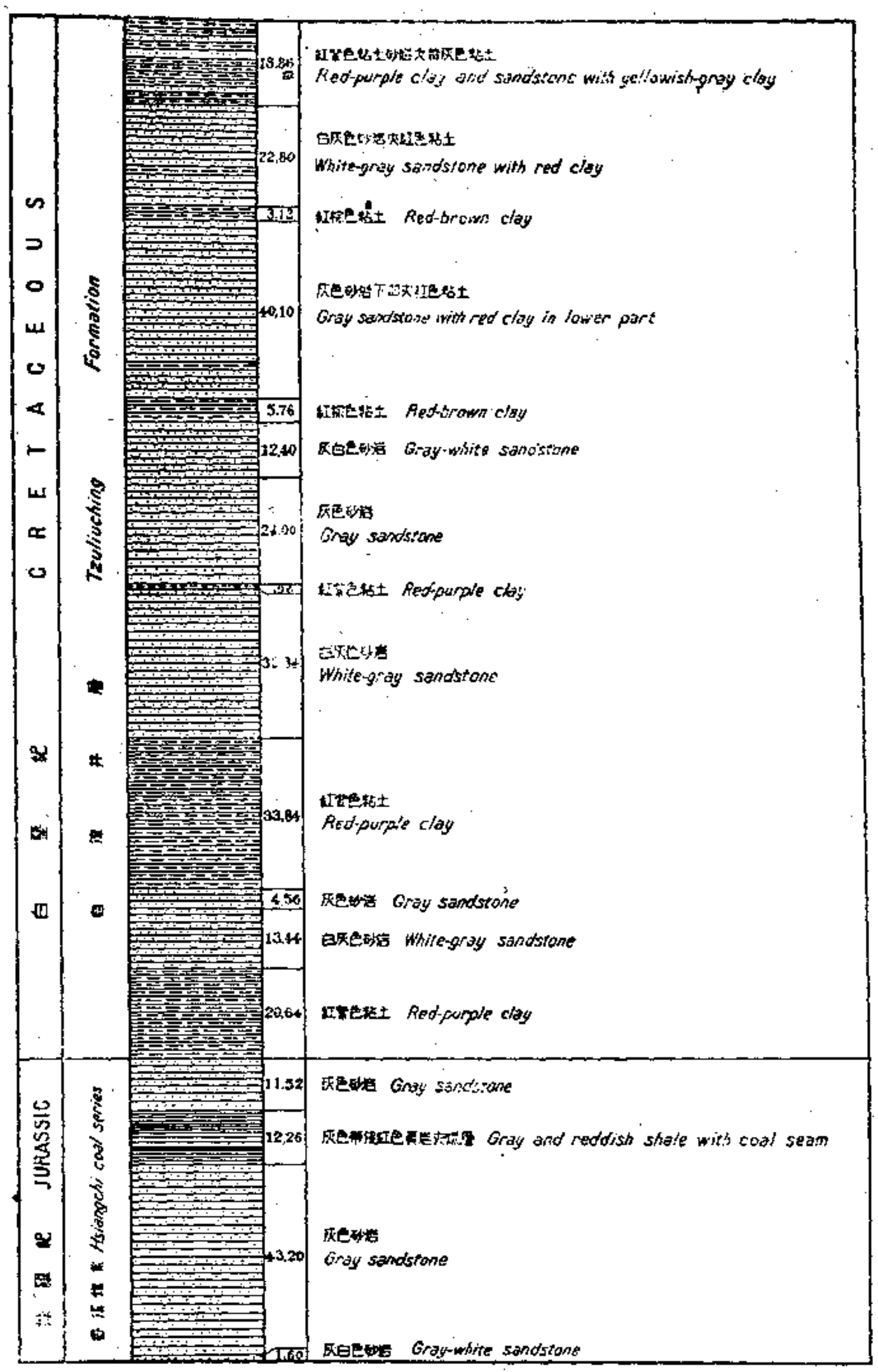
犍爲樂山爲四川產鹽次多之區，僅遜於富榮鹽場，年產約八十萬担，稅收約一百八十萬元，近年來鹽斤運銷頗佳，鹽商多有盈餘，鹽業有駸駸日上之勢，且兩場官商，均能合作，有組織探礦機關，下探較深鹽水之計畫，如辦理妥善，著有成效，鹽業發展，利莫大焉。

位置　犍爲產鹽所在，以五通橋爲中心，在犍爲縣城北約八十里。樂山產鹽所在，以牛華溪爲中心，在樂山縣城南稍東約二十里。犍爲區東西約六十餘里，南北約四十餘里，位於岷江之東，著名地點，爲楊柳灣，甕草灘，灰山井，順河街，紅豆坡，王村場，馬踏井，三江鎭，瓦滓灘，金石井等處。樂山區東西長約八十里，南北廣約二十六里，位於岷江兩岸，著名地點，河東爲牛華溪，河洱坎，里仁場，河西爲蔡金場，觀榜場，新場子等處。犍樂鹽區井數甚多，常以千計，現採者有四千餘井，多於富榮鹽區者約十倍，惟井淺產少，尙不及富榮之繁盛也。（圖見第十七版）。

地形　犍樂鹽區，爲小山邱陵地，無顯著之山嶺，地面起伏，相差不大，無攀登之難。岷江中分全區，岷江以東，小山羣立，中有小河，曰四望溪，爲區內主要河道。山之高者，高於江岸不過一百五十公尺，通常在五十公尺一百公尺之間，小山名稱頗多，自岷江沿四望溪而上，較著者，爲豹子山，官頭山，鵝項嶺，高於岷江均在一百公尺以上，在四望溪之下游，再上至馬踏井，三江鎭，河洱坎一帶，有獅子山，將軍山等，均不顯着。四望溪下游，剝蝕較深，小山坡際，常有絕壁，鹽井多在其旁。上游剝蝕較淺，地面凸凹高低，相差不多，坡邊緩漫，不現絕壁懸崖。四望溪自金山寺以下，可行小船，竹排，載運鹽煤，至岷江，鹽斤換載大船下運。岷江以西，地形與河東相同，亦無較大山嶺，北有銅河，臨江河近處，地勢平坦，自岷江而西，爲一帶小山，狀如邱陵，最高山巔，高於岷江均不過一百公尺，溝渠蜿蜒，不成大水，注入岷江銅河，轉運率用挑負，不能利用水運也。

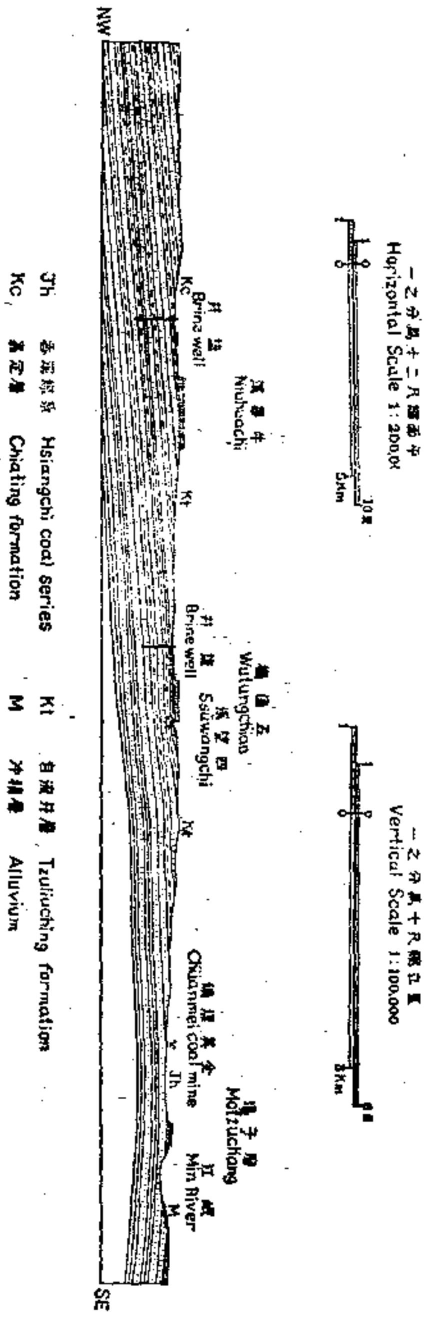
地質　犍樂鹽區地質簡單，地表地層露出者，幾全爲白堊紀自流井層，僅區域北部河洱坎牛華溪以北，及近銅河處，稍有嘉

定層。鹽區之南，磨子場石麟等處，有侏羅紀煤系上部暴露。自流井層以紫紅色粘土及白黃灰色粗砂岩爲主，夾黃綠灰色灰岩，厚約五公尺，含葉鰓類化石頗夥，分佈甚廣，鹽區南部，悉其組成。嘉定層以紅色粘土爲多，夾紅色砂岩，分佈於鹽區北邊，出區北至樂山附近，暴露較多。侏羅紀煤系露出者，有白灰淺黃灰色砂岩，爲煤系與自流井層接觸之部，其下爲黑灰色頁岩，夾煤層。在五通橋油井坡灰山井等處所見，爲淺黃棕色及灰色砂岩，質粗，常呈交叉層狀，其下常爲紅色紫土粘土，夾薄層灰岩及灰



第一圖　犍爲區順河街福裕井鑿井地層柱狀圖

貫頁岩，均屬於自流井層。此為地層之露出者。地下地層，只可於鹽井鑿井岩石記錄，得其梗概，但土人所得石屑，命名不同，有時不能準確比較。在順河街有寶通井，深約一百二十四公尺，尚未到鹽水，井口在灰岩上之黃色砂岩打下，再下所得，為大紅岩二紅岩淡紅岩與瓦灰岩黑瓦灰岩夾雜而生，所謂紅岩即紫色粘土及砂岩，瓦灰岩即灰色灰白色砂岩，即自流井層之下部，惟在五十公尺左右，應見灰岩一層，土人未能分別，統歸於瓦灰岩內。又福裕井亦在灰岩之上砂岩打下，位置稍高，先見一種紅色岩石，井深約三百〇二公尺，由井口至二百三十四公尺處，以紅岩大紅岩淡紅岩瓦灰岩青瓦灰岩白瓦灰岩等等為多，尚有粉紅岩烟紅岩及草白沙白醬岩等，所謂紅岩等，即紫紅色粘土及砂岩，瓦灰岩草白沙等，即灰色灰白色砂岩，當為自流井層之下部，其中灰岩一層，亦未分出，或包括於瓦灰岩內。自二百三十四公尺以下，岩石色性稍異，紅色岩石極不顯著，多青瓦灰岩及瓦灰岩，並夾煤炭，所謂瓦灰岩仍為灰色砂岩，煤炭當為煤層，確為侏羅紀煤系之上部，煤層位置在距紅灰岩石分界下約二十公尺，或與磨子場北所見之豐炭相當，為煤系最上之煤層。（見第一圖）至牛華溪東北金華井，井口位置尤高，當在嘉定層內，深約六百二十六公尺，上部所見，幾全為大紅岩及淡紅岩等，而瓦灰岩白岩只有數處，下部大紅岩粉紅岩外，瓦灰岩白岩漸次加多，上部即紅色粘土砂岩，



第二圖 四川犍爲樂山鹽區油田地層構造剖面圖

當屬於嘉定層，下部即紫紅色粘土及灰白色砂岩，當屬於自流井層之一部，惟二層分界，未能確定，因二者均有紅色岩石，紫紅色及紅色在露出石層，又不易分辨也。就各處露出地表地層觀察，自流井層在犍爲樂山一帶，厚在四百公尺以上，或不及四百五十公尺，金華井底，向在自流井層內，未至侏羅紀煤系，井深現爲六百二十餘公尺，除自流井層外，當有二百餘公尺爲嘉定層之地層。地表地層，互相比較參証，則鹽區地質情形，自可得其梗概也。

犍爲樂山鹽區地質構造亦簡單，無顯著斷層之跡，可見者惟地層起伏之狀，及低平之背斜層而已。在鹽區之南，有背斜層，可名竹根灘背斜層，頗低平，脊在磨子場之北，大致成東西方向，東向漸次低盡，西向逾岷江，漸高而開張，在岷江以東，南翼地層傾斜較緩，不過數度，北翼地層傾斜較陡約七八度。在岷江以西，侏羅紀煤系三疊紀灰岩及紫色砂岩，均暴露地表，而成山嶺，兩翼地層傾斜，亦均不甚大，犍樂鹽區，在此背斜層之北翼，地層傾斜大致向北，或偏西北，或稍偏東北。（見第二圖）。在五通橋附近，地層傾斜向北五度西，斜角約五度左右。至順河街向北十度東傾斜，斜角六度。再東北至金山寺附近，有向北偏西三十度或向北偏東三十度傾斜者。至河洱坎附近，地層向西北二十度至五十五度傾斜，斜角均不過數度，或近平層。由河洱坎至牛華溪途中，地層亦均向西北傾斜，或稍偏北。惟自河洱坎以東，又爲威遠榮縣大背斜層所在，河洱坎適在其西端，故犍爲樂山鹽區地質構造，南與竹根灘背斜層有關，而東受威遠榮縣大背斜層之影響也。

礦床　犍樂鹽區鹽產來源，均爲鹽水，向無岩鹽，鹽水鹹度雖大小不等，而無黑水黃水之別，井愈深，鹹度愈增。全區井數四千餘，深淺有差，最深者不過一千二百餘尺，合六百餘公尺（犍爲每尺合四十八公分樂山每尺有時合六十三公分。）據調查所得，在五通橋一帶，井深由七十餘丈至九十四丈，即由三百三十餘公尺至四百五十餘公尺。在楊柳灣一帶，井深由九十丈至一百○五丈，即由四百三十餘公尺至五百餘公尺。在叢草灘一帶，井深均約一百一十丈，合五百二十餘公尺。在金山寺附近，井深由八十丈至九十八丈，即由三百八十餘公尺至四百七十餘公尺。在順河街灰山井一帶，井深由六十丈至一百二十丈，即由二百八十餘公尺至五百七十餘公尺。在紅豆坡一帶，井深均約一百○五丈，合五百餘公尺。在馬踏井金石井瓦滓灘王村場河洱坎等處，井

深由五十丈至一百丈，卽由二百四十公尺至四百八十公尺。岷江以西，各處鹽井鹽竈規模較小，深度愈減，普通約八九十丈，合四百餘公尺。此鹽水所在之深淺也。然井口地位所在，各處不同，有在白堊紀自流井層鑿下者，有在嘉定層鑿下者，而兩層又有上下之分，非遍察各井所在，而得其深度，兩相比較，無由知其鹽水層位。但遍觀各井，絕非有限時間所能辦到。今僅就大略言之，自河渠坎牛華溪以北，爲嘉定層分佈所在，鹽井均在其下部鑿下。自河渠坎牛華溪以南各地，及燊金場新場子等處，爲自流井層分佈所在，鹽井多在其上部鑿下。如兩處鹽井在同一深度得見鹽水，則鹽水層位，必非相當，當有上下之分。若兩井在同一地層鑿下，而鹽水深度不同，則鹽水層位，亦當分上下。如順河街福裕井深約二百九十八公尺，井口在自流井層上部鑿下，故深至二百三十四公尺，已至侏羅紀煤系，且已進大六十餘公尺矣，鹽水層位，當在侏羅紀煤系之上部。但順河街灰山井鹽井深度不等，最深者可至一百二十丈，爲五百七十餘公尺，而井口位置均在自流井層上部，高低相差不多，以此計算，則最深井鹽水，當在侏羅紀煤系下部，已深入三百四十餘公尺。故由煤系之頂以下六十公尺至三百四十餘公尺處爲鹽水層帶，其間層位不易分辨。在河渠坎高山舖一帶，鹽井深一百一十五丈至一百四十丈(每尺合營造尺一尺二寸)，卽由四百四十餘公尺至五百三十餘公尺，井口均在嘉定層之下部，按地層厚度及鹽井深度計算，井底尙在自流井層內，未至侏羅紀煤系。如斯則鹽水層位，在自流井層之下部。在牛華溪金華井深六百二十餘公尺，仍爲紅色地層，在自流井層之下部，未至侏羅紀煤系，水已變鹹，鹹度一兩餘，尙繼續下鑿，其層位似與河渠坎高山舖鹽水相當，亦爲自流井層下部之鹽水層。故犍樂鹽區鹽水層位甚多，無法比較對照，如以帶論，自流井層下部，爲一鹽水帶，而侏羅紀煤系深三百餘公尺以上，爲一鹽水帶。至含鹽水層岩石種類，均爲一種白灰色砂岩，卽土人所謂草白沙是也。

礦質　犍樂鹽產，均爲鹽水，常因所在深淺位置之不同，頗有濃淡之差，而煎成之鹽，亦種類有異。惟鹽水未經分析，成分不能確知，僅就鹽水鹹度大小，成鹽種類，略分述之，以示其質。鹽水鹹度計算，以煎成之巴鹽數量爲準，卽每斤鹽水，可煎成若干巴鹽，爲鹹度之數。據最近調查，在五通橋一帶，鹽水鹹度由一兩至一兩二錢。在楊柳灣一帶，由一兩一錢至一兩三錢。在

蘿草灘一帶，由一兩二錢至一兩四錢。在金山寺一帶，由一兩一錢至一兩三錢。在順河街灰山井一帶，由一兩二錢至二兩四錢，最佳鹽水有每斤可出鹽二兩二錢者。在紅豆坡一帶，由一兩一錢至一兩三錢。在馬踏井金石井三江鎮瓦滓灘等處，由一兩至一兩四錢。在王村場河洱坎一帶，由一兩至一兩四錢。但據川鹽紀要所載，五通橋一帶鹽水鹹度由一兩至一兩五錢。順河街一帶，鹽水由一兩一錢至二兩四錢。灰山井紅豆坡一帶，鹽水由一兩二錢至一兩五錢。金山寺一帶，鹽水鹹度爲一兩七錢。馬踏井由一兩一錢餘至一兩六錢餘，至三江鎮金石井等處，鹽水鹹度低至六錢餘至八錢餘，河洱坎一帶，鹽水由一兩一錢可至二兩四錢，至牛華溪一帶、鹽水由一兩二錢至一兩九錢，就上述各處鹽水鹹度，互相比較，頗有今昔不同之處，如前後計算所用標準相同，則犍樂鹽水平均鹹度，現已大減，未悉原因何在，犍樂成鹽，亦分花鹽巴鹽，但均爲炭竈所造，故曰炭花鹽炭巴鹽。炭花鹽多售票鹽，又有上中下之分，每種價值不同，雪花鹽較優。炭巴鹽分白口炭巴鹽及青口炭巴鹽，白口炭巴鹽質較佳，與他處火巴柴巴相較，亦無稍遜，青口炭巴鹽，因鹽水不清，鹽渣不潔，質較劣，而價亦較低，玆將英國薩爾曼皮卡德公司所分析犍爲樂山鹽區成鹽之結果，表列如左：

成鹽種類	白巴鹽	青巴鹽
綠化鈉	九七·九七	九七·九〇
不溶物	〇·六〇	〇·六〇
養化鈣	〇·四〇	一·〇〇
養化鎂	〇·〇七	〇·五三
硫養三	〇·四四	微量
合計	九九·四八	一〇〇·〇三

採製　欲採鹽水，須先鑿井，法與富榮鹽區相同，但井較淺，工易舉，費款少，時間短。大井口徑大者約一尺一二寸，深以

至堅硬岩石爲度，小井眼徑由二寸四五至四寸二三，以營造尺計。深由五六十丈至一百二十丈，以倒針尺計（合營造尺一尺五寸或一尺六寸）。井深者費款約二萬元，閱時三四年，淺者費款僅一二千元，費時一二年，如今年順河街鑿一新井，大井（卽大井口徑一尺二寸，深三十丈，子眼（小井口）徑四寸二分，深一百丈之譜，爲犍樂鹽區大井一類，共費款約一萬八千元。如同時開鑿兩井，再加費什之五卽可，是爲平頭雙車，可減人工牛力。中等井大口徑約一尺，深一二十丈不等，子眼徑三寸至四寸，深八九十丈至一百丈，鑿井用費，較省什之三四。小井大口徑六七寸，深數丈至十數丈，子眼徑二寸餘，深五六十丈，鑿井費用，較省十之七八。最小之井，鑿井所費，不及大井十之一。井成功見水後卽豎立天車，或以一木爲之，名曰引筒，或以四木作架，高約六七丈，旁有牛車或機車，犍廠有機車數處，樂廠全爲牛車，或一井一車，或兩井一車，此上彼下，藉減牛力。（圖見第三十版）。汲水用竹筒，下有活塞，亦名皮錢，鹽水汲上，一人鈎起皮錢，水卽流入存水礄內，由梘桿流於㮾桶或水池，再轉入竈房。犍樂鹽區，均自井自煎，井竈一商，梘爲附屬，無專商營之。梘以楠竹或斑竹爲之，井竈距離遠者約十餘里，須用楠竹千餘條，如鹽水由低處向上汲取，常以人工，用楠竹一條，中通其節，內貫一篾，篾下聯一活塞，上加木柄，斜置竹筒於存鹽水處，以手執柄升降竹篾，活塞開，鹽水上升，亦有用人挑越者。鹽水入竈，用法煎熬，製鹽法以鹽鍋置於竈上，支以石礅，圍以鐵塊，是爲滷邊，更以鹽和泥塗之，使無隙縫，下置煤燃火。鹽鍋種類，分雙七百鍋，重一千四百斤，可煎巴鹽五百五十斤左右，雙六百鍋，重一千二百斤，可煎巴鹽五百斤左右，大千斤鍋，重一千斤，可煎鹽五百斤，平千斤鍋，重八百斤，可煎鹽四百五十斤左右，加刀鍋，重六百斤，可煎鹽四百斤左右，頂平鍋，重五百斤，可煎鹽三百五十斤左右。鍋之重量，係以生鐵入爐之鐵量計，成鍋後重量減少什之一二。製花鹽以鹽水入鍋，煮以烈火，使其沸騰，加豆汁提取雜質，俟鹽質濃集，結成晶粒，卽用竹箕濾出，遲則沉底成巴，旋濾鹽旋添滷（卽鹽水），經兩晝夜，以滷盡爲度，息火停煎，每次成鹽由三百斤至五百斤。製巴鹽以鹽水入鍋，不必純用烈火，時大時小，火大時使鹽質結晶，火小時使晶粒下沉成巴，成鹽之前，加豆汁提雜質，使成白口，如此經兩晝夜，卽成巴鹽一餅，厚約四五寸，大如鍋，普通徑四尺，重不同，由一百四五十斤至五百餘斤。每餅巴鹽用鹽水多少不等，大鍋每餅用

鹽水約六千斤。此採鹽水製成鹽之大略也

礦業　犍樂產鹽之始，無可稽考，惟按載籍，唐之盛時，印眉嘉有鹽井十五，時嘉定州卽今樂山，似已產鹽。宋朝川有賫井，內載嘉州。元時四川有鹽場十二處，內載嘉定場。至明朝始有犍爲樂山等縣鹽井，確知產鹽，淸嘉慶間始盛，乾隆間置鹽大使於牛華溪，管理兩縣鹽政。民國初年改爲犍樂鹽場稅監，旋易榷稅官，後改鹽場知事，分爲犍樂兩場，各設場署，歷年鹽業盛衰不同，近年來稍有振興之望，官商亦思整頓。犍樂鹽商，大抵井竈一商，視附於竈，另有行商，專運引鹽，鹽販販運票鹽。井商於計畫擇地鑿井後，卽用石工數人開鑿，工價每工每日約洋二角四分，鑿井工人，山匠一人，計畫工程，督率工人，每月工資十餘元，筒匠三人，受山匠之指揮，作搗鑿之工作，每工每月工資四五元，趕水匠三人，爲趕牛轉車者，每工每月三四元，如作夜工，工人增加一倍。鑿井資本，已如上述，或獨資經營，或集資合辦，地主如非井商，收取井竈規租。現有鹽井共四千餘眼，井成後所有鑿井工人，移作井工，筒匠專司汲取鹽水，治理井病，如用機車，須添用機師機匠等，均由自流井僱來，機師每月工資可至五十元，機器一部，價由自流井購買，約七千元。鹽井每日產量多少不同，大井最多者，日出鹽水可至七萬斤，而小井最少者，僅一二百斤，普通鹽井，日產三四千斤。井竈相連，有一井供數鍋之用，有數井供給一鍋者。犍樂鹽區現有竈戶一千三百餘戶，鍋二千餘口，均爲炭竈，煤出自附近石麟磨子場及犍爲張溝屏山黃丹等處，水運陸運，遠近不同，價值亦異，卽以石麟煤運至犍場而言，由石麟煤窰運至岷江西岸西壩，每挑重九十斤，値洋貳角五分，由此再運至犍場各竈，平均運費三角，有時漲至五角。鹽鍋價値不同，由頂平鍋至雙七鍋百，每口價由七十餘元至二百元。如煎巴鹽，每月可煎十五次，成鹽平均約七十担，票鹽如次數相等，成鹽較少。製鹽成本，犍場樂場不同，犍場鹽產成本，每百斤由三元五角至三元九角，樂場引鹽，每百斤由四元四五角至四元五六角，票鹽每百斤由四元五六角至五元一二角，均有淡季旺季之分，淡季成本較少，每担可差二三角。鹽成後引鹽入倉，票鹽入垣，不准商竈直接交易，犍場有公倉二十五處，官公垣五處，樂場有公倉十八處，官公垣七處。鹽入垣倉後，由商販購運，凡鹽販在官公垣定購鹽斤後，持具憑單稅款向收稅處繳納，由稅務員查點數目相符，秤準鹽斤，卽塡發稅票放行。鹽商

購買引鹽，須按照規定稅率，塡具納稅單，註明商名引担，及應繳稅洋數目，向五通橋中國銀行照納，掣取收稅聯單，限一個月內，向鹽務稽核支所稅務課或收稅處報運，以便掉換放鹽准單，再向秤放處持投報請秤放單，由秤放處派員赴倉秤放後，再由查驗處點驗秤掃，向收稅處換照放行。票鹽係用竹簍裝盛，每簍裝鹽由四十斤至一百斤。引鹽係用竹篛包裝，每包毛重一百六十六斤，淨重一百六十斤，除篛皮三斤，滷耗三斤。引鹽每一百斤爲一担，每八十担爲一引。成鹽售價，犍場每担價洋由四元〇九分至四元八角八分，旺季較高。樂場引鹽每担由四元五六角至四元七八角，票鹽由四元六七角至五元四五角。稅率引鹽每担二元一角，票鹽一元八角，但水運票鹽，亦二元一角。鹽斤外運，票鹽由鹽販用竹簍多由陸路挑運或駝運，間由水運。引鹽用大木船沿岷江下運，或用小木船及竹筏溯江而上。運費票鹽多少不同，隨地而異，不易確定。引鹽每引運費，由犍場至滇岸宜賓查驗局洋三十元五角。至永岸敍永查驗局洋一百三十五元五角。至納萬川岸瀘納查驗局洋四十七元五角。由樂場至成都，水漲時，需洋五十元，水落時，需洋七十元。至新津水漲時，洋三十六元，水落時，洋五十六元。至雅安水漲時，洋六十元，水落時洋八十元。犍樂鹽區兩場，銷岸有別，犍場銷岸有滇岸，銷犍爲，馬邊，雷波，宜賓，屏山，慶符，高縣，筠連，珙縣，南溪，江安，長寧，古宋，興文，及雲南昭通，東川，鎮雄等縣，有永岸，銷敍永，古宋，古藺等縣，有納萬川岸，銷納谿，古宋，瀘縣，涪陵，忠縣，酆都，石柱，萬縣。此外配銷樂場三岸。票鹽行銷附近各鄉鎮，及犍爲縣。樂場銷岸有府河計岸，銷成都，華陽，青神，眉山，彭山，新繁，彭縣，崇寧，金堂，新都，郫縣，仁壽，汶川，理番，灌縣十五縣，有南河計岸，銷新津，崇慶，雙流，溫江，印崍，大邑，蒲江，七縣，有雅河計岸，銷雅安，夾江，峨眉，滎經，漢源，天全，蘆山，七縣。又票岸銷樂山，洪雅，峨邊，丹稜，名山五縣。四川之越嶲冕甯及西康之瀘定康定，亦有一部銷售犍樂巴鹽。鹽斤運銷各岸，配有定額，滇岸每年應銷三千九百九十三引，永岸應銷二千〇八十三引，納萬岸應銷一千六百三十六引，涪岸應銷一千二百五十八引，但涪永兩岸，原係富鹽犍鹽合銷，嗣後永岸劃歸犍鹽專銷，涪岸專銷富鹽。而樂鹽有時不敷分配三岸，須借配犍鹽，規定每年以借配一千引爲限。樂鹽配銷府河岸每年二千〇二十引，南河岸配銷一千四百二十二引，雅河岸配銷五百五十七引，共計三千九百九十九引，現

雖借配犍鹽，但每年仍能銷售三千三四百引。此運銷之大概也。

犍樂鹽區每年產銷額數不同，常有變遷，因而稅收亦增減無定，茲將由民國九年以來產銷及稅收總數，表列如左。

犍為樂山鹽區產額表

年別	犍為區每年產鹽担數	樂山區每年產鹽担數
民國九年	四七二、七五五·二七担	四一九、一〇〇·〇九担
十年	五〇一、七一二·三三	三八三、二九四·〇七
十一年	五三四、九一八·七一	三八五、八三〇·〇〇
十二年	五六二、〇七七·三三	三八〇、二〇六·七二
十三年	五一九、〇五〇·三六	三六七、四六九·三一
十四年	三八一、五九三·六六	二七五、七五〇·〇一
十五年	四〇六、二八〇·九一	三〇〇、七六四·二三
十六年	四四五、七八七·五二	三〇六、一六六·三八
十七年	四五八、七八七·二〇	三二〇、八〇九·〇九
十八年	四八八、二七二·一六	三二九、四四八·七二
十九年	五四六、一二四·九一	三八〇、七五〇·六三

犍為樂山鹽區銷額表

年別	犍為區每年銷鹽担數	樂山區每年銷鹽担數
民國九年	四三三、四六〇·三九担	三九七、九五八·一二担

十年	四九〇、三〇三·九七	三七六、九三七·〇四
十一年	五三五、二三八·五九	三七七、九一〇·三二
十二年	五二一、四一九·〇四	三七一、八一二·三〇
十三年	五二一、七〇九·四〇	三六〇、八七五·七〇
十四年	三九二、〇三五·一八	二六九、七〇八·八〇
十五年	二九八、〇九四·五五	三〇〇、一五〇·五〇
十六年	四五一、五一〇·七六	三〇九、三三六·九〇
十七年	四五七、七四四·六六	三一二、一〇八·〇〇
十八年	四七七、二五三·九八	三一七、五七三·五〇
十九年	五四八、〇二一·一〇	三九〇、三四七·六〇

犍爲樂山鹽區稅收表

年別	犍爲區每年稅收數目	樂山區每年稅收數目
民國九年	九七五、一一八·二二元	八二一、七八一·八四元
十年	九四七、二三八·九四	八四二、六二二·六七
十一年	一、〇六四、八一三·五七	七七〇、〇四六·五八
十二年	一、一〇六、一一九·六二	七九五、三八二·一四
十三年	一、〇五九、八四七·五〇	七五〇、二〇八·二六
十四年	八〇三、八三〇·〇六	五六一、一九五·八四

十五年	八二三、六一〇・一〇	六一九、一三四・九〇
十六年	九〇九、三〇三・二六	六四九、五一八・四二
十七年	九四九、七九一・七八	六四〇、二二六・四〇
十八年	九四一、九九七・一八	六四五、〇三六・三〇
十九年	一、一二七、二九三・九八	七八七、一〇五・六八

犍為鹽區鹽務機關，行政方面，設有犍為鹽場公署，樂山鹽場公署，各有場長，屬有驗放處點驗所等。稽核方面，有鹽務稽核支所，設於五通橋，屬有秤放處查驗處收稅處等，樂山鹽場有收稅處秤放處查驗局等。緝私方面，有緝私第六營，駐五通橋，第七營駐牛華溪。

井研仁壽資中鹽產

原為井仁資中兩鹽場，在川南鹽區，列為中等，產額居七八位，共計約一百餘萬担，稅收十餘萬元，位於富榮犍樂兩大鹽區之旁，產銷大受限制，僅有票岸，而無引額，東鄰簡陽樂至鹽場，又有時被侵銷之虞，惟鹽產範圍甚廣，區內人煙稠密，鹽業雖未必有大事發展之希望，然保持原狀，不至中落，則甚易也。

位置　鹽產在井研仁壽資中三縣境內，而產鹽地點散漫甚遠，由最南之產地，至最北之產地，約二百五十里，東西產地相距，亦二百餘里。在井研縣境者，為大水灣，千佛寺，鹽井灣，胡家店等處，均距井研城三四十里，再北為烏抛灣，距城七十餘里。在仁壽縣境內者，為楊泗井等處，北距仁壽城三十餘里，為城北門外，再北為中壩井，距縣城約一百里。在資中縣境者，為羅泉井一帶，在資中城西約一百一十里，金李井一帶，在城西約五十五里。鹽區內現出水者，共有井約一千六百餘眼，井淺而小，統屬於竈，規模猶遠不如犍樂鹽井也。(圖見第八版第十一版)。

地形　威遠榮縣以北山嶺，盤亙於四川盆地之西部，分向四周，山勢以次而低，鹽產環繞，南有富榮鹽產，西南為犍樂鹽產

，西，西北，北，東北四方俱爲井仁資中鹽產所在，井研鹽場居其西，仁壽鹽場在其西北，資中羅泉井鹽場居其北，金李井鹽場在其東北。而井仁資中鹽產以北，又爲一帶山嶺，東起簡陽，西南經仁壽之北，井研西北，可稱簡陽仁壽山嶺，高處約在七八百公尺之間，高度遜於威遠榮縣山嶺，兩大山嶺之間，爲低山邱陵區域，卽井仁資中鹽產所在。鹽區可分兩組，一在遠威榮縣山嶺西北坡麓，一在簡陽仁壽山嶺東南坡麓。井研城高出海面四百餘公尺，附近鹽區爲威遠榮縣山嶺西端低下之部，成一帶小山岡阜，高於井研不過數十公尺。由井研而東北，爲仁壽楊泗井鹽區，亦爲威榮山嶺向西北低下之部，而在其麓，成小山區。往東爲羅泉井鹽區，在威榮山嶺坡際，沿小河兩岸，羅泉井在河北岸，地勢較低，高出海面約四百五十公尺，而附近山嶺，高於羅泉井可至百餘公尺，鹽井均在山坡，高於小河數公尺至數十公尺，河向東北流，出區入沱江。再東爲金李井鹽區，在威榮山嶺東北坡，跨小河兩岸，附近小山高出，而鹽井均在山坡，河出區亦入沱江。此南組鹽區地形之大概。北組鹽區在井研爲烏抛灣區，在簡陽仁壽山嶺南坡，地勢高於井研，區內高低相差較大。往東北至仁壽縣城鹽區，傍城分佈，縣城高出海面約五百公尺，在簡仁山嶺南麓，向西北地勢高起，高巔高於縣城在二百公尺以上，縣城附近小山，亦常高出數十公尺，向東南地勢低平，鹽井所在，高與縣城相差不多，適在小谷低處。再東北至中壩井鹽區，在簡仁山嶺南麓，而亦成小山區域也。

地質　全區面積雖頗廣大，而地質尙屬簡單，地層次序關係可尋。攬觀之，南組鹽區，均與威遠榮縣大背斜穹窿層有關，而在其東北西三方，北組鹽區，多與仁壽斷層有關，而在其西。威遠榮縣大背斜穹窿層中部，有三疊紀灰岩層露出，由此分向四周，卽侏羅紀煤系所在，分佈甚廣，威榮一帶山嶺上部，多爲煤系所組成，穹窿層坡翼，白堊紀自流井層漸次發育，直至低山邱陵區域，向東南爲富榮鹽區，向西北卽井仁資中南組鹽區。低山邱陵區域北部，白堊紀嘉定層暴露較廣，而鹽產多不在其中，再北簡陽仁壽山嶺起處，有一斷層，自流井層因而露出，鹽井就此鑿下，仁壽鹽區卽斷層以西者也。井研城一帶鹽區，自流井層較爲發育，多紅紫色粘土及淺綠黃灰色砂岩，未見灰岩，當屬於自流井層上部，向西北有紅色粘土砂岩暴露，已至嘉定層之下部，但鹽井多在自流井層最上部鑿下。羅泉井鹽區附近，全爲自流井層，紅紫色粘土及淺綠灰色砂岩暴露最多，夾灰岩兩層，間有淺綠

色粘土，上層灰岩較厚，在十公尺以上，當相當於自流井大安寨灰岩，下層灰岩厚不過二三公尺，或與自流井東岳廟灰岩相當。據開鑿鹽井所得，先見紅色岩石，深處見黑色灰色灰白色砂岩，夾有煤層，紅色岩石爲自流井層之下部，深處卽當爲侏羅紀煤系。仁壽鹽區附近，地層可見者爲紅紫色粘土砂岩，深棕及棕紫色雲母砂岩，夾白灰色砂岩及淺綠色粘土，當屬於自流井層，而爲其中上部，在斷層之東者，爲紅色紫紅色粘土砂岩，夾淺綠色粘土砂岩，係屬於自流井層上之嘉定層。井仁資中鹽區，鹽井記錄多失而不存，卽存而亦不詳其所見，故地腹地質情形，所知甚少。至地質構造，最著者，爲威遠榮縣大背斜穹窿層，前已言之，南組鹽區，均位於穹窿層東北西坡翼，地層傾斜，由井研一帶至仁壽南境大致初向西北偏西，繼向西北偏北，斜度緩漫，由四度八度至十餘度不等　至羅泉井鹽區，地層傾斜大致向北，或稍偏西北，或稍偏東北，斜度甚緩，通常不過三五度。由羅泉井至仁壽縣，自流井層之紅紫色粘土淺綠灰色砂岩，及嘉定層之紅色粘土，大致均向西北傾斜，有時稍偏北，斜度頗緩，約在五度左右。

仁壽縣城東端有斷層，向東北西南延長，仰側爲自流井層，俯側爲嘉定層，斷層面向東南傾斜，斷層之西，地層大致向西北偏北傾斜，斜角十度左右，惟斷層近處，傾斜方向多無一定，在城北一帶，略成背斜穹窿層之狀，斷層之東，地層亦向西北偏北傾斜，斜度較緩，不過五度。仁壽斷層向東北西南是否延長甚遠，未能跟踪追尋，尙難確定，惟簡陽仁壽以北山嶺，東北自簡陽東北起，西南至井研之西止，延長數百里，而山嶺南坡，常有白堊紀自流井層暴露，而山麓低處，則常爲嘉定層，仁壽縣附近情形如斯，簡陽縣之北地層關係亦然，但未見明顯斷層接觸，尙難斷言，如果簡陽仁壽山嶺南麓，自流井層與嘉定層全爲斷層接觸，則仁壽斷層不過已發見之一部耳。(圖見第九版)。

礦床　井仁資中鹽產，各處均爲鹽水，產於地層中，與富榮犍樂鹽水大致相同，惟地點散漫寬廣，鹽井地位有異，故鹽水層位，亦有上下之分。井研一帶，鹽井多在自流井層上部鑿下，而井深由四五十丈至七八十丈，合一百六七十公尺至約三百公尺，犍樂鹽區一帶，自流井層厚度四百餘公尺，向東至富榮鹽區不下六七百公尺，井研鹽區臨近犍樂，而在其東，自流井層似當增厚，如此計算，井研鹽水尙未至侏羅紀煤系，而在白堊紀自流井層之下部，惟鹽井深淺不等，鹽水層位上下不同，無法參照比較

，只可暫以鹽水層帶名之，此一帶鹽水層，確在自流井層之下部，一部當與樂山河洱坎一帶鹽水層位相當。資中羅泉井鹽井，多在自流井層大安寨灰岩之下鑿下，井深由五十餘丈至一百八十丈，合二百公尺至六百餘公尺，大安寨灰岩下至侏羅紀煤系，不及二百公尺，即最淺之井，已進入侏羅紀煤系上部，而最深之井且已達侏羅紀煤系下部矣，如準確計之，開源竈富源潮源洪源三井，均在大安寨灰岩之底附近鑿下，而各井高低相差不多，富源井深約五百二十九公尺，潮源井深約五百二十三公尺，洪源井深約五百二十四公尺，大安寨灰岩距侏羅紀煤系一百八十公尺，如此計算，在煤系自頂而下三百四十餘公尺處，為一鹽水層位，但各鹽井深淺不等，層位不易分清，亦以帶名之，羅泉井有二鹽水層帶，一在侏羅紀煤系上部，距煤系之頂不遠，不過數十公尺，一在侏羅紀煤系下部，距煤系之底在二百公尺以內。仁壽鹽井，在自流井層上部鑿下，井深約六十丈合二百三十公尺有奇，附近一帶，未見灰岩露出，由鹽井所在，上登約一百一十餘公尺，即為嘉定層之紅色粘土，地層斜度在十度左右，如此計之，上由自流井層之頂，至鹽水層，約為三百公尺，自流井層厚度，在井研仁壽一帶，以五百公尺計，則鹽水層當在自流井層之下部，下距侏羅紀煤系，約二百公尺，在大安寨灰岩以下，與井研鹽水層帶一部相當。其餘鹽區未能觸處觀察，詳情未悉，但就鹽區位置及地質關係推論，資中金李井鹽水層帶，或與羅泉井一層帶相當，井研爲抛灣及仁壽中壩井鹽水層，或與仁壽城鹽水層相當。綜攬上述井研仁壽資中鹽區，有三鹽水層帶，一在侏羅紀煤系之下部，如羅泉井之深鹽水，一在侏羅紀煤系之上部，如羅泉井之淺鹽水，一在白堊紀自流井層之下部，如井研城仁壽城等處之鹽水是也

礦質　鹽水鹹度大小，各處不同，而成鹽種類，亦不一律，據川鹽紀要所載，羅泉井鹽水每斤淡者出鹽九錢三分，濃者一兩七錢六分。金李井鹽水淡者六錢五分，濃者一兩三錢六分。井研各區鹽水鹹度由八錢至一兩六錢五分。仁壽各區鹽水由九錢四分至一兩三錢六分。就調查所知，羅泉井裕模竈各井鹽水鹹度濃者一兩二錢，淡者七八錢，開源竈各井鹽水鹹度深井八九錢，淺井五六錢。金李井鹽水鹹度由六錢至一兩五錢。仁壽城順成竈鳳泉井鹽水鹹度一兩二錢。井研區各井鹽水鹹度由五錢至一兩。成鹽亦分花鹽巴鹽，在井研仁壽鹽區花鹽色白，爲細粒，巴鹽黑白色　資中羅泉井鹽分三種，爲巴鹽，花鹽中之精鹽，及普通花鹽，

均白色。金李井鹽分四種，爲花鹽，色白粒扁，花鹽中之精鹽，色白粒圓，花鹽中之面鹽，及巴鹽，色灰質不及花鹽。此鹽水成鹽質分種類之大概也。

採製　欲治鹽業，須先鑿井，鑿井法器，大致與富榮犍樂相同，惟井淺口小，工費低減，較易將事。井仁鹽井深由四五十丈至七八十丈，卽由一百六七十公尺至三百公尺，井口徑二寸餘。資中鹽井深由五十餘丈至一百八十丈，卽二百公尺至六百餘公尺，井口二寸四至三寸，普通二寸八。如鑿井深八十丈，需時十個月，用款約一千元。井成上立棚架，旁設盤車，汲水用竹製汲筒，長數丈，底安活塞，棚下立花滾子一個，上立竹竿，長三四丈，汲水筒上端繫竹篾，下入井，竹篾經花滾子繞於盤車上，車用牛推挽，二三牛不等，汲水筒下至井底，水冲開活塞入筒，筒上塞閉，汲水至井口，以竹篾引筒倚竿而上，不致傾倒，俟筒底出井，以鈎啓活塞，水流入積池，每筒盛水一百餘斤。井竈相距不遠，不必多用竹梘，製鹽之法，井仁資中各不相同，井仁製鹽花巴並成。燃料多用煤，井研間有用柴者。井仁製鹽用千斤鍋一口，重七百餘斤，徑四尺三寸，再用溫鍋及花鍋，溫鍋重二三百斤，徑四尺三寸，用溫鹽水，花鍋重五六十斤，徑二尺八九寸，用落鹽渣。鍋置於竈，燃火後徐徐添加鹽水，在成鹽之前，加豆漿提取雜質，使鹽潔白，約二三日可成鹽一餅，每次需鹽水一萬四千斤至二萬斤，成鹽重四五百斤至七百斤。花鹽製法略同，不使鹽質沉底，而多結成粗粒，每晝夜可出鹽三四百斤。資中鹽區煎鹽竈鍋方法不同，羅泉井又與金李井稍異，羅泉井一鍋內花鹽巴鹽並成，竈身深約四尺二寸，口徑四尺六寸，中置一大鍋，重一千二百斤，徑四尺一寸，深四寸餘，四圍安置小鍋四口或六口，小鍋重十六七斤，徑約二尺，四鍋者名梅花式，六鍋者名七星式，竈周圍均以砂石糊之，並加鐵塊爲邊，先將鹽水傾注四圍小鍋內，俟水沸騰，然後用木瓢陸續摻入大鍋，待煎一二日後，大鍋所成鹽末，名曰子鹽，復將子鹽舀還小鍋，陸續煎化，再行摻入大鍋，如此大鍋底面所結巴鹽，質始堅細，至四晝夜後，大鍋鹽質煎盡，所餘之水，名曰鹹水，舀盡鹹水，卽爲撤鹵，一面再將鹽水摻入小鍋，煎製如前，但須用豆漿提清，至七晝夜鹽成，下爲巴鹽，上爲花鹽，每次用鹽水約四萬斤，成鹽平均二千斤。金李井製巴鹽法與羅泉井同，鹽鍋較小，僅成巴鹽，製花鹽法稍異，竈式有兩種，爲牛尾竈及蜻蜓竈，

均於開煎時用炭火猛燒，俟鹽水煎濃，卽將豆漿摻入小鍋內，提淨雜質，越時生鹽，沉入鍋底，再以木瓢舀入大鍋內，迨其愈煎愈乾，只餘鹹汁，卽將鹽舀入篾簍，流去鹹水，則成花鹽。成鹽時間，約十二小時，製巴鹽需七日，每次用鹽水一萬餘斤，成鹽一千四百斤，花鹽每次用鹽水數百斤至千餘斤，成鹽數十斤至三百斤。此井仁資中鹽產採製大概之情形也。

礦業　據鹽務載籍，資中產鹽始於秦、盛於宋元，井研鹽場唐代最盛，元時併入仁壽，金李井採鹽始於明，至清代復興，清雍正間，羅泉設官管理鹽務，及後分爲羅廠金廠，民國以來，兩廠統名爲資中鹽場，設場署於羅泉井，設場分署於金李井，井仁場在清末設立票釐局於胡家店，民國以來改榷稅司，今改場署，設井研縣城。井仁資中鹽商，大抵以竈統井，往往以竈立號，而無井名，開辦之始，先鑿鹽井，數目不一，深淺不同，所用資本，每井由五百元至一千元，以井之深淺大小而異，現有井一千六百餘眼，井成見水，卽組織鹽竈，小者用款一百元，如金李井小竈，大者可至二十餘萬元，如羅泉井開源竈，普通一千元至三千元，仁壽順成竈資本一萬元，羅泉井裕模竈資本約一萬五千元，爲竈之大者。共有竈戶三百四十餘家，竈商費款除備置物品外，爲人工及燃料，鹽井出水，須用牛推，需牛數頭十數頭不等，每頭價平均六七十元。竈房用鍋，羅泉井大鍋每口價一百餘元，小鍋價二三元，金李井大鍋每口約七八十元，井仁場大鍋價洋約一百六十元，温鍋一百一二十元，花鍋約五六元。資中鹽場汲水工人，工資以月計，每人每月二三十吊，約合洋二元，山匠月約四元，煎鹽工人，煎巴鹽二人晝夜換班，至成鹽止，每次每人工資十餘吊，約合洋捌角。井仁鹽場井工，每人每日工資一吊合洋六七分，鹽匠每人每日工資一吊二百文，約合洋八分，均由商給食。燃料除井研一小部有時用柴外，均用煤，羅泉井煎鹽一鍋，每次用煤約一萬一千斤，價約四十元，由仁壽萬家溝運來，仁壽煎鹽一餅，用煤約四千二百斤，每斤價由九十文至一百二十文，共合洋三十元，亦自萬家溝運來，井研煎鹽一餅用煤二千二三百斤，每斤價一百文，共合洋約十八元，由榮縣仁壽煤窰運來。成鹽成本羅泉井每百斤巴鹽七元，精花鹽六元，普通花鹽五元五角，有時成本低減，每百斤三元四元不等，金李井每百斤巴鹽成本六元，精花鹽四元二角，普通花鹽四元　，井仁場每百斤巴鹽成本由四元至五元，花鹽由二元七八角至三元一二角。據今年調查所知，仁壽每餅巴鹽重七百斤，成本六百數十吊，約合洋四十餘元

，井研每百斤成本八十吊，約合洋六元。成鹽在場售賣價值，井仁場每百斤巴鹽由四元五角至五元五角，花鹽由二元七八角至三元五角，貧中羅泉井鹽價每百斤巴鹽七元，花鹽五元六角，金李井巴鹽六元二角，花鹽四元三角。就今年調查所知，羅泉井巴鹽每百斤一百一十吊，約合洋七元四角，精花鹽八十八吊，約合洋五元九角，普通花鹽七十八吊，約合洋五元二角，，仁壽鹽價每斤一吊，約合洋六分，每百斤合洋六元，此井竈經營之大概也。

鹽成卽行抬入官公垣，存儲倉內，倉門啓閉，均有定時，由官商會同管理，花鹽均用篾簍裝好，巴鹽不加包裝：凡商販運鹽，先向官公垣報運，繳淸鹽價，掣取憑單，向收稅處繳稅，稅率每百斤正稅一元六角，領取運票，持向官公垣取鹽，過秤後，由收稅處秤對，再由場署員丁查驗放行，鹽斤包裝，花鹽用竹簍，巴鹽用竹簕，每簍簕均約一百斤，花鹽加滷耗二斤至六斤，皮重四斤至六斤，巴鹽加滷耗一斤半至三斤，皮重三斤。運鹽或人力担挑，或騾馬駝負。運費每鹽一百斤每里一百二十文，卽每一百里約需洋捌角　運銷仁壽井研榮縣簡陽貧中資陽威遠境內，無引鹽，故銷額無分配之定數。玆將各場產銷數目，及稅收多少，按年分別表列如左。

井研仁壽貧中鹽區產額表

年別	井仁區每年產鹽担數	貧中區每年產鹽担數
民國九年	一〇七、〇二八・二五担	四四、九三五・〇八担
十年	一〇一、八六三・八四	四三、八八一・七八
十一年	一〇三、四八四・六八	四三、七一〇・七二
十二年	一〇六、三六七・二四	四六、五七〇・五四
十三年	九九、四八八・六一	四四、五八八・八三
十四年	八七、二二一・一七	四〇、一六〇・三八

十五年	七八、七八二・八三	四〇、三〇〇・七六
十六年	七二、〇一二・四九	三八、〇九六・五八
十七年	七三、〇三五・九八	三五、六二七・八三
十八年	六七、二〇二・五五	三〇、八一八・九五
十九年	八三、六三四・二一	三六、九〇〇・五一

井研仁壽資中鹽區銷額表

年別	井仁區每年銷鹽担數	資中區每年銷鹽担數
民國九年	一〇五、三九三・五八担	四四、五一〇・六〇
十年	九七、三六三・二二	四五、九八五・二〇
十一年	一〇〇、一六八・六六	四二、八五五・一〇
十二年	九八、二四三・五〇	四四、七五六・七〇
十三年	九六、六六二・六〇	四〇、五五三・一〇
十四年	七八、一九〇・六〇	四一、一七四・〇〇
十五年	七三、四八七・四〇	三六、九〇二・三〇
十六年	七一、〇〇七・六〇	三六、六六六・一〇
十七年	六六、五五六・五〇	三二、〇六九・〇〇
十八年	六五、三六一・三〇	三三、八四二・五〇
十九年	八四、五四七・九〇	三五、一七〇・七〇

井研仁壽資中鹽區稅收表

年別	井仁區每年稅收數目	資中區每年稅收數目
民國九年	一六八、六二九・七二八元	七一、〇四二・三〇元
十年	一五五、六二一・五二	七三、五七六・三二
十一年	一六〇、二六九・八五六	六八、五六八・一六
十二年	一五七、一八九・六〇〇	七一、六一〇・七二
十三年	一五四・六六〇・一六〇	六四、八八四・九六
十四年	一二五、一〇四・九六〇	六五、八七八・四〇
十五年	一一七、五七九・八四〇	五九、〇四三・六八
十六年	一一三、六一二・一六〇	五八、六六五・七六
十七年	一〇六、四九〇・四〇〇	五一、三一〇・四〇
十八年	一〇四、五七八・〇八〇	五四、一四八・〇〇
十九年	一三五、二七六・六四	五六、二七三・一二

井仁資中鹽區鹽務管理，行政方面，有井仁鹽場公署設井研縣城，資中鹽場公署，設羅泉井，分署設金李井。稽核方面，有井仁鹽稅局，在井研縣城，資中鹽稅局，在羅泉井，下有收稅處分住各區。緝私方面，有緝私第七營第二連駐井研城，第五營第二連駐羅泉井。

川北鹽產

四川產鹽區域，向有川南川北之分，屬于川南者十六場，屬于川北者十二場，川南川北，非但鹽業情形不同，產額稅收多寡

有差，而採製方法規模，鹽產地質鑛床，亦稍殊異。以區域言，川南鹽場，散漫甚遠，東至奉節，而西達鹽源，長數千里，範圍超出四川盆地，而川北鹽場，大致多相連接，距離不遙，均位于四川盆地西部，而偏北方。以地質言，川南鹽場多與地質構造有關，而鹽產所在，有時甚深，川北鹽場除西邊一小部外，多在地層平緩區域，構造頗不顯著，而鹽產鑛床，距地面不遠，淺于川南深鹽水層者倍蓰。川南鹽水鹹度大者，每斤含鹽在三兩以上，鹽井大者，每晝夜可出鹽水十萬斤，而川北鹽水鹹度一兩五六錢者，即為旺井，鹹度在二兩以上者極少，旺井每日鹽水多者，不過數千斤。川南鹽竈大者，有鹽鍋數百口，日出鹽三四萬斤，川北鹽竈大者，不過十餘鍋，數十鍋者甚少，惟綿陽一竈有五十餘鍋者，日出鹽至多不逾千斤。相形之下，優劣判然。然治其業者，數十萬人，年產鹽一百數十萬担，稅收一百數十萬元，亦川中一大利源也。鹽產區域，包有南閬鹽場，綿陽鹽場，三台鹽場，西鹽鹽場，中江鹽場，蓬中鹽場，射洪鹽場，射蓬鹽場，蓬遂鹽場，樂至鹽場，簡陽鹽場，南鹽鹽場，共有鹽井約十萬眼。分佈面積，東西長約五百里，南北廣約四百里，而鹽場區域大者，在數十里範圍以內也。

位置　川北鹽產分佈雖廣，然鹽場所在，非彼此相連，而常各成一區，每區各部，有時亦斷而不續，故計其實際產鹽面積，不甚寬大，不能依其範圍而定也。茲按鹽場略分述其位置範圍。南閬鹽場，在南部縣北部，閬中縣南部，及兩縣交界一帶，著名地點，在南部縣城東者，為馬料溪三合場瀘溪場羅面場，楠木寺等處，在城西者，為定水寺，黃連埡，碾埡場，吳家場，杜家井，大橋場，老鸛場等處，在閬中縣境者，為興隆場，樓埡場，水觀音等處。產鹽地點分佈所在，東西長約一百餘里，南北寬五六十里，為川北鹽場之大者。射蓬鹽場，在射洪縣東南境，蓬溪縣西南境，兩縣交界一帶，產鹽地點，為太和鎮，羊溪鎮，青堤渡，柳樹沱，青岡場一帶，東西長約六七十里，南北寬約四五十里。三台鹽場，在三台縣境，在城東北產鹽地點，為興隆場，田邊子，南峯寺，楊家井，三清觀，槐樹場，塔子山，馬康橋，柳池井等處，南北廣約四五十里，東西長約一二十里，在城南為河嘴黃明月，魚洞井，下觀音橋，石板灘等處，東西長約三四十里，南北廣約二三十里，在城西北為黃泥井，攔河堰一帶，東西長約三四十里，南北寬約一二十里。蓬中鹽場，在蓬溪縣中部北部，產鹽地點，散漫廣遠，著名者，在城北為上河街，下河街，三

匯場，文井場，鑼鍋場，槐花場，板橋場，在城西者，為明月場，常樂場等處，東西長約六七十里，南北廣約四五十里。綿陽鹽場，在綿陽縣東南部，著名產鹽地點，為豐谷井，白池口，左家岩，五里梁，小梘溝一帶，南北長約三四十里，東西寬約一二十里。蓬遂鹽場，在蓬溪縣西南境，遂寧縣西境，及兩縣交界一帶，產鹽地點，在蓬溪境內者，為錢家井，石板灘，玉峯場，觀音寺，甑子場，地風井，河邊場，大堰場等處，在遂寧境內者，為洛陽橋，欄江河，廣福寺，白馬寺，分水嶺一帶，南北長約八九十里，東西廣約四五十里。西鹽鹽場，在西充縣東北西三部，鹽亭縣東北部，散在兩縣屬境，面積廣大，故另分出一部，名為南鹽鹽場，著名地點，在西充境內，為忠和場，永興場，義興場，碾埡場，槐樹場，羊鹿場，會龍場等處，在鹽亭境內為金鷄場，會實場一帶，鹽區東西之長一百餘里，南北寬處亦近百里。射洪鹽場，在射洪縣中部，縣城與太和鎮之間，南北長約五十餘里，東西廣約四十里。中江鹽場，在中江縣東南部胖子鎮一帶，產鹽地點，為矮子橋，新場，永灃場，普興場，大河邊等處，南北長約四五十里，東西寬約二三十里。樂至鹽場，在樂至縣中部西部，惟東南一隅不產鹽，著名地點，為太極場，石佛場，金龍場，塘堰場，賓林場，七壩場，放生場，香泉舖，高寺場，童家壩，中天場，桂林場，臨江場，興隆場，孔雀場，石湍鎮等處，產鹽區域長寬均一百餘里。簡陽陽鹽場，在簡縣北部西部一，在由縣城至成都大路附近一帶，及沱江西岸，石橋井海井關等處，南北長約三十餘里，東西寬約十餘里，一在城西老君井附近，長寬不過數里而已。南鹽鹽場，原為南閬西鹽兩鹽場之一部，在鹽亭中部西部三元場，棕樹溝，黃泥井，雙碑埡，毛公場，兩河口等處，東西長約四五十里，南北寬約三四十里，及南部西部富村驛一帶，長廣不過十餘里。此川北鹽產所在地域之情形也。(圖見第十一版)。

地形　四川盆地，四周環山，中有山嶺數條，高大而顯著者，在東部為華鎣山嶺，在西部為威遠榮縣山嶺，及簡陽仁壽山嶺，地勢較高，餘多小山邱陵區域，山不高大，而常成孤立，川北鹽產，除簡陽鹽區一部外，均位于小山邱陵之一部，地形特異，與普通小山區域不同。北自岷山大巴山山脈以南，山勢漸低，至綿陽閬中以北，陡落為小山區域，或一部為平原，卽川北鹽產之北界。簡陽仁壽山嶺由西南綿延而東北至簡陽之東北，山勢漸殺，沒于小山區域，簡陽鹽區卽在簡仁山嶺之盡端。華鎣山逾嘉陵

江而西，勢猶未盡，至銅梁大足之北，沒于小山區域，再北為樂至蓬遂鹽區，此川北鹽產之南界也。嘉陵江上游自合川而北至閬中為鹽產之東界，向東地形雖未變改，而無鹽場，再東為大巴山華鎣山支脈所在。鹽產區內重要水道，東為涪江，為嘉陵江之支流，西為沱江上游，支流縱橫，貫注全區。山均低小而數極多，遠望之，山巔棋佈，高似相等，高度均在五百六百公尺之間，高于沿河低處，由數十尺至百餘公尺，山多孤立，上部不相連接，因而溝渠廻灣甚多，上下崎嶇，道路蜿蜒，其有剝蝕較淺部份而成岡阜者，坡緩溝淺，轉運較便。曠觀之，川北鹽產區域，北部高而南部低，北部剝蝕較淺，邱陵地形稍著，而間有狹小平原，南部剝蝕較深，小山地形較多，溝渠少處，岡阜亦顯，推此區域地形之成，原係一帶低原，地面平坦，後經剝蝕作用，河流侵削，地層多為平緩，構造不著，水系不受其影響，而依以前地面凸凹之形勢而成者也。

地質　川北鹽產區域，地質頗為簡單，地層系統不多，地質構造不著，除區域西南端簡陽鹽區一部，為白堊紀自流井層外，大致均為白堊紀嘉定層，在區域之北盆地山地交界，侏羅紀煤系之上，有紅紫棕色砂岩粘土夾礫岩，屬自流井層，除受斷層之影響局部有變動外，地層大致傾斜東南偏南。自流井層以上，即嘉定層，兩相整合，入鹽產區域，地層多成平層，分佈廣遠，直至東界南界出區猶繼續暴露不變，西南部簡陽鹽區之北，龍泉驛山，為簡陽仁壽山嶺之一部，似為自流井層紅棕色砂岩，內夾礫岩，又與區域之北者近似，簡陽附近為嘉定層之上部，中間接觸情形，分界所在，未能確悉，而鹽井均在嘉定層鑿下者，嘉定層地層簡單，大部為紅色粘土砂岩，有時夾淺綠灰色砂岩粘土，岩石色性，各處無多變改，粘土砂岩交互而生，地層如成平層，砂岩常成懸崖絕壁，而粘土所在，每為斜坡，望而可辨其岩層種類也。據美國人勞德伯克報告，由蓬溪縣蓬萊鎮至射洪縣中間所見地層，下部為紅色粘土頁岩，夾紅色砂岩，砂質頁岩，綠色頁岩，及淺紅灰白色砂岩，上部為白色厚砂岩，紅色粘土頁岩，灰色砂岩，夾紅色粘土砂岩，由射洪至西充，不外紅色粘土頁岩夾白灰棕色砂岩，與遂甯蓬溪射洪等處之紅色岩層相同，即作者所名之嘉定層也。鹽產區域，因大部地層平緩，地質構造極為簡單，地層僅有上下起伏，呈波彎之狀，而鮮褶皺構造，據作者所經區域南部樂至遂甯蓬溪一帶，未見顯著背斜向斜層踪跡，地層傾斜雖有時可至五度以上，而方向無定，不便解以成形構造，而強

爲湊合。據日人報告，在區域北部，有時有背斜層或半穹隆層之跡，然卽其圖而考所注地層傾斜，率皆漫無定向，斜角頗小，而所標構造，有時實嫌牽強，未可依據。簡陽鹽區，在簡仁山嶺坡麓，簡陽縣城之北龍泉驛山，呈背斜層之觀，北翼地層傾斜較陡，而南翼地層較緩，鹽區一部與背斜層有關，然向南至簡陽城地層又多成平層矣。

鑛床　川北鹽產區域，地表露出地層，均屬白堊紀嘉定層，分佈最廣，自流井層僅見于一隅，而侏羅紀煤系，深藏地腹，未能暴露，鹽井除簡陽鹽區一小部在自流井層外，餘均鑿于嘉定層內，因鑿井記錄不存，地腹地層未能確悉，故鹽水層位，不易推測比較，惟就各層厚度及鹽井深淺位置，互相考證，鹽水層帶，或可粗定，如龍泉驛山南麓，確有斷層，自流井層在其仰側，則簡陽鹽區老君井鹽水，似爲川北鹽產之最深者，鹽井深度，雖不一律，但均不過數十丈，普通約一二百公尺，鹽井在自流井層中部鑿下，計其所及，尙在自流井層下部，或與仁壽鹽水層帶相當。其他各鹽區鹽井最深者不過一百二十丈，約合四百六十餘公尺，鹽井所在，爲嘉定層之中部，嘉定層平均厚度約五百公尺，如此計算，最深鹽井已進入自流井層，不過二三百公尺，猶較淺于簡陽老君井鹽水層位，而另成一鹽水層帶，中等鹽井，由五十丈至八十丈，卽由約二百公尺至三百餘公尺，尙限于嘉定層之下部，而成一鹽水層帶。淺鹽井約二三十丈，卽一百公尺左右，鹽水層位更淺，不出嘉定層中部。又在樂至鹽區所見，鹽井頗淺，有十丈者有一百六十尺者，卽由四十公尺至六十餘公尺，鹽井均在嘉定層中部鑿下，而位于山坡高處，此與鹽井深一百公尺者，可同屬于一鹽水層帶，而在嘉定層之中部。綜覽上述，川北鹽產鹽水層位，可分四帶，由上而下，一爲嘉定層中部鹽水層帶，樂至蓬遂鹽井之鹽水屬之，二爲嘉定層下部鹽水層帶，各鹽井鹽水深五十丈至八十丈者屬之，三爲自流井層上部鹽水層帶，各鹽區鹽水深在一百丈以上者屬之，四爲自流井層下部鹽水層帶，簡陽鹽區老君井之鹽水屬之。川北鹽水，大致均出自草白沙內，卽含鹽水層爲一種白灰色或淺綠灰色砂岩也。

鑛質　川北鹽水，鹹度較小，且含雜質，故于煎熬之前，經過濾晒方法，去其雜質，增其鹽量，普通各竈，所云鹹度，率皆濾晒以後每斤所含鹽量，或用包氏量滷表度計算。據川鹽紀要所載，三台鹽水鹹度每斤含鹽由四五錢至一兩五六錢，蓬中鹽水每

斤由一兩二三錢至一兩七八錢，蓬溪鹽水每斤由七八錢至一兩三四錢，簡陽鹽水每斤七八錢，而樂本鹽水鹹度最大，每斤含鹽二兩一二錢。如按包氏表度計算，射洪原鹽水鹹度爲六，經濾晒後增至十一，射蓬原鹽水爲七，濾晒後爲十六，簡陽原鹽水爲五又四分之三，濾晒後爲十，三台原鹽水爲六又十分之七，濾晒後爲十四，綿陽原鹽水爲七，濾晒後爲十一，西鹽原鹽水爲七，濾晒後爲十四，中江原鹽水爲七又三分之一，濾晒後爲十一，蓬中原鹽水爲八又四分之三，濾晒後爲十四又二分之一，樂至原鹽水爲十，濾晒後增至二十，射蓬原鹽水爲十三，清濾後量無增減。此鹽水質分之優劣也。成鹽種類不外花巴兩種，而所用燃料不同，有火氣煤柴之別，故又分炭花鹽炭巴鹽柴花鹽柴巴鹽火花鹽，而巴鹽又分白巴黑巴，樂至鹽場製有一種特別花鹽，名墩子，質堅色白，較普通花鹽質佳，而價亦較昂也。

採製　川北鹽場，採鹽製鹽，規模較小，鹽井，淺開鑿易，鹽場大者，動輙鹽井數萬，可證其工輕易舉，此井涸竭，便可另鑿新井。鑿井方法與川南鹽場相同，器具大同小異，井深十數丈數十丈百數丈不等，口徑二三寸，井成後旁設轆轤式盤車，用以盤繞竹篾，提取汲筒，筒亦竹製，下有活塞，上連竹篾，長約二丈餘，可盛鹽水數十斤，井旁立一竹桿，上有環，另有竹篾繞經下垂，盤車用人力，筒出井後，用竹篾引上，依附竹竿，至筒底出井，啓活塞出鹽水，（圖見第三十一版），鹽井出水多者，每日可至五六十担，少者半担一担不等，各鹽場鹽井多少不同，未必俱爲旺井。射蓬鹽場有鹽一井萬餘眼，旺井只五十餘眼，每井每日出水二三担。南閬鹽場鹽井約兩萬眼。蓬中鹽場一萬餘眼。射洪鹽場一千餘眼。樂至鹽場鹽井兩萬餘眼，內有廢井六千餘眼。綿陽鹽場鹽井二千五百餘眼，內有廢井一千八九百眼。西鹽鹽場鹽井二千八百餘眼。中江鹽場鹽井二千六百餘眼，內有廢井一千餘眼，又有火井二百餘眼。蓬溪鹽場鹽井一萬餘眼。三台鹽場鹽井三千餘眼。簡陽鹽場鹽井五百餘眼，壞井甚多，出鹽水者，僅二百餘眼。鹽水出井後，大抵均用木桶挑担，運入竈房，但在煎熬之前，須經濾晒。在南閬鹽井，于竈後設壠，縱橫架土磚，中留火路，磚燒紅，以鹽水浸之，名曰冰土，碎冰土入桶溶化，濾出之水，始能煎鹽，竈有大中小之分，鍋有大鐵鍋二號三號鐵鍋之分，大竈燒大鐵鍋八九口，中竈燒二號鐵鍋五六口，小竈燒三號鐵鍋二三口或一口，燃料用煤與柴，鹽水入鍋，用烈火

煎至結晶時，名曰老水，取之入樑桶，濾清，略加猪肉，再入鍋以微火熬至結晶成鹽，爲花鹽。在射蓬鹽場，以鹽水與黃泥裝于篁內，澄過一次，復用草燒灰，另裝一篁，以黃泥澄過之鹽水，再澄過一次，方用以煎鹽，竈亦有大中小之分，鍋有大平鍋二平鍋兩種，大竈燒大平鍋三口或二口小平鍋一口，中竈燒大平鍋一口，小竈燒大平鍋一口或二平鍋一口，燃料用煤與柴，將澄過之鹽水，梘入温水鍋內煎熬，再轉入大平鍋內，以火煎之，一晝夜成鹽，分花巴兩種。在三台鹽場，將鹽水潑灰晒鹹濾過，始能煎鹽，竈亦分大中小三種，鍋有大元鍋，二元鍋，大元坦鍋，二重鍋，平重鍋，加水鍋，小薄鍋等等，大竈燒鍋十餘口，中竈七八口，小竈二口至五口，燃整用柴或煤，鹽分花巴兩種。在綿陽鹽場，濾晒鹽水煎鹽，手續甚繁，燃料用柴與煤，其製造手續，一曰灌竈，竈成長式，列鍋數口十餘口，兩鍋之旁，掘一高約一尺之方坑，時以鹽水注之，經火烘乾鹽水竈土，經十餘日，取竈土入篁，以鹽水透之，二曰發爐，以篁內透過之土，作成磚形，堆砌竈尾，高丈餘，圍三丈，竈烟經過，火烘磚乾，時以鹽水潑之，約經三十日，將爐磚取入篁內，仍以鹽水透之，三曰晒灰，取透過之爐土竈土，搗細成灰，舖置地上，每值晴日晒之，復以鹽水潑十餘次，晒乾，再取入篁內，仍以鹽水透之，四曰濾水，每竈另置一鍋，上安漏底鍋一口，內裝草灰，面蓋篾笆，將鹽水煎沸，淘入濾鍋，濾去渣滓，五曰取穌，鹽汁煎沸時，穌水浮于鍋面，鹽質沉于鍋底，將穌撇入穌鍋，另將鹽汁，取入鹽鍋，淘洗數次，鹽成花巴兩種。在西鹽鹽場，先將水澄清再煎，竈鍋均分大中小三種，大中竈用三種鍋，小竈只用中小鍋，燃料用柴，鹽水澄清後，入温水鍋，加皂角水提煉，鍋成花鍋一種。在中江鹽場，分柴竈火竈兩種，有大中小之分，鍋有大鹽鍋金圓鍋尾鍋大斗鍋小斗鍋等等，大鹽鍋徑七尺，金圓鍋徑三四尺，大小斗鍋徑二尺餘，于竈後設壠，橫架土磚，中通火路，磚燒紅後，以鹽水浸之，經二十日，取磚碎之，入桶溶化成汁，柴竈製鹽，以鹽汁入温水鍋，再轉入鹽鍋，約一晝夜，可成鹽，火竈製鹽鹽汁直入鹽鍋，煎熬，鹽成，亦分花巴兩種。在射洪鹽場，先以泥灰舖地，時以鹽水潑之，晒乾，旋潑旋晒，再澄清濾過，方能煎熬，竈鍋均分大小，燃料用煤，取濾清之鹽水，入温水鍋中煎熬，濾去鹹質，然後用烈火煎一晝夜成鹽，分花巴兩種。在蓬中鹽場，將鹽水濾過數次，然後煎熬，竈分大中小，鍋爲一種，燃料用柴與煤，鹽水入鍋煎一晝夜成鹽，分花巴兩種

。在蓬遂鹽場，先將鹽水澄清濾過再煎，竈分大中小，式分燕尾長竈樓竈三種，鍋有雙鍋單鍋熬飯鍋，水多者燒二口，爲雙鍋，水少者燒一口爲單鍋，貧民半耕半商，自汲自煎者，爲飯鍋鹽，燃料用柴與煤，鹽水入溫水鍋，如煎花鹽，則加豆漿提煉，成晶粒，如煎巴鹽，則加花鹽數十斤及新鹽水熬煉成冰塊。在樂至鹽場，先以鹽水潑灰，法係修竈兩座，一煎鹽，一溫水，竈後接修泥爐，用泥作團若干，堆積爐上，由鹽鍋火尾直冲竈上，薰乾泥團，以鹽水浸之，名曰鹹頭泥，將泥團打碎，入桶溶化，濾出之水煎鹽，竈亦分大中小三種，鍋有二元鍋大飯鍋小飯鍋等，燃料用柴與煤，鹽水梘入溫水鍋，再轉入鹽鍋煎熬成鹽，近鍋底者爲巴鹽，在鍋面者爲花鹽。在簡陽鹽場，先于平地挖竈，按次安鍋三四口不等，在鍋頭築方形磚圈，鹽爐上潑鹽水，用竈中火力烘乾，旋乾旋潑，至九晝夜之久，然後拆取爐土，以鹽水泡取鹽汁，竈爲中竈，鍋分大小，燃料用柴與煤，鹽汁入鍋煎熬，成花巴鹽兩種。南鹽鹽場，本由南閬西鹽兩場分出，製鹽方法與兩場相同。此川北鹽產採製之大概也。

鑛業　川北鹽產開發肇始，各場不同，以中江鹽場爲最古，秦廣漢之地，卽今中江縣境，已有鹽井之富。簡陽產鹽始于漢代，陽明鎭卽廢井處。三台鹽產亦開自漢代，時爲郪縣，有山原田富國鹽井。其餘各鹽場，大抵均始于唐。射洪卽唐之通泉縣，時有赤東鹽井。蓬溪唐時有化鹽池。遂寧卽唐之方義安居普慈等縣境，時有鹽井三十所。綿陽卽唐之魏城縣鹽泉縣境，已有鹽井。西充南充閬中鹽亭樂至等縣，在唐時均已產鹽，惟詳多不可稽考耳。至明朝鹽業漸興，清初大盛，迄今未衰。區內井竈甚多，大小不等，營業複雜，不能詳述，只就所知產銷情形，按場略敍，用備參考。南閬鹽場有竈一千五百餘戶，每年產額約三十七萬餘担，每担徵稅一元〇四分，設有公垣三十一處，配銷通江南江巴中儀隴廣元昭化劍閣蒼溪蓬安等縣。射蓬鹽場有竈六七百戶，年產花鹽約九十餘萬担，巴鹽十二萬担，引巴鹽每引五十包，每包一百六十斤，每担徵稅二元，引花鹽每引五十包，每包二百斤，每担徵稅一元六角一分，票鹽分花巴及水運陸運，水運花鹽，每担徵稅一元三角二分，巴鹽一元四角六分，陸運花鹽，每担徵稅一元一角，巴鹽一元一角二分，設有公垣五處，分垣七處，引鹽配銷巴縣之木洞涪陵之藺市及南川江北廣安岳池等縣，票鹽行銷射洪蓬溪合川等縣。蓬中鹽場有竈四百餘戶，年產鹽約十三萬餘担，每担徵稅一元一角二分，設有公垣十處，行

銷遂寧南充營山武勝等縣。射洪鹽場有竈二百餘戶，年產約八十餘萬担，水運花鹽每担徵稅一元三角二分，巴鹽每担一元四角一分，陸運花鹽每担徵稅一元一角，巴鹽一元一角二分，設有公垣兩處，行銷上至中江廣漢德陽什邡羅江，下至合川璧山銅梁武勝等縣。綿陽鹽場有竈一百餘戶，年產鹽十二三萬担，每担徵稅一元一角，設有公垣五處，行銷綿陽中江三台安縣北川梓潼羅江彰明江油什邡平武茂縣等縣。西鹽鹽場有竈三百五十餘戶，年產鹽約十萬担，每担徵稅一元〇七分，設有公垣六處，行銷西充鹽亭梓潼劍閣巴中營山武勝蓬安南部閬中蒼溪廣元儀隴三台岳池渠縣射洪通江南江昭化廣安等縣。中江鹽場有竈八百餘戶，年產花鹽約一萬二千餘担，巴鹽萬三千餘担，花鹽每担徵稅一元一角，巴鹽一元一角二分，設有公垣八處，行銷中江縣之胖子店良安場太平橋積金場廣福鎭及淮州廣漢等處。三台鹽場有竈六百餘戶，年產鹽約十萬餘担，花鹽每担徵稅一元一角，巴鹽一元一角二分，設有公垣二十處，行銷三台中江廣漢什邡江油茂縣綿陽綿竹梓潼羅江等縣。蓬遂鹽場有竈四百六十餘戶，年產鹽約八萬七千餘担，花鹽每担徵稅一元一角，巴鹽一元一角二分，設有公垣十四處，行銷除中江遠近各場外，上至金堂廣漢什邡彭縣，下至遂甯潼南安岳等縣。樂至鹽場有竈五百餘戶，年產鹽約十五萬担，花鹽每担徵稅一元一角，巴鹽一元一角二分，設有公垣十七處，行銷樂至安岳簡陽遂寗金堂中江廣漢資陽等縣。簡陽鹽場有竈四十餘戶，年產鹽約七萬餘担，分引鹽票鹽，引巴鹽每引五十包，每包一百六十斤，每担徵稅一元七角四分，票鹽不論花巴，每担徵稅一元四角七分，設有公垣三處，引鹽配銷成都華陽新都金堂四縣，票鹽只銷簡陽資陽廣漢等縣。南鹽鹽場由南閬西鹽兩場分出，鹽亭三元場榤樹溝雙碑埡毛公場兩河口六公垣所統井竈，及南部富村一垣所統井竈屬之，年產鹽五萬担以上，稅率銷岸與南閬西鹽兩場同。此川北鹽產鑛業大概之情形也。

川東鹽產

川南鹽區，統有十六鹽場，散在各處，相距甚遠，地質情形旣不盡同，地形狀況亦各殊異，川東各處鹽場，本屬川南，但距川南鹽區重要部份，近者一千餘里，遠者在二千里以上，地形地質均不連屬，故另分出，名爲川東鹽產，而區域內各鹽場地形地

質，多有聯帶關係。以地質構造而言，由涪陵至奉節本為一大向斜層，而川東忠縣萬縣雲陽開縣奉節大寧六鹽場，多與此向斜層有關，忠縣萬縣雲陽奉節四場，均在向斜層中，臨近層底，大寧開縣均在其北，開縣鹽場似與其北背斜層有關，而大寧鹽場則在此向斜層外之褶皺區域，而與其東端相連。惟產鹽地層，未必處處相同，採製方法，鹽業盛衰，亦各不一致，雲陽鹽場年產三十餘萬担，而萬縣鹽場年產僅二三百担，相差如斯其鉅，然井淺數少規模不大則一也。

位置　川東鹽產，分佈廣遠，然各鹽場不相連屬，均自成一區，雖所在面積頗大，而出鹽地域，則甚狹小。茲按鹽場敍其位置。忠縣鹽場分為二區，一在㽏鄉，南距縣城約三十里，名㽏井，產鹽地點南北相距里許，一在汝溪鄉，西南距縣城約七十里，名塗井，產鹽地點南北相距一里，而兩區相距約七十里。萬縣鹽場在萬縣南區約九十里長灘井一帶，在大江以南，產鹽地域狹小。雲陽鹽場在雲陽縣城西北三十里雲安鎮一帶，產鹽地點東西較長，不過里許。奉節鹽場在奉節縣城東約七里磧壩一帶，大江以北為北廠，以南為南廠，產鹽地域南北不過里許。大甯鹽場在巫溪縣北約三十里，區域東西長約五里，南北寬不及半里，然產鹽地點，僅為一池，為鹽產之特別者。開縣鹽場在開縣東北約六十里温塘井附近，區域南北相距約一里半，東西寬處里許，但鹽井所在地點尤狹，只限于沿河兩岸。此川東產鹽之方位也。(圖見第十一版)。

地形　川東產鹽區域，多與揚子江谿谷有關，奉節鹽場緊傍江岸，忠縣雲陽萬縣三場，距江雖均數十里，而大致尚不出谿谷範圍，大甯鹽場僻處巫山山區，而開縣鹽場遠在梁山山脈之陽，然其河流所趨，均向南流入長江，而為其直出之支，亦為揚子江流域之一部也。就各鹽產區域地形而言，奉節鹽區在長江兩岸沙磧坪壩，分向南北地勢漸高，而成岡阜，再遠方成小山。雲陽鹽場在東陽河兩岸，東陽河為長江之支流，由雲陽城溯流而上三十里，兩旁山嶺高者約四百公尺，至鹽場附近，山嶺高約三百公尺，而產鹽地點，則在谷內，高于長江不及一百公尺，東陽河可通小舟。大甯鹽場位于大甯河谷，大甯河自川陝交界雞心嶺而來，至巫山縣城入長江，兩岸懸崖絕壁，河中淺灘急流頗多，山之高者幾至二千公尺，在鹽場一帶，高峯約一千公尺，而鹽池所在，高約三百公尺，大甯河兩岸壁立，谿谷頗狹，可通小木船，下駛至長江。忠縣鹽場兩區均傍河渠，㽏井產鹽所在，近㽏井河兩岸

，塗井河上游由金灘河水磨河合流而成，至忠縣城東入長江，塗井產鹽地點傍塗井河，河東南流約三十里，至石寶寨之西入長江。開縣鹽場在彭溪河上游兩岸，彭溪河至小江鎮入長江，上游可行船隻，鹽區附近，岡陵起伏，無大山嶺。萬縣鹽場在長江之南，僻處小山區域，詳情未悉。此川東鹽產地形之大概也。

地質　川東鹽產區域，分佈廣遠，而地質情形，較為複雜，不似川北鹽產地質易于推知統述。惟鹽場半數，曾由地質學者道經觀察，地質情形，略悉梗概，可藉參考，其有僻處遙遠，未經調查而眞像不詳者，只可暫付闕如。奉節鹽場附近，地層露頭雖少，然遠處山嶺，各紀地層暴露明顯，奉節縣城以西，侏羅紀煤系分佈清晰，而城東夔峽為二疊紀灰岩所組成，兩紀之間當為三疊紀地層，上為灰岩或灰質頁岩，在奉節縣城一帶，下為紅棕色砂岩頁岩，在奉節縣城及白帝城之間，即鹽產所在之地層也。雲陽鹽場一帶，白堊紀侏羅紀三疊紀地層均發育暴露，白堊紀大致為自流井層，侏羅紀煤系全部存在，三疊紀上部為灰岩及灰質頁岩，下部為紅棕色砂岩頁岩，鹽井均在此紅棕色地層鑿下者，此法人阿邦登諾之圖說也。大寧鹽場附近灰岩最發育，威利斯名為巫山灰岩，定其時代為石炭紀，又有頁岩，伊稱之為新灘頁岩，為屬于中古生代者，巫山灰岩在鹽產附近，為黑灰色灰岩，下部有時含燧石結核頗多，並有化石，在大寧河谷內，總厚約一千二百公尺，新灘頁岩為綠色及雜色頁岩，時帶砂質，總厚約五百公尺，此為威利斯之記載。及後巫山灰岩分為陽新大冶兩層，一屬二疊紀，一屬三疊紀，新灘頁岩確定時期為志留紀，此大寧鹽區之地層也。忠縣萬縣開縣鹽產地質，未經調查，不能確定，然就其所在位置而推言之，忠縣萬縣兩場，居近長江，距白堊紀地層暴露所在不遙，地質情形，或與雲陽鹽場近似，鹽產在三疊紀地層內，開縣鹽產所在，地勢較四周為低，而南為揚子江大向斜層之北翼，或為白堊紀地層分佈之區域，鹽產或在自流井層中。就地質構造而言，川東鹽產所在，多與一大向斜層有關，由涪陵縣而東北至奉節縣，為一大向斜層，長江即沿其底而行，地層在層底附近，傾斜較緩，兩翼向中傾斜，緩處不過一二十度，向兩翼遠處，地層傾斜漸陡，有時幾至直立，惟向斜層東北西南延長頗遠，而並不甚寬廣，實為一狹長深峻之大向斜層，鹽區在大向斜層內者有四。一為雲陽鹽場，在向斜層之東部，而居其北翼，在雲陽縣城附近，白堊紀自流井層地層，向東南偏南傾斜，斜角約

十五度，由縣城而北至雲安鎮鹽產所在，中間經過褶皺斷層數處，侏羅紀煤系三疊紀地層，均受其影響，突出地表，至鹽產附近，地層褶曲所暨，成一背斜層，鹽井適近其層軸，為三疊紀紅棕色砂岩分佈所在，南翼地層為三疊紀灰岩灰質頁岩，及侏羅紀煤系，向南傾斜甚陡，有時路呈倒轉之狀，北翼地層為三疊紀灰岩侏羅紀煤系，及白堊紀地層，向北傾斜較緩，大致成一不對稱之隆起背斜層。一為奉節鹽場，在向斜層之東端而稍偏南翼，無地層露頭，遠處三疊二疊紀地層，大致向西北傾斜，斜度頗不一致。一為忠縣鹽場，在向斜層之西部，而居其北翼，忠縣附近，白堊紀地層，大致向東南傾斜，向北及東北至鹽產區域，詳情未悉。一為萬縣鹽場，在向斜層之中部，而居其南翼，萬縣以南，長江南岸，白堊紀地層大致向西北傾斜，向南至鹽產區域，不悉異像。大寧鹽場，在大向斜層之東北，而居巫山褶皺區域內，由巫山縣沿大寧河而上，至鹽產所在，中間褶皺頗多，背斜向斜，屢見不鮮，大致向東西延長，鹽場為一褶曲地帶，向斜背斜，聯跡而生，鹽池近一背斜層脊，兩旁復有向斜層，均為二疊紀灰岩發育之處，地層大受擠壓，褶皺劇烈，構造不甚簡單。開縣鹽場，在大向斜層之北，關係不明，如由大寧鹽場地質構造情形，及兩場位置距離參照推論，開縣鹽產所在，似亦為一褶皺區域，南以向斜背斜層，與揚子江大向斜層相連者也。

鑛床　川東鹽產，未能特詣考察，詳情不得周悉，雖有時學者曾至其地，而于鹽產生成，未甚注意，亦難得以參考，故鑛床底蘊，率多模稜，不能確說。奉節鹽產，逼近江邊，易于察及，觀其鹽井地位，確在三疊紀紅棕色砂岩內，而以人力用木桶汲取鹽水，可證鹽井不深，約三十尺左右，足見鹽水生于三疊紀地層中，或以一種砂岩為儲存之所。雲陽鹽井，亦在三疊紀紅棕色砂岩鑿下，井深約六十公尺，鹽水似當仍在三疊紀砂岩中。忠縣萬縣鹽場，均由鹽井汲水，位置所在，與雲陽鹽場距向斜層層底遠近，大致近似，鹽水或亦在三疊紀地層內。開縣鹽場鹽水源出河心，鑛床情形不明。大甯鹽場鹽水所在，頗為奇異，據威利斯調查，鹽場附近，為巫山灰岩分佈之區，南北遠處，有新灘頁岩，出鹽之處為龍池，鹽水係由灰岩洞內流出，但不知此處鹽水所自流出之灰岩，屬於巫山灰岩之下部抑或上部。如在上部，是為大冶灰岩，仍屬三疊紀。如為下部，是來自陽新灰岩，為四川他處所無、則鹽產鑛床假說有二，一為鹽水原生于他種地層，而得機流入陽新灰岩隙縫循洞而出，一為鹽水本生于陽新灰岩內，如三

疊紀灰岩之有鹽水者然，灰岩多洞，易于流露，如此則四川鹽產時代，又多二疊一紀，不僅中生代地層爲儲鹽之所已也。

鑛質　川東鹽場，均產鹽水，大致多淡，含鹽較少。據川鹽紀要所載，雲陽鹽場，鹽水鹹度，每斤含鹽一錢九分至六錢三分八。開縣鹽場，鹽水鹹度，每斤含鹽只一錢四分至一錢八分。大甯鹽場，鹽水鹹度，大小不定，夏秋水漲，鹽水多而淡，每斤含鹽不及四錢，冬春水落，鹽水少而濃，每斤可出鹽一兩二錢。各鹽場所成鹽類均爲花鹽，但亦稍有分別。開縣鹽場製白細花鹽。忠縣涂井製白細花鹽，而塗井分炭鹽，色白，柴鹽，色灰黑，均爲細花鹽。雲陽鹽場製花鹽灰白色，質細，間有渣粒。奉節鹽場製花鹽灰白色，粒細。大甯鹽場製白色細花鹽。萬縣鹽場亦製花鹽一種。此川東鹽水成鹽性質種類之大概也。

採製　川東鹽產生成情形，所在深淺，鹽水濃淡不同，故採製方法，隨場而異。開縣鹽場鹽水源出河心，採取方法特殊，先在河邊掘井，以石砌成陰溝，導鹽水入井，井上用石泥和石灰築牆圍之，高于河面丈餘，以防洪水，以丈餘斑竹二條相接，製成汲水筒二個，鹽水由第一汲水筒汲至貯水處，再由第二汲水筒汲至高處，由梘流入竈房，用工人兩名，所汲之水，足敷一竈之用，鹽竈爲圓形，高一丈五尺，徑丈餘，用石泥和石灰砌成，竈內用土磚造成徑約四尺之竈口，上安一鍋，鹽水甚淡，須先澆于鱗上及炭渣上，浸炙至七八晝夜，再挖取鱗上炭渣泡水煎鹽，燃料用煤，每晝夜約成鹽十餘鍋，分裝兩包，每包重二百斤。忠縣鹽場先鑿鹽井，大井徑約三尺，深十餘丈，小井徑約二尺，深三五丈不等，採法以木架置于井邊，用二桶繫橫木上，以人力提取，井口旁有石缸，用貯鹽水，以人力挑運入竈房池內，竈周圍用泥砌成，竈後砌泥壠，內置泥團，以鹽水潑壠，並浸及竈圈，藉火力燒炙，鹽質結于灰泥，經數晝夜，挖取竈圈泥土及壠內泥團，入桶溶澄，煎熬成鹽，燃料用煤與柴。雲陽鹽場鹽井徑約三尺，深者約二十丈，井上置井樓，架一木軸，上懸井索，索之兩端繫小木桶，人立井旁，挽索循環，提取鹽水，傾入大木桶內，以竹梘引入竈房貯水桶內，竈有大鍋四口，小鍋四口，分別排置，第一第二兩列，各置大鍋一口，第三列置大鍋二口，第四第五兩列各置小鍋二口，第六第七兩列爲鹽田，以土磚砌成，上鋪炭灰渣，下層中空，與竈通，第八列爲煙筒，先以鹽水浸灌鹽田，經熱上蒸，乾而復灌，經十日後，挖出土磚，碎入大桶，溶澄煎鹽，八鍋之中，僅第一大鍋出鹽，餘七鍋爲蒸濃鹽水之用，燃料用煤

，每日出鹽四次，鹽成後取入另一鍋內，約澄一小時，再傾入大篾簍內濾乾，取裝篾包，大竈日出鹽約十八包至二十包，每包重約八十斤。奉節鹽場鹽井深約三十尺，口寬成坑，僱水夫用木桶，在井晝夜分班輪流汲取，挑入竈房，竈以煤灰鹽水修造，竈後鑿大池，將鹽水挑入池內，加煤舉火，再將池中鹽水徐徐灌入煤灰，漏入竈膛，旋乾旋灌，約二十日，煤灰遂成鹽磚，然後挖出碎入桶內，以鹽水溶澄，梘入鍋內煎熬，約一晝夜成鹽，燃料用煤。大甯鹽場鹽水由龍池流出，而無鹽井，池前橫安鐵板一道，鑿孔六十八個，以梘引鹽水入竈房，竈分炭竈煤燒大鍋，柴竈柴燒小鍋，竈後設壠，架以土磚，中通火路，磚燒紅後，以鹽水浸之，名曰冰土，將冰土碎入桶內，溶濾煎鹽，或用皂角提取雜質，燃料用煤與柴。萬縣鹽場有鹽井一口，用小桶汲取，梘入竈房池內，以鹽水潑于土上，燒乾碎之，再以鹽水溶澄，入鍋煎熬，燃料用煤。此川東鹽產採製之情形也。

鑛業　川東鹽產開發，起于何時，各場不同，據鹽務載籍，忠縣鹽場始于漢代，清朝設官徵稅，民國初年設鹽井委員兼権稅署，後改爲忠縣鹽井委員署及鹽稅局，㽏井有大井一眼，小井十二眼，柴竈十七座，涂井有大井一眼，小井五眼，柴竈九座，炭竈六座，每座有鍋一口，竈戶煎鹽，須到收稅處報領煎鹽証單，成鹽粒細，最易溶化，隨產隨銷，未設鹽倉，成鹽成本，每百斤約六圓二三角，旺月約高二角，淡月約低二角，鹽價在場售賣，每百斤淡季約六元三四角，旺季可至七元一二角，稅率每百斤一元二角，鹽販購鹽納稅後，均由尖底篾簍裝盛，㽏井鹽毛重七十斤八十斤九十斤不等，除皮重三斤，涂井鹽四十斤五十斤不等，除皮重二斤，全爲票鹽，用四十斤至一百斤稅票，運鹽由人力負運，運費每百斤約一元，運銷忠縣汝溪場黃金灘金鑑石冉家坝與隆場三匯場豐收場宜壩場，及萬縣王場，梁山縣石家場等處，茲將最近十一年產銷担數稅收洋數，列表如左。

年別	產鹽担數	銷鹽担數	稅收洋數
民國九年	二、八四一・八一	二・八四一・八一	三、三八二・〇八
十年	二、五五五・三一	二、五五五・三一	三、〇六六・三七
十一年	二、五九七・八〇	二、五九七・八〇	三、一一七・三六

十二年	二、五七二·五〇	二、五七二·五〇	三、〇八七·〇〇
十三年	二、六三二、六〇	二·六三二·六〇	三、一五九·一二
十四年	四、一八九·五〇	四、一八九、五〇	五、〇二七·四〇
十五年	四、二六二·一〇	四、二六二·一〇	五、一一四·五二
十六年	四、二二二·一〇	四、二二二·一〇	五、〇六七·二四
十七年	五、〇七四·三〇	五、〇七四·三〇	六、〇八九·一六
十八年	四、五九四·七〇	四、五九四·七〇	五、五一三·六四
十九年	四、九三七·九〇	四、九三七·九〇	五、九二五·四八

忠縣鹽場鹽務管理機關，行政方面有忠縣鹽井委員署，在忠縣城，塗井㽃井各設管理處。稽核方面有鹽稅局，設忠縣城，在兩井各設收稅處。緝私未設專管機關。

萬縣鹽場始于晉代，至宋朝每年產鹽不過十五萬斤，清初開至十井，清末井多淤塞，現僅存一井，有竈七座，鍋七口，製鹽成本，每百斤八元五角，在場售賣九元五角，稅率一元二角，成鹽自存，未設倉垣，鹽販買鹽直接竈戶，價稅統付，運鹽均為挑運，運銷場南各鄉，運費至各場每百斤約五角，鹽務管理由萬巫查驗局兼辦鹽井委員事宜，玆將產銷稅收表列如下。

年別	產鹽担數	銷鹽担數	稅收洋數
民國九年	未詳	四九六·〇〇担	五九一·三六元
十年	未詳	二七二·八〇	三二七·三六
十一年	一四二·四〇	一四二·四〇	一七〇·八八
十二年	四〇四·八〇	四〇四·八〇	四八五·七六

十三年	四二三·二〇	四二三·二〇	五〇七·八四
十四年	一七六·八〇	一七六·八〇	二一二·一六
十五年	三八三·二〇	三八三·二〇	四五九·八四
十六年	三八六·八〇	三八六·八〇	四六四·一六
十七年	三八八·四〇	三八八·四〇	四六六·〇八
十八年	二九三·八〇	二九三·五〇	三五二·二〇
十九年	一一八·〇〇	一一八·〇〇	一四一·六〇

雲陽鹽場始于唐，惟詳不可考，宋代有滰井，明置雲安鹽課司，淸初鹽業大盛，迄今未衰，原有鹽井三十三眼，竈六十七座，大鍋一百二十五口，小鍋三百五十六口，現有鹽井九眼，竈六十七座，大鍋一百九十八口，小鍋三百一十七口，製鹽成本，每百斤四元二角，在場售賣四元四角，票鹽稅率一元二角，鹽均自存，雖有公垣兩家，有名無實。鹽商販運，引鹽先塡具報運單，註明鹽斤重量繳納稅款竈名船名銷岸，每引納稅洋一百五十元，由稅局點收塡發准單，鹽商持單向竈戶取鹽，運鹽時呈秤放單到局，由秤放員秤驗鹽斤相符，蓋章准單，再由鹽商持單向稅局換取運照運行，鹽販販運票鹽，自向竈戶買鹽，至公垣掣取出口單報塡，往竈取鹽，至監秤處秤放後，往收稅處繳稅，由處塡發稅票，票四聯，有存根發票運票驗票等，發票存場署，鹽商持票至秤放處呈驗，數目相符放行，運票限本日出關，過期無效，驗票于過卡時截留，鹽斤包裝用篾包，每包淨重八十斤，皮三斤，每引一百二十五包，合一百担，引鹽運至距場十五里硐村起載，寄放堆棧，轉發騾馬駝運出縣，再僱用木船，轉運長江上下游各銷岸，運費至萬縣每引需洋七十七元，至大溪八十四元，至巫山九十九元六角，票鹽遠者用木船水運，近者挑運，運費每八十斤每百里約需洋一元二角，運銷引鹽，分川計岸，銷萬縣，楚計岸，銷四川巫山，及湖北恩施建始宣恩鶴峯利川等縣，票鹽銷萬縣開縣開江梁山奉節雲陽境內，玆將產銷稅收數目表列如下。

年別	產鹽担數	銷鹽担數	稅收洋數
民國九年	未詳	一九二、三八七・七六担	二四二、六八五・三〇元
十年	一九九、四二六・二四	二一二、九〇〇・四〇	二六七、九〇〇・四八
十一年	二三八、九九三・九二	二一六、一八一・六八	二六二、五六八・〇〇
十二年	二二七、八八八・二八	二三一、五〇三・二〇	二九三、六四三・八四
十三年	二九五、〇七三・五〇	三〇六、七八七・〇〇	三九五、三八四・四〇
十四年	二八〇、九七二・八〇	二七一、四〇〇・〇〇	三三二、九一〇・〇〇
十五年	二七四、〇五七・六〇	二七〇、四二四・〇〇	三四〇、六七八・八〇
十六年	二七七、〇五八・四〇	二八二、二一七・六〇	三五一、三五一・一二
十七年	三〇七、一一四・四〇	二九四、二三〇・四〇	三五九、五八六・四八
十八年	二八七、〇四八・〇〇	二九三、二五四・四〇	三六七、〇五五・二八
十九年	三〇二、五六一・六〇	三〇九、七四五・二〇	三九一、七三四・二四

雲陽鹽場鹽務管理，行政方面有雲陽鹽場公署，稽核方面有雲陽鹽稅局，緝私方面有緝私第三營一連連部。

奉節鹽場始于隋代，至清咸豐年間，始定爲官井，汲煎至今，分爲南北兩廠，南廠有井一眼，北廠有井三眼，現淘用一眼，南廠有竈鍋約二十口，北廠約二百口，近來多停工歇業，竈戶煎鹽均由運署頒發門牌，以便稽查，成鹽成本，每百斤約五元〇七分，在場售賣，五元三角，稅率一元四角，鹽斤向由竈戶自存，民國十一年改設官垣，但迄今並未實行入垣，鹽販購鹽，先納稅取運票，用司碼秤秤放鹽斤，限本日出關，裝鹽用籮篼，每挑毛重一百一十斤，淨重一百斤，運鹽或由人力挑運，或用船運，運費每百斤每百里約需洋一元四角，運銷本縣境內，玆將產銷稅收數目列表于左。

年別	產銷担數	稅收洋數
民國九年	三〇、〇二八・〇〇担	四一、六二三・六四元
十年	二五、七五一・〇〇	三六、〇五一・四〇
十一年	三一、三五三・〇〇	四四、四五四・〇〇
十二年	三二、二七九・一〇	四五、一九〇・七四
十三年	二七、二一八・五〇	三八、一〇五・九〇
十四年	三〇、五四七・六〇	四二、二七六・六四
十五年	二六、九四一・三〇	三七、七一七・八二
十六年	二五、九八六・一八	三六、三八一・二四
十七年	二五、八二七・五〇	三六、一五八・五〇
十八年	二三、四三二・五〇	三二、八〇五・五〇
十九年	三一、九〇三・一〇產 三一、九〇一・六〇銷	四四、六六二・二四

奉節鹽場鹽務管理，行政有奉節鹽井委員署，稽核有奉節鹽稅局，均在奉節縣城，緝私有緝私第三營一連一排，駐北廠武侯祠。

大甯鹽場始于唐代，源發于大甯縣北三十里之寶源山，自唐以來，涓涓不息，迄宋淳化間，嵌以鐵龍頭，泉自兩腮流出，龍口下有池，故曰龍池，至今仍由此取水製鹽。現有炭竈六十五家，柴竈二十九家，鍋二百六十口，竈戶煎鹽由場署發給門牌，製鹽成本，每百斤炭花鹽由三元八角至四元三角，柴花鹽由六元八角至七元二角，在場售賣，炭鹽每斤價洋由三元九角至四元五角，柴鹽由七元至七元六角，稅率引鹽每担一元五角，票鹽一元二角，設有官垣二處，公垣三處，午前售鹽，午後進鹽。鹽商購運

引鹽，先具報稅單，持往稅局繳稅，領取放鹽准單，往場署蓋印，裝齊鹽斤，並請予秤放驗訖後，換領運照出關，鹽販購買票鹽，先向收稅局繳清稅款，塡寫稅票，領取運票驗票，運鹽啓行，限一日出卡。裝鹽用篾包，引鹽每包連皮耗共重一百〇五斤，淨重一百斤，每引一百担，票鹽每包連皮耗共重七十三斤，淨重七十斤，運鹽引鹽用船水運，票鹽由人力挑運，運費由場至大昌每引四十元，至巫山八十元，至巴東一百三十元，至興山一百九十元，引鹽行銷引額，定爲四百九十引，運銷四川巫山縣，及湖北秭歸興山巴東長陽鶴峯五峯宣恩等縣，票鹽運銷四川巫溪，湖北竹山竹溪房縣，及陝西平利安康磚坪漢陰洵陽白河紫陽石泉鳳縣等縣，玆將產銷稅收數目列後。

年別	產鹽担數	銷鹽担數	稅收洋數
民國九年	未詳	一〇一、五六六・一〇担	一二八、四六八・三九元
十年	未詳	一〇八、八七四・七〇	一三六、八五九・六四
十一年	一二〇、〇〇〇・〇〇	一一八、一六八・二〇	一五一、八八一・八四
十二年	一四七、一八〇・九〇	一三七、六六六・〇〇	一八八、四七九・二〇
十三年	一五一、一七〇・二〇	一五七、四三九・一〇	一九三、四二六・九二
十四年	一四七、六八五・八二	一四七、〇七一・六〇	一八九、六五五・九二
十五年	一一四、三九一・〇九	一一三、三三九・一〇	一四四、九七六・九二
十六年	九二、八一四・〇〇	八九、二六五・七〇	一一三、〇八八・八四
十七年	一八、一三六・一〇	一七、九五四・九〇	二二、七七五・八八
十八年	五八、五九〇・三〇	五九、五九〇・三〇	七三、一二八・三六
十九年	一〇九、八九三・六〇	一一一、〇六四・七〇	一三五、七六七・六四

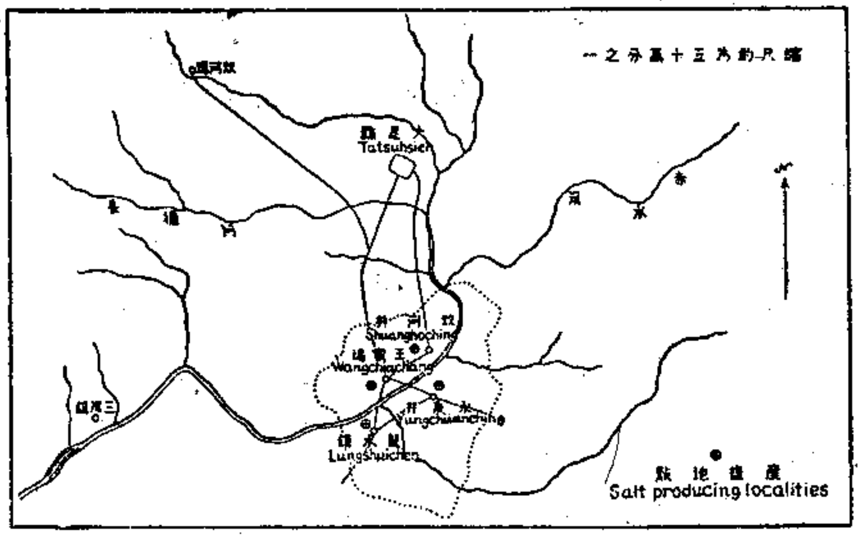
大甯鹽場鹽務管理，行政有大甯鹽場公署，稽核有大甯鹽稅局，緝私有緝私第三營二連連部。

開縣產鹽始于唐，宋時已有溫湯井，至清康熙年間，始起課報部，鹽井五眼，河東爲溫湯溫塘二井，有三十五竈，河西爲裕泉裕龍膏谷三井，有五十五竈，乾隆年間，部定一竈一鍋，共有竈九十座，鍋數稱之，迨後水不濟煎，嘉慶年間，呈部請准註册，沿河覓滷，沿山採煤，于是改柴草爲煤煎，有大小鹽井十九眼，民國八年以後，日漸倒塌，今所存者，僅河東溫湯井。河西膏谷井玉堂井玉堂小井，竈四十二座，鍋四十二口而已。製鹽成本，每百斤由五元八角至六元，在場售價約六元二三角，稅率一元二角，鹽成存入官垣，有官垣兩處。鹽販購鹽，先至官垣領取飛票，至收稅處納稅，領取鹽票，到垣取鹽，由監秤員秤驗放行。裝鹽用篾箱，每挑七八十斤，皮重五斤，滷耗照實計算，運鹽或由水運，或由人挑，運費水運每百斤由場至開縣六十里，約一角八分，陸運每百斤每百里約一元，運銷開縣開江城口宣漢萬源達縣梁山等縣，茲將產銷稅收數目列後。

年別	產鹽担數	銷鹽担數	稅收洋數
民國九年	未詳	三八、五九八·四二担	四五、八〇三·二一元
十年	未詳	五三、五七二·三三	六四、二八六·八〇
十一年	七九、五九六·〇〇	五三、三八三·四二	六四、〇六〇·一〇
十二年	三五、五三二·八〇	三五、五三二·八〇	四二、六三九·三六
十三年	二八、〇一五·一二	二六、九〇六·七〇	三二、二八八·〇四
十四年	二九、八一〇·二四	二九、七八九·六〇	三五、七四五·一二
十五年	二二、九九五·九〇	二二、八四七·〇〇	二七、四一六·四〇
十六年	二四、四三八·六〇	二四、四一二·六〇	二九、二九五·一二
十七年	二九、二〇八·二〇	二八、九七六·二〇	三四·七七一·四四

十八年	二八、四二六・四〇	二八、二八三・七〇	三三、九四〇・四四
十九年	二九、九一八・七五	二九、六五二・四〇	三五、五八一・八八

開縣鹽場行政有開縣鹽場公署，稽核有開縣鹽稅局收稅處，緝私有緝私第三營二連三排。



第三圖　四川大足鹽產區域圖

大足鹽產

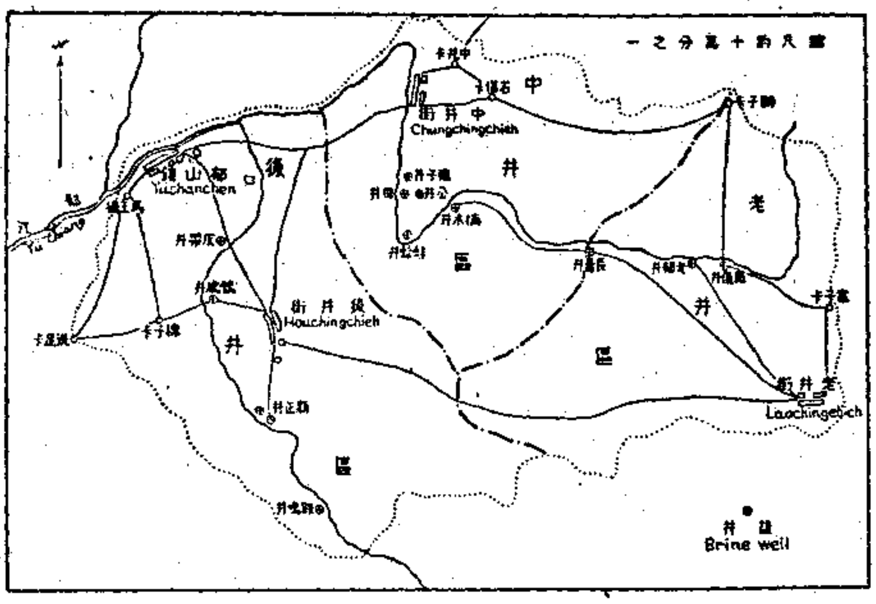
大足鹽場，屬川南鹽區，與各鹽場均相距遙遠，不相連屬，故分述之，但鹽業凋敝，產額不多，地質鑛床情形，採製方法，多不明瞭，只就參考所知，簡略敍述，聊備一區耳。地在大足縣城西南約四十里王家場一帶，產鹽地點，爲龍水鎮王家場雙河井永泉井等處。(見第三圖)。區內有河一道，上游由長橋河赤水溪自大足銅梁流來會合而成，出區經榮昌瀘縣境，流入沱江，鹽區跨河分佈，無高山大嶺，亦爲小山岡阜區域。就地質而言，當與大足榮昌兩處地質無甚軒輊，榮昌一帶爲白堊紀自流井層分佈所在，以紅紫色粘土及黃灰色砂岩爲最發育，而地層層向大致西南東北，或稍偏南北，大足一帶亦以自流井層爲多，地層層向亦爲西南偏南東北偏北方向，大足鹽場適在榮昌大足之間，且與兩處並成西南東北方向，其地層層向，似當與兩處地層一致，或亦爲自流井層地層暴露所在也。大足鹽場地層如爲自流井層，鹽井當由其地層鑿下，聞鹽井均不深，鹽水所在，或不出自流井層下部，至深不過在侏羅紀煤層上部。採製方法未詳，據川鹽紀要所載，有眼井三百五十餘眼，竈三十七座，煎鹽以煤爲

滷料，出花鹽多，亦有巴鹽。鹽場始于何時，無可稽考，至清朝始有記載，清統一志載縣有鹽井九眼，雍正年間有九井，乾隆年間廢五井，存朱溪王家永泉雙河四井，光緒年間朱溪井廢，僅存三井，鍋十一口，清末禁止煎鹽，至民國四年，始由四川鹽運使派員查勘徵稅。均爲票鹽，稅率每担一元二角，運銷大足銅梁境內，民國五六年間，平均產銷年約三千三百餘担，茲將近幾年來產銷稅收數目表列如左。

年別	產鹽担數	銷鹽担數	稅收洋數
民國十六年	一、七四五·一〇担	一、七四六·八〇担	二、〇九六·一〇元
十七年	一、六二五·〇〇	一、六一五·〇〇	一、九三八·〇〇
十八年	一、三〇四·八〇	一、三〇四·八〇	一、五六五·七六
十九年	九八四·四〇	九八四·四〇	一、一八一·二八

彭水鹽產

彭水鹽產，僻處四川東南隅山地，南至貴州，東至湖南，東北至湖北，距離不遙，由長江沿岸涪陵溯黔江而上，至鹽場約四百餘里，而由鹽場至貴州湖北境，均不過二百餘里，又與川東鹽場不相連屬，故分述之。鹽產在彭水縣東北約一百二十里郁山鎮一帶，著名產鹽地點，爲后井街中井街老井街等處。區域東西相距約十五里，南北相距約三里，中有郁江支流，由黔江西流，經鹽區入郁江，西南流，會黔江。(見第四圖)。因交通不便，途中多阻，學者至其地而考察之者極鮮，故地形地質鑛床情形，多無從參考，暫付闕如。所知者，現有鹽井六眼，鹽水鹹度在后井區每斤含鹽由三錢四分至三錢九分餘，在中井區



第四圖 四川彭水鹽產區域圖

每斤含鹽約三錢五分，在老井區每斤含鹽由三錢至三錢四分。採取鹽水，多用人力汲取，惟后井區新正井，係仿照自流井用牛推水，均以竹梘流入竈房，有竈五十四座，鍋一百〇七口，有大鍋中鍋小鍋之分，製鹽先以泥土成餅，堆積鍋旁，日以鹽水漬之，加以燒炙，漬燒約七日，取出入桶，以鹽水泡之，澄清後，入鍋煎熬。彭水鹽場始于唐，有伏牛山出鹽井，宋時有一井，明代郁山四井，皆小竈，焚草煎鹽，清雍正時，有井五眼，歷康熙乾隆漸盛，至光緒年間，有十四井，民國七年設局管理，原有四井，後漸增至十井，近年僅有六井。煎熬花鹽，成細末，稍呈淡紅色，成本每百斤約九元二角，在場售賣約九元五角，稅率每担一元二角，成鹽概入官公垣。鹽販在公垣買鹽後，掣取報運出口單，持往收稅處，過秤蓋章，納稅款，換取運票，當日出關。包裝用篾包篾簍，重由四十斤至一百斤，每百斤除皮五斤，大宇由人力挑運，一部用木船，運費每担每百里約需一元二三角，概爲票鹽，運銷彭水保家樓羊頭鋪白溪走馬嶺厰魚口等處，黔江兩匯場濯河壩，及酉陽縣境，並銷湖北咸豐來鳳兩縣，玆將產銷稅收數目表列如次。

年別	產鹽担數	銷鹽担數	稅收洋數
民國九年	未詳	三七、三八二·四〇担	四四、四八〇·〇四元
十年	四二、四三二·七七	四一、七六六·五〇	五〇、一一九·八〇
十一年	三九、五五九·七三	四〇、一四七·五〇	四八、一七七·〇〇
十二年	四二、三七〇·七五	四二、七二八·九〇	五一、二七四·六八
十三年	四五、三四五·五二	四三、一四七·四〇	五一、七七六·八八
十四年	三六、五七三·〇四	三七、四九八·一〇	四四、九九七·七二
十五年	三五、九五五·五〇	三四、八二六·三〇	四一、七九一·五六
十六年	三二、四二一·二四	三二、五三四·六〇	三九、〇四一·五二

十七年	三三、九五二·四三	三三、一〇三·七〇	三九、七二四·四四
十八年	三二、三〇一·二四	三一、九三七·二〇	三八、三二四·六四
十九年	二二、一五三·一三	二一、八六三·〇〇	二六、二三五·六〇

彭水鹽場鹽務管理，行政有彭水鹽場公署，稽核有彭水鹽稅局，緝私有緝私第二營二連，均在郁山鎮。

鹽源鹽產

鹽源鹽產，在四川西南隅，與雲南交界地方，僻處夷巢，交通不便，夷匪刼殺成性，行旅危險，故人至其地者甚少，致關於地形地質鑛床種種情形，無可參考。就所知者而言，鹽源鹽場在鹽源縣境內，分爲白鹽井黑鹽井二區，白鹽井在縣城西約四十里，黑鹽井在縣城西二百〇五里，（圖見第十一版）。白鹽井區又分白鹽井本部及小鹽井，區域東西相距四里，南北相距五里，黑鹽井區東西距約三里，南北距約二里，鹽井共有七眼，白鹽井有正班上井一眼，深約四十尺，井口長約八尺，寬二尺餘，硝水下井一眼，深不過三十尺，小鹽井有最下小井三眼，黑鹽井有中井一眼，下井一眼，深只數尺。各鹽井均出鹽水，鹹度不同，白鹽井上井鹽水最旺，終年汲取不盡，每斤含鹽八九錢，下井鹽水較少，每斤含鹽二錢四錢不等，黑鹽井鹽水鹹度較大，每斤可含鹽一兩餘。採取鹽水用木桶，接以小竹竿數條，長約四丈餘，繫桶入井提水，鹽水提出，傾入槽缸，或各竈房，加鹹土泡之，澄清滲入鍋內，或以鹽水潑灑鹽田，俟其蒸乾，將田內泥沙收集，泡水澄清，混合煎熬。鹽竈共九十四家，白鹽井大竈十八家，小竈六十八家，大鍋四百五十九口，小鍋六百四十三口，黑鹽井大竈八家，大鍋八十口，鹽鍋形均如吊罐，大鍋徑長約一尺半，深三尺半，小鍋徑約五寸，深尺餘，溫鍋形如飯鍋，用以溫鹽水，竈爲泥製，通常燒大小鍋二十五口，排置如扇形，再安溫水鍋二口，每鹽鍋內放碎鹽三斤，再生火加煤，鍋燒紅後，再添鹽水，如鹽成約一分厚時，復將鍋燒紅，陸續滲水，直至成鹽時，再將鍋燒紅，滲水一次，卽去火，俟水乾鍋冷，將鍋抬起，以冷水澆鍋，並以鏟鑿鍋邊，鹽卽漸漸脫出，白鹽井燒鹽煤柴兼用，兩晝夜成鹽，黑鹽井只用松柴，一晝夜成鹽，此採製之情形也。鹽源鹽產，僻在邊區，何時開發，詳不可考，據載漢定莋縣卽今鹽源縣

境，已出鹽，明洪武中鹽井衛有黑白二井，卽鹽源鹽井，至淸康熙年間，封禁黑鹽井，設官駐白鹽井收課，光緒年間，黑鹽井啓封再開，民國以來，設局徵稅。所出之鹽名帽殼鹽，分爲斑水鹽硝水鹽，每個重由數斤至五六十斤不等，製鹽成本每百斤由七元八角至八元二角，在場售賣，價由八元五角至九元五角，稅率每担正稅一元五角，附稅二角，鹽成後送入公垣存儲。凡鹽販購鹽，先赴收稅處報運鹽斤，照章納稅，領取發票四聯，持往公垣，照票發鹽，當日出關。裝鹽用篾包，由人力負運，或騾馬駝運，運費每百斤每百里約一元五角，運銷鹽源鹽邊西昌會理等縣，及雲南永北縣，茲將產銷稅收數目列表如左。

年別	產鹽担數	銷鹽担數	稅收洋數
民國九年	四一、三〇七•〇八担	四一、四〇一•五一担	六二、一〇二•二七元
十年	四四、四一九•八九	四〇、六六七•八一	六一、〇〇一•七二
十一年	三六、八三四•〇八	四〇、一六二•四八	六〇、二四三•七二
十二年	四四、四三〇•五三	四四、五七二•七七	六六、八五九•一六
十三年	四〇、一六〇•九一	三九、七五八•〇六	五九、六三七•〇九
十四年	二九、八六七•五七	三〇、七二三•三〇	四六、〇八四•九五
十五年	三七、七七九•八七	三四、四三五•五〇	五一、六五三•二五
十六年	四〇、二二一•八二	三七、七六七•八〇	五六、六五一•七〇
十七年	三八、四七五•〇五	三六、八五二•八〇	五五、二七九•二〇
十八年	三五、八一二•五〇	二九、〇七九•八〇	四三、六一九•七〇
十九年	三七、〇五五•一九	三二、八七四•六〇	四九、三一一•九〇

鹽源鹽場鹽務管理，行政設有鹽源鹽場公署，稽核設有鹽源鹽稅局，緝私有緝私第七營一連三排，均駐白鹽井。

四川鹽產鑛床之成因

綜覽四川鹽產種類，有岩鹽鹽水之分，而其鑛床，則均生于水成地層內，不過層位不同，時期各異。岩鹽惟自流井大坟包附近產之，在三疊紀嘉陵江灰岩層下部，面積頗狹。而鹽水所在，範圍甚廣，上自白堊紀嘉定層，下迄三疊紀飛仙關砂岩層，各紀各層，均有鹽水發見。據威利斯所見，大甯鹽產附近，為巫山灰岩，鹽水即自灰岩泉峒流出，如果鹽水來自巫山灰岩下部，是二疊紀地層，亦含鹽質，鹽水所在，範圍愈廣，非只中生代地層而已。即此鹽水地質分佈如斯之廣，則其成因當甚複雜，或不可以已成假說解之，岩鹽分佈面積，如斯其狹，則其成因，似亦奇異，更不可以常理衡之。惟就觀察所得事實，猶嫌不足，現所依據以假說四川鹽水岩鹽之成因者，為(一)各鹽井鑿井時之岩石記錄，(二)井商及井工歷來所得井下之情形，(三)鹽井之位置及深度，(四)鹽水鹹度之大小，(五)鹽水及岩鹽之分佈(六)鹽水及岩鹽之層位及層帶，(七)鹽區附近露出地層之觀察。即理推論，以求其可通，固不可目為原則也。

四川鹽產既分岩鹽鹽水，其成因或當不同，據已成假說而言，岩鹽生成，不外(一)因海岸沼澤，障於沙洲，不與海洋常通，海水蒸發，鹽質沉澱，漸成岩鹽，此為著名之沙洲說 (Bar Theory)。(二)因內海或湖泊蒸發涸乾，海水或湖水原含之鹽質，沉澱而成岩鹽，此為涸乾說 (Desiccation Theory)。(三)因地下已成鹽層，再受溶解，浸濾而上，至較新地層內，重經結晶沉澱而成岩鹽，或因近地面之水，溶解含鹽地層之鹽，成為含鹽溶液，迨至他地層內，因鹽質逾飽和之量，結晶沉澱而成岩鹽，此可名之為浸濾飽和說(Leaching-Supersaturation Theory)。就自流井大坟包岩鹽生成情形而簡括言之，(一)岩鹽生于三疊紀灰岩層內，而在其下部，岩層繼續沉澱而生，未嘗間斷。(二)岩鹽所在面積，長寬均約八百公尺，形不規則，出此範圍，向未鑽獲，常分為二三層，厚度不一律，總計由二公尺至五公尺。(三)現採取岩鹽，係由井灌入清水，溶化岩鹽，再汲出鹽水，各岩鹽井地下均已相通，由一井入水，即可由他井出水。(四)據井商言，按岩鹽面積厚度，計其容積，與歷來由岩鹽水所出鹽之容積相比，應已取盡，而現仍繼續汲出，鹹度不減。(五)在產鹽區域附近各處露出之三疊紀灰岩內，向無些許岩鹽發見，中上部幾全為灰岩，稍

有泥灰質灰岩，下部間有灰質頁岩，全屬較深水中之沉澱。故就此種種事實，觀察推論，則自流井岩鹽成因，似不可以沙洲說及涸乾說解之，蓋因三疊紀灰岩層內，無海邊沼澤及湖泊沉澱夾雜其中，岩鹽上下地層，均無不整合之接觸，而岩鹽面積，如斯其不廣，似非在較爲普遍情形之下，而成此局部孤立之沉澱也。至浸濾飽和說，雖未經普遍承認，然自流井岩鹽成因，却有一部與其近似，不過鹽質所自來，及含鹽溶液向上向下，稍有不同耳。曠觀四川鹽產，以鹽水爲主，分佈甚廣，而岩鹽僅在一處見之，面積頗小，然岩鹽之成，似由鹽水濃集逾飽和之量，而重經結晶沉澱者。四川鹽水，雖生于中生代各紀地層，但其來源，似僅在白堊紀紅色紫色地層，及三疊紀紫棕色砂岩層內。原含于白堊紀地層內之鹽質或鹽水，溶于潛水中，而成多量鹽水，因鹽水清水比重不同，而自然分層，鹽水向下浸濾，經細小隙縫，愈沉愈深，而鹹度亦愈深愈濃，經侏羅紀煤系至三疊紀灰岩層中，鹽水聚濃，已逾飽和之量，鹽質有分出結晶之勢，而適遇灰岩中含有孔洞或隙縫，鹽質遂由鹽水結晶，沉澱于此，而成岩鹽，其面積之不廣，厚度之不同，及生成之不普遍，在在顯其孔隙沉澱之眞像，故在事實未搜集充分，及未得更相當解說以前，暫以浸濾飽和說釋之，是否尚待考察證明也。

鹽水成因，約有二源，一爲鹽水原生于含之之地層，在地層沉積之時，鹽水卽含于其多孔部分，及後地層雖屢受變動，而鹽水不失。二爲地面之水，下沉以後，經過含有鹽質之地層，溶解其鹽質，而成鹽水。但四川鹽水，生于中生代各紀地層內，而鹹度大小有差，生成情形，頗爲複雜，二說之一，似不足以解之。茲就所知事實，另爲假說，先將事實臚列，用資依據，(一)四川產鹽區域，除川東鹽產多與三疊紀紫棕色砂岩層有關外，均在白堊紀地層最發育之處。(二)鹽水所在，無顯著之層位，雖上下分佈成帶，而亦無一定分界，似連續而生者。(三)鹽水層帶之深淺，似與鹽井地面位置有關，鹽井位置較高，而鹽水所在層位亦隨之而高。(四)鹽水鹹度大小，與鹽井及層帶之深淺，成正比，三疊紀灰岩層內之鹽水，平均含鹽約百分之二十，鹽井平均深約一千公尺，侏羅紀煤系內之鹽水，平均約百分之十，鹽井平均深約五百公尺，白堊紀地層內之鹽水，平均約百分之五，鹽井平均深約二百公尺，但火井出火氣最多者，及三疊紀砂岩層之鹽水，不在此例。(五)地下鹽水，徐徐流動，以供鹽井之提取，如鹽水爲

原含于地層者，則鹽水取盡，鹽井卽當涸竭，但鹽井如無人事變遷，或阻碍，常經數十年而鹽水不盡，鹹度不減。今據此種種事實，以解說四川鹽水之成因如左。

(一)鹽質或鹽水在乾燥氣候之地，與含之之地層，同時沉積于淺水之中。

(二)白堊紀紅紫色地層，及三疊紀紫棕色地層，似均爲含有此種鹽質或鹽水之沉積物。

(三)地面之水，流向地下，溶解地層鹽質，或與所含鹽水混合，而成地下鹽水，因鹽水清水，比重不同，有自然分層之趨向，鹽水鹹度大者較重，而漸向下沉濾，淸水或鹽水鹹度淡者較輕，浮于上層。

(四)地殼上部，常生裂隙，通常稱之爲裂隙帶，地下鹽水，可沿裂隙向下沉濾，至鬆空地層中，得機存留，而徐徐流動，如再遇裂隙，又可向下沉濾。

(五)地下鹽水，漸次向下沉濾，經時旣久，愈聚愈濃，一部可存留于鬆空地層，而成較淡鹽水，層位較淺，其餘仍向下沉濾，聚爲較濃鹽水，而層位較深。

(六)鹽水之在白堊紀地層及三疊紀砂岩內者，或爲原含之鹽水，或爲原鹽水與地面水混合而成者。但侏羅紀煤系及三疊紀灰岩中之鹽水，似爲由白堊紀地層所含之鹽水，再經分濾聚濃而來者。因三疊紀灰岩，空隙不著，沉澱之際，可否容此多量鹽質或鹽水，甚難確言。侏羅紀煤系沉積之時，陸上氣候情形，水中鹽質分量，能否聚生鹽水，鹹度如現在所採者，亦殊可懷疑。且灰岩內所出泉水，及煤系內所出鑛水，向未聞有味鹹而可以煎鹽者，其含鹽水之來源，不可不求諸他層也。如斯則其上之白堊紀地層，下之三疊紀砂岩層，均可爲鹽水之源。但三疊紀砂岩內，鹽水鹹度較小，普通含鹽不過百分之三四，由此浸濾而上，分散于兩紀地層內，似不能聚集如斯其濃，而鹹度可至百分之二十以上者。如鹽水源出白堊紀地層，漸次分濾聚濃而下，而成鹹度較高鹽水，似較可通，觀其由白堊紀地層，經侏羅紀煤系至三疊紀灰岩，鹽水鹹度，漸次而增，而再深至三疊紀砂岩層內，鹽水鹹度驟減，便知鹽水至灰岩內，常阻于緻密地層，不易下沉，未至砂岩層內，而砂岩內之淡鹽水，爲原含于其中者也。

四川鹽產副產品之利用

四川鹽水分析結果，除含有食鹽外，鈣鎂鉀錕綠化物，亦占成分之一部，鈣鎂用途狹少，而量亦不多，錕則含量尤少，皆無重大價值，不足注意研究，惟鉀之用途既廣，而量亦多，將來提取得法，大可利用，故歷來就四川鹽水而考察鉀之產量者，頗不乏人，雖迄未經着手設備，實地製取，但已足證有注意之價值矣。近來本所化學試驗室金開英張天璹二君，在鹽水鹹水中，發見硼碘二質，硼價固高于鉀，而碘價又高于硼者，不啻十倍，如將來鹽水附產，多可製出利用，不但鹽業藉此補助，得以發展，而于工業製造前途，更有莫大之裨益也。

四川鹽水含鉀之豐，自英國聯華銀公司取鹽水化驗之後始知之，化驗爲薩爾曼皮卡德公司所作，鹽水取自自流井，黑水黃水假黑水岩鹽水及鹽水沫渣(鹹水)均含有鉀質，爲量之豐，他處鹽水罕有其匹，玆將其分析結果，表列如左。

鹽水/物質	黃水	岩鹽水	鹽水沫渣(鹹水)	假黑水	黑水	備考
綠化鉀	○·七○	一·○三	三·九三九	一·三三	三·○二	鹽水所含之百分率
綠化鉀	四·三○	六·二○	六·七○	九·四○	一三·九○	全固形物所含之百分率
鉀質	二·二五	三·二四	三·五○	四·九一	七·二六	全固形物所含之百分率
全固形物	一六·一八八	一六·六○四	五八·七八	一四·一二四	二一·七六	鹽水所含之百分率

據今所知，鹽水含鉀最多者，爲美國加州西爾斯湖 (Searles Lake)，鹽水含綠化鉀百分之一三·三，而自流井黑水所含綠化鉀，爲百分之一三·九，量數實超過之，然此猶未足以代表自流井含鉀最豐之鹽水，或尙有較佳者，而未嘗注意及之耳。以如此富量之鉀鹽，而產于工價低小燃料不昂之中國，殆未有能阻止其發達，而不成爲肥料及化學藥品之產地者，此不第于中國有莫大之利，而遠東各國，或亦將受其惠賜矣，此英人薩爾曼皮卡德公司對於四川鉀產之意見也。

前農商部工業試驗所曾經徵集四川鹽水鹹水鹹巴而分析之，以試其質，當由丁文江王季點二先生作爲「關於四川鉀鑛之研究」

茲將當時分析之結果，列表比較如下。

物質＼鹹巴或鹹水	自流井鹹水	樂山鹹巴	三台鹹巴	備考
綠化鉀	一·六三	一·四五	五·四四	全固形物所含之百分率
鉀質	○·八五六	○·七六	二·八五	全固形物所含之百分率
全固形物	六八·五七			鹹水所含之百分率

物質＼鹽水或鹹水	自流井黑水	自流井黃水	自流井岩鹽水	自流井鹹水	備考
綠化鉀	四·二六	三·四五	一·三○	一·六四	鹽水所含之百分率
綠化鉀	一六·五一六	二五·五六	四·二八	二·三九	全固形物所含之百分率
全固形物	二五·六六	一三·六四	三○·四○	六八·五七	鹽水或鹹水所含之百分率

據上列分析之結果，丁王二先生估計自流井鹽區約含鉀鹽三百萬噸左右，以吾國農業國家，需鉀正多，如有豐富鉀鑛，其有裨益于吾國農業者，將不可限量也。

又據農商部工業試驗所民國十二年所出報告內，尚有四川自流井貢井鹽區鹽水鹹水鹹巴分析數種，併列於此，以資參考。

物質＼鹽水鹹水鹹巴	黑水	鹹黃水	淡黃水	岩鹽水	假黑水	旋泡子	鹹水	備考
綠化鉀	三·七六	七·八七	○·八五	五·二三	九·七一	三·九五	三八·一八	除鹹水外綠化鉀及鉀質
鉀質	一·九七	四·一三	○·四五	二·七四	五·○九	二·○七	二○·○○	均爲全固形物之分數
全固形物	二五·七九	一九·○○	一○·五四	三二·一四	一七·五○	二三·七六		

物質＼鹹巴	自流井白鹹巴	自流井青鹹巴	自流井黑泥巴	備考
綠化鉀	二一·一七	一八·五二	○·九一	青鹹巴黑泥巴中之綠化鉀及鉀爲百

鉀質	一一·〇九	九·七〇	〇·四八	分率白鹼巴為全固形物之分數
全固形物	四三·〇〇		七·五二	

及後財政部鹽務署派人前往四川，調查鉀鹽，據報告所載，自流井黑鹽水含綠化鉀百分之三·六九五七，岩鹽水含綠化鉀百分之四·七七五，鹼水含綠化鉀百分之一三·二二八，自貢兩鹽場產鹼巴總數，年約二十六萬餘担，而全川年產不下六十萬担，如以半額計算，當有三十萬担，為鉀質之來源。

近年本所人員，入川考察，亦嘗調查鹽產，採集鹽水，由本所化學試驗室，按鹽水種類，詳經分析，茲將所含綠化鉀及鉀質成數表列如左（下列鹽井均在自流井鹽區內）。

鹽水種類	岩鹽水	黑鹽水				黃鹽水		
鹽井名稱	炎泰井	寧山井	厚福井	洪順井	積富井	銓湧井	鼎生井	同昌井
綠化鉀	一·六四	一·〇一	一·四九	一·五〇	〇·九六	〇·七四	〇·三七	〇·六七
鉀	〇·八六	〇·五三	〇·七八	〇·七八	〇·五〇	〇·三九	〇·一九	〇·三五

鹼水鹼巴常含鉀質，經分析後，得左列結果。

鹼水鹼巴	鹼水	鹼巴	備考
鹽井名稱	會龍井	王家井	會龍井在自流井鹽區內王家井在鄧井關鹽區內
綠化鉀	五·〇九	〇·三五	
鉀	二·六七	〇·一八	

四川鹽水鹼水鹼巴，經本所化學試驗室分析後，除鉀質可作鹽產附產品外，尙有碘溴二質，向未經人注意研究，溴之價值，巴較鹽中所含鉀鎂原質為高，而碘又當十倍於溴，如能提取而利用之，於工業上有莫大之裨益。據分析所得，碘溴二質，鹼水最多，黃水次之，而黑水內常有溴而少碘，茲將鹼水鹽水所含二質數目多少表列如左（表內數目為每公升所含之克數）。

鹽水鹹水 鹽井名稱	鹹	會龍井1	會龍井2	鼎生井	銓湧井	同昌井	寶山井	厚福井	洪順井	積富井
		鹹水		黃鹽水			黑鹽水			
溴	二·二〇	一·五〇	一·五〇	〇·八〇	一·〇〇	一·〇〇	〇·八〇	一·五〇	〇·四〇	一·〇〇
碘	二·九〇	二·三〇		〇·九〇	一·三〇			一·〇〇		

1. 鹹水　　2. 鹹水中之結晶物

如以富榮鹽場成鹽產額計算，每年約出鹹水二十五萬担，或三千三百四十萬磅，按鹹水所含溴碘二質，均在二克以上，即以二爲其量數，則溴碘每年所產，均爲五萬一千二百磅，即各二十五噸餘，按現在市價而言，溴之所值約七萬元，而碘之所值約八十八萬元。但四川產鹽區域，除有數鹽井鹽竈由鹹水煎熬鹹巴賤價售賣外，餘均棄而不取，只富榮一區，鹹水所含溴碘，年可拋棄約百萬元，計四川所有鹽區數十年間，有用物質所失已成鉅數，如不設法取出而利用之，誠可惜也。

鹽產參考書目

勞德伯克　四川石油調查報告　未出版　民國四年

漢讀(哈安姆)　四川自流井地質構造　兩廣地質調查所特刊第六號　民國十九年

　四川重慶附近地質構造及石油　、兩廣地質調查所特刊第八號　民國二十年

趙亞曾黃汲清　秦嶺山及四川之地質研究　實業部地質調查所地質專報甲種第九號　民國二十年

林振翰　川鹽紀要　民國八年

寇德瑞　四川之鹽水火井　法國鑛業年報第八卷第十九期　一八九一

何　賽　四川及其物產實業富源　一九二二

威利斯　中國考察誌　第一卷　一九〇七

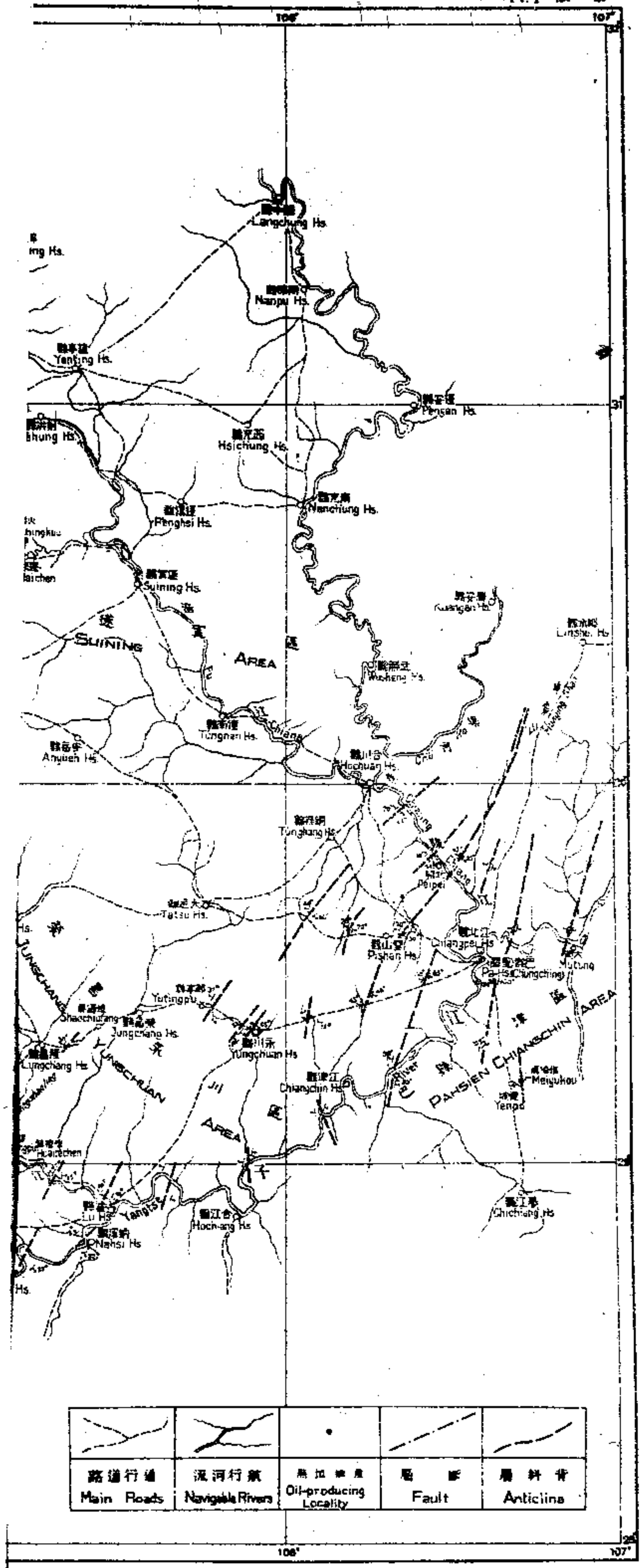
阿邦登諾　四川省赤色盆地之地質　一九〇六

交域區置位田油川四

showing the Locations,

ticlines and Faults

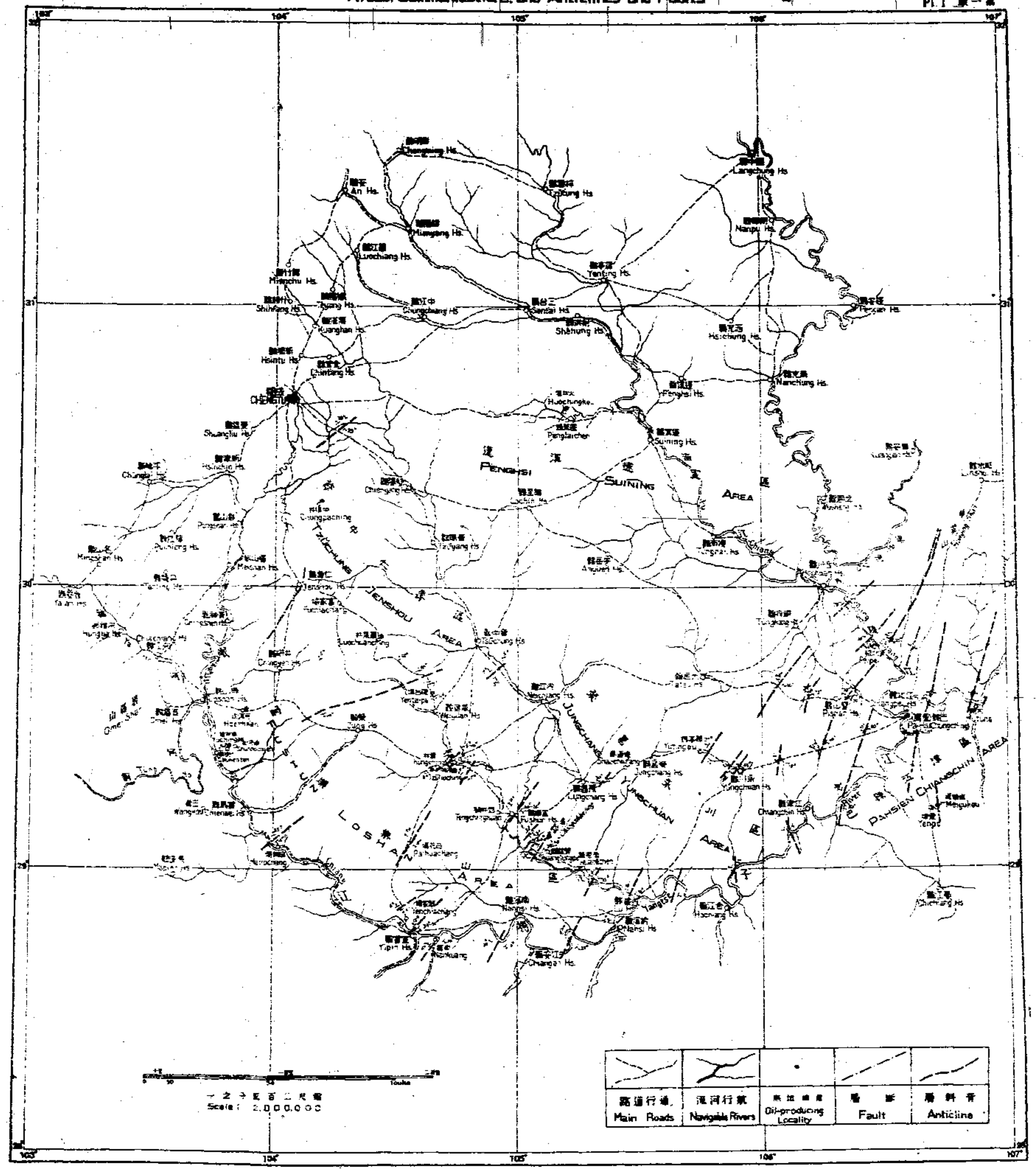
Pl. I 版一第



圖略造構層斷層斜背及通交域區置位田油川四

Map of the Oil Fields in Szechuan showing the Locations, Areas, Communications, and Anticlines and Faults

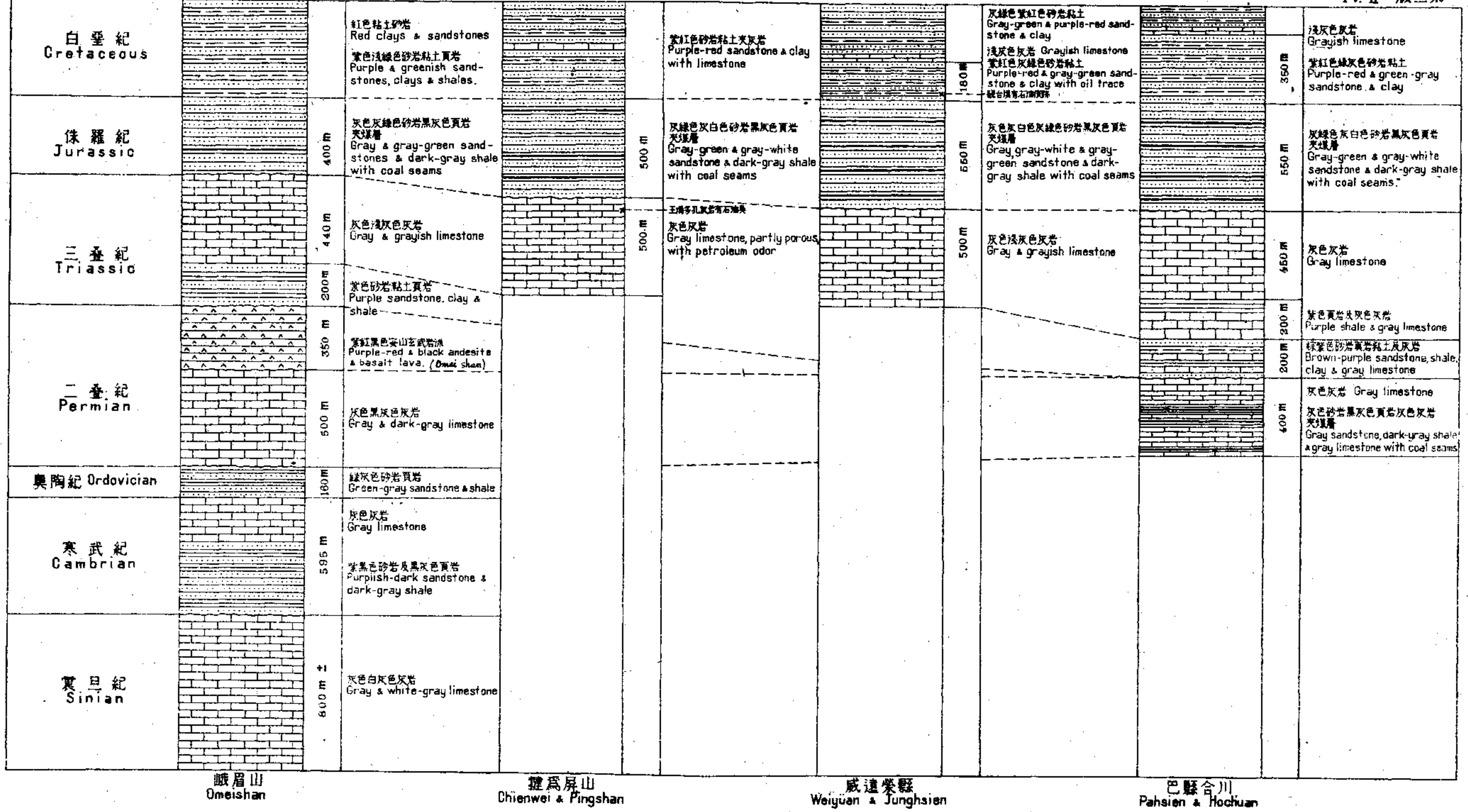
Pl. I



四川石油區域附近各地地層比較柱狀圖

COLUMNAR SECTIONS SHOWING THE GENERAL STRATIGRAPHY OF THE REGIONS IN CONNECTION WITH THE OIL FIELDS IN SZECHUAN

Pl. II 第二版



自流井貢井地表地層柱狀圖
COLUMNAR SECTION SHOWING THE SURFACE STRATIGRAPHY IN TZŬLIUCHING AND KUNGCHING REGION

下白堊紀自流井層 TZŬLIUCHING FORMATIEN OF THE LOWER CRETACEOUS

珍珠沖粘土 Chênchuchung Clay	[illegible] Limestone	大坟包粘土 Tafênpao Clay	[illegible] Sandstone	馬鞍山粘土 Maanshan Clay	大安寨灰岩 Taanchai Limestone	凉高山沙岩 Liangkaoshan Sandstone
	51.4 m	467 m	29.0 m +	50 m	230–246 m	
棕紫色粘土間夾淺綠色粘土 Brownish-purple clay with greenish clay	[illegible] Greenish-yellow hard & fine sandstone, grayish & dark-brown marl, grayish & dark-gray limestone, & greenish-yellow clay	紫色粘土夾淺綠黃色粘土 Purple clay with greenish-yellow clay [illegible] Purple clay with greenish-yellow clay, greenish & dark-gray shale with coal seam (3 mm–1 cm thick) & petrified wood	[illegible] Greenish, yellowish & gray sandstone, & greenish, yellow, gray, purple, red clay	紅紫色粘土 Red-purple clay	白灰帶淺紫色灰岩，白灰間灰紫色泥灰岩，紅紫綠綠白灰色粘土 White-gray limestone with purplish tint, white-gray, dark-gray, purple marl, red-purple, greenish, white-gray clay	淺黃灰色粗砂岩夾棕紫綠色粘土及黃綠色粗砂岩一層 Yellowish & gray coarse sandstone with brown, purple & green clay & a bed of yellow-green coarse sandstone

COLUMNAR SECTION SHOWING WELL LOG OF HUNGLUNGCHING AT KUNGCHING IN FUSHUN AND JUNGHSIEN REGION

富順榮縣區貢井灯井龍井鑿井地層柱狀圖

Pl. IV 第四版

COLUMNAR SECTION SHOWING WELL LOG OF YÊNT'AI CHING AT TZŬLIUCHING IN FUSHUN, AND JUNGHSIEN REGION

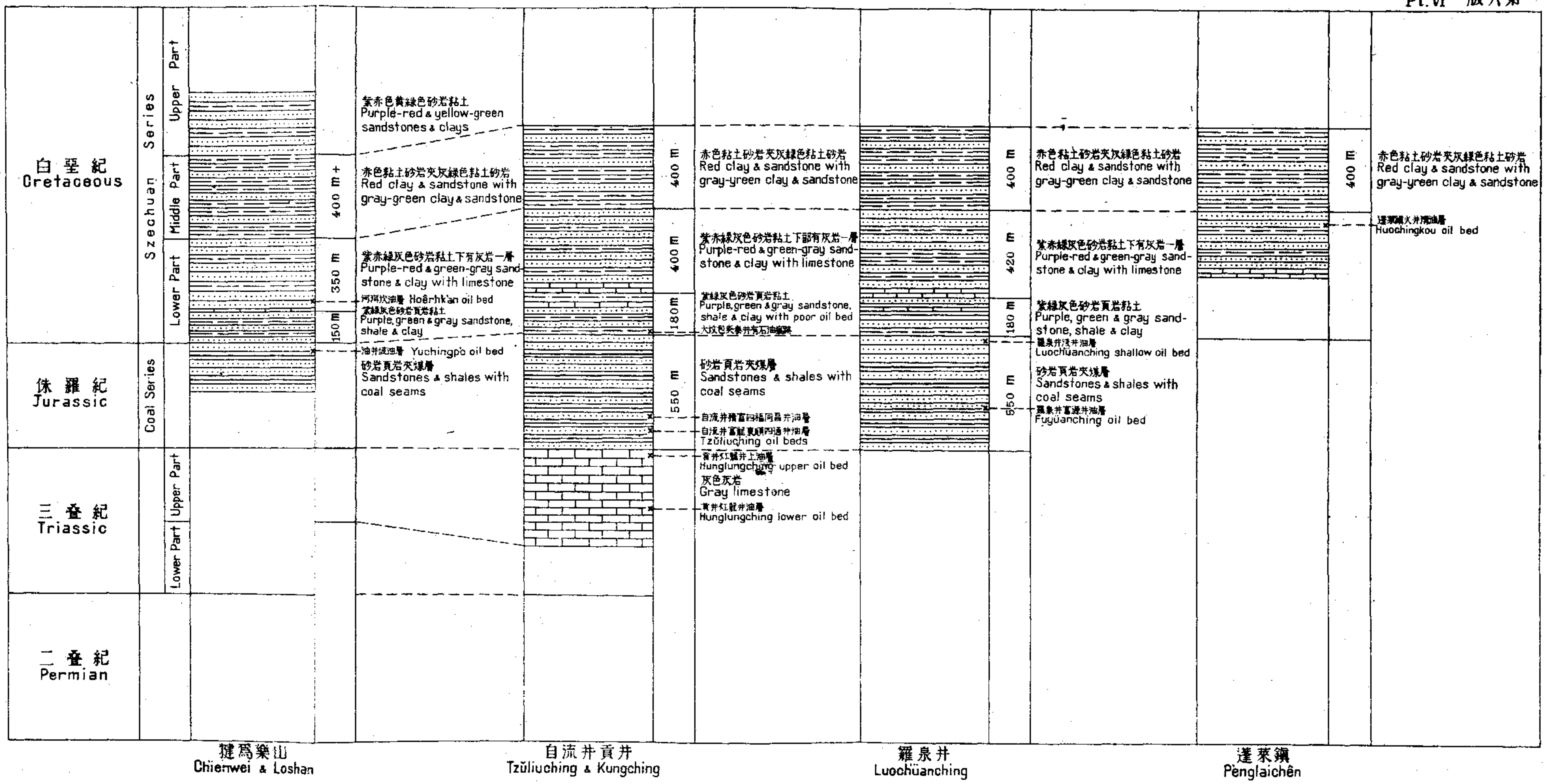
富順榮縣區自流井炎泰井鑿井地層柱狀圖

Formation	Thickness (m)	Description
白堊紀自流井層 TZŬLIUCHING FORMATION OF LOWER CRETACEOUS — 上粘包墳大 Tafêngao Clay	24.12 m	岩石記錄缺 Rocks unrecorded
	7.12	紅紫色砂岩粘土 Red-purple sandstone & clay
	6	白灰色灰色灰岩及泥灰岩 White-gray & gray limestone & marl
	4	灰色砂岩及黃灰色粘土 Gray sandstone & yellow-gray clay
上粘冲珠珍 Chênchuchung Clay	7.39	紅紫色粘土 Red-purple clay
	4.53	灰黃色砂岩 Gray-yellow sandstone
	35.07	紅紫色粘土夾灰色砂岩 Red-purple clay with gray sandstone
	14.76	灰色白灰色砂岩稍有石油 Gray & white-gray sandstone with small amount of oil 紅紫色粘土夾灰色白灰色砂岩粘土 Red-purple clay with gray & white-gray sandstone & clay
侏羅紀 JURASSIC — 香溪煤系 Hsiangchi Coal Series	15.48	灰色砂岩夾灰色頁岩 Gray sandstone with gray shale
	8.26	灰色頁岩夾黑色頁岩 Gray shale with black shale
	2.37	灰色頁岩夾煤層 Gray shale with coal seam
	5.55	灰色砂岩 Gray sandstone
	7.92	灰色黑色砂岩夾白灰色頁岩及煤層 Gray & black sandstone with white-gray shale & coal seam
	15.77	灰色黑色頁岩砂岩 Gray & black shale & sandstone
	2.88	白灰色砂岩 White-gray sandstone
	14.47	灰色黑色頁岩砂岩 Gray & black shale & sandstone
	5.94	白灰色砂岩 White-gray sandstone
	6.48	灰色頁岩 Gray shale
	19.41	白灰色砂岩 White-gray sandstone
	3.35	灰色頁岩 Gray shale
	24.21	白灰色砂岩夾灰色頁岩 White-gray sandstone with gray shale
	6.48	灰色頁岩夾白灰色砂岩 Gray shale with white-gray sandstone
	10	白灰色砂岩夾黃色頁岩 White-gray sandstone with yellow shale
	5.4	黑色頁岩白灰色砂岩 Black shale & white-gray sandstone
	2.63	黑色頁岩夾煤層 Black shale with coal seam
	19.92	灰色白灰色砂岩夾灰色頁岩 Gray & white-gray sandstone with gray shale 灰色黑色頁岩 Gray & black shale
	12.73	灰色砂岩夾黑色頁岩 Gray sandstone with black shale
	34.56	白灰色砂岩有鹽水(鹹量一兩四) White-gray sandstone containing brine (with about 13 % salt)
	4.32	灰色白灰色砂岩及黑色頁岩上部夾煤層厚三十六公分 Gray & white-gray sandstone & black shale with coal seam in upper part, 36 cm thick
	11.52	黑色灰色頁岩夾灰色砂岩及煤層二層一層厚三十六公分 Black & gray shale with gray sandstone & two coal seams, one amounting to 36 cm
	25.2	灰色砂岩 Gray sandstone
	11.6	白灰色砂岩 White-gray sandstone
	3.42	灰色頁岩 Gray shale
	6.12	灰色砂岩 Gray sandstone
	61.71	白灰色砂岩稍夾灰色黃色砂岩 White-gray sandstone with gray & yellow sandstone
	12.61	黑色灰色頁岩白灰色黑灰色砂岩 Black & gray shale & white-gray & dark-gray sandstone
	27.82	白灰色砂岩 White-gray sandstone
	6.12	黑色頁岩夾白灰色砂岩 Black shale with white-gray sandstone
	7.2	白灰色砂岩夾灰色砂岩 White-gray sandstone with gray sandstone
	43.92	黑色灰色頁岩上部夾煤層 Black & gray shale with coal seam in upper part
	19.86	白灰色砂岩 White-gray sandstone
	11.2	灰色黑色頁岩砂岩 Gray & black shale & sandstone
	[illegible]	白灰色砂岩 White-gray sandstone
	7.92	黑色頁岩灰色白灰色砂岩夾煤層二層一厚約二十四公分一厚約三十六公分 Black shale & gray & white-gray sandstone with two coal seams, one amounting to 24 cm in thickness, the other to 36 cm.
	34.41	白灰色砂岩 White-gray sandstone
	5.58	白灰色砂岩上有黑色頁岩 White-gray sandstone with black shale
	3.68	黑色灰色頁岩 Black & gray shale
	18.5	灰色黑色頁岩稍夾黃灰色頁岩 Gray & black shale with yellow-gray shale
三疊紀 TRIASSIC — 嘉陵江層 Chialingchiang Formation	62.38	灰色黑灰色灰岩夾黃白色泥灰質灰岩 Gray & dark-gray limestone with yellow-white marly limestone
	19.76	灰色黑灰色灰岩一部質粗 Gray & dark-gray limestone, coarse in part
	9.4	灰色黑灰色灰岩夾黃色泥灰質灰岩 Gray & dark-gray limestone with yellow marly limestone
	15.12	灰色黑灰色白灰色灰岩 Gray, dark-gray & white-gray limestone
	47.52	白灰色灰色黃色黑灰色灰岩 White-gray, gray, yellow & dark-gray limestone 綠灰色灰岩厚六十五公分 Green-gray limestone, 65 cm thick
	32.04	灰色白灰色黃灰色灰岩 Gray, white-gray & yellow-gray limestone
	15.12	黃色灰岩 Yellow limestone
	27.72	灰色及雜色灰岩 Gray & variegated limestone
	24.12	灰色白灰色黃灰色灰岩 Gray, white-gray & yellow-gray limestone
	19.08	灰色灰岩質稍粗 Gray limestone, coarse
	10.4	白灰色灰色灰岩一部質稍粗 White-gray & gray limestone, coarse in part
	5.04	白岩鹽紅岩鹽中夾灰色粗灰岩厚七十二公分 White rock salt & red rock salt with gray limestone between, 72 cm thick
	5.8	灰色白灰色灰岩一部質稍粗 Gray & white-gray limestone, coarse in part

四川石油田油層位置比較柱狀圖

COLUMNAR SECTIONS SHOWING THE HORIZONS OF THE PETROLIFEROUS BEDS IN THE OIL FIELDS OF SZECHUAN

Pl. VI 第六版



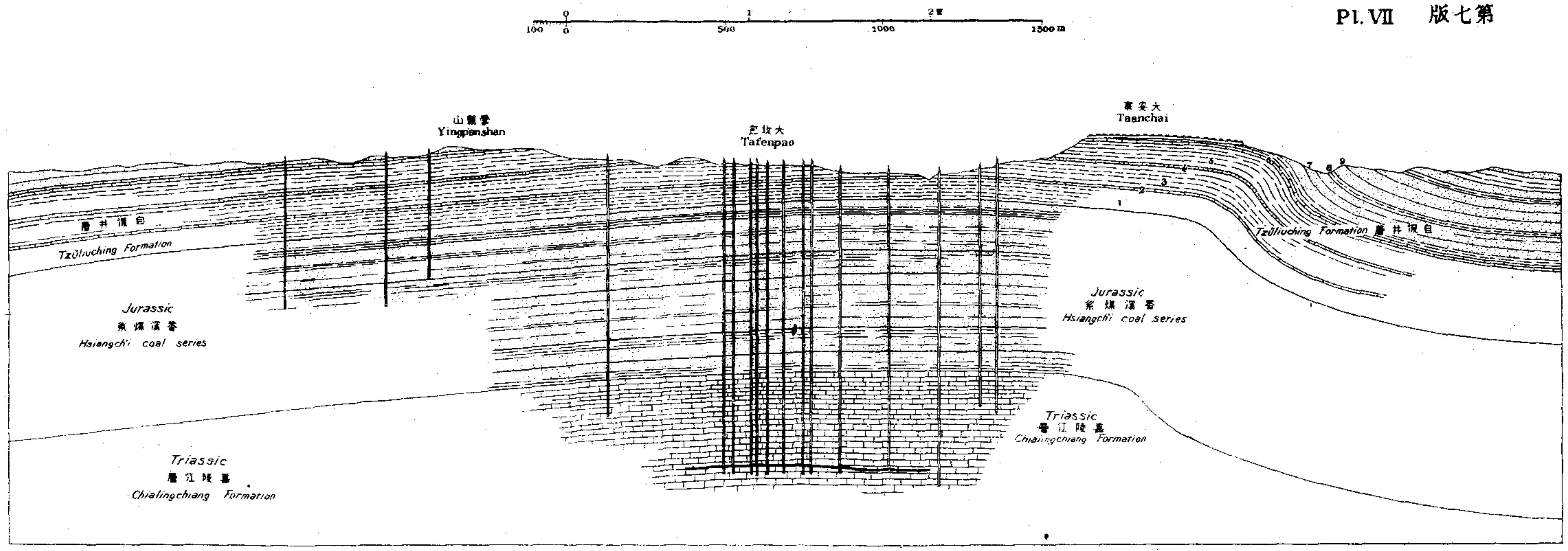
自流井背斜層剖面圖
表示岩鹽產狀

SECTION OF THE TZULIUCHING ANTICLINE
SHOWING THE OCCURRENCE OF ROCK SALT

縮尺一萬五千分之一

Scale 1 = 15,000

Pl. VII 第七版

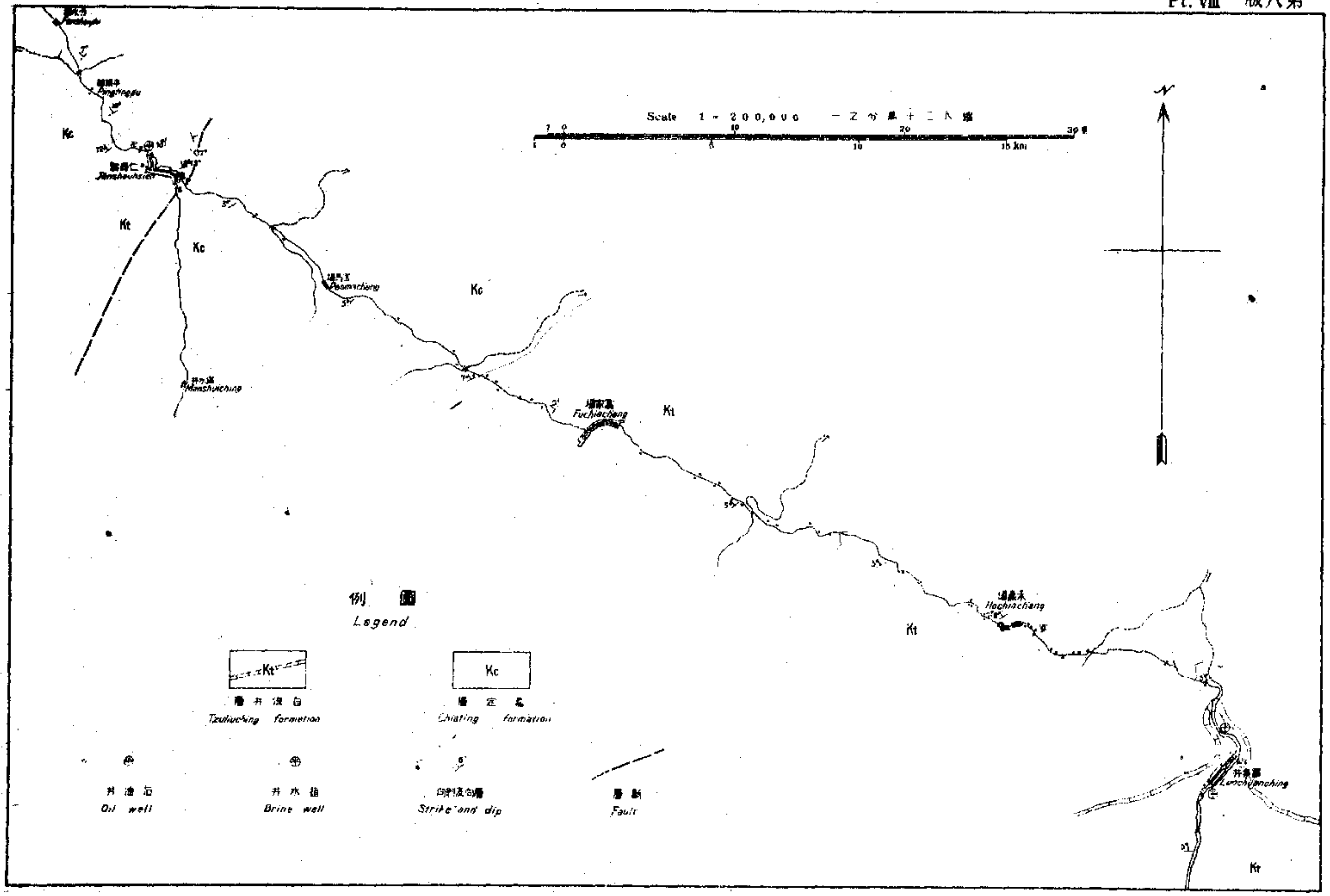


1. 珍珠冲粘土 *Chenchuchung clay* 2. 東岳廟灰岩 *Tungyomiao limestone* 3. 大墳包粘土 *Tafenpao clay* 4. 郭家坳砂岩 *Kuochiao sandstone* 5. 馬鞍山粘土 *Maanshan clay* 6. 大安寨灰岩 *Taanchai limestone* 7. 8. 9. 涼高山砂岩 *Liangkaoshan sandstone*

四川仁壽及羅泉井鹽產油田區域圖

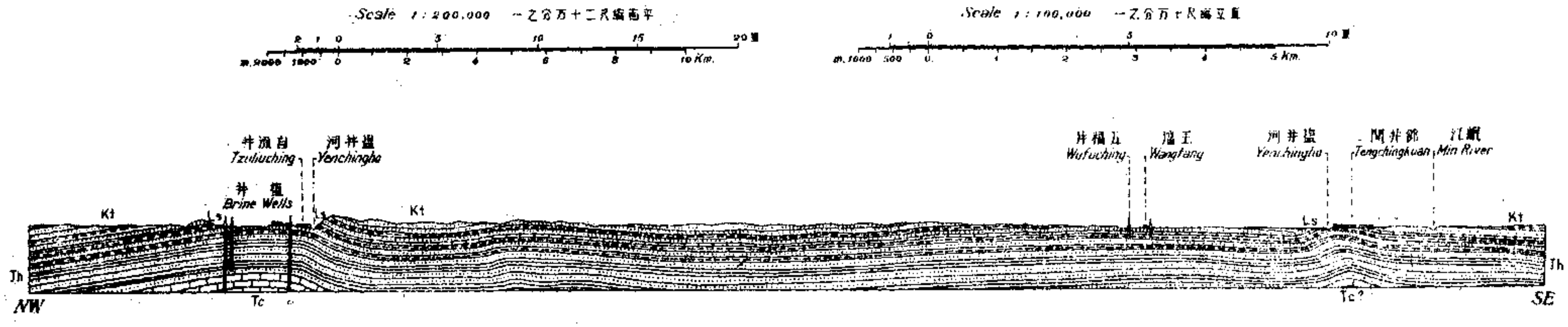
SKETCH MAP OF THE SALT DEPOSITS AND THE OIL FIELDS IN THE JENSHOU AND LUOCHUANCHING REGIONS, SZECHUAN

Pl. VIII 第八版



Pl. IX 第九版

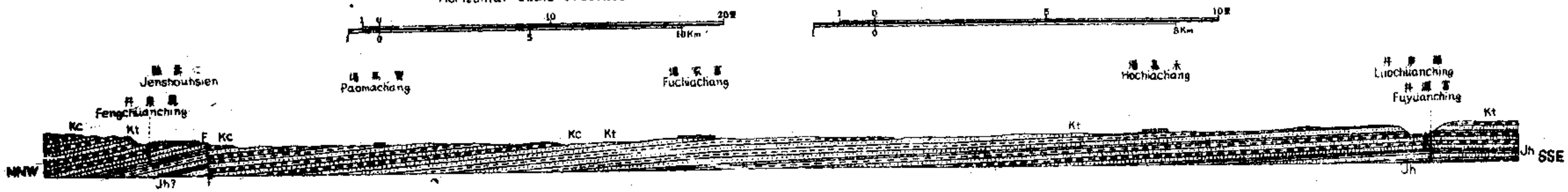
四川富順榮縣鹽區地層及構造剖面圖
SECTION SHOWING THE STRATIGRAPHY AND STRUCTURE OF THE FUSHUN-JUNGHSIEN SALT AND OIL AREA, SZECHUAN



Tc 嘉陵江層 Chialingchiang formation   Jh 香溪煤系 Hsiangchi coal series   Kt 自流井層 Tzuliuching formation   (Ls 大安寨灰岩 Taanchai limestone)

四川仁壽縣及羅泉井鹽區油田地層構造剖面圖
SECTION
SHOWING
THE STRATIGRAPHY AND STRUCTURE OF THE JENSHOU AND LUOCHÜANCHING SALT AND OIL REGIONS, SZECHUAN

平面縮尺二十萬分之一 Horizontal Scale 1:200,000   直立縮尺十萬分之一 Vertical Scale 1:100,000

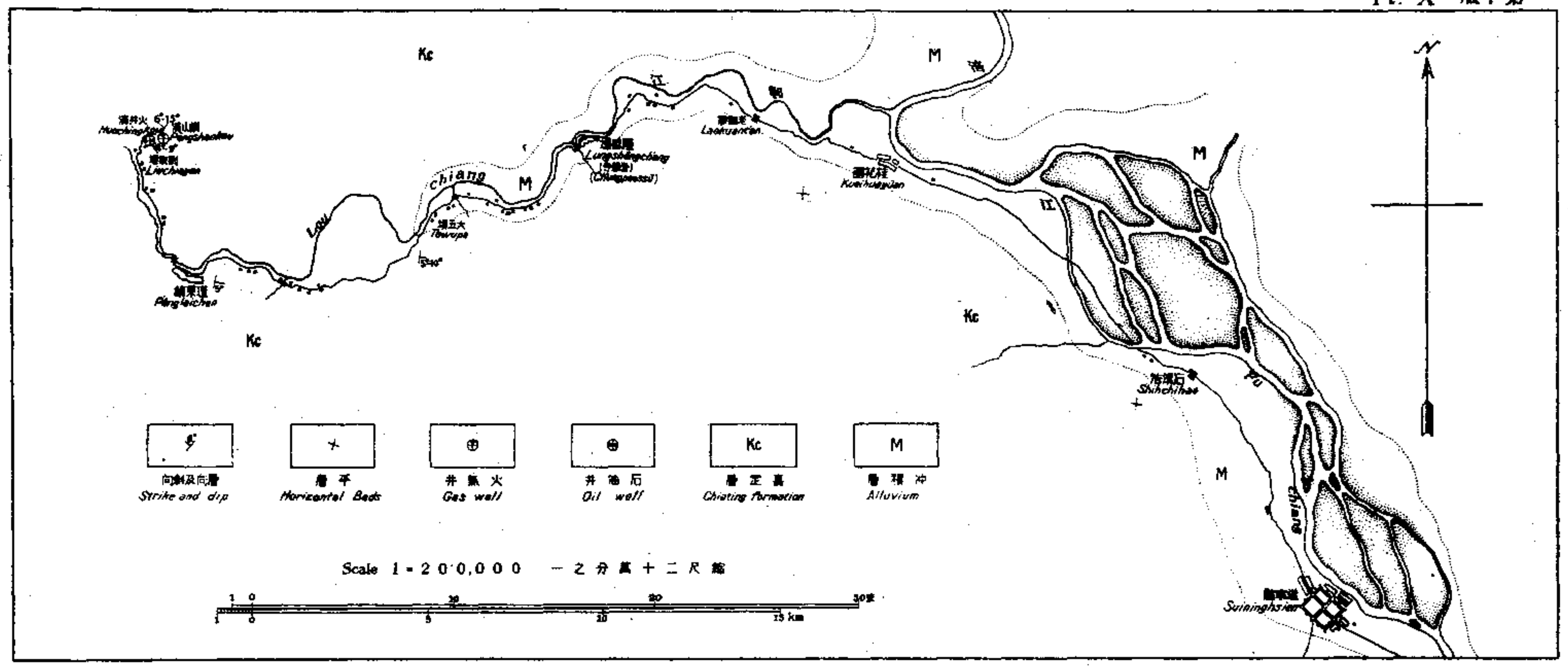


Jh 香溪煤系 Hsiangchi coal series   Kt 自流井層 Tzuliuching formation   Kc 嘉定層 Chiating formation

四川蓬溪縣蓬萊鎮火井溝油田圖

SKETCH MAP OF THE HUOCHINGKOU OIL FIELD NEAR PENGLAICHEN IN THE PENGCHI DISTRICT, SZECHUAN

Pl. X 第十版

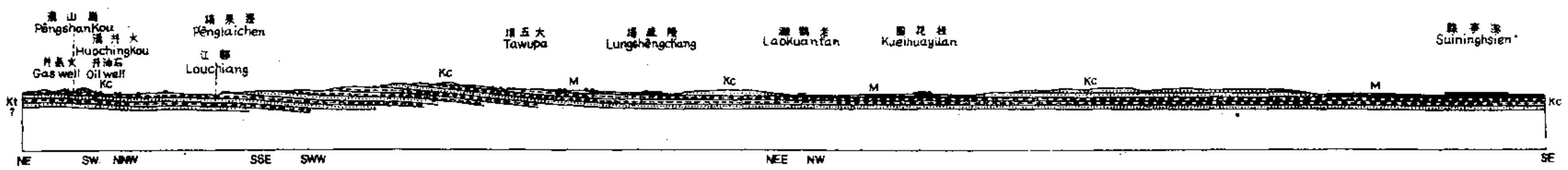


四川蓬溪縣蓬萊鎮火井溝油田一帶地層及構造剖面圖

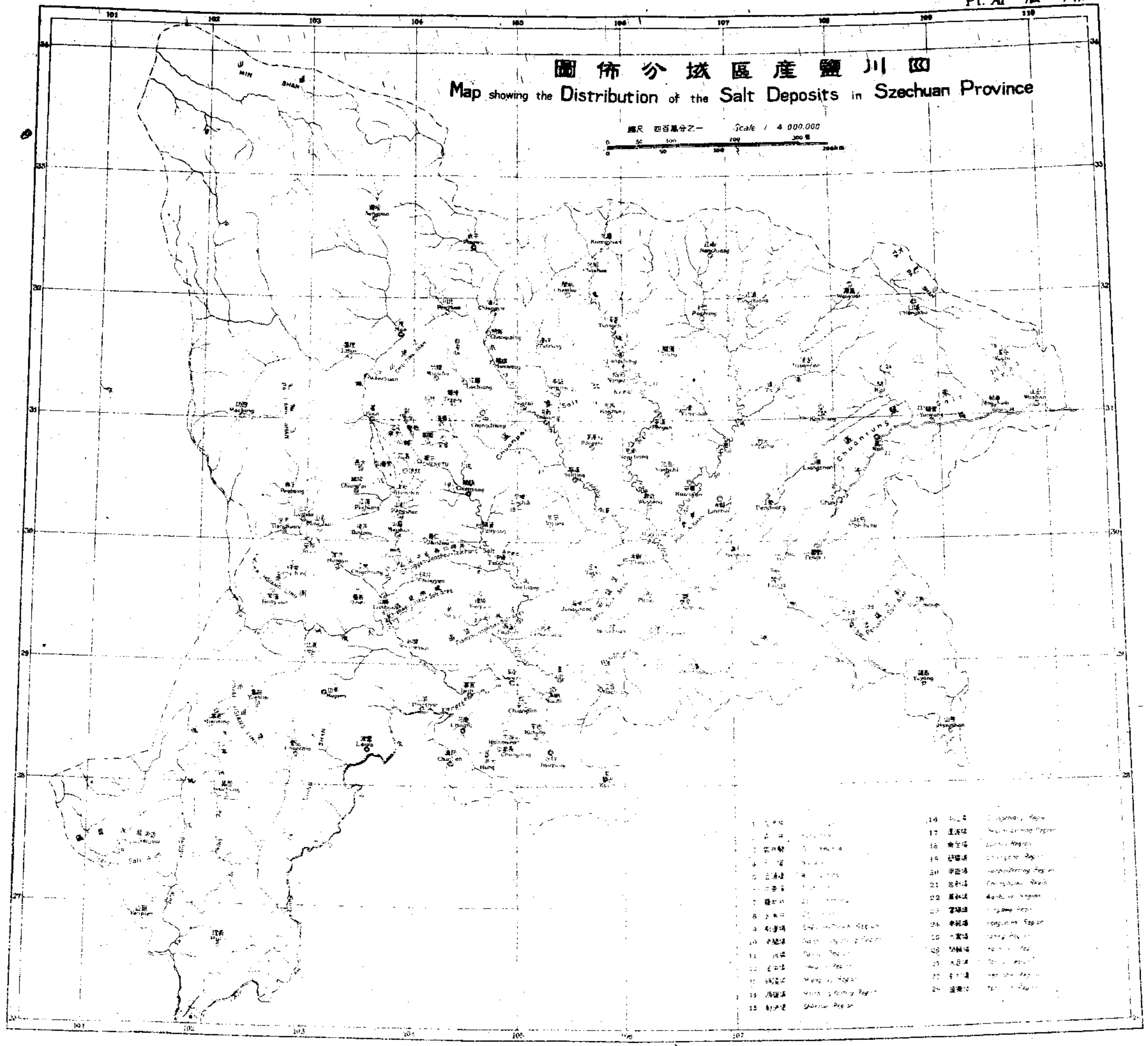
SECTION SHOWING THE STRATIGRAPHY AND STRUCTURE OF THE ENVIRONS OF THE HUOCHINGKOU OIL FIELD NEAR PENGLAICHEN IN THE PENGCHI DISTRICT, SZECHUAN

平面縮尺二十萬分之一
Horizontal Scale 1:200,000

直立縮尺十萬分之一
Vertical Scale 1:100,000



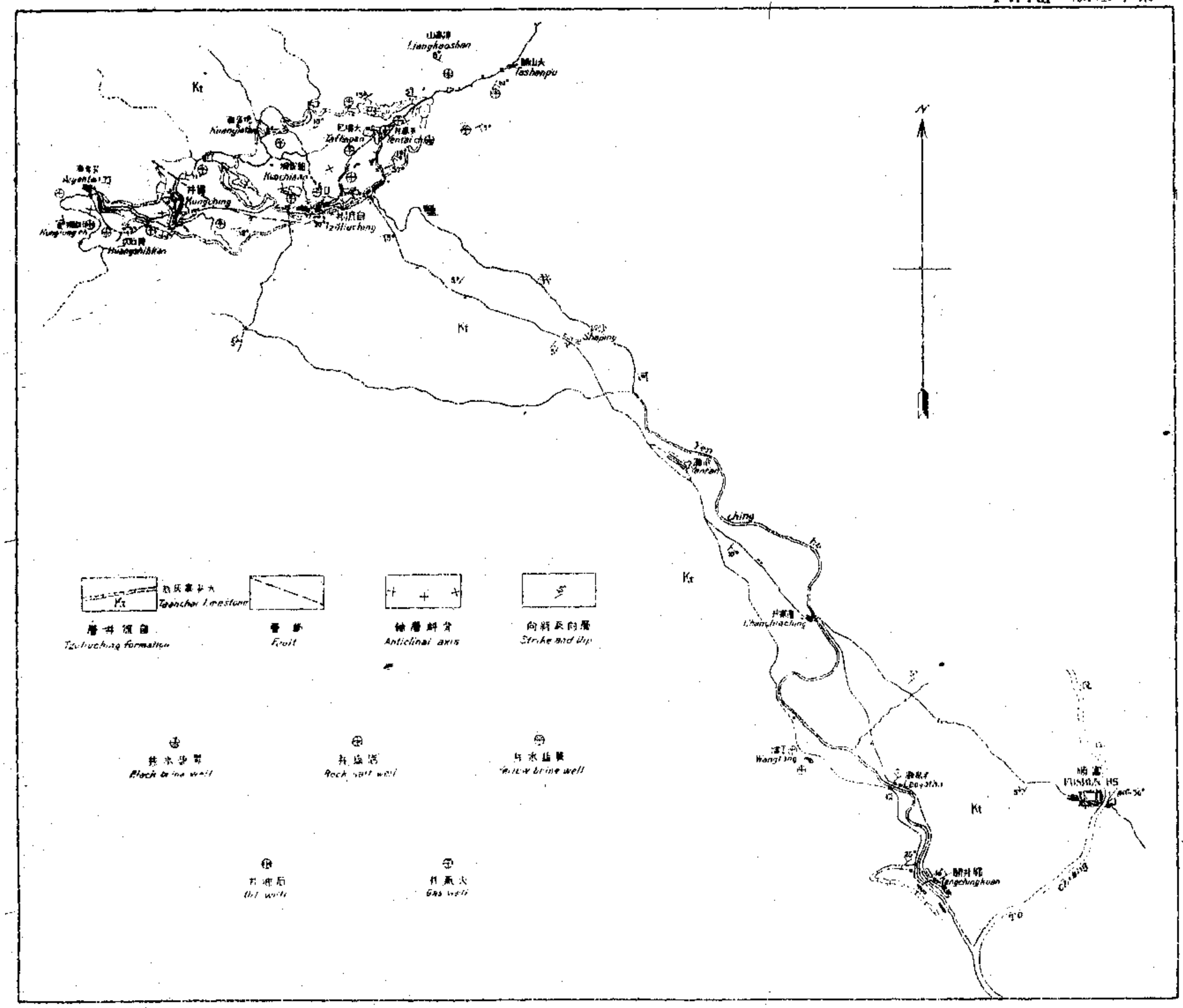
Kt 自流井層 Tzuliuching formation   Kc 嘉定層 Chiating formation   M 沖積層 Alluvium


四川鹽產區域分佈圖
Map showing the Distribution of the Salt Deposits in Szechuan Province
縮尺 四百萬分之一
Scale 1 : 4 000.000

四川富順榮縣鹽產油田區域圖

SKETCH MAP OF THE SALT DEPOSITS AND THE OIL FIELDS IN THE FUSHUN AND JUNGHSIEN AREA, SZECHUAN

Pl. XII 第十二版

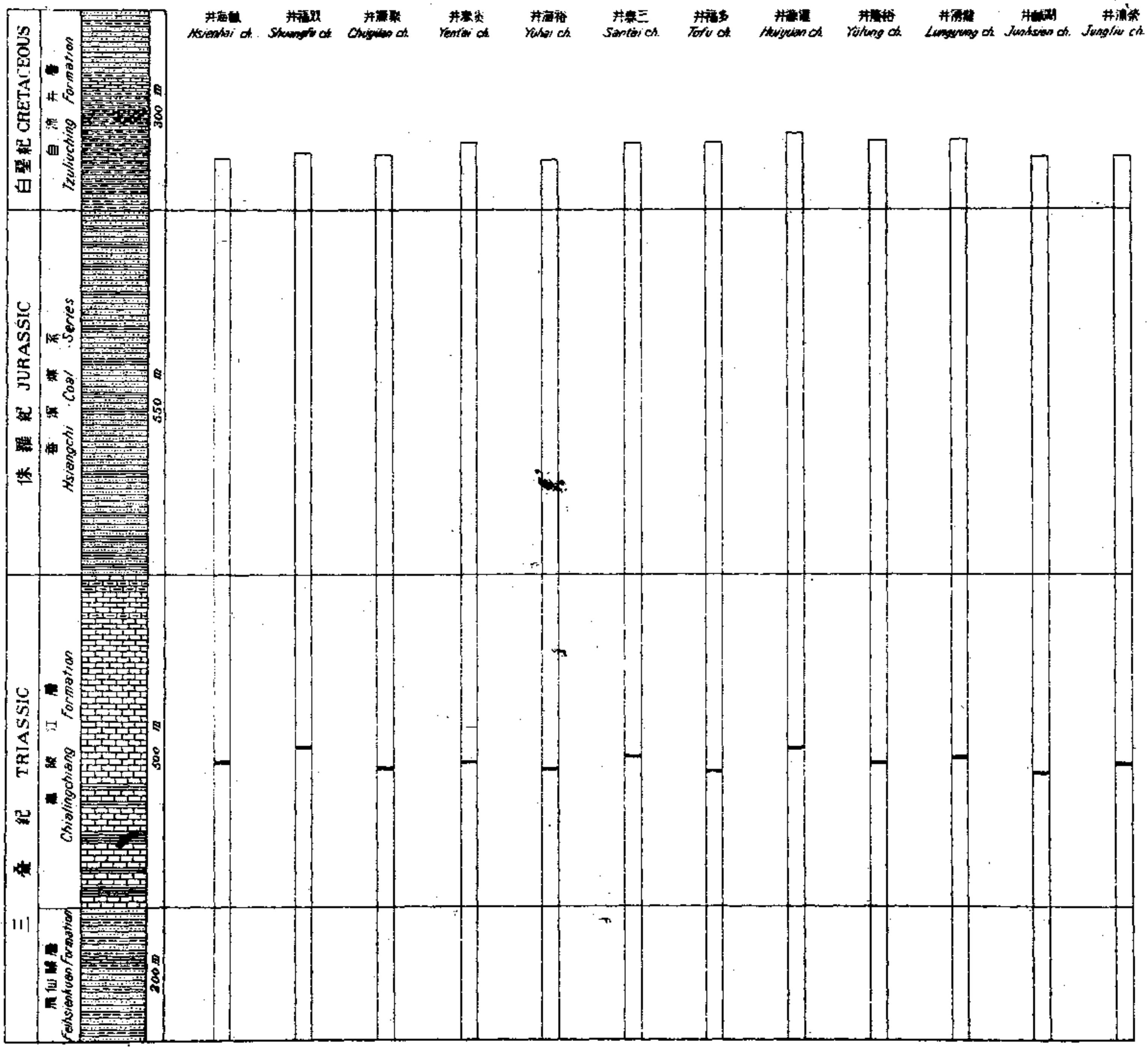


Scale 1 : 200,000　縮尺二十萬分之一

自流井大墳包岩鹽層位比較圖

第十三版 Pl. XIII

DIAGRAM SHOWING THE HORIZON OF ROCK SALT AT OBSERVED WELLS IN THE VICINITY OF TAFENPAO IN THE TZULIUCHING REGION



自流井貢井黃鹽水及王墻白鹽水層位比較圖

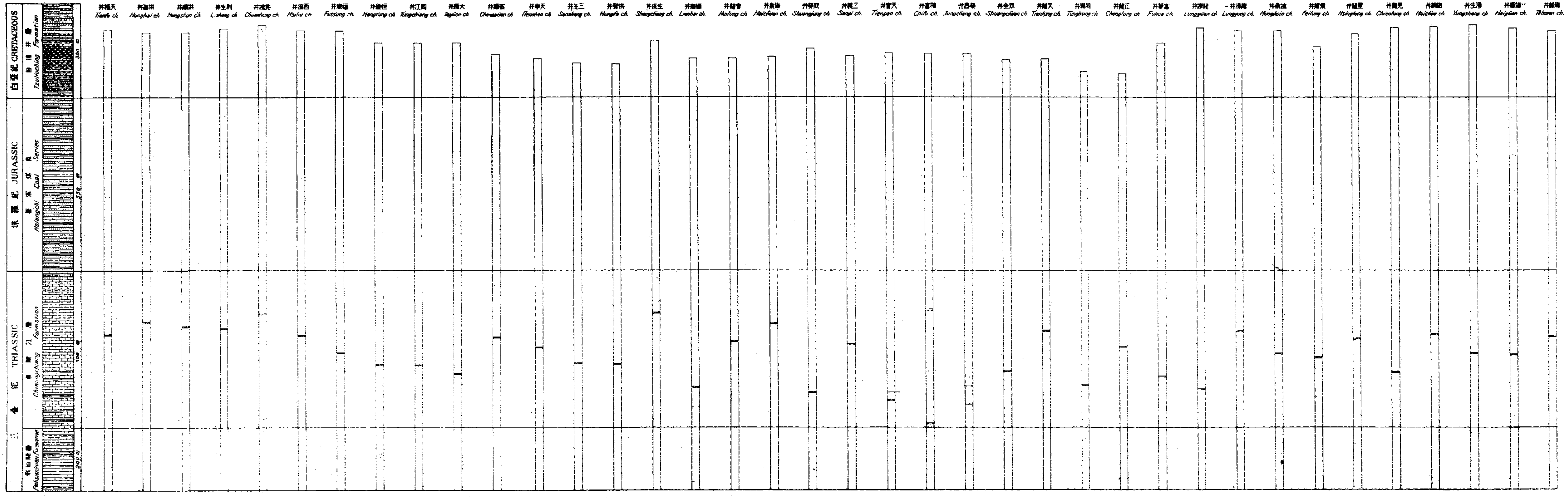
DIAGRAM SHOWING THE HORIZONS OF YELLOW BRINE AT OBSERVED WELLS IN THE TZULIUCHING-KUNGCHING REGION AND WHITE BRINE AT WANGTANG

Pl. XIV 第十四版

自流井貢井黑鹽水層位比較圖

DIAGRAM SHOWING THE HORIZONS OF BLACK BRINE AT OBSERVED WELLS IN THE TZULIUCHING-KUNGCHING REGION

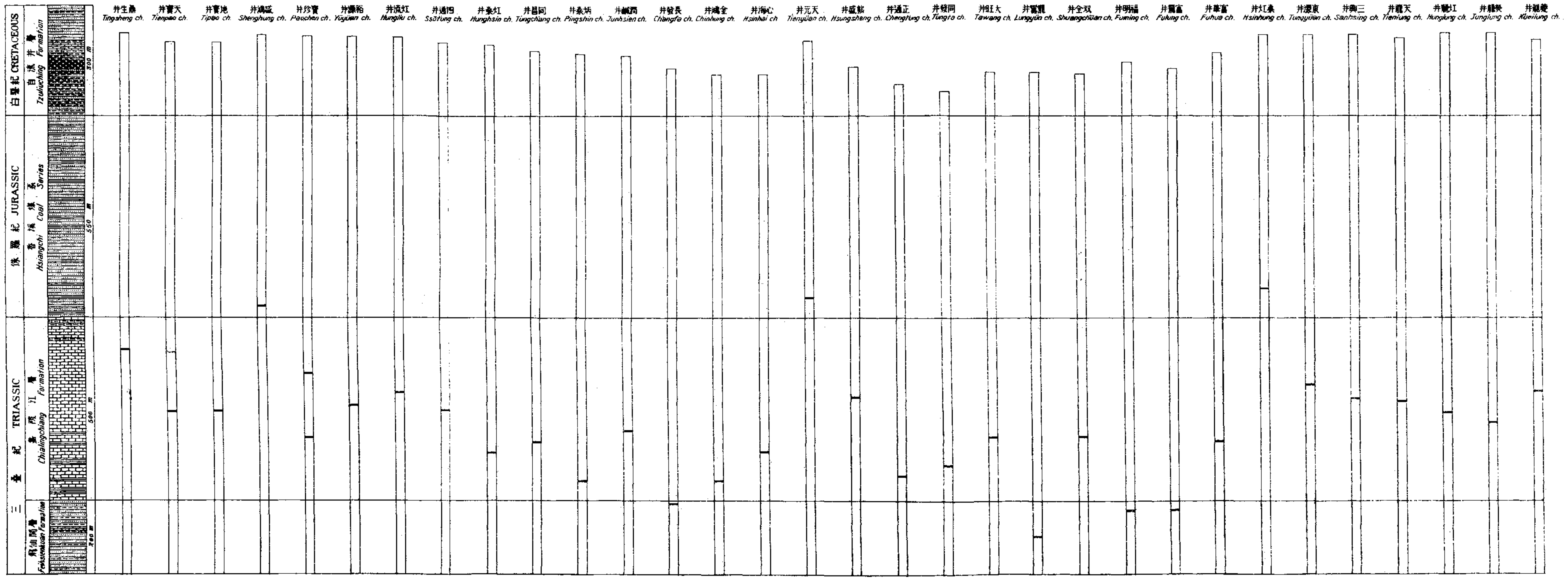
Pl. XV 第十五版



自流井貢井雜鹽水層位比較圖

DIAGRAM SHOWING THE HORIZONS OF ABNORMAL BRINE AT OBSERVED WELLS IN THE TZULIUCHING-KUNGCHING REGION

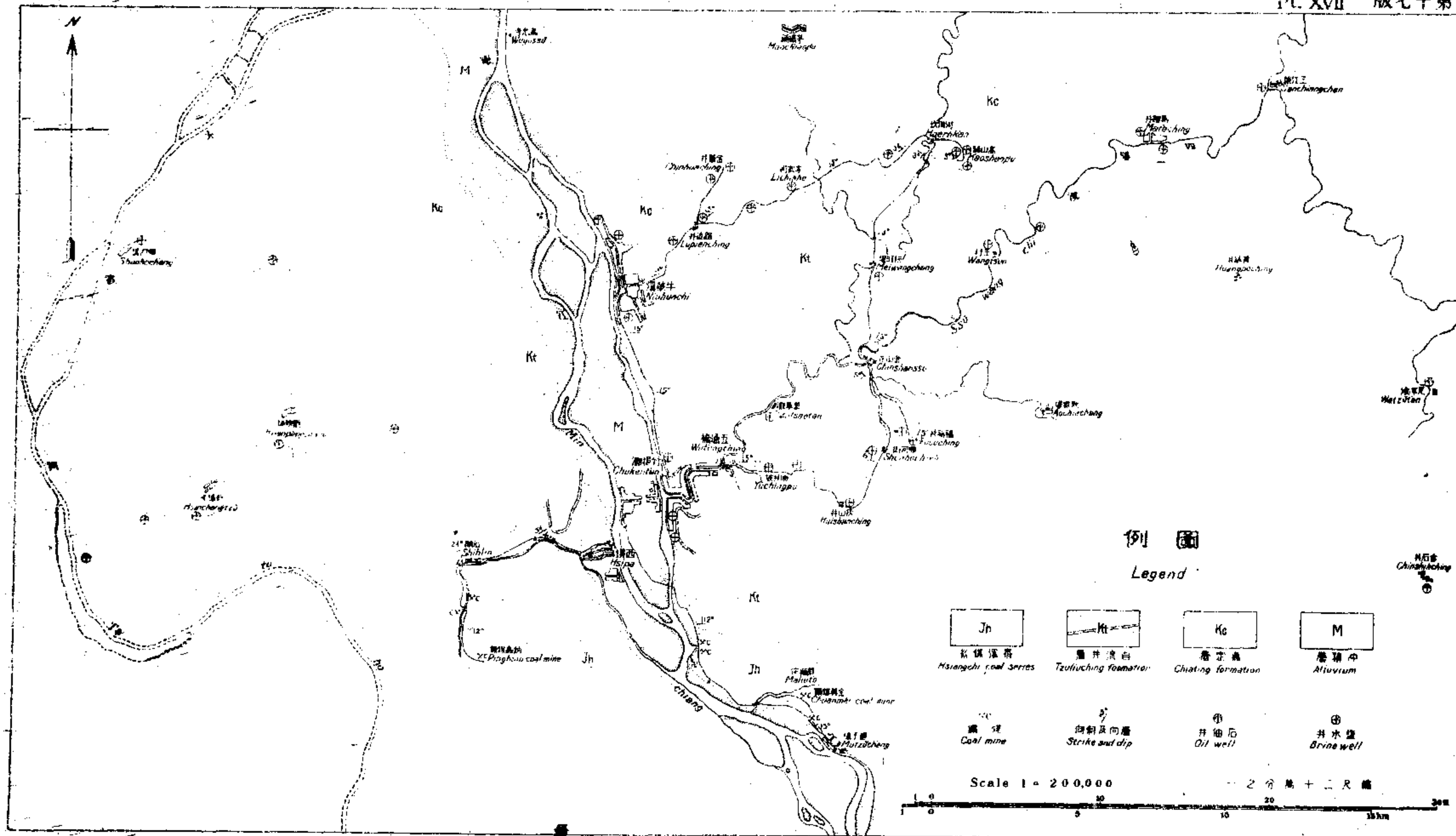
Pl. XVI 第十六版



四川犍爲樂山鹽産油田區域圖

SKETCH MAP OF THE SALT DEPOSITS AND THE OIL FIELDS IN THE CHIENWEI AND LOSHAN AREA, SZECHUAN

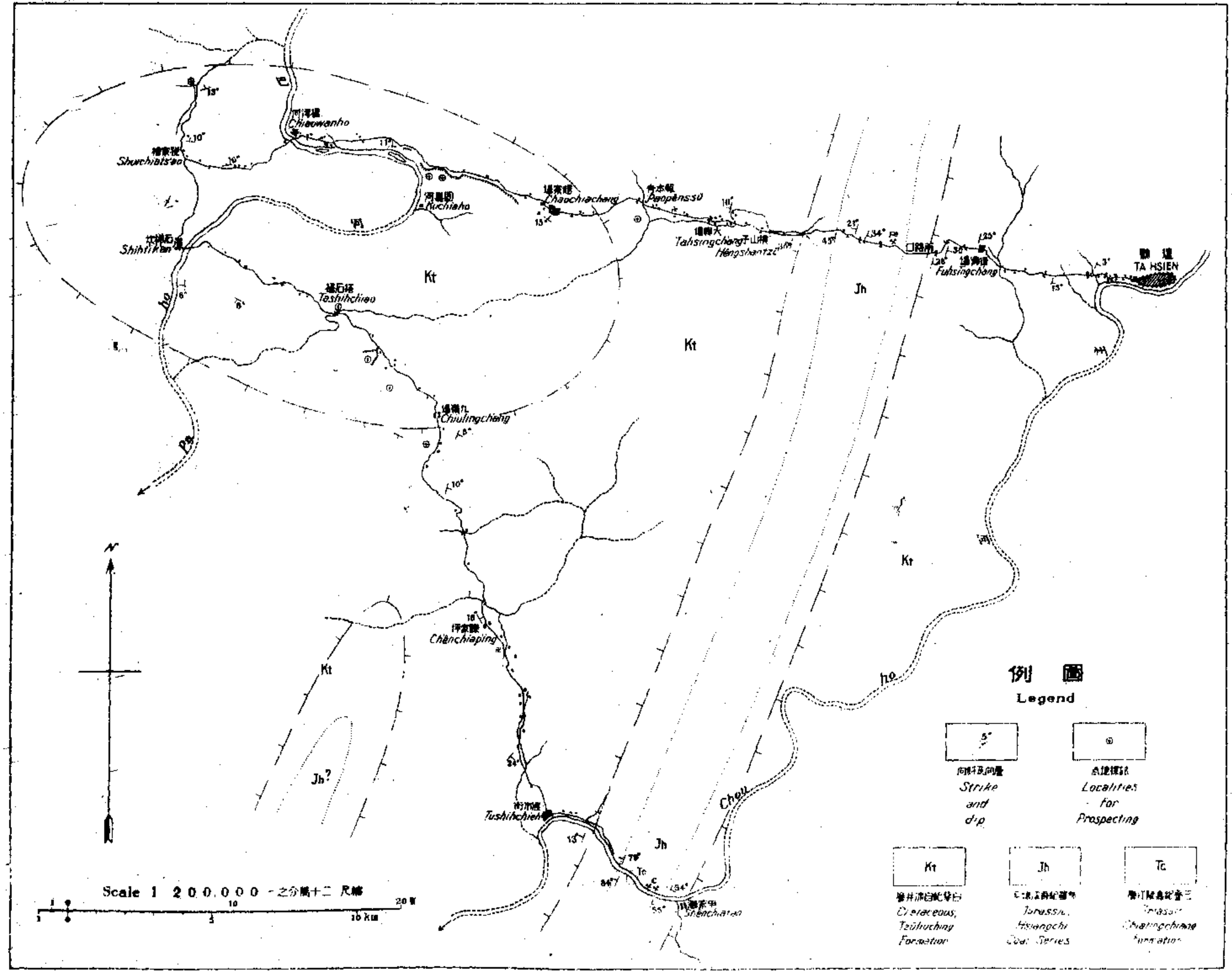
PL. XVII 第十七版



四川達縣油田地質略圖

SKETCH MAP OF TAHSIEN OIL FIELD, SZECHUAN

Pl. XVIII 第十八版



第十九版 Plate XIX

自流井區大墳包附近岩鹽鹽水井

Rock salt and brine wells in the vicinity of Tafenpao in the Tzuliuching region.

(一) 自流井區黑鹵水井

1. Black brine well in the Tzuliuching region.

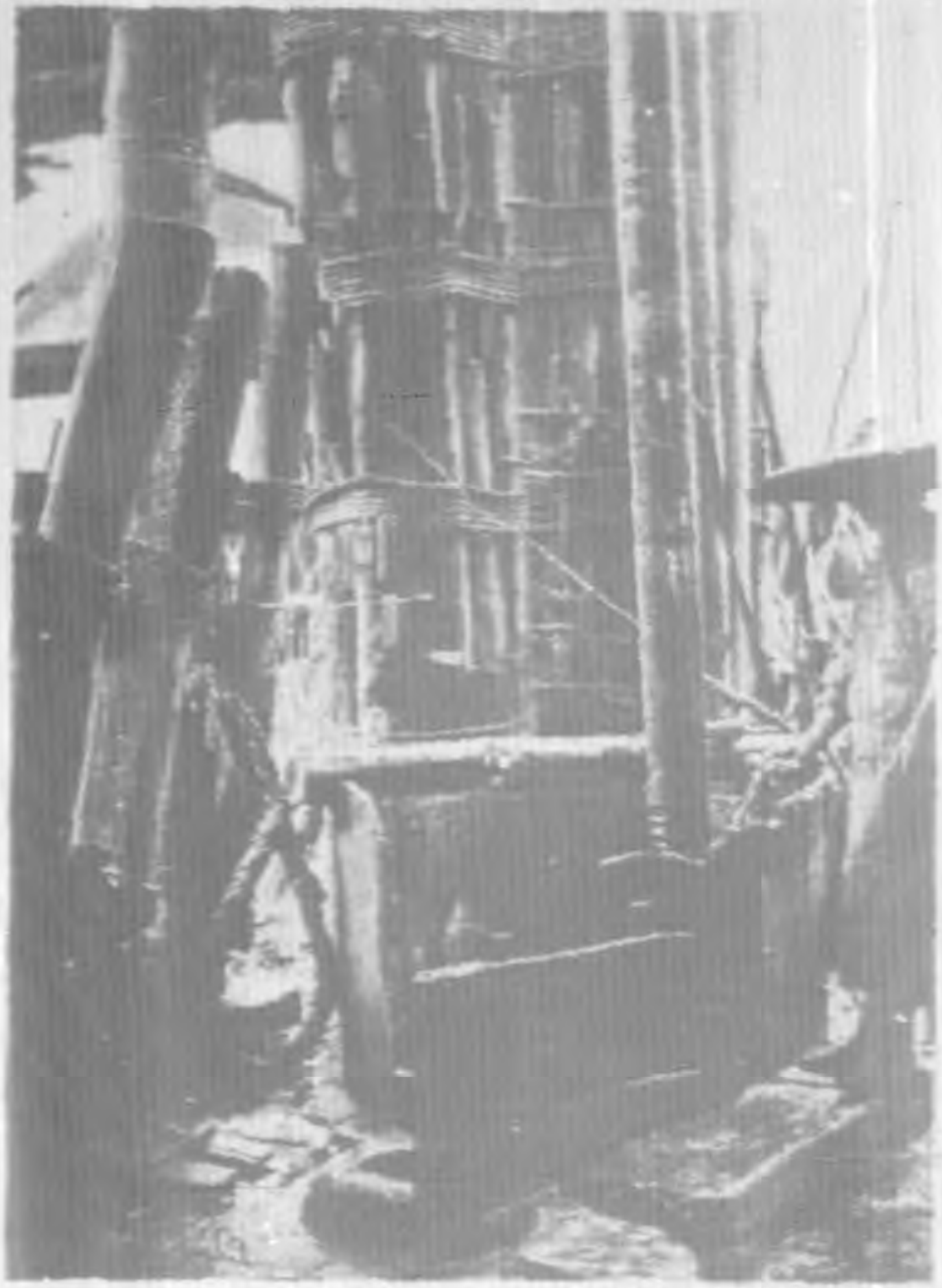
(二) 自流井區黃鹵水井

2. Yellow brine well in the Tzuliuching region.

(三) 自流井區岩鹽井

3. Rock salt well in the Tzuliuching region.

第二十一版 Plate XXI

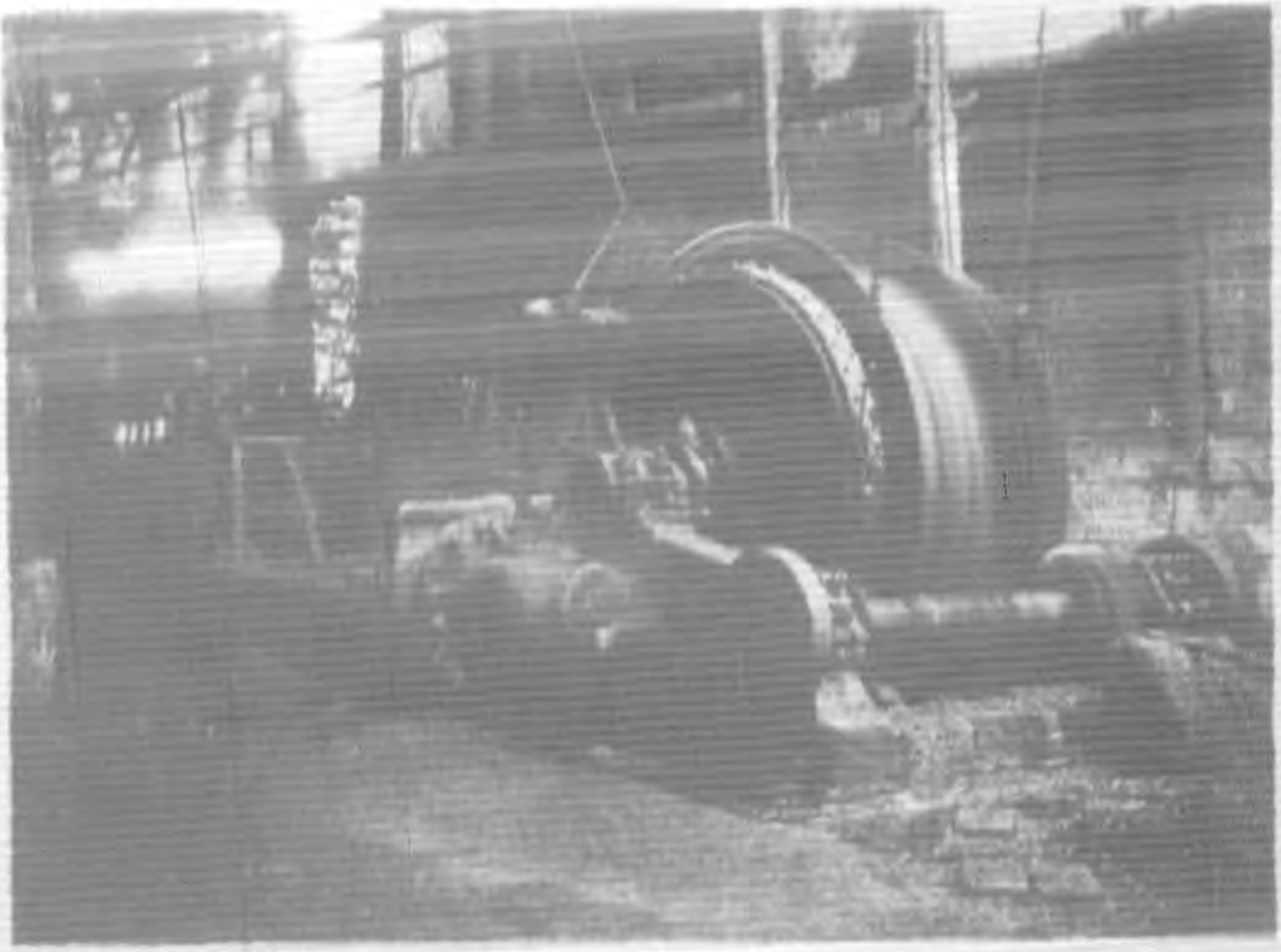


（一） 自流井區黑鹵水井放注鹵水

1. Pouring out of brine from bailing tube at black brine well in the Tzuliuching region.

（二） 自流井區黃鹵水井放注鹵水

2. Pouring out of brine from bailing tube at yellow brine well in the Tzuliuching region.



(一) 自流井區岩鹽井汽力捲揚機

1. Steam winding engine for bailing brine at rock salt well in the Tzuliuching region,

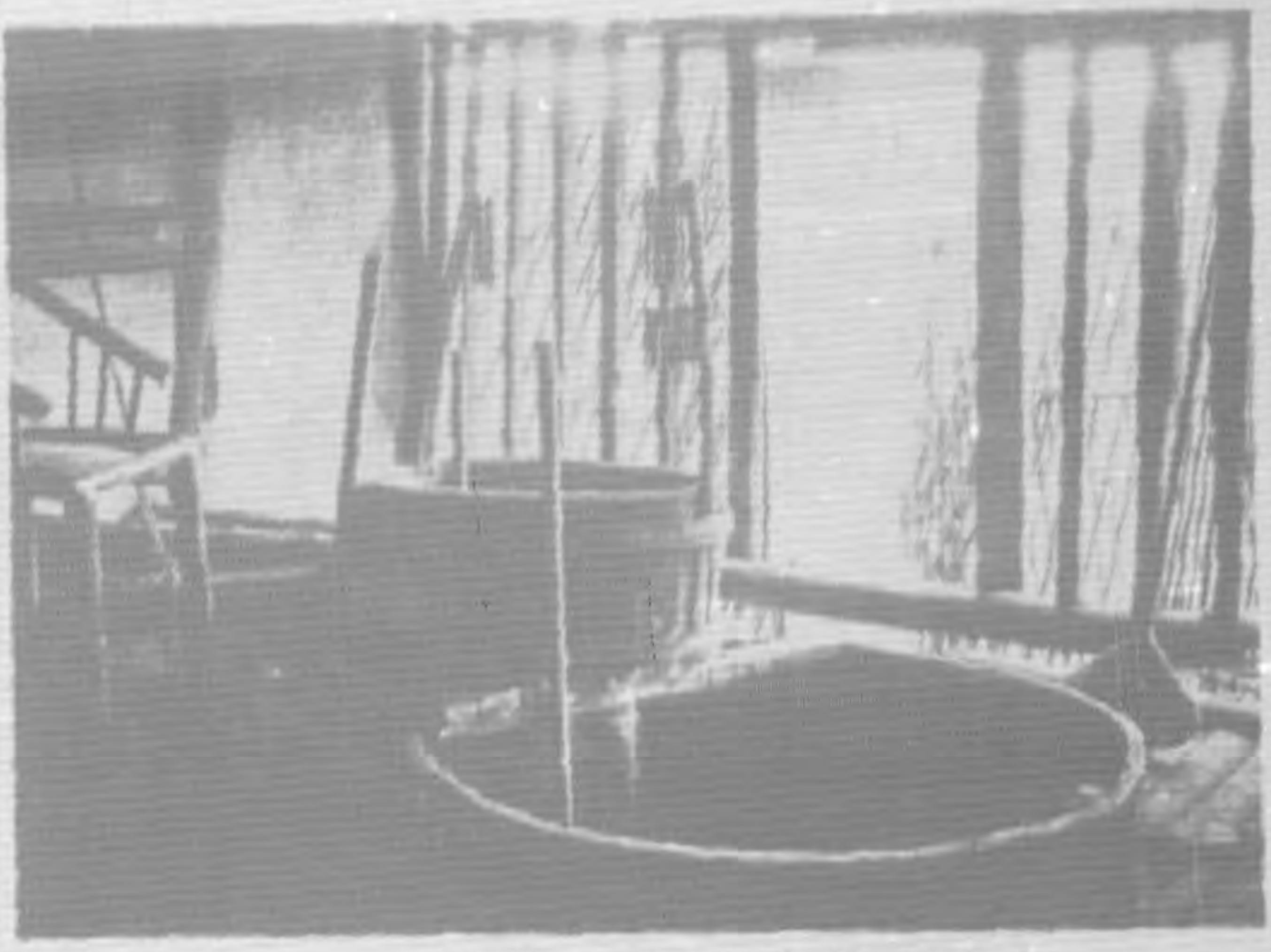
(二) 自流井區黃滷水井提水牛車

2. Oxen windlass for bailing brine at yellow brine well in the Tzuliuching region,

第二十三版 Plate XXIII

（一） 自流井區岩鹽井貯水木池（枧桶）

1. Wooden tank for reserving brine at rock salt well in the Tzuliuching region.



（二） 自流井區岩鹽井量水木桶

2. Wooden tank for measuring brine at rock salt well in the Tzuliuching region.

第二十四版 Plate XXIV

(一) 貢井區梘桿梘窩

1. Bamboo pipes and pipe line junctions in the Kungching region.

(二) 貢井區梘桿運送鹽水

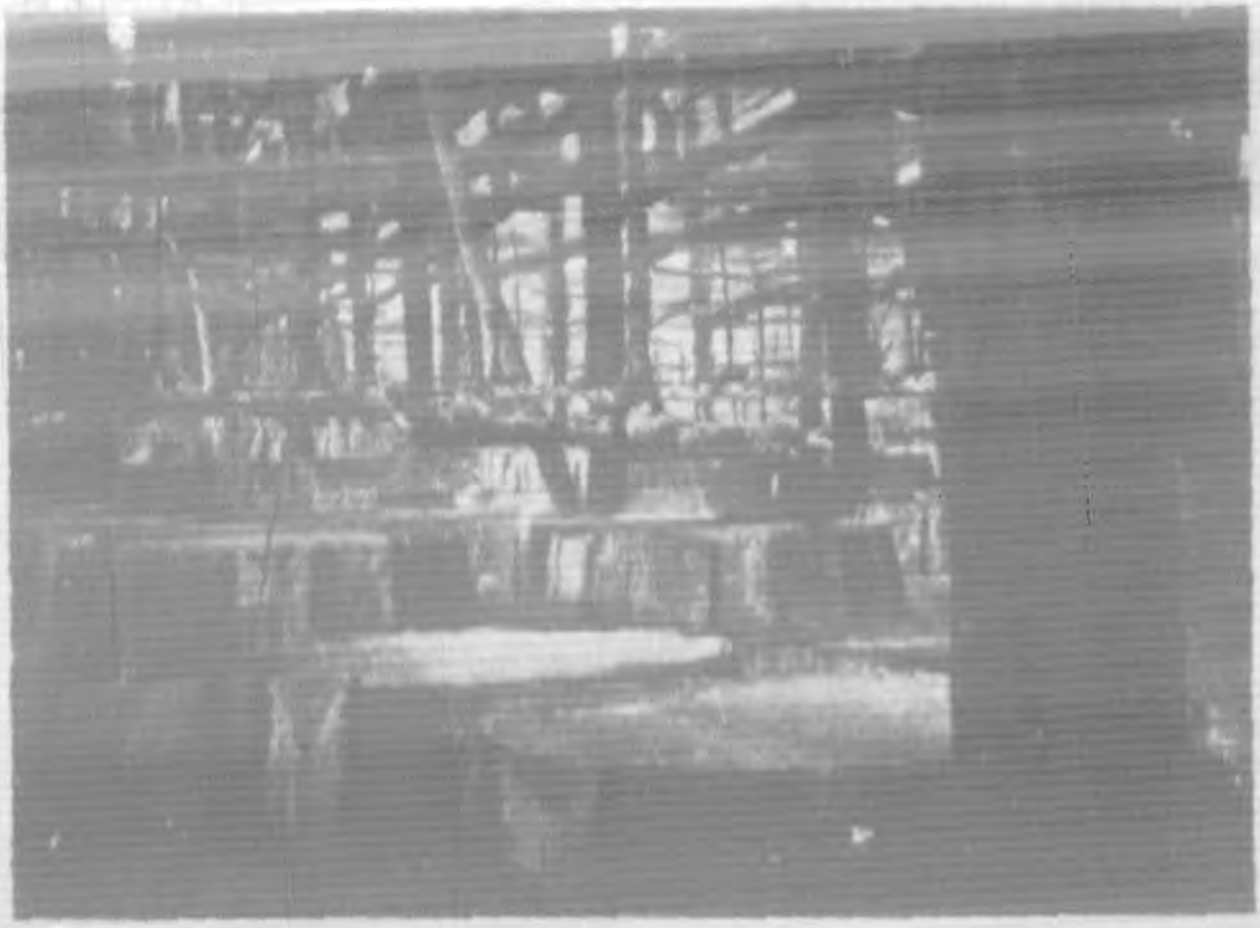
2. Pipe lines for conveying brine in the Kungching region,

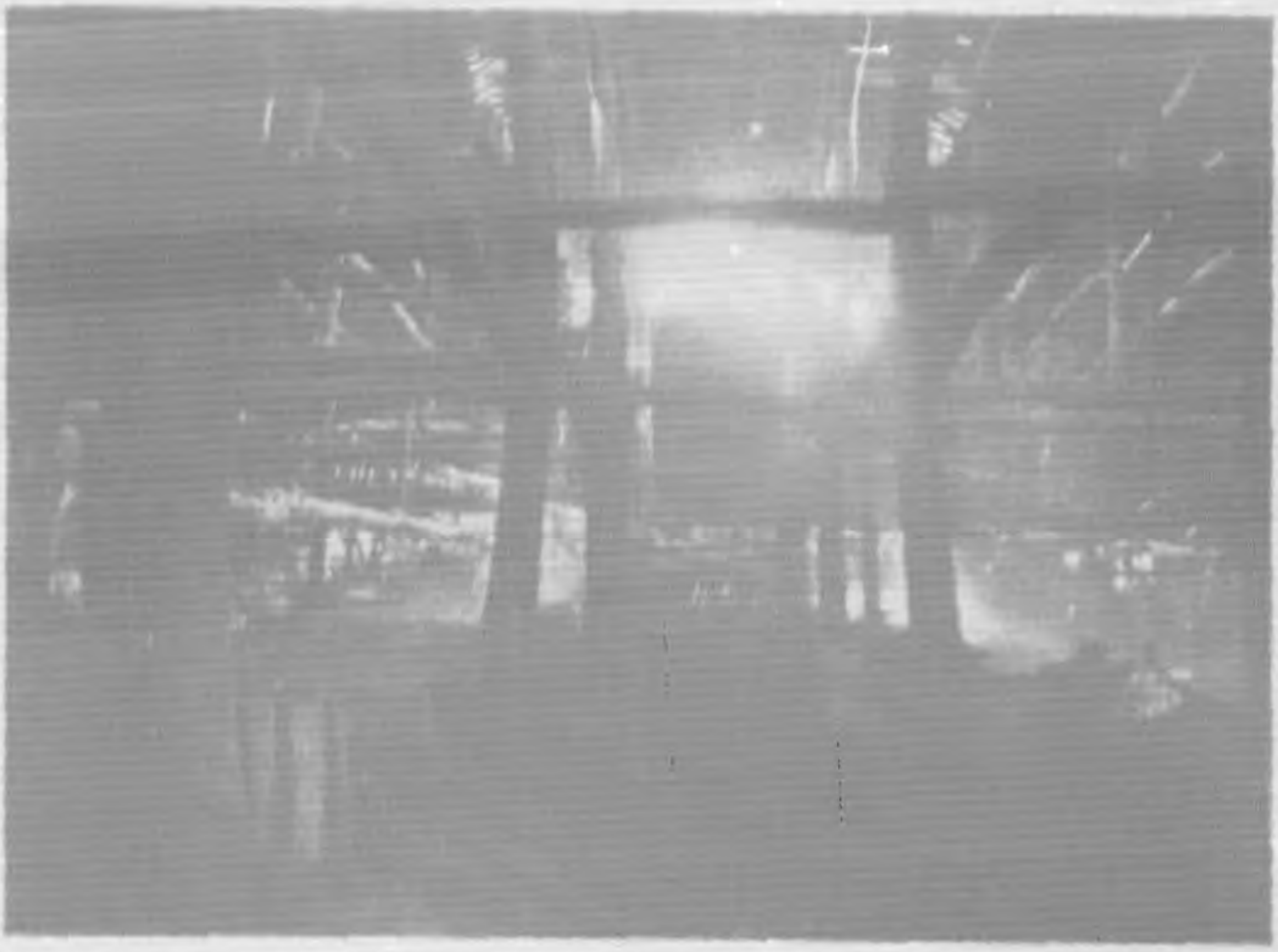
第二十五版 Plate XXV

自流井貢井區梘樓梘窩

Pipe line towers and junctions in the Tzuliuching-Kungching region,

第二十六版 Plate XXVI





自流井貢井區鹽灶內鹽鍋排列安置
Arrangement of salt pans in salt plant.

第二十七版 Plate XXVII

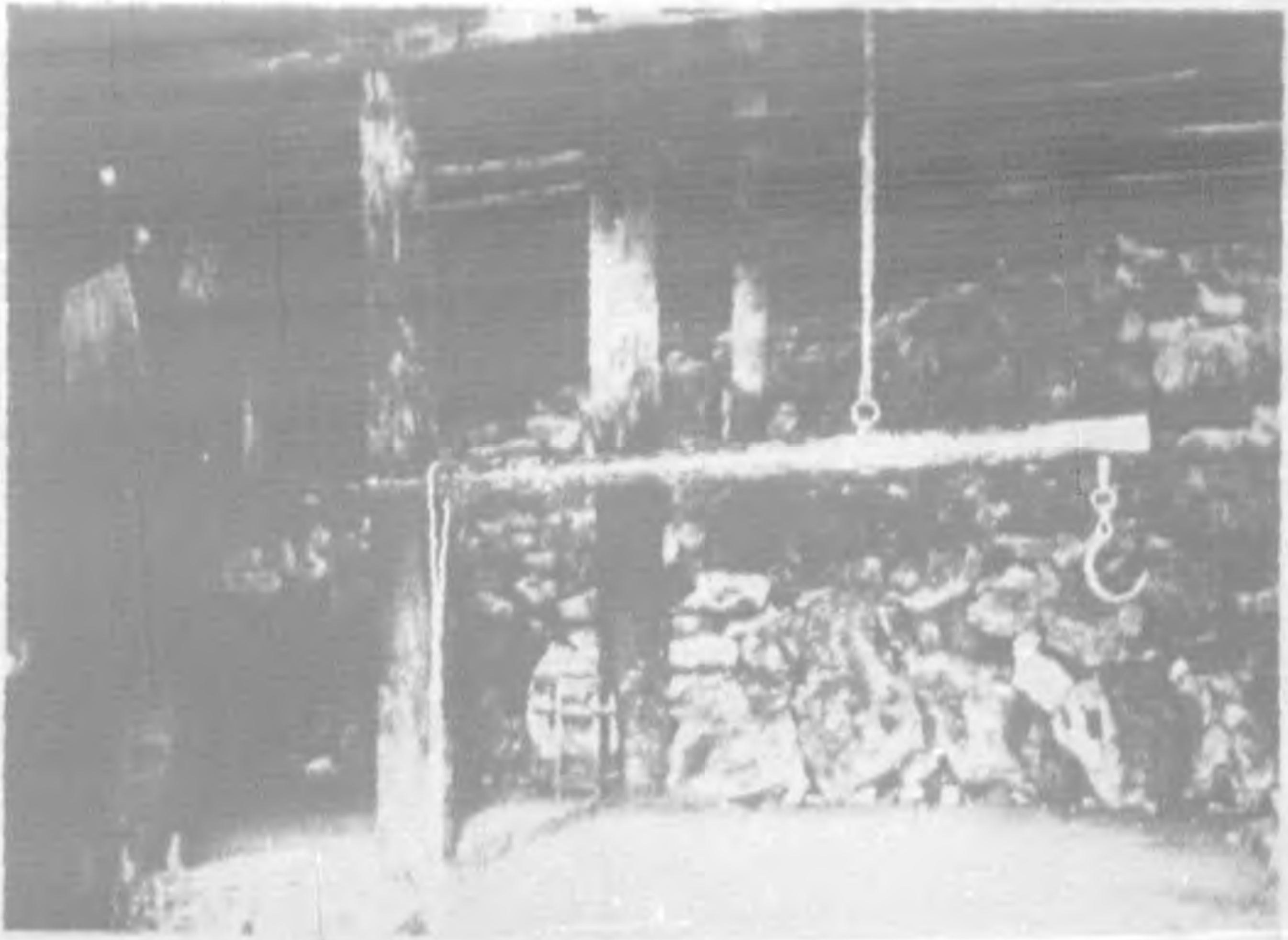
（一） 自流井貢井區滷鹽房及泡滷土桶

1. Salt plant and filtering tub in the Tzuliuching-Kungching region.

（二） 自流井貢井區煎滷鐵鍋（貢井論貢井）

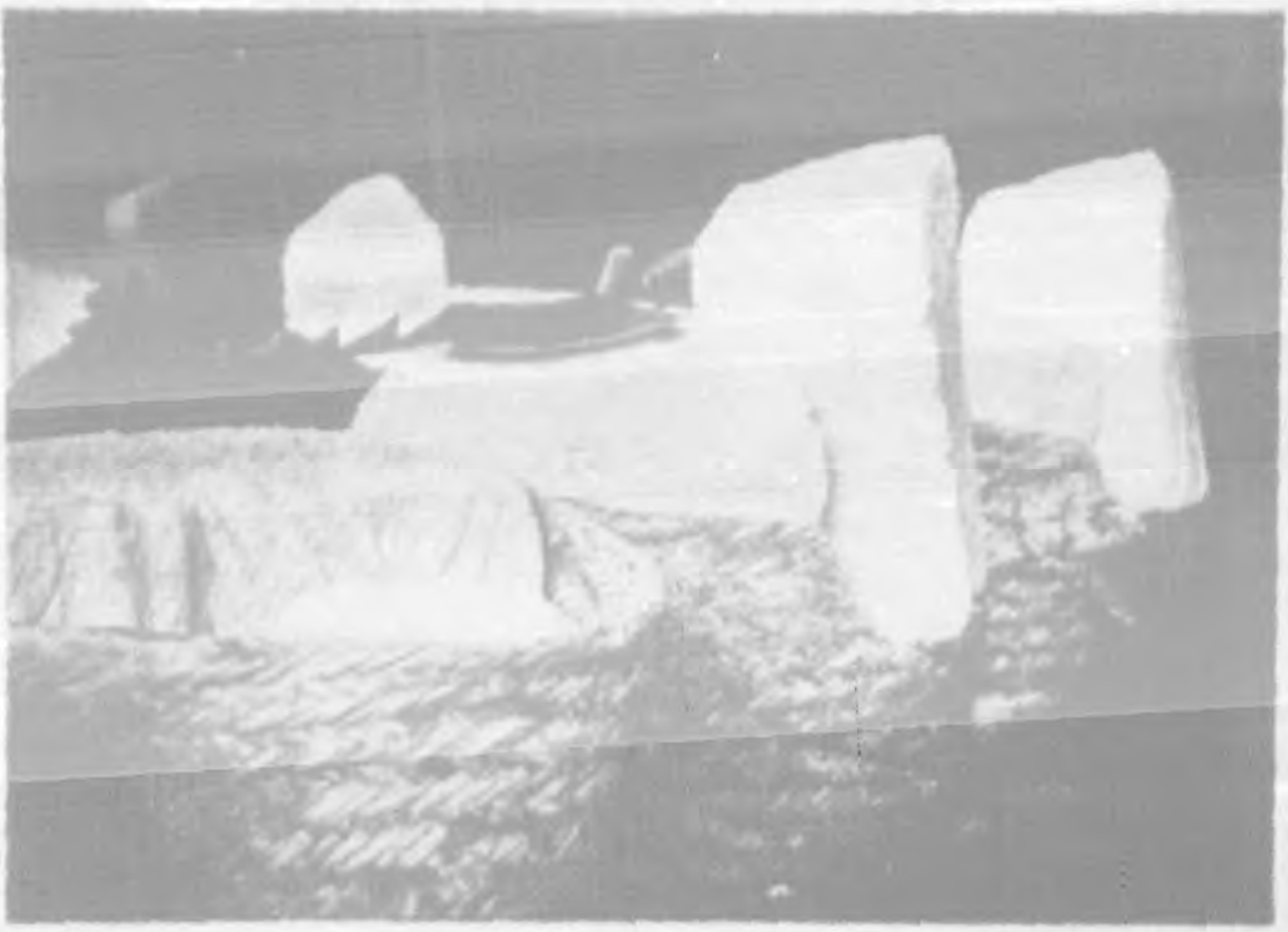
2. Salt pans used in the Tzuliuching-Kungching region.

第二十八版 Plate XXVIII



（一） 貢井官倉內巴鹽及鹽秤（司馬秤）

1. Pan or cake salt and salt steelyard in Kungching public storehouse.



（二） 自流井郭家坳官垣內花鹽及鹽簍

2. Grain salt and salt baskets in Kuochiaao public storehouse.

第二十九版 Plate XXIX

(一) 富榮鹽區票鹽負運

1. Carriers carrying grain salt consumed in the environs of the salt regions.

(二) 富榮鹽區引鹽水運

2. Wooden boats for transporting the salt consumed at distant markets.

第三十版 Plate XXX

犍 為 樂 山 鹽 區 鹽 井

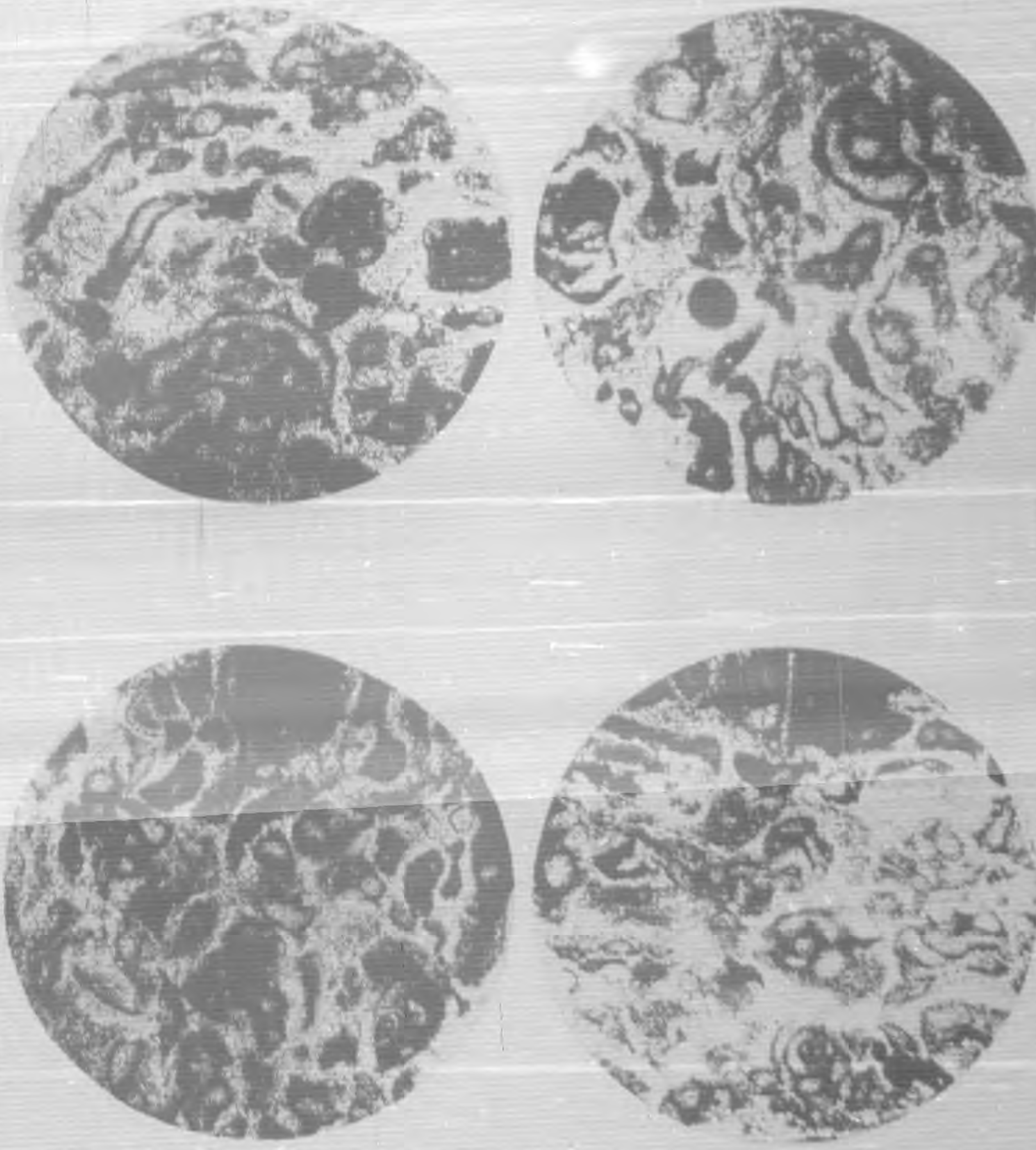
Brine wells in the Chienwei-Loshan salt area,

(一) 樂至鹽區鹽井提取鹽水

1. Bailing of brine at some shallow brine well in the Lochih salt region.

(二) 蓬溪縣蓬萊鎮火井溝山崩溝火氣井及火焰

2. Gas well and gas flame at Pengshankou in the Penglaichen oil field, Pengchihsien.



四川威遠縣新場三疊紀灰岩中之多孔蟲化石 放大六十四倍

Foraminiferas in the Triassic limestone at Hsinchang in the Weiyuan district, Szechuan. 64 x

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(Being the continuation of the **Bulletin of the Geological Survey of China,**
to be quoted as **Bull. Geol. Surv. China**)

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CONTENTS

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9 PING MA SSU,
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CONTENTS

OIL FIELDS IN SZECHUAN PROVINCE

BY

H. C. T'AN AND C. Y. LEE

INTRODUCTION.

The occurrence of oil in Szechuan Province has long been known, but no systematic information has been published. In 1931 the writers had a favourable opportunity to make observations on most of the oil fields in the said province. The field work was started from the Tzuliuching and Kungching fields where four weeks were spent for both geological studies and industrial inquiries not only of the oil but also of the salt and gas which both occur in intimate relation to the oil. In the Chienwei and Loshan oil fields which are next to the Tzuliuching and Kungching fields, a week was spent for studying, in addition to the oil, gas and salt, the associated coal fields. Finally they spent one day at Luochuanching in the Tzuchung district and another at Huochingkou near Penglaichen in the Pengchi district. Of the known oil-producing localities in Szechuan only two were not visited: namely Chungpaching in the Jenshou district where the wells have long been free from oil and Meiyukou in the Pahsien district where the condition was then not peaceful. The time spent for the study of the oil fields was only about 40 days out of the total of 80 days for the whole field work in the Szechuan red basin, in which the oil fields occupy only a very small part.

Tzuliuching and Kungching constitute the most famous oil field where there are about 30 wells now producing oil out of the numerous wells of brine. Only seven wells produce small but some real amount of oil, while the remainder either show mere oil scum floating on brine or are now already exhausted. At Hoerhkan several wells are productive in very small quantity. Yuchingpo in the same field though known for oil well, is no more producing. Louchuanching has four wells producing small amount of oil. At Huochingkou about 2.5 miles NW of Penglaichen there were many oil wells, but now only one gas well is active. Meiyukou and Chungpaching have not been visited by the writers, but according to other investigators and well people, at Meiyukou the oil seepage occurs in a small ravine near the axis of an anticline, and at Chungpaching some of the brine wells have really produced oil, though the output was low. Indications for oil have been known at many other localities; these are oil film or scum on the brine in salt regions, bituminous rocks in some coal field and certain rocks with petroleum odor.

Although the occurrences of salt, gas and oil in Szechuan have been frequently mentioned by many travellers in that province, little has yet been published on the geology of the oil fields. In 1915 an American geologist, Prof. G. D. Louderback was appointed by the Chinese National Oil Administration to investigate the Szechuan oil fields. We have now in the Government files his interesting reports which remain so far unpublished.[1] Dr. A. Heim, Professor of geology at the Sunyatsen University, paid two successive visits in 1929 and 1931 to the oil fields of Szechuan and published some of his observations.[2] Finally Messrs. Chao and Huang[3] gave a brief but excellent account of the geology of the Tzuliuching region to which we have only to add minor details.

In order to facilitate the description, we propose to proceed by grouping together the many oil occurrences into petroliferous provinces which are characterized each by its own topographical and structural features. And in order to avoid confusion with the word "province" and "district" used for political divisions, the main units here described will be called "areas" which will be in turn subdivided into "regions" and "fields". So the oil fields in Szechuan are grouped into the following main divisions: Fushun-Loshan Area, Tzuchung-Jenshou Area, Pengchi-Suining Area, Pahsien-Chiangchin Area and Jungchang-Yungchuan Area (Pl. I).

THE FUSHUN-LOSHAN AREA

This area comprises the well-known and most productive oil fields of Tzuliuching, Kungching, Wutungchiao and Hoerkan in the Fushun, Junghsien, Loshan and Chienwei districts. It is situated north of the Yangtze River, east

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1 George D. Louderback: Reports on Petroleum Explorations in Szechuan; manuscript, 1915.

2 Arnold Heim: The Geological Structure of Tseliutsin, Szechuan, the world's oldest Bore Field; sp. pub., Geol. Surv. Kwangtung and Kwangsi, China, No. 6, 1930. Studies on Tectonics and Petroleum in the Yangtze Region of Tshungking; sp. pub., Geol. Surv. Kwangtung & Kwangsi, No. 8, 1931.

3 Y. T. Chao and T. K. Huang: The Geology of the Tsinlingshan and Szechuan. Mem., Geol. Surv. China, Ser. A, No. 9, pp. 222-228, 1931.

of the Min River, west of the T'o River and south of the Chingyen and Weiyuan cities. It is more than 200 kilometers in length and not less than 150 kilometers in width. The structural and stratigraphical features show that many localities other than those already known are favorable for oil prospecting. They have not been known to produce oil because of the lack of wells which are always drilled for brine but seldom for oil (Pl. I).

Topography

This area occupies the south-western part of the so-called Szechuan Basin which is surrounded by mountain ranges such as the Minshan Range and the Tapashan Range on the north, the branches of the Tahsuehshan Range on the west, the Wushan Range on the east and the Taloushan Range on the south. While these border ranges rise to considerable heights from 2,000 to over 3,000 meters, the relief in the Szechuan Basin is relatively low, the highest altitude reached being Huayungshan in the Hochuan district, 1,560 meters above sea level. Next to Huayungshan are the ranges in the Weiyuan and Junghsien districts, the highest summit of which is estimated at about 1,000 meters, and the range in the Chienyang and Jenshou districts is the third. The remainder is composed of only low hills and small ranges with the mean elevation of 500-600 meters. The Fushun-Loshan area lies south of the Weiyuan-Junghsien ranges with the three rivers running in the western, southern and eastern parts and having their tributaries extending to the inner part. The lowest place in this area is Luhsien at the junction of the Yangtze River and the T'o River, estimated at about 300 meters above sea level by aneroid readings. From Luhsien through Fushunhsien to Tzuliuching the elevation increases from 300 meters to about 400 meters and the Fushun city is about 343 meters high. The elevation of the Yipin city at the junction of the Yangtze River and the Min River and of the Loshan city at the north-western corner of this area is estimated at about 320 and 380 meters respectively. This area is a typical hilly region, most part of which is composed mainly of isolated hills, the remainder is occupied by small ranges which lie frequently in NEE and SWW direction. The topography is often conformable with the geological structure, thus most of the ranges coincide with the anticlinal folds which extend in NNW and SSE direction. The ridges are mostly not more than 700 meters above sea level and only 100-200 meters higher than the surrounding low land. The topographical feature here described may be simply represented by a gentle-inclined plain from northwest to southeast, with initial heights of anticlinal folds gradually dissected by antecedent rivers. The area has undergone already prolonged erosion though the relief appears not very rough. The topography may be regarded as being in the later mature stage.

Geology[1]

The surface geology of the basin area is very simple, being completely covered by the Cretaceous red beds. Older rocks are met with only on the border of the basin or across the anticlinal ridges. Three regions were visited by the writers, where stratigraphical sequence could be studied; they are (1) the western part of the Omei district, (2) the border region between the Chien-wei district and Pingshan district and (3) the Weiyuan and Junghsien ranges (Pl. II). Especially in Omei Shan[2], we have the most complete sequence ranging from Sinian to Cretaceous.

Outside these regions, the Szechuan basin is essentially constituted by Cretaceous red beds with old formations, Jurassic, Triassic and Permian cropping out only along or in anticlinal folds. The Cretaceous rocks in the Omei district are classified into two divisions, namely the Tzuliuching formation and Chiating formation. The former being the lower, comprises purple-red, greenish-yellow and greenish-gray clay, sandstone and shale and amounts to about 300 meters in thickness, the latter being the upper, contains red clayey shale and sandstone with undeterminable thickness. The third division of the Cretaceous, the Mengshan formation known from other parts of the red basin is not observed in this area. The Jurassic formation is represented by the coal measure, named the Hsiangchi coal series and estimated at about 400 meters. The Triassic rocks are grouped into two formations, the lower is named the Feihsienkuan formation, composed chiefly of purple sandstone and clay about 200 meters thick; the upper is named Chialingchiang formation and consists of limestone with some clayey shale at uppermost part, with a measurable thickness of 380-440 meters.

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1 The detailed geological conditions of the Tzuliuching-Kungching Region will be published in a separate paper as a part of the Memoir entitled "The Geology of Szechuan and Hsikang"

2 H. C. T'an & C. Y. Lee: Geology of Omei Shan, Bull. Geol. Surv. China, No. 20, pp. 13-45, 1933.

In the Chienwei and Pingshan border region the stratigraphic succession from Triassic to Cretaceous is almost identical with that observed in Omei Shan, but the Tzuliuching formation increases in thickness and has at some localities (as in the type locality Tzuliuching) thin beds of limestone which are absent in Omei Shan. The Jurassic coal series becomes thicker. The Triassic limestone is also completely exposed.

In the Weiyuan and Junghsien ranges, the Tzuliuching formation is developed to a thickness of over 600 meters and continues with that in the Tzuliuching and Kungching region. The Jurassic coal series is estimated at about 550 meters; but there the Triassic limestone is not entirely exposed with the basal sandstone and shale concealed underground.

The Triassic limestone in all the three regions above-mentioned is characterized by the petroleum odour and porous structure at certain horizons.

Stratigraphy

In the Tzuliuching-Kungching region the exposed rocks belong to the lower Tzuliuching formation of Cretaceous age and consist of the following seven divisions from below upward:

(1) Chenchuchung clay, partly exposed,
(2) Tungyomiao limestone 5.14 meters thick,
(3) Tafenpao clay 46.7 meters thick,
(4) Kuochiaao sandstone 2.92 meters thick,
(5) Maanshan clay 50 meters thick,
(6) Taanchai limestone 23.02-24.6 meters thick,
(7) Liangkaoshan sandstone with undertermined thickness (Pl. III).

The Taanchai limestone may serve as the key bed for determining the horizons of both petroleum and salt beds.

In the Hoerhkan-Wutungchiao region both the Tzuliuching and the Chiating formations are wide-spread, the former is well developed in the environs of Wutungchiao while the latter in the vicinity of Hoerhkan. Tzuliuching formation contains a limestone which corresponds to the Taanchai limestone but is thinner than the latter; no other limestone was observed around the region.

Below the Tzuliuching formation immediately lies the Jurassic coal series which amounts to about 550 meters in average thickness. The Jurassic rocks are generally exposed along anticlinal zones, for instance, on the range between Junghsien and Tzuliuching and Chingshanling between Luhsien and Fushun. The Triassic formations in turn underlie the Jurassic coal series with the thickness of about 500 meters for the upper limestone formation and of about 200 meters for the lower sandstone.

As the strata are usually flat-lying in the Szechuan basin, the geology observable by surface examination is often monotonous except in a few folded ranges. In order to have some idea of the underground geology, it is interesting to study the well logs, drillings and traditions of local brine wells which are widely scattered in Szechuan and often reach great depths over 3,000 feet as in the case of the Tzuliuching-Kungching region. From the latter region several well logs have been collected and thoroughly studied by the writers, one from Hunglungching in the Kungching field, others for some rock salt wells at Tafenpao in the Tzuliuching field. The Hunglungching well is sunken from the lower part of the Liangkaoshan sandstone and went down to the middle part of the Triassic limestone formation. In this well the parts of the Tzuliuching formation encountered correspond to those exposed and the characters and colours of the rock debris pumped up from the drill fairly agree with those observed on the surface. The Jurassic coal series encountered in the Hunglungching has a thickness of 540 meters, with 10 coal seams. For the Triassic limestone a part of 266 meters was penetrated, different in characters and colours in various layers, 2 oil-bearing beds were met with within this zone among which the lower one is productive. Four rock salt wells at Tafenpao have furnished their original drilling records showing the underground geological conditions. These wells were drilled from the Tafenpao clay, penetrated through the lowest members of the Tzuliuching formation and the Jurassic coal series and went down to the middle part of the Triassic limestone. The subsurface members of the Cretaceous formation are chiefly purple-red clay about 67 meters thick. The Jurassic from 543 to 553 meters in thickness is represented mostly by sandstone and shale with several coal seams. The Triassic limestone penetrated is 275-300 meters thick and contains rock salt at the bottom. The detailed rock sequence is shown in the columnar sections of the well logs of Hunglungching and Yentaiching (Pl. IV & Pl. V).

In the Hoerhkan and Wutungchiao region drilling records of some brine and oil wells of much lesser depths have also been obtained. Most of the wells are known to penetrate through red clay and some sandstone and are still confined in the Tzuliuching formation. In some other deeper wells, coal seams were encountered, this showing that the upper part of the Jurassic coal series has been reached. But no well has been known to have reached the lower part of the coal series. The subsurface stratigraphy is shown by the well log of Fuyüching at Shunhochieh (Fig. 1, p.54).

Petroliferous Horizons

The oil-containing beds have as a rule no direct exposure, and when they do crop out, they contain no more oil. The stratigraphic position of the oil horizons has thus to be determined by the position of oil wells on the surface, the depth of the wells at which the oil was struck, and the thickness of the formations and beds calculated or estimated from their exposure in the adjacent regions or reliable well logs. The deepest of the oil horizons has been known to occur at Hunglungching in the Kungching field, where the well is sunken to about 1,034 meters in depth and has its surface location in the Liangkaoshan sandstone (Pl. VI). According to the well log it has passed through the Tzuliuching formation and the Jurassic coal series, and penetrated the Triassic limestone formation to a depth of about 266 meters from the top of the formation. Above this deep oil bed in the Triassic strata there are two other oil horizons which were encountered at the depths of 563 and 793 meters from the surface but gave very little oil. The first oil bed is probably a member of the lower part of the Jurassic coal series, and the second contained in the upper part of the Triassic limestone.

At Fulungching in the Tzuliuching field the oil is obtained from a depth of about 634 meters from the surface and included in the lower part of the Jurassic coal series. This holds true for the oil from Tungshunching, Ssutungching and Chenchuanching in the same field. According to the depth of the wells and their location on the surface the oil from Chifuching, Ssufuching and Tungchangching is higher in horizon than the Fulungching oil though it is also contained in the lower part of the Jurassic coal series, the interval between the two oil beds amounting to about 80 meters.

The shallowest or highest oil horizon in the Tzuliuching-Kungching region occurs at Yentaiching in the Tzuliuching field, where a basal member of the Tzuliuching formation showed some trace of oil when the drilling was undertaken.

In the Loshan field only some brine wells in the environs of Hoerhkan produce some amount of oil, one of them is known to have a depth of about 440 meters, sunken from the lower part of the Chiating formation. This fact shows that the well has entered into the Tzuliuching formation to a depth of more than 300 meters; accordingly the oil is contained in the lower part of the same formation. This is still higher than the Yentaiching oil and is the highest oil horizon in the Fushun-Loshan area (Pl. VI). There are thus found altogether six oil horizons: two in the Triassic and two each in the lower part of the Jurassic and the Lower Cretaceous formation, but only 4 have been worked.

Character of the Petroliferous Bed and Cap Rock

Unless the core-drilling has been specially conducted for prospecting, the productive beds and the cover rock cannot be known with certainty from the debris or dust pumped up from the brine wells during the drilling operation. No geologist or expert took part in the drilling for studying the samples, nor did the well people keep the samples for investigation though the drilling records have been made in their own style. As far as we can learn from such records the oil is certain to occur in three different systems: (1) the Triassic which is mainly composed of limestone, (2) the Jurassic coal series which comprises sandstone and shale, and (3) the Cretaceous formations which consist largely of clay and sandstone with thin beds of limestone. According to the well log of Hunglungching the deepest oil occurs in some gray-yellow sandy rock and gray-yellow limestone. It may be deduced that the oil in the Triassic formation is contained in some porous and rather coarse limestone with some dense or fine limestone serving as cap rock. This is confirmed by the fact that at some localities in the Weiyuan and Pingshan districts the upper part of the Triassic limestone includes some gray-white porous limestone and yellow soft marly limestone which often give petroleum odour when struck by hammer. It was reported by the well people in the Tzuliuching-Kungching region that the oil which was obtained from shallow wells occurs in some straw-white sandy rock. This should be some gray-white sandstone of the Jurassic coal series and this information agrees with the principle that the oil tends to occur in some coarser rocks. The cap rock is here undoubtedly the shale under which the oil probably forms pools. In the Cretaceous no better rock than the greenish sandstone can be the reservoir for the oil. The oil from some wells in the Hoerhkan field seems to be included in this sandstone though no reliable data have been obtained from the well people and their poor drilling records.

Structure of the Oil Fields

The Szechuan basin surrounded on all sides by mountains of folded and metamorphosed strata is a large basin of flat-lying Cretaceous red beds locally complicated by anticlinal folds (Pl. I). In the Weiyuan and Junghsien districts in the western part of the Szechuan basin there is an important dome-anticline lying in northeast and southwest direction, on the south and west of which are situated the Tzuliuching-Kungching-oil field and the Hoerhkan oil field. This anticline of Weiyuan and Junghsien is uplifted high enough for the Jurassic sandstone to appear on the axial zone. The Tzuliuching-Kungching oil field occupies another dome-anticline which may be named the Tzuliuching anticline (Pl. VII). It has nearly the same direction stretching south-westwest- and northeasteastward as the Weiyuan-Junghsien big anticline but is of much smaller magnitude than the latter, amounting to about 20 kilometers in length and about 3 kilometers in width. The southern limb of the dome-anticline dip toward southeast and south-southeast, at angles varying from a few degrees near the axis to over 50 degrees farther from it. The northern limb dip to northwest and north-northwest at angles from a few to over 10 degrees. The strata at the eastern and western ends of the dome are inclined toward northeast-east and southwest-west respectively dipping at not more than 10 degrees. The central part of the dome-anticline is constituted by the lower part of the Tzuliuching formation with its overlying rocks already mostly eroded away, thus leaving there local depressions where most of the oil wells are located.

The Hoerhkan oil field is situated on the southwestern end of the Weiyuan-Junghsien anticline, but it itself is marked by no special structural feature. On the south of Chukentan or Wutungchiao there is a low unsymmetrical anticline with the axis lying in east-west direction and the northern limb steeper than the southern one, the brine wells are located on the former, and the old oil wells in the vicinities of Yuchingpo, Yangliuwan and Shunhochieh are likely to have relationship to this anticline (Fig. 2, p.57).

In addition to the structural features mentioned there are several other anticlines and synclines in the Fushun-Loshan area, though no oil has been known to occur (Pl. I). Between Chienwei and Yipin there is an unsymmetrical anticline north of Maliuchang, which has its axis trending in southwest and northeast direction and the southern limb steeper than the northern. The remaining part shows numerous undulations, though complete anticlines and synclines are not conspicuous. In the environs of Yipin and Nankuang the strata are much folded, the folds include the anticline at Yipin and that at Nankuang with the syncline between them, the former anticline having its southern limb steeper while the latter anticline having its northern limb more inclined, both extending in southwest to northeast direction. There are several anticlines and synclines in the vicinities of Nanchi, Chiangan and Luhsien, though the structure is nowhere very marked. From Luhsien to Fushun there occur a series of minor folds composed of five anticlines and four synclines, which are mostly shallow and indiscernible, except the Chingshanling anticline which is outstanding with the Jurassic coal series brought out to the air. At Fushun there is another conspicuous anticline which has its southern limb steeper than the northern. Between Fushun and Tzuliuching there are several low and shallow anticlines and synclines which are almost indiscernible. Between Tzuliuching and Yipin, Junghsien and Hoerhkan the strata are undulating and form some incomplete anticlines and synclines.

Relation of Brine and Gas to Petroleum

With the exception of the Meiyukou seepage and the oil trace at Huochingkou, the petroleum in Szechuan always occurs in association with brine and often with gas. In the Tzuliuching-Kungching oil field the petroleum, brine and gas are produced but not always from the same well. At Hunglungching the lowest petroliferous bed in the Triassic limestone contains also brine and gas. The brine of Hunglungching is low in salinity, the gas is used to furnish about 50 flames for salt-evaporation. The daily production of oil amounts to a little more than 10 catties. The upper petroliferous bed in the same formation includes very small amount of oil and gas without brine.

The lower petroliferous bed in the Jurassic coal series is very variable in its content of oil, brine and gas in different wells. At Fulungching all the three substances are produced, a brine of low salinity, the gas not abundant and a daily output of oil amounting to 6-7 catties. At Tungshunching the brine is deeper and less saline, the gas comes next in small quantity, and the oil is from a shallower horizon and only several catties a day. At Ssutungching the oil and brine were associated without gas, the brine being of low salinity and the daily production of oil varying from several to hundreds of catties. At Chenchuanching the three substances occur in association, the oil and gas are not abundant and the brine is less saline.

The upper petroliferous bed in the same coal series is also variable in its relation with brine and gas in different wells. At Chifuching all the three substances are present, it is reported by the well owner that at the deeper portion of the same well gas was found in large amount and brine high in salinity. At Ssufuching the brine is less saline and the oil production amounts to only about two catties per day, but the gas in large quantity and several petroliferous beds have been known to occur at lower horizons. At Tungchangching all the three substances are produced in small amount.

From the facts mentioned above it may be concluded that no certain relation can be made out as to the position of occurrence or order of presence of oil, brine and gas in the same field or in the same well. Broadly speaking, in the same well brine seems to be generally shallower while oil often occurs below; the gas may be found to come up from beneath the brine or the oil and may become more and more abundant downwards. In the Tzuliuching-Kungching region, oil and gas occur at different horizons in association with brine.

In the Loshan-Chienwei salt region some brine wells at Shunhochieh, Hueishanching, Tsatsaotan and Yuchingpo are reported to have produced oil and gas from the upper part of the Jurassic coal series. In the Hoerhkan oil field the wells at Kaoshanpu produce brine and oil with little amount of gas, the latter from a horizon above the former two.

Brief History of Oil Production

The petroleum in most of the oil fields in Szechuan occurs in association with brine and gas. According to the historical records the brine[1] in Szechuan was discovered far back in the Ch'in Dynasty (about 200 B.C.) and the gas was known since the Han Dynasty. But no reliable information on the discovery of petroleum has been recorded. Brine wells became soon wide-spread in central Szechuan. The salt deposits in the Fushun district are known to have been worked from the Han Dynasty and the work continued through the Chin, Suei and T'ang Dynasties. The brine-producing localities were first concentrated in the environs of Tengchingkuan, with shallow wells sunken in the Cretaceous beds but producing no petroleum. At the beginning of the Sung Dynasty brine wells were started to open in the vicinity of Tzuliuching. At Kungching the salt industry was started since the T'ang Dynasty. In the middle of the Ch'ing Dynasty, about 100 years ago, gas was first discovered in the Tzuliuching-Kungching field, and thereafter the production gradually increased and reached the highest point about 60 years ago.

In regard to the discovery of petroleum no reliable data are available from Chinese history. In 1827 M. Imbert, a French Missionary, visited Tzuliuching and reported on brine and gas without mentioning petroleum. In 1891 another French Missionary, M. L. Coldre[2] noticed the presence of petroleum, the brine wells which produced petroleum were counted at 40. Some years later the Frenchmen Durand and Marteau visited Tzuliuching and stated that the oil was very good in quality. There were at their time 15 wells which produced much oil with daily production of about 5000 liters in several earlier months and of about 500 liters in later days. Certain oil well produced 1500 kilograms per day and the deep oil wells went then to 1200-1500 feet in depth. About 30 years ago one oil well was sunken to 2160 feet in depth and produced about 3000 catties per day and another oil well to 2500 feet in depth with a daily output of about 1000 catties.

In 1915 G. D. Louderback[3] visited various oil fields then known in Szechuan. Special account was given of the Tzuliuching and Kungching

1 C. H. Lin: General Statement on the Salt Industry in Szechuan (in Chinese), 1919: Other Chinese books dealing with salt.

2 L. Coldre: Les Salines et les Puits de Feu de la Province du Se-Tchoan; Ann. Min., Ser. 8, t.19, pp. 441-528, 1891.

D. Louderback: op. cit.

oil from which the following summary is made. There were several tens of brine wells with oil scum but only some 10 wells produced some serious amount of oil. These wells were between 1700 to 2900 ft. in depth, the most productive well had a daily output of about 300 catties within the earlier 40 days and about 60 catties later. The total production of 11 wells amounted to about 160 catties.

In 1931 when the writers were in the Tzuliuching-Kungching field oil wells numbered more than 20, most of them had only oil scum, only the wells Ssufuching, T'ungchangching, Tungshunching, Chifuching and Fulungching in Tzuliuching field and Hunglungching in Kungching field had some appreciable production. Hunglungching was the most productive well and had a daily output of more than 10 catties, the others produced only from ounces to less than 8 catties of oil a day. The crude oil was heated by which process all the gaseous products were lost, leaving a coloured liquid, which costed about 15 cents per catty and was locally used for lighting. The oil has been analysed by the Chemical Laboratory of this Survey and the results have been published.[1]

In the Chienwei-Loshan salt region the brine wells with oil occur in the vicinities of Wutungchiao, Shunhochieh, Yuchingpo and Tzatsaotan, but now they are exhausted and abandoned. Hoerhkan is the only oil-producing locality. The date of the discovery of petroleum is found from some records to have been in the middle of the Ming Dynasty. In 1915 G. D. Louderback[2] made a rather detailed study on the petroleum in the Chienwei-Loshan salt region. He reported that in the vicinity of Yangliuwan there were two brine wells with oil, one 1710 ft. deep produced gas and trace of oil, the other 1550 ft. deep had some oil scum. Near Yuchingpo some brine wells had a depth of more than 700 ft. and produced some amount of oil. One brine well only 250 ft. deep had some oil film on brine, and some other wells gave gas odour or oil trace on brine. Near Tzatsaotan a brine well was named Yuchingerh (oil well) with a depth of 1740 ft. which was then the most productive well with a daily production of oil of 12

1 K. Y. King: Chemical Analysis of Some Chinese Crude Oils; Bull. Geol. Surv. China, No. 19, pp. 77-83, 1932.

2 G. D. Louderback: op. cit.

catties. Another brine well 1650 ft. deep produced some green-brown oil scum with an output of about 5 catties per day. In the environs of Shunhochieh and Hueishanching there were 5 brine wells with oil scum or film, 4 of them produced little amount of gas, the deepest well was estimated at about 1800 ft. and the shallowest 1425 ft. One oil-producing brine well was located at Lianghokou west of the Min River with a production of a few ounces of dark-green oil per day.

In 1931, at the time of the authors' visit, two brine wells with some oil scum were known in the environs of Shunhochieh and Chinshanssu, with very little production. About 7 of the brine wells at Hoerhkan and Kaoshanpu produced some amount of oil with the highest output of only 4 catties per day for one well. The well Hsuehchiaching which had a production of about 90 catties of oil per day some time ago produced then only three catties, while the well named Sungchiaching which had a daily output of about 20 catties was then exhausted. The oil from Hoerhkan has been analysed.[1]

THE TZUCHUNG-JENSHOU AREA

This area is situated on the north of the Fushun-Loshan area with the Weiyuan-Junghsien ranges intervening between, including portions of the Tzuchung, Jenshou, Chingyen, Tzuyang and Chienyang districts. It is about 180 kilometers both in length and width. The known oil-producing localities are Luochuanching in the Tzuchung district and Chungpaching in the Jenshou district, and the brine well at the Jenshou city (Pl. I & Pl. VIII). According to the geological conditions this is a hopeful area for oil though very few oil-producing localities are yet known.

Topography

Between the Weiyuan-Junghsien ranges and the Chienyang-Jenshou ranges occurs the Tzuchung-Jenshou area which is composed chiefly of low hills with flat low lands, at about 480 meters in average above sea level. The distance between Jenshou and Luochuanching is more than 70 kilometers but the difference of the elevations between them is only about 50 meters. On the south, the Weiyuan-Junghsien ranges rise to 1000 meters while on the north are the Chienyang-Jenshou ranges of more than 800 meters in height. The

1 K. Y. King: op. cit.

Min River forms the western boundary and the T'o River flows on the eastern margin of the area, both lying in the valleys of a little more than 400 meters in altitude. It is thus seen that the area is limited on the south and north by two anticlinal ranges but is open on the east and west to the Min and T'o rivers, the latter condition is very favorable for the pipe transportation if the oil industry is to be developed.

Geology

The geology of the Tzuchung-Jenshou area is relatively simple, only complicated by some small faults. Within the area little can be seen of the stratigraphic sequence owing to the flat-lying Cretaceous beds. But the Weiyuan-Junghsien anticline furnishes much clew on the older strata. Neither much can be obtained from the well logs which do not go very deep.

Stratigraphy

The surface geology is represented only by part of the Tzuliuching and Chiating formations. The former consists chiefly of purple-red and green-gray sandstone and clay with thin beds of limestone, while the latter mainly comprises red sandstone and clay with green-gray clay and sandstone. In the Luochuanching oil field in Tzuchung district occurs the lower part of the Tzuliuching formation which is composed of the purple-red clay, green-gray sandstone and greenish clay with two beds of limestone, the lower limestone probably corresponds to the Tungyomiao limestone in the Tzuliuching-Kungching region and has a thickness of 2 or 3 meters and the upper to the Taanchai limestone about 10 meters thick. These thin limestones form the key beds which may be used to correlate the oil horizons.

Between the Luochuanching oil field and the Jenshou city where some oil scum floats on brine, are found the purple rocks of the upper Tzuliuching formation and the red rocks of the Chiating formation. In the environs of tht Jenshou brine wells are exposed the purple-red and greenish clay, brown-purple, dark-brown and white-gray micaceous sandstone, which belong to the upper Tzuliuching formation. The remaining part of this area is composed either of the Tzuliuching or the Chiating formation. The informations as regards the subsurface geology are scanty, for few well owners keep drilling records and some are not the original well drillers. The only records obtained are from some oil wells in the Luochuanching field. The Chaoyuanching oil well is located just below the Taanchai limestone. It reaches the dark-gray and white-gray sandstone from about 362 meters downward and the coal seam at the depth of 523 meters. The petroliferous bed occurs just above the coal seam At Fuyuanching the rocks from about 469 meters below the surface are gray and white-gray sandstones, most of which contain oil. It was told by the well people in the Yümo salt plant that the wells penetrated from the red rocks and met the coal seam at a depth of about 284 meters. They reach the brine in the dark-gray sandstone and white-gray sandstone at about 532 meters. The red rocks belong to the Tzuliuching formation and the gray rocks with coal seams without doubt belong to the Jurassic coal series. The wells mentioned above are the deepest ones in this area and all confined to the Jurassic beds; this shows that no Triassic limestone has been reached in this area.

Horizon of the Petroliferous Beds

The Luochuanching brine wells which produce oil were more than ten in number but in 1931 only 4 wells were known to have oil. The shallowest of the oil wells is about 206 meters deep and has the hole situated between the Taanchai and the Tungyomiao limestones. The part of the Tzuliuching formation below the Taanchai limestone is estimated at about 180 meters, so the well has penetrated into the uppermost part of the Jurassic coal series, in which the oil was encountered. This is the upper horizon of the oil known to occur in the Luochuanching oil field. The other wells which produce oil are Fuyuanching, Chaoyuanching and Hungyuanching and all amount to more than 520 meters in depth. They are all located just below the Taanchai limestone on the surface, penetrate through the lower Tzuliuching formation and enter into the Jurassic coal series for about 340 meters. The oil thus occurs in the lower part of the Jurassic and its horizon probably corresponds to one of the two oil beds in the Jurassic of the Tzuliuching-Kungching region (Pl. VI).

At the Jenshou city only oil scum is known to occur on the brine which is bailed up from the lower part of the Tzuliuching formation, probably of the same horizon as that of the oil bed in the Hoerhkan field.

Character of the Petroliferous Beds and Cap Rock

There are thus two oil horizons in the Jurassic of the Luochuanching field. The lower oil horizon is contained in a gray-white sandstone while the upper one is said to occur in some white-gray sandstone. The cap rock in both cases is probably the shale interbedded with the sandstone. At the Jenshou brine well the oil comes from some greenish sandstone of the lower Tzuliuching formation.

Structure of the Oil Fields

The Luochuanching oil field is situated on the northern limb of the Weiyuan-Junghsien dome-anticline (Pl. I). The inclination of the strata gradually decreases from north of the anticlinal axis to the vicinity of Luochuanching where it becomes very gentle with the dipping angles of only 3-4 degrees and nearly horizontal at some localities. In the Luochuanching oil field itself no special structure, such as anticline, dome, etc., can be noticed except some slight undulation (Pl. VIII). At the Jenshou city there is a normal fault trending in northeast and southwest direction with the downthrow side composed of the Chiating formation and the up-throw side of the Tzuliuching formation (Pl. IX). The brine well is located on the up-throw side of the fault, and the strata there dip to NNW at about 10 degrees. Between Luochuanching and Jenshou the strata dip also to NNW at about 5 degrees. In the environs of Yinshanchen there occurs a dome-anticline which ends on the northeast and seems to connect with the Weiyuan-Junghsien dome-anticline on the southwest. In this area there seems to be no prominent folded structure which would cause the accumulation of oil, but the fault may have some influence.

Relation of Brine and Gas to Petroleum

In this area the petroleum occurs in association with brine but often without gas. Local information shows that very little gas has been known in the Luochuanching oil wells and on the other hand some brine well of the Yümo salt plant produces small amount of gas without any trace of oil. The brine well of the Jenshou city has little gas in association with oil scum but not enough to produce continuous flame.

Brief History of Oil Production

In this area again the salt industry can be traced far back in the history, but the beginning of the oil production is unknown. The Jenshou brine was known since the Han and the Tzuchung brine since the T'ang Dynasty but no mention was made of oil. The oldest of the brine wells now existing in the Luochuanching field was started early in the Ch'ing Dynasty but it never produced oil, though some amount of gas is known to occur. All the wells now producing oil are only about 30 years old and some of their drilling records are still available. One well is said to have produced about 200 catties of oil and has been abandoned a few years ago. The well named Fuyuan encountered gas at the depth of 505 meters and oil at 517 meters; the oil becoming more abundant downward and the well had once a daily production of 30 to 120 catties when reaching 529 meters, lasting about a year. The well Chaoyuan struck oil at 516 meters and had an output of 20 to 140 catties per day. The Hungyuan well reached oil at 524 meters. In 1931 each well produced only 3 or 4 catties per day. The crude oil after being washed through hot water was used for lighting. The oil from Luochuanching wells has been analysed.[1] At the Jenshou city only some yellowish film of oil scum floats on the brine with little gas. At Chungpaching in the Jenshou district a brine well which once produced oil has been abandoned some years ago.

THE PENGCHI-SUINING AREA

Here oil is known to occur only in the vicinity of Huochingkou north of Penglaichen in a very small area (Pl. X). But according to the occurrence of brine and the related geological features, the area which is proposed to be prospected is large and includes many salt regions between the two rivers Chialingchiang and Tochiang in northern Szechuan (Pl. I). In many brine wells in Chungchiang and Pengchi districts gas is known to occur and used for brine evaporation. The oil-bearing beds of Huochingkou extend widely which may be expected to be oil reservoir elsewhere also, and deeper petroliferous horizons may also be expected.

1 K. Y. King: op. cit.

Topography

This area is remarkably flat with small and low hillocks. The hills are mostly isolated and rarely connected to form ranges. When being viewed from high and distant point, the tops of the hills stand here and there, nearly at the equal elevation of about 500 meters above sea level. The area is drained by the Fuchiang, a tributary of the Chialingchiang, and its subsidiary streams. The two named rivers are navigable but most of the tributaries are rather shallow. It seems probable that a peneplain has been formed in northern Szechuan in Tertiary time and thereafter dissected by the streams to form the present topographical feature, most of the streams being in the late mature stage.

Geology

The surface geology is very simple, nearly entirely consisting of the Chiating formation which includes red clay and sandstone with intercalated beds of greenish sandstone and clay. The Mengshan formation may occur in some places in the northern part of this area. According to the stratigraphical succession of the Szechuan basin the Tzuliuching formation, the Jurassic coal series and the Triassic formations should be present beneath the Chiating formation and form the subsurface geology of this area. But the oil horizon so far known in this area is very shallow, so that the underlying Jurassic and Triassic formations have no relationship to the oil geology here concerned unless deeper oil beds will be prospected in the future. At Huochingkou north of Penglaichen, the only oil-producing locality in this area (Pl. X), the oil was encountered at a depth of more than 70 meters below the surface in many wells. The wells were drilled from some red sandstone in the lower part of the Chiating formation and seem to have entered the uppermost part of the Tzuliuching formation. This is the highest oil horizon known in Szechuan. It was told by the well people at Huochingkou that the oil was always encountered in some green rock. This shows that the greenish sandstone of the Lower Cretaceous formations is often the reservoir rock.

The geological structure of this area is also very simple, the strata are mostly horizontal, gently inclined or slightly undulating, and no conspicuous folds are present though Dr. Heim states that the oil wells seem to be located on an anticlinal high.[1] In the vicinity of Huochingkou the strata are somewhat undulating; on the north of the Hu building the red clay and sandstone with greenish clay dip to NE at 4 to 9 degrees, while at Pengshankou the same strata dip at 6-15 degrees to N 50°-60° W. No conspicuous syncline or anticline was noticed (Pl. X). If the prospecting for oil will be undertaken the structure of the whole area needs more detailed surveying.

In this area the brine is being worked in several regions known as the Chuanpei salt area, and the gas is known to occur at many localities in Chungchiang district and in the environs of Huochingkou. But the brine wells do not produce oil and the oil occurs rarely in association with gas. Only at Huochingkou both oil and gas have been worked, but the two substances do not often occur in the same well. At Pengshankou a gas well is active and has never produced oil, while the oil wells around the Hu building are said to have produced little gas. In oil wells the water is not saline enough to make salt, though the brine has long been searched for by the natives. In comparing the horizons of oil and gas it is known that the gas is deeper than the oil in stratigraphic position. This may show that the gas has its source below and deeper petroliferous beds may be discovered if the two substances have mutual relation in origin.

Brief History of Oil Production

In the Huochingkou field gas has been known since about 60 years ago, and some 30 years later when the natives drilled wells for gas the oil was first discovered at a depth of more than 70 meters. The oil was good in quality and so clear that it looked like pure water, with an output of several hundred catties in a month. In the next year the drilling was started again and about 60 wells were drilled within about four years, all at the depth of about 140 meters and producing oil at 70 meters. The daily output of each well ranged from several catties to more than 1000 catties, the total production of the wells being more than 10,000 catties. The work lasted about four years. In 1930 two wells were drilled for oil; one well was about 140 meters deep and produced about 22 catties of oil at 70 meters; the other had about the same depth without producing oil. The prospecting was stopped in the same year. In

1 A. Heim: Studies on Tectonics and Petroleum in the Yangtze Region of Tschungking; sp. pub., Geol. Surv. Kwangtung & Kwangsi, No. 8, p. 38, 1931.

1931 when the writers visited the place, no oil was produced at all except some derrick set on the abandoned well. At Pengshankou there was a gas well about 115 meters deep, the gas was used for cooking and lighting (Pl. XXXI, Fig. 2).

THE PAHSIEN-CHIANGCHIN AREA

The only oil-producing locality is Meiyukou which is about 60 kilometers south of Chungking though this area is defined to include parts of the districts Pahsien, Chiangchin and Chichiang. The writers have been informed that at some locality south of Chiangchin district some oil seepage has been found. The structural features in some part of the area as well as in the environs of Meiyukou are favorable for oil accumulation, so the area is hopeful for further prospecting (Pl. I).

The area is composed of low hills and small ranges between 400 and 700 meters above sea level. The Yangtze River runs along the northern margin of the area, and the difference between the average elevation of the area and the Yangtze River bed is estimated at over 200 meters. The Pahsien city (at Chaotienmen near the River, Chungking) is about 240 meters above sea level and the Meiyukou oil seepage is situated at about 300 meters, but the hills near Meiyukou rise to more than 400 meters. This area shows more relief than the other areas in the Szechuan basin.

In this area the Tzuliuching and the Chiating formations are well developed, and where the anticlines exist the Jurassic coal series and the Triassic limestone often come to light[1]. Meiyukou, the only oil-producing locality, was not visited by the writers, but the geology there has been described by Dr. A. Heim[2]. The exposed rocks are reddish and greenish sandstone and brown-purple clay which probably belong to the upper part of the Tzuliuching formation. The oil seeps out probably along some cracks from reddish sandstone and has its source far down below. The oil horizon may correspond to one of those

1 Personal communication from Y. L. Wang of the Geological Survey, who visited the place in 1930.

2 A. Heim: Studies on Tectonics & Petroleum in the Yangte Region of Tshungking; sp. pub., Geol. Surv. Kwangtung & Kwangsi, No. 8, pp. 23-24, 35-36, 1931.

at Hoerhkan and at Huochingkou or above them. A Japanese report[1] mentioned a low anticline in the vicinity of Meiyukou with the limbs gently dipping at more than 10 degrees. According to Heim in the environs of Yenpo there is a fold which may be called the syncline and anticline of Yenpo, west of Yenpo the strata form a syncline while east of Yenpo occurs a perfect unsymmetrical anticline, near the axis of which the oil seepage is situated, with a wide and gentle eastern limb and a short and steep western limb. Between the Yangtze River and Yenpo there is a larger anticline which extends in NNE and SSW direction with the Triassic limestone in the central part and the Jurassic coal series and the Cretaceous formations on two limbs; the inclination of the strata on both limbs varies from several degrees to more than 60 degrees.

When exactly the seepage at Meiyukou was discovered is not known. The natives said that two wells drilled about 60 years ago struck brine but without oil, one of which was 250 meters deep. According to Heim[2] in 1929 at Meiyukou was sunk a shaft to a depth of about 1.5 m, in which black, heavy and viscous oil floated on fresh water. About 300 catties of oil per month were gathered from the shaft, the oil was sold at Chungking at the price of 16-18 dollars per 100 catties and used for lighting.

THE JUNGCHANG-YUNGCHUAN AREA

Although no oil occurrence has yet been actually known in this area, conditions seem favorable for the existence of oil. The area includes parts of the districts Jungchang, Lungchang, Yungchuan, Tatsu and Luhsien and may be regarded as an eastern extension of the Fushun-Loshan area (Pl. I). At some localities in this area brine has been produced and in Tatsu district there are wells now producing (Fig. 3, p.73). Communication is more convenient here than in any other area described above; the Yangtze River runs on the south and the river T'ochiang flows on the west, both are navigable. The topography is similar to that of the Fushun-Loshan area. Samll ranges run in NE and SW direction with average height between 500 and 600 meters. The Tzuliuching formation is well developed in most part of the area and in continuation with that in the Fushun-Loshan area. Where small ranges are formed by

1 G. Kobayashi & N. Horiuchi: Geographical Research in China; Tokyo Geographical Society, Vol. 2, pp. 410-411, 1917.

2 A. Heim: op. cit., sp. pub., No. 8, p. 36.

anticlinal folds often comes to light the Jurassic coal series. The Triassic limestone is found only in the hills on the east of the area. The geological structures seem to be favorable for the accumulation of oil; between Lungchang and Yungchuan the folds consist of three folds of anticline and syncline (Pl. I). These folds run in NE to SW direction, the anticlines are mostly low and broad and often short so as to form dome-anticlines.

FACTORS CONCERNING THE FUTURE DEVELOPMENT OF THE OIL FIELD IN SZECHUAN

Before formulating any opinion on the future prospect of the oil fields in Szechuan, the writers would like to cite some of the discussions and conclusions made by the previous workers, especially Dr. Louderback and Dr. Heim. Dr. Louderback in his unpublished report gave the following conclusions:[1]

> "The shallower formation . . . . . all the oil hitherto produced in Szechuan, comes from horizons that lie above the level of the black brines of the Tzuliuching district, that is, above the lower portions of the dolomitic series. It is to these formations that the term shallower formations is intended to apply . . . . . the oil is found along certain belts, while the brine occupies other and neighboring belts of ground . . . . . all of the areas in which oil might with most reason be expected, have been prospected by numerous wells without disclosing any definite oil pool or zone . . . . . the Szechuan wells being drilled particularly for brine and not being cased, would be very liable to the displacement of oil by the heavier salt water. But the field has been so widely drilled and by such a large number of wells, it is hard to imagine any large body of oil being driven out of some of the areas without appearing in others. It could hardly have been entirely driven from the field. The effect of the brine should be to force it up towards the axis of the anticline so that the wells situated there would have the large yield. Many wells are drilled right along or very near this axis without showing any large amount sometimes not any oil. The case is even more striking because many of these wells were drilled long ago and have practically exhausted the upper brines in their locations, and have been deepened for the purpose of reaching the lower brines and increasing their supply to proportions that would pay. If the oil were forced up and floated on the brines, then we would expect that it would appear in these wells where the brine surface had been lowered

1 G. D. Louderback: op. cit.

by bailing. But this does not occur. All of these considerations, together with the irregular and very small appearance of oil in the various wells, must lead to the conclusion that no large body of oil exists in the shallower strata of the Tzuliuching district.

"The deeper strata. Up to the present no production of oil has been obtained from the deeper strata, that is below the top of the black brine of the Tzuliuching district, although traces have been reported in some of the deeper wells. The consistency and strong supply of black brine would indicate that no oil is to be expected in that horizon, particularly as this brine is developed along the axis of the anticline where the oil should be if it were in the brine yielding strata. . . . .

"It sometimes happens that gas along the axial region is followed by oil towards the flanks, and it should be noted that no wells have penetrated this horizon on the flanks of the Tzuliuching anticline. It naturally lies deeper below the surface there, and where reached in the shallowest portions of the field, is 3400 or 3500 feet deep. It may therefore happen that later developments will lead to oil porduction from this horizon. All we can say at the present time is that where observed in the field they showed no evidence of oil production or concentration, and the wells so far put down have not yielded any oil in measurable quantities. . . . . "A few of the deepest wells have penetrated into barren maroon shales. It is not possible to estimate how deep they will extend in the district . . . . . These carry us to considerably below 4000 feet in the shallowest portions of the field. As to still deeper formations it is hard to hazard a guess. . . . . Without further evidence their prospecting by drilling would seem to be unwarrented."

In regard to the Chienwei-Loshan oil fields the following are cited from Dr. Louderback's report:[1]

"......petroleum actually occurs in this territory, and is brought up in several wells. At the same time it is evident that no well has any important yield, and that no present and past production gives any direct evidence that the territory is of commercial importance from the petroleum standpoint......

"One or even several wells that fail to produce oil do not necessarily mean that a field is incapable of commercial development......Non-producing prospect wells may fail to disclose the real content of a territory on account of one or more of the following reasons: They may not be located right with respect to the structural features;

1. G. D. Louderback: op. cit.

they may not reach the necessary depth; due to some local irregularity in structure or strata they may have been drilled in some dry spot; by carelessness, lack of skill or ill luck, the oil may be held or driven back by the water in the well and make no or very little showing.

"As regards the first consideration, it should be noted that the wells are distributed plentifully throughout the whole structural range that could reasonably be expected to carry oil in concentration—practically from the top to the bottom of the anticline.

"As regards the second consideration, the wells reach 1000 feet or more below the limestone of Hueishanching, which is probably the same as the Tzuliuching limestone that will be used as a standard of comparison in the Tzuliuching report. The actual depths below the surface are sometimes over 2000 feet. This is hardly deep enough for a satisfactory test of the field, and it seems probable, in the light of later investigations, that within the next thousand feet more brine and more gas and oil would be obtained.

"The large number of wells—several hundred at least—disposes of the third possible difficulty.

"In regard to the possible masking of the oil by water, in particular, by brine, this seems particularly likely as the wells were drilled primarily for brine, and no effort has been made to especially conserve, or protect, or develop the oil. This may affect individual wells from which the oil may be driven, and this may in part account for the presence of oil in one well while a neighboring well of corresponding depth, and producing from the same horizon, may show to trace of oil with the brine. However, with the large number of wells involved, scattered from the lower edge of the flexure to its summit, it would seem that any oil driven from one or more lower wells would surely make its appearance in some higher ones. In particular, the summit of the anticline seems to have been drained of its brine and the the wells originally situated there to have gone dry and been abandoned. They did not turn into oil wells, nor were they originally oil wells, so no large quantity of oil appears to have been floated up by the water pressure operating through the lower wells.

"Conclusions. Taking into consideration all the facts as outlined above, it may be said that the formations involved in this territory from which some oil is being obtained, do not appear favorable to the production of any large quantity of petroleum; that the oil actually appearing in the wells is very small in amount—a minute fraction of the brines with which it is associated and irregular in occurence; it has apparently been produced in very small quantity in connection with the brines it accompanies, and can not be taken as indicating the presence of a commercially important supply. The possibility was considered that the oil occuring in the wells might have migrated up from some deeper and richer source which might be reached by deeper wells. The nature of the strata involved, however, and a study of the oil distribution and brine relationships, seem to show very definitely that the oil is not related to any faults, and that the brine is well sealed in its proper strata, so that there has not been any migration of brine across the strata, and surface water is prevented from reaching the brine-bearing strata. As the strata between brine or oil bearing layers are not impregnated with oil or oily products, it would seem impossible that any oil migration has taken place. It is quite possible, and I believe it to be correct, that the oil has been produced in the strata within which it is now found, and that it was produced in limited quantities only."

The following are some of the suggestions on the value of the Tzuliuching, Yenpo (Meiyukou) and Penglaichen (Houchingkou) oil fields, quoted from Dr. Heim's[1] reports.

"Unquestionably, the tectonical structure of Tzuliuching anticline is ideal for an oil field. "The question thus arises, if the failure in producing paying quantities of oil is due to errors of drilling "Indeed, if the holes were full of water, the pressure against the oil, at 1,000 meters, would be 100 atmospheres. But this is not the case. The holes usually are filled only with 10-30 meters of brine or even less. Since they are uncased, the oil would flow into the hole if there would be any amount of it. "The only question which remains is: may we expect deeper oil horizons which have not been reached yet. "......the Fumindjing well struck gas with little oil at 3,010 ft., at a level which apparently is below the lower salt. But it is true that the deepest wells did not give any hope for further oil horizons, nor does this Triassic series where it comes to the surface...... "The hopes thus to strike oil in large quantities with new drilling methods until depths to 1,100 meters are to be cancelled, and the probability of finding paying quantities below this depth are very small. "The anticline of Yenpo is of a totally different type, and steep enough to cause migration even for a heavy viscous oil. It thus is possible to strike productive layers on Yenpo anticline at depths below 250 meters. "The oil of Penglaichen is totally different: a water-clear light oil like a refined product, perhaps made by natural filtration, associated with much

1 A. Heim The Geological Structure of Tseliutsin, Szechuan; sp. pub. Geol. Surv. Kwangtung and Kwangsi, No. 6, pp. 26-27, 1930. Studies on Tectonics and Petroleum in the Yangtze Region of Tshunking; sp. pub. Geol. Surv. Kwangtung & Kwangsi, No. 8, p. 41, 1931.

gas, but without indications of salt...... "The question now arises where this oil and gas of Penglaichen has originated. Apparently it derives from the same horizon which is about 50 meters only below the valley bottom. The gas coming out with strong pressure shows that the red shales must make a perfect impervious cap upon the gas and oil sand. "Although the origin of oil of the surroundings of Chungking remains an unsolved problem, prospects for oil are not hopeless."

Thus Louderback and Heim agree in concluding that the well-known Fushun-Loshan oil fields are of no commercial importance and hopeless for future development. Their conclusions are based upon the poor production of oil from all the oil fields in Szechuan and lack of oil pool or zone even where the geological structure is most favorable for the accumulation of oil. But on account of the scarcity of the reliable data they still maintain some hope which would justify more detailed observations and investigations. According to the writers' opinion it would be a matter of regret to have the Szechuan oil fields abandoned before more serious prospecting is undertaken. It may be useful to review some of the factors which would determine the value of oil fields.

(1) *The Quantity of the Oil Originally Formed*

Whatever is the origin of the oil, its quantity originally formed is the first thing to be taken into consideration for determining the value of the oil fields. As has been pointed out by Louderback and Heim the scarcity of the original quantity of oil would make the field hopeless for development. But the area of the oil-producing localities known at present is only a very small fraction of that of the whole regions which may have oil reserve, it may be estimated at merely 1/200 of the latter. We are yet unable to know where exactly the main reserve of oil exists and whether it occurs in considerable amount or in limited quantity. The oil so far produced in Szechuan is mostly obtained from brine wells, there are many places in which the geological conditions are exactly the same as the oil-producing ones but which have never been worked for salt. It is possible to obtain oil from these places.

(2) *The Number of the Petroliferous Beds*

Although one single rich bed may be richer in oil than several poor beds combined, yet the great number of petroliferous beds give in any case some hope for the value of the oil fields. In Szechuan the oil beds prove to exist in all the three Mesozoic systems and often several beds in each. Among the known petroliferous beds six have been and are being worked in various fields. The six beds may be different in oil content; if one of them contains workable pools or pockets the field will become valuable. So the chance here in Szechuan is six times where one single bed occurs.

(3) *The Structure of the Oil Fields*

Accumulation of oil in pools or pockets is chiefly due to favorable structures which are the most important of the factors to be considered in judging an oil field. Anticlines and domes are structures most favorable for oil accumulation. Of the mentioned areas except the Pengchi-Suining area where the strata are mostly horizontal and gently undulating, anticlines or dome-anticlines are often well developed, especially in the Fushun-Loshan and Jungchang-Yungchuan areas they are numerous in number and the strata often show suitable inclinations for oil accumulation. The oil fields which have such favorable structures are likely to have workable pools if the original quantity of oil is not very poor. Faults are not common in the oil areas, at the Jenshou city there occurs a normal fault in NE to SW direction and affects the northern part of the Tzuchung-Jenshou area. If the oil exists in this area, it is likely to tend to accumulate along the fault plane.

(4) *Characters of the Petroliferous Beds and Cap Rocks*

Good reservoir and impervious cover are other important factors for the accumulation of oil and thus affect the value of the oil field. So far as has been known the oil in Szechuan is contained in different reservoirs; the Triassic oil is contained in porous limestone, as shown by the oil well Hunglungching in the Kungching field, this is confirmed by the petroleum odour of the Triassic porous limestone at Pailungchihkou in Weiyuan district and at Wangkou in Pingshan district and by the presence of petroleum in some pores in the limestone of Triassic age at Paomuchung[1] in the Kueichow province. The Jurassic oil is contained in the white-gray sandstone which is named by the well people "straw-white sands." And, the Cretaceous oil is included in the greenish-gray sandstone interbedded with red clay and sandstone. These

1 S. S. Yoh: Notes on the Geology of the Paomuchung Oil Field near Kueiyang, Kueichow Province; Bull. Geol. Surv. China, No. 12, pp. 19-21, 1929.

are good oil reservoirs. In regard to the cap rock our information is not clear. So far as known from the drilling records the cap rock above the Triassic oil bed at Hunglungching is some coarser limestone and that above the Jurassic oil bed at Luochuanching is some dark-gray sandstone. The limestone is sometimes a good cover but the sandstone is not. If the cover can not prevent the oil to remove or diffuse the oil pools would hardly be formed. Reliable testing for this is important.

(5) *Relation of the Underground Water and Gas to the Migration and Accumulation of Oil*

After having been formed the oil would undergo migration and accumulation to form oil pools. Many factors concern and promote such movements; some have been stated above, there remain to be considered the underground water and natural gas. The underground water intervenes in the accumulation, migration and preservation of oil by its capillary action, slow motion and hydrostatic pressure. The separation of oil and water in different beds would be aided by the capillary action and the oil thus tends to migrate into coarser rocks, such as sandstones. The presence of oil in some horizontal or non-structural beds is likely due to the slow motion of underground water, the oil is left behind to form some pools owing to the friction while the water slowly moves away. The oil pool thus formed may become removed and destroyed unless it is held in stable state by the hydrostatic pressure of underground water which maintains the pool in equilibrium. The transmission of the gas through the reservoir rocks is likely to promote the separation of oil and water and the gas may bring about some accumulation by carrying up oil as envelopes of bubbles. But on the contrary the oil as well as the water may be compelled aside by gas and the oil pools may be affected and destroyed by its compulsion.

In Szechuan oil occurs in both the regions with favorable structures and the non-structural regions and often in association with brine and gas. Although the good structures tend to aid the accumulation of oil to form pools the slow motion of underground water may be responsible for the formation of some workable oil pockets in the non-structural regions. The Pengchi-Suining area is composed of nearly horizontal and slightly undulating strata and is known to produce oil at Huochingkou near Penglaichen. If the underground water carries oil in a moderate quantity, some oil pools may be expected to occur in the Pengchi-Suining area. The Tzuliuching-Kungching field has very favorable structure for the accumulation of oil and most probably contains some profitable oil pools; but as a matter of fact the oil production in this field has not been plentiful and is now so scarce that the most productive well has an output of only 10 catties per day. There would be some other reason for this unless the original quantity of oil is limited. If the factors considered by Dr. Louderback and Dr. Heim are not responsible for the scarcity of oil in the Tzuliuching-Kungching field, it may be thought that the stable condition due to the hydrostatic pressure of the underground saline water has been disturbed by the taking out of part of the brine, and thus the oil pools would have been destroyed and the oil removed and diffused. The oil which is now being worked may be the scattered part from the destroyed oil pools. In the Tzuliuching-Kungching field the most productive gas wells often do not produce oil and have small amount of rather dilute brine, the absence of oil and scarcity of brine may be due to the compulsion of the gas which issues from beneath with considerable pressure. Thus the gas compulsion may also affect the preservation of the oil pools which have been formed in the Tzuliuching-Kungching field.

Suggestions on the Origin of Petroleum

As the petroliferous beds occur in different formations within a vertical range of about 1400 m., the oil is likely to have been derived from different sources. The Cretaceous oil is found to occur in a thick series of sandstones and clays with beds of limestone in the lower part and shale at many horizons. Should the oil have not been migrated along some fissures upward from the underlying Jurassic formation, its origin must be searched from among the members of the formation itself. The limestone contained in the Tzuliuching formation comprises plenty of pelecypods and some clayey shales in the Mengshan formation gives petroleum odor at some locality; the source of the Cretaceous oil may be here in the limestone and shale.

The Jurassic oil is contained in a series of sandstones and shales with coal seams. If the oil has not been derived from other formations, it would be formed of the hydrocarbons which have originated from the vegetal or other organic matter either microscopic or macroscopic contained in some shales in the coal series.

In regard to the source of the Triassic oil in limestone the animal origin must be taken into consideration. But very few fossils were found from the limestone. In Omeishan two horizons are known to contain determinable fossils; one being the uppermost part of the limestone, which includes some brachiopods and cephalopods and is too high in position for the source of the oil which occurs far below; the other being the lowest part which comprises some nautiloids in poor state but did not yield any fossil at other localities. Where is the source of the oil in the limestone? Fortunately the microscopic examination on some limestone slice reveals that some part of the Triassic limestone is found full of micro-organisms which belong to the Foraminifera. But very few individuals show their inner structure, most of them have clear shape (Pl. XXXII). The limestone which contains the micro-organisms was collected from Hsinchang in the Weiyuan district, which is adjacent to the Tzuliuching-Kungching oil field, and the horizon of the limestone is corresponding to or quite near that of the limestone which comprises the Hunglungching oil in the Kungching field. The source of the Triassic limestone oil may be searched from the micro-organism bearing strata.

THE TAHSIEN OIL FIELD, SZECHUAN

BY C. Y. LEE

When the general paper on oil field was already in press, I had the opportunity to make another visit to Szechuan. The Tahsien oil field which has not been visited in our former trip was studied in May 1933 and is hereby briefly reported.

Locality: Besides the oil fields as mentioned above there is another locality of oil seepage which is situated in the western part of the Tahsien district, about 120 li (45 km) from the city and 15 li (7 km) from the village of Chiaowanho. Tahsien formerly known as Suiting is situated at about 200 km in straight line NE of Chungking. According to the structure of this region the oil field is not only restricted in the vicinity of the oil seepage but extends as far as to Chaochiachang and Chiulingchang on the east and beyond Chiaowanho and Shihtikan on the west, occupying about 20 km in length and 11 km in width. Including the whole area, it is called the Tahsien oil field (Pl. XVIII).

Topography: The western part of the Tahsien district is a hilly region. The drainage in this region consists of two main rivers, the Paho and the Chouho joining at Sanhwei in Chühsien. The average altitude is about 430 m above the sea and the tops of the hillocks are estimated at 120-150 m higher than the river. On the east side of the oil field the hill-range of Tiehshan runs in NNE and SSW direction having a height of 1,120 m and being cut to form a gorge by the Chouho between Tushihchieh and Shenchiatan. On the north there is another range, a little lower than the preceding one, trending along the strike of the north limb of the dome. In a general view the disection of the rivers seems to remain in the young mature stage. On account of the navigability of the river by junk the transportation will not be inconvenient in future if the field will be developed.

Geology: *Stratigraphy*—The surface stratigraphy is very simple, consisting entirely of the Tzuliuching formation of Lower Cretaceous, with the red-purple clay, sandstone and yellow-gray sandstone as essential constituents. The subsurface geology can only be known by comparing it with that in other places. In the gorge between Tushihchieh and Shenchiatan the upper part of Triassic Chialingchiang limestone is exposed. It may be regarded as the oldest rock in the stratigraphy of the oil field. The thickness of the Chialingchiang limestone here still remains unknown. In the upper part it contains 20-30 meters of calcareous shale and shaly limestone, being most probably the transitional phase of the Patung series and Chialingchiang limestone. Lying upon it the Jurassic Hsiangchi series is known to have a thickness of 470-480 m consisting mostly of dark gray sandstone and shale. Coal seams are few and thin. The lower part of the Tzuliuching formation is a little different from that in the western Szechuan. Below the Taanchai limestone there is no rock in red color but all are gray and yellow-gray shale and sandstone, amounting to more than 100 m in thickness. The Taanchai limestone itself is only 8 m thick as exposed in the Shenchiatan gorge. Above it lie the red-purple sandstone, clay and yellow-gray sandstone with the thickness of no less than 800 m for exposed part. The oil seepage occurs in a bed of the sandstone in this series at a horizon about 600 in above the limestone (Fig. 1). According to the stratigraphical study in other oil fields of this province it is shown that there are six worked oil horizons, 1 in the Chialingchiang limestone, 3 in the Hsiangchi coal series and 2 in the lower part of Tzuliuching formation. As regards the source of the oil seepage the shallower is believed to be much easier than the deeper. Thus the petroliferous bed here in this field is probably confined to the lower part of the Tzuliuching formation or the upper part of the Hsiangchi series.

Structure:—The structure of the oil field is apparently a dome-anticline elongating in the direction of NWW and SEE. At Chaochiachang the strata dip to NE at an angle of 15 degrees. In the vicinity of Chiaowanho they dip at 10-12 degrees to north. On the north of Suichiatsao, near by the seepage they dip to NW at 13 degrees and south of Shihtikan at 6 degrees to west. And on the east of Shihtikan the dip turns to SW and then to SE. Therefore it looks like the structure of the Tzuliuching region but is different from the latter in that the dips are much gentle and the area is larger (Fig. 2). In addition to the dome-anticline there are two other anticlines on the east and south of the oil field. The former constitutes the hill-range of Tiehshan, trending in NNE and SSW direction and dipping steeper on the western limb than on the eastern in the Shenchiatan gorge and being symmetrical at the locality 20 km north.

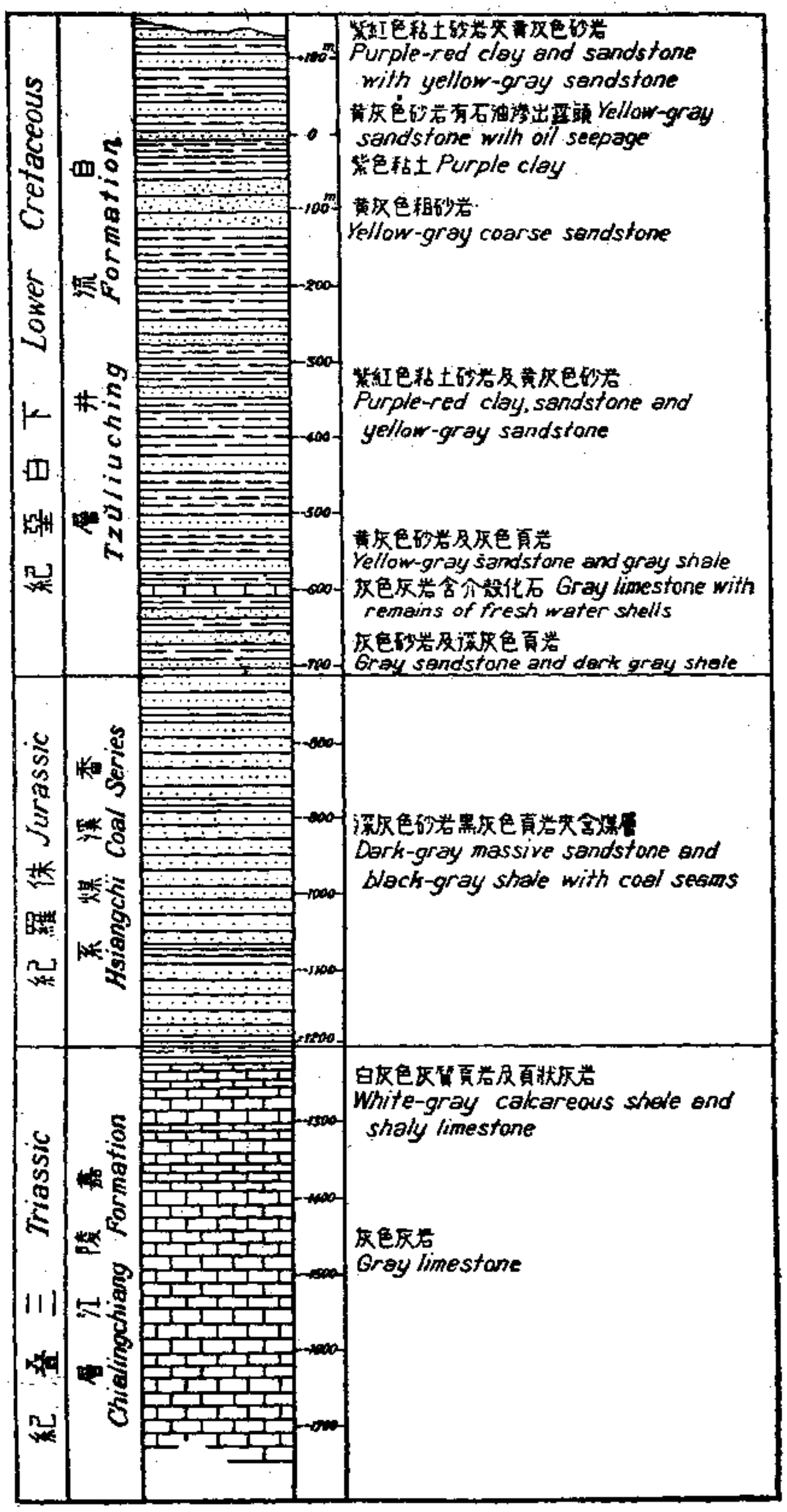

Fig. 1. Columnar section showing the sub-surface stratigraphy in the Tahsien Oil Field Szechuan.

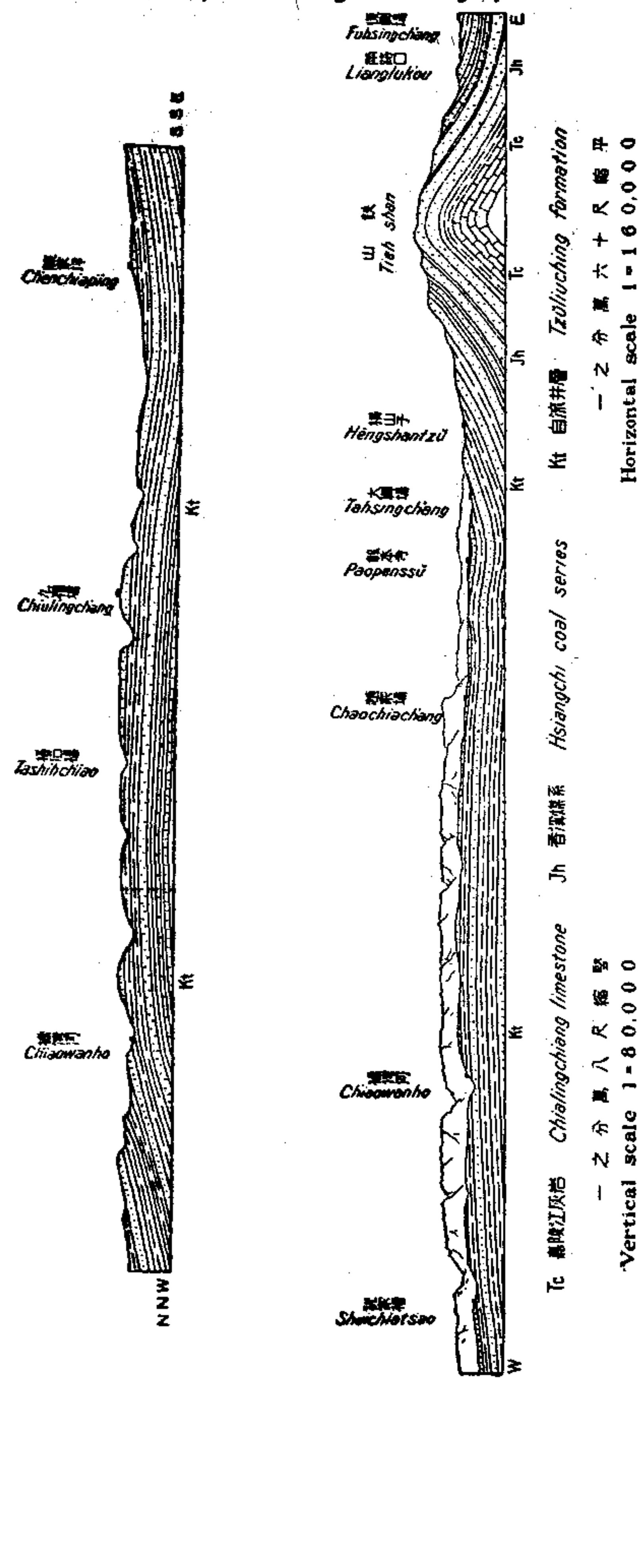

Fig. 2. Sections of the Tahsien Oil Field showing the stratigraphy and structure.

The latter forms another range nearly parallel to the former, pitching to north and disappearing on the west of Chenchiaping.

Observation on the seepage: The oil seepage is situated on the NW limb of the dome-anticline and on the side-slope of a small valley. The oil slowly seeps out from a bed of yellow-gray sandstone associated with a fine spring water. Natives dig in the sandstone a small pond in a size of 1.5 ft in diameter in which the water is preserved with the oil floating on the water surface. According to the informations of the natives only a catty of crude oil can be gathered per day and even less in winter. The oil appears deep brown in color and thin in viscosity. It is not yet analysized.

Localities suggested for prospecting: Basing upon the structural and topographical features several localities have been suggested for the preliminary prospecting, they are the vicinity of the seepage, the locality of Tashihchiao, the locality under the cliff on the north of Kuchiaho, the places on the north-west and south of Chiulingchang and on the south of Paopenssu.

SALT DEPOSITS AND INDUSTRY OF SZECHUAN PROVINCE

BY

H. C. T'AN AND C. Y. LEE

INTRODUCTION

The salt in Szechuan is generally intimately associated with the oil so that much can be referred to what has already been written about the oil in the previous paper.

Much has been published[1] about the Szechuan salt, chiefly as to the technique of production in the Tzuliuching region. It is the aim of the present paper to give a general description of all the known salt producing areas in that province.

DISTRIBUTION OF SALT DEPOSITS

It is known that nearly all the districts in the Szechuan basin (Pl. XI) produce or have produced salt, but the production of some localities is now no more continued. In the western part of the Szechuan basin are situated the important salt regions including Tzuliuching and Kungching which produce about 90 per cent of the total output of salt. In the eastern part of the basin there are several scattered salt regions. In the southeastern corner of the province there lies the Pengshui region and isolated in the southwestern corner is the Yenyuan salt region.

The Tzuliuching-Kungching region in the Fushun and Junghsien districts is the most productive in salt. The salt region in the Chienwei and Loshan districts is second in production. Both are situated in the southwestern part of the Szechuan basin. The Nanpu-Langchung salt region in the northwestern part of the basin is very large in area estimated at not less than 500 sq. km., but producing centers are not concentrated as in the case previously mentioned. The salt bearing strata extend far into the northeastern corner of Szechuan as known by the brine spring at Taning.

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1 C. H. Lin: General Statement on the Salt Industry in Szechuan, (in Chinese), 1919. Other Chinese books dealing with salt. L. Coldre: Les Salines et les Puits de Feu de la Province du Se-Tchoan, Ann. Min., ser. 8, t. 18, pp. 441-528, 1891. A Hosie: Szechuan, its products, Industries and Resources, 1922, etc.

The production of a salt region is not proportional to its area; the Tzuliuching-Kungching region which only occupies about 120 sq. km. has the largest production, while the Nanpu-Langchung salt region produces only one-nineth of the Tzuliuching-Kungching output.

The salt deposits of Szechuan may be described under a number of areas distinguished according to the topographical and geological conditions, each area to include one or more smaller areal units named region[1]. They are as follows (Pl. XI):

1. Fushun-Junghsien area including the Tzuliuching, Kungching and Tengchingkuan salt regions.
2. Chienwei-Loshan area containing the Chienwei and Loshan salt regions.
3. Chingyen-Jenshou-Tzuchung area comprising the Chingyen, Jenshou and Tzuchung salt regions.
4. Chuanpei (Northern Szechuan) area consisting of the Nanlang, Shêpeng, Pengchung, Shêhung, Mienyang, Hsiyen, Chungchiang, Santai, Pengsui, Lochih, Chienyang and Nanyen salt regions.
5. Chuantung (Eastern Szechuan) area comprising the Chunghsien, Wanhsien, Yunyang, Kaihsien, Fengchieh and Taning salt regions.
6. Tatsu salt area.
7. Pengshui area.
8. Yenyuan area.

FUSHUN-JUNGHSIEN AREA

Location

The salt deposits are situated in the environs of Tzuliuching and Tengchingkuan in the western part of the Fushun district and in the vicinity of Kungching in the southeastern part of the Junghsien district. This area may be divided into two parts, namely the Tzuliuching-Kungching on the west and the Tengchingkuan-Wangtang on the east, with non-productive

1. The salt regions as here called mostly correspond with the administrative units "Chang" 場.

part between. In the Tzuliuching-Kungching region the most productive localities are Tafengpao, Huangshihkan, Liangkaoshan, Kuochiaao, Tungyomiao, Koushihpo, Touyawan and Aiyehtan; numerous brine wells are concentrated in the vicinities of Tafengpao and Huangshihkan. In the Tengchingkuan-Wangtang region the salt producing localities were Chantang, Wangtang, Taitang, Sungtang and Hsutang, most of them have been abandoned, there are now only two brine wells in the vicinity of Wangtang.

Geology

The geology[1] of this area is rather simple and consists on the surface of the lower part of the Cretaceous red beds with salt bearing formations concealed below (Pl. XII-XIV).

The surface rocks thus belong to the Tzuliuching formation which is the lower division of the Cretaceous red beds or the Szechuan series. It may be divided here into 7 beds which have been already described in the report on oil (p.5) and summarized in Plate III.

The subsurface geology can be inferred from other regions where older rocks crop out or from the drillings. From such data it is known (Pl. II) that all the three Mesozoic formations may contain salt or brine and should be taken into consideration. It may be remembered that the Cretaceous is subdivided into Tzuliuching, Chiating and Mengshan formations respectively 200 to 1,200 m, 500 m. and 800 m. thick; the former two are important for the salt. The Tzuliuching formation contains the Taanchai limestone (Pl. III) a typical key bed at about 180 meters above the top of the Jurassic coal series. The Jurassic coal series has rather a uniform thickness of about 550 meters. The Triassic is represented by two formations, namely the upper the Chialingchiang formation and the lower the Feihsienkuan. The former formation is about from 380 to 650 meters thick in average in the Fushun-Junghsien area. The Feihsienkuan formation is from 150 to 240 meters thick.

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1 The detailed geological conditions of the Tzuliuching-Kungching region will be published in a separate paper as part of the Memoir entitled "The Geology of Szechuan and Hsikang". A brief but excellent account with a geological map is to be found in Chao & Huang's geology of Tsinling & Szechuan, Mem. Geol. Surv. Ser. A. No. 9.

Among the drilling records kept in the Tzuliuching-Kungching salt region, two of them are especially interesting as showing the subsurface stratigraphy of the area, they are the well log of Yentaiching (Pl. V) at Tafenpao in Tzuliuching and that of Hunglungching (Pl. IV) at Shantzutsui in Kungching. Yentaiching is located at the Tafenpao clay on the surface. The rocks obtained from the drilling are the Tafenpao clay, the Tungyomiao limestone and the Chenchuchung clay of the lower part of the Tzuliuching formation. Below these the rocks change to gray sandstone and black shale of the Jurassic coal series. At a horizon about 24 meters below the top of the gray, black rocks there occurs a coal seam. Further down more sandstone and shale are found alternating with several coal seams. Some brine occurs at a horizon about 200 meters below the top of the coal series which amounts to about 548 meters in thickness. At the depth of about 650 meters below the surface, comes the Triassic limestone. At the depth of about 930 meters there are two beds of rock salt with some rock between, the upper bed being white and 2-3 meters thick the lower bed reddish and about 2 meters. The depth of the well is about 944 meters, and the Triassic limestone drilled amounts to about 293 meters.

Hunglungching is located at the Liangkaoshan sandstone on the surface but the rocks first recorded belong to the Taanchai limestone. Below these is the Maanshan clay. Some sandstone with clay follows it and may be the Kuochiaao sandstone. The succeeding red-purple clay with white-gray sandstone is correlated with the Tafenpao clay. Further down is the Tungyomiao limestone. The red-purple clay occurs again and belongs to the Chenchuchung clay. The succession of the strata drilled fairly corresponds with the stratigraphical divisions observed on the surface, though their thickness may vary. Further downward no red or purple rocks have been drilled, and the gray sandstone and shale of the Jurassic coal series begin to occur. At the depth of more than 20 meters below the top of the coal series there exists a thin coal seam contained in some dark-gray shale. The coal series drilled amounts to about 540 meters with more than 10 coal seams. At the depths of 320 meters and 335 meters below the top of the coal series some amount of oil has been encountered. Below the coal series is the Triassic limestone which has been penetrated in this well for about 266 meters; the limestone is mostly gray and dark-gray and in some part yellow and white-gray; within an interval of over 10 meters to 40 meters below the top of the formation there occur some gas and oil, within an interval of 208 to 231 meters gas is also found, and below 260 meters gas and oil occur in association with brine.

The structure of the Fushun-Junghsien area is rather simple; the folds include only some low and shallow domes or anticlines and synclines and a few slight undulations. Some fault is assumed to occur but without clear trace on the surface (Pl. XII). The Tzuliuching-Kungching region is characterized by a typical dome-anticline, (Pl. VII) in NEE and SWW direction (see the oil report p.9-10). Most of the salt-wells are situated on or near the axial zone of the dome-anticline and none have been found outside the limbs of it. In the Kungching field are exposed two groups of limestone which have about the same characters and thickness, with their overlying and underlying strata quite alike. If they are evidenced not to belong to two distinct horizons, there should be a fault between the exposures of the limestone. This is confirmed by the wells logs. The fault lies in northwestern and southeastern direction and has the plane dipping to northeast likely at high angle. The throw of the fault varies in different parts; in the vicinity of Huangkoshu in the southern part of the Tzuliuching field the repeated outcrops of the limestone can be seen with some red-purple clay between them, and thus the throw is very small. On the other hand, in the environs of Kungching only the limestone of the upthrow side is exposed on the Tienchihssu hill. The limestone which crops out along the stream north of Kungching seems to be the Tungyomiao limestone and the limestone of the down-throw side does not come to light, the throw there is estimated at about 100 meters. Between the mentioned places the faulted condition can be hardly detected owing to the regularity of the strata and the uniformity of the dipping.

Between Tzuliuching and Tengchingkuan the strata are slightly folded and show some low and shallow anticlines and synclines. In the environs of Wangtang the Tzuliuching formation is gently inclined, to north and northwest at angles of rarely more than 8 degrees. In the vicinity of Tengchingkuan the strata dip to northwest with the dipping angles amounting 40 degrees at some locality, no perfect folds have been observed.

Occurrence of Salt

In the Fushun-Junghsien salt area the salt is found in form of rock salt and brine; the former is confined only to the vicinity of Tafenpao, while the latter is wide-spread throughout all the salt regions and at different horizons and in different concentration known as black brine, yellow brine or white brine. According to the well logs the rock salt occurs in the lower part of the Triassic limestone formation and forms irregular beds or lenticules 2 or 3 in number with some rocks between. It is the same horizon which has been reached which varies in thickness, colours and characters in different wells.

In the well Hsienhaiching (Pl. XIII), Yangchiachung, there are 3 salt beds interbedded with rock layers, the group includes, in descending order, rock salt 1 meter thick, gray rock .144 meters, rock salt .144 m, gray rock .432 m. and rock salt .792 m., the salt beds amounting to about 2 meters in total thickness. In the well Yühaiching salt beds are interbedded with gray rock more than 4 meters in total thickness. In the well Chuyuanching, Chouchiachung, there are two salt beds with white and gray clayey rock of about 1.368 meters between, the upper bed being white and about .72 meters thick and the lower bed containing white rock salt of about .36 meters and gray rock salt of 1.512 meters, the total thickness of salt beds being 2.592 meters. In the well Hueiyuanching the salt bed comprises white rock salt of .216 meters and gray rock salt of 2.52 meters. In the well Santaiching, Lailungwan, the rock salt is said to be only 1.656 meters thick. In the well Yentaiching, Lailungao, there are two salt beds, the upper being white and 2.3 meters thick and the lower reddish and 2 meters thick, with some gray clayey rock of about .72 meters between them. In the well Shuangfuching, Tafenpao, two salt beds are known, the white rock salt composing the upper bed and amounting to about 1 meter in thickness and the reddish rock salt forming the lower bed and having a thickness of 1.8 meters with clayey and sandy rock of 1.332 meters between them. In the well Tofuching there are also 2 salt beds, the upper being white and 1.152 meters thick and the lower being reddish and 1.728 meters thick with some gray rock of .504 meters between them. At the well Lungyungching there occur 3 salt beds interbedded with rock layers, the sequence in descending order includes white rock salt of 1.584 m. clayey rock of .36 m., reddish rock salt of .72 m., clayey rock of .36 m and gray rock salt of 2.52 m., the total thickness of rock salt being nearly 5 meters.

According to the position of the salt wells and the total thickness of the salt beds it is known that the salt beds are thicker in the eastern part of the area, the total thickness being from 2 to 5 meters. The area is estimated at about 800 m. × 800 m. but irregular in shape; the northern part is wider. Outside the area mentioned the rock salt has never been found although many deeper salt wells have been drilled here and there for detecting it. According to the position and the depth of the salt wells the rock salt occurs within a zone between the depth of more than 270 meters and that of about 300 meters below the top of the Triassic limestone formation. It is undeterminable whether the salt forms continuous beds or irregular bodies included in the Triassic rocks.

The brine occurs in variable position. The so-called yellow brine is low in salinity and relatively shallow in underground position while the black brine is more saline and deeper. But the brines are derived from many beds which may constitute zones, and increase in salinity with the depths, and the zones are likely to be continuous without sharp demarcation between them. In comparing the 50 yellow brine wells observed in field it is shown that the horizons of yellow brine are almost all included in the Jurassic coal series, especially in its middle and lower parts (Pl. XIV). At about 40 black brine wells the black brine is all contained in the Triassic limestone formation, mostly in the middle part (Pl. XV). At more than 30 abnormal brine wells the horizons of brine are scattered throughout the Triassic limestone except some in the Jurassic coal series and some in the Triassic sandstone formation (Pl. XVI). Thus it is obvious that the salinity of brine increase downward and reaches the maximum in the middle part of the Triassic limestone formation, in which the rock salt occurs at some localities. But below the maximum point the brine decreases in salinity and becomes nearly fresh water at Yunlungching, one of the deepest wells in the Tzuliuching field, which is likely to have penetrated into the Triassic sandstone formation.

In the Tengchingkuan-Wangtang salt region the salt wells are shallow and the active ones at Wangtang amount to only about 100 meters in depth. The brine bailed is called "white water" and very low in salinity. The wells are located at the Liangkaoshan sandstone on the surface and have the bottom at the depth about 50 meters below the Taanchai limestone. It is deduced that the brine may be contained in the sandstone corresponding to the Kuochiaao sandstone (see Pl. III) which is about 50 meters beneath the Taanchai limestone. This is the highest of the brine-bearing beds in the Fushun-Junghsien salt area (Pl. XVI).

The nature of the salt container or reservoir rock varies widely. In the Triassic some sandstone contains brine and the limestone in the upper part yields both brine and rock salt. How the limestone contains the salt is not exactly known. There may be some cavernous or porous layers. The Jurassic brine is known to be derived from what the natives call "straw white sands", that is some white-gray sandstone in the coal series. In the Cretaceous, brine is found in the greenish-gray or gray sandstone interbedded with red-purple clay in the lower part of the Tzuliuching formation.

Quality of Brine and Salt

As has been stated above the salt occurs in form of brine and rock salt, the latter, before being bailed out, must be dissolved by fresh water to form saline solution which may be named artificial brine, or rock salt brine. The method for measuring the salinity of brines is crude: a wooden bowl is used to carry a certain volume of brine from which a certain amount of salt is produced by evaporation. For example, if two ounces is produced from that much of brine, the salinity of that brine is said to be 2 ounces. But the size of the wooden bowl and the amount of brine contained are different at different wells, so that the salinity of brines can hardly be comparable. Some generalization may be however made by combining the results of brine analyses and the calculations made from the salinity of various brines at different wells, it is thus known that the artificial brine (rock salt brine) contains from 23.2 to 25.7 per cent salt, the black brine from 17.1 to 26.6 per cent with 21.6 per cent as an average, the yellow brine from 8 to 14.6 per cent salt and the white brine at Wangtang contains only 2.5 per cent salt. The analyses of the brines taken from the Fushun-Junghsien salt area are given in the following tables:

Analyses of Brines of Fushun-Junghsien Area

(by Industrial Laboratory, Ministry of Agriculture and Commerce)

Brines	Total solids	K	Na	Ca	Mg	Cl	So_4	Al	KCl	NaCl	$CaCl_2$	MgCl	$AlCl_3$	$CaSO_4$
Artificial brine	32.14	2.74	10.28	0.23	10.06	18.67	0.33		5.23	26.12	0.25	0.24		0.47
Black brine	25.79	1.97	7.83	0.48	0.09	14.80	0.25		3.76	19.90	1.05	0.36		0.35
Yellow brine (high in salinity).	17.50	4.13	3.737	0.057	0.017	10.635	trace	0.13	7.87	9.49	1.15	0.07		
Yellow brine (low in salinity).	19.00	0.45	2.34	0.43	0.43	6.57	trace		0.85	5.89	1.18	1.73	0.69	
Abnormal black brine.	10.54	4.09	2.48	0.08	0.02	9.87	trace		9.71	6.29	1.47	1.07		

Analyses of Brines of Tzuliuching Field

(by Industrial Laboratory, Ministry of Agriculture and Commerce)

Brines	Total solids	KCl Percentage in solution	KCl Percentage in total solids	NaCl
Artificial brine	30.40	1.30	14.28	27.65
Black brine	25.66	4.238	16.516	15.83
Yellow brine	13.64	3.45	25.56	6.70

Analyses of Brines of Fushun-Junghsien Area
(by Chemical Laboratory, Geological Survey of China)

Brines	Salt well	Na	K	Ca	Mg	Cl	NaCl	KCl	$CaCl_2$	$MgCl_2$
Artificcial brine	Yentaiching	9.85 gram. per 100 c.c.	0.86	0.10	0.11	16.70	25.02	1.64	0.27	0.44
	Ningshanching	9.51	0.53	0.34	0.15	16.32	24.16	1.01	0.94	0.59
	Houfuching	7.32	0.78	0.31	0.12	12.60	18.60	1.49	0.86	0.47
Black brine										
	Hungshunching	6.69	0.78	0.87	0.16	13.46	17.01	1.50	2.42	0.63
	Chifuching	3.68	0.50	0.89	0.21	8.33	9.36	0.96	2.46	0.84
	Chuanyungching	5.74	0.39	0.52	0.19	11.63	14.60	0.74	1.43	0.73
Yellow brine										
	Tingshengching	4.73	0.19	1.09	0.24	9.63	12.01	0.37	3.03	0.94
	Tungchangching	3.34	0.35	0.83	0.15	7.35	8.48	0.67	2.27	0.60

Analyses of Brines of Tzuliuching field
(by Sulman and Picard, London)

Brines	Insoluble matter in suspension	Iron & Alumina (soluble)	Calcium Chloride (with strontium)	Magnesium Chloride	SO_3 as sodium sulphate	Potassium Chloride	KCl % on Total solids	K % on Total solids	Sodium Chloride	Barium Chloride	Total solids
Artificial brine	0.30 gram. per 100 c.c.	0.05	1.60	0.604		1.03	6.2	3.24	12.60	0.42	16.604
Black brine	0.028	trace	1.09	0.303	0.444	3.02	13.9	7.26	16.90		21.76
Yellow brine	0.035	trace	1.01	0.433		0.70	4.3	2.25	13.30	0.71	16.188
White brine (inferior black brine)	0.03	0.017	1.056	0.422	0.599	1.33	9.4	4.91	10.67		14.124

The salt produced is generally classified as, according to the grain of crystallization and of fuel used in evaporation; there are thus coarse and fine grain salts, and gas and coal salt, and the latter is distinguished into gas white and gas black pan salt and coal white and coal black pan salt. There are still other kinds of salt for different markets. The refined salt is also made, and this and the coarse grain salt being all crystalline and pure are the best of the salts. The white and fine pan salt is preferable while the coal black pan salt is locally consumed. Some salts were analysed and the results of analyses are given in the following tables:

Analyses of salt of Tzuliuching field

(by Sulman and Picard)

Salts	NaCl	CaO	MgO	SO_3	Insoluble matter	Total
Black pan salt	97.90	0.50	0.04	0.51	0.66	99.61
Gray pan salt	98.86	0.40	0.06	0.25	0.30	98.87
White pan salt (1)	97.69	0.53	0.05	0.32	0.08	98.67
White pan salt (2)	98.70	0.66	0.02	0.33	0.40	100.11
White coarse grain salt	98.86	0.20	0.06	0.18	0.10	99.40
White grain salt	99.00	0.20	0.03	0.17	0.15	99.55

Analyses of salt of Tzuliuching field

(by Salt Examination Office, Salt Revenue Department)

Salts	NaCl	KCl	$CaCl_2$	$MgCl_2$	$CaSO_4$	H_2O	Insoluble matter	Total
Grain salt.	97.74	0.23	0.21	0.06	0.77	0.96	0.10	100.07
Refined salt.	95.50	0.13	0.07	0.02	1.53	2.71	0.02	99.98

Salt Mining and Salt Making

With the exception of the rock salt in the environs of Tafenpao the salt is derived from the brines to be bailed up from great depth. The rock salt is dissolved by fresh water which is poured down from the surface, to form artificial brine to be bailed up again. So the salt in Szechuan is mostly produced from wells. Thus the main work consists of the drilling of wells and the bailing of brine. The drilling method is primitive with simple and rough tools. It is a kind of cable drilling, the cable is made of bamboo slips instead of steel wire, and the bit and stem are only an iron rod with one end steeled and flattened as a bit and the other end connected to the bamboo rope. There are several kinds of bit in various shapes. A timber derrick is set on the well for hoisting and the rig consists of a wooden frame with a walking beam, which is supported by an iron axle. To one end of the beam is connected the bamboo rope with the bit and the other end is tramped down and up by some people when the drilling is in operation. For hoisting the drill are used oxen in place of steam engine. The debris and dust chiselled at bottom are pumped by the bamboo tube at the lower end of which is set up a valve of leather or cloth.

The month of the well is in general about 40 cm in diameter and cased with hollow stone blocks and wooden pipes with the diameter coincident with that of the well. The lower part of the well is from about 8 cm to more than 22 cm in diameter without casing but in part lined with putty, a mixture of lime and wood oil. The depth of the wells drilled is variable, some wells of white brine at Wangtang are only about 120 meters deep while some well of black or abnormal black brine in the Tzuliuching-Kungching region reach more than 1200 meters in depth, and the prevailing depths are between 400 and 1000 meters.

As soon as the brine or rock salt has been reached the drilling operation is stopped and the process of bailing brine is to be started. On the well is set a strong derrick which is made timbers or bundles or tibers and amounts usually to from about 20 meters to more than 40 meters in height. On one side of the derrick is placed a big windlass about 8 meters in diameter which lies with the axle standing vertically. Between the derrick and the windlass is put a wooden wheel about a meter in diameter, standing vertically and supported by wooden frame; and on the top of the derrick is placed another wheel standing also vertically. The rope for hoisting is made either of bamboo slips or of steel wire, bound around the windlass with one end and fixed to it, passes through the two wheels, and is connected with the other end to the bailing tube. The tube is made usually of bamboo and sometimes of tin and from about 15 meters to about 40 meters long with the diameter coincident with that of the well. At the lower end is set up a valve which is made of leather or cloth and used for closing the brine in the tube. The windlass is pulled by oxen for hoisting, and the operation is very slow. In recent years at most of the deep wells, the oxen windlass is replaced by small steam winding engines and the derrick is made stronger and like some headgear used in coal collieries. The bailing tube is different in size, some big bamboo tubes can carry 400-500 catties (250-300 kg) and some large tin tubes more than 1200 catties (740 kg). In regard to the rock salt the fresh water should be put into the wells from the surface to dissolve rock salt, the artificial brine thus produced is bailed up again by tin tubes. (Pl. XIX, Pl. XX, Pl. XXI).

The brine bailed up is poured into a wooden tube or earthen jar and then led through bamboo pipes into a big wooden tank from which it is taken by some wooden barrels to salt plants or lifted up to a small wooden tank and from there led through bamboo pipes to different salt plants. The transportation of the brine from wells to salt evaporation plants depends largely upon the bamboo pipes. The latter are connected to form long ones and tied and wrapped by linen with putty. The arrangement of the bamboo pipes is different according to the topography of the country which they pass through; the pipes may be exposed on the surface or lie underground. Instead of the pipe small boats are used where stream transport is available, and wooden barrels are also used to convey brine from wells to salt plants in adjacent localities. (Pl. XXII, Pl. XXIII, Pl. XXIV, Pl. XXV, Pl. XXVI).

The salt making process employed in the Fushun-Junghsien salt area may be named the open pan process accomplished by direct-heat evaporation. The pans are made of cast iron different in size and kind, the most prevailent ones are the "thousand-catty pans", which are round in shape, about 1.5 m in diameter, 8 cm deep and 15 cm thick. The pans are supported by tile-like iron plates placed on the furnaces and arranged in rows in some large salt plants. The fuel used is either gas or coal, the former is most important. The largest salt plant in which gas is used as fuel has more than 400 pans. The method for making grain salt is different from that for producing pan salt. For making grain salt the brine is poured into pans heated and boiled, some bean juice is added several times for purification. After the impurities are taken out, some salt crystals formed in other small pans are added, the brine is boiled until it is exhausted and the salt grains are formed. The salt thus formed is taken into some bamboo baskets for filtering out the bittern, then soaked through by some boiled brine and becomes white grains. For making pan salt some fine salt is put in the pans and heated until the pans become red-hot, the brine is gradually poured into the pans and heated, finally a salt cake is formed after continuous precipitation. From 80 to 140 catties of grain salt can be produced per 24 hours. The salt cake which is about 1.5 m in diameter, 20 cm thick and weighs about 700 catties, is formed in from 4 to 8 days. (Pl. XXVII, Pl. XXVIII).

Salt Industry

The Fushun-Junghsien salt deposits were already known in Han Dynasty. The productive centers were then in the Tengchingkuan-Wangtang region and there were only a few wells of not more than 80 meters in depth. Thereafter the salt industry extended northward and the places in the environs of Tzuliuching became the most productive salt region. In Tang Dynasty Kungching was known to produce salt. Tzuliuching and Kungching are closely situated and then formed one salt region. In Sung Dynasty the salt industry of the Fushun district which included Tengchingkuan, Tzuliuching and Kungching was the most prosperous of Szechuan province. The salt industry declined in Ming Dynasty and became very prosperous again in the Ching Dynasty. The area was divided into two regions, namely Tzuliuching-Kungching region and Tengchingkuan region. Now the Tzuliuching-Kungching region plays an important role in the salt industry in China.

The price of the brine varies according to its salinity and its distance. For example, 300 catties of black brine of Lienhaiching, containing 50 catties of salt, are sold to the salt plants at Kuochiao at 55 cents.

The production of salt of the Fushun-Junghsien area is given in piculs in the following table:

Year	Production of Tzuliuching-Kungching Region	Production of Tengchingkuan-Wangtang Region
1925	2,673,766.17 piculs	1,433.48 piculs
1926	3,747,551.36 ,,	2,122.96 ,,
1927	3,724,612.37 ,,	2,106.32 ,,
1928	3,541,769.76 ,,	1,752.64 ,,
1929	3,574,017.64 ,,	1,650.53 ,,
1930	2,923,138.37 ,,	1,608.47 ,,

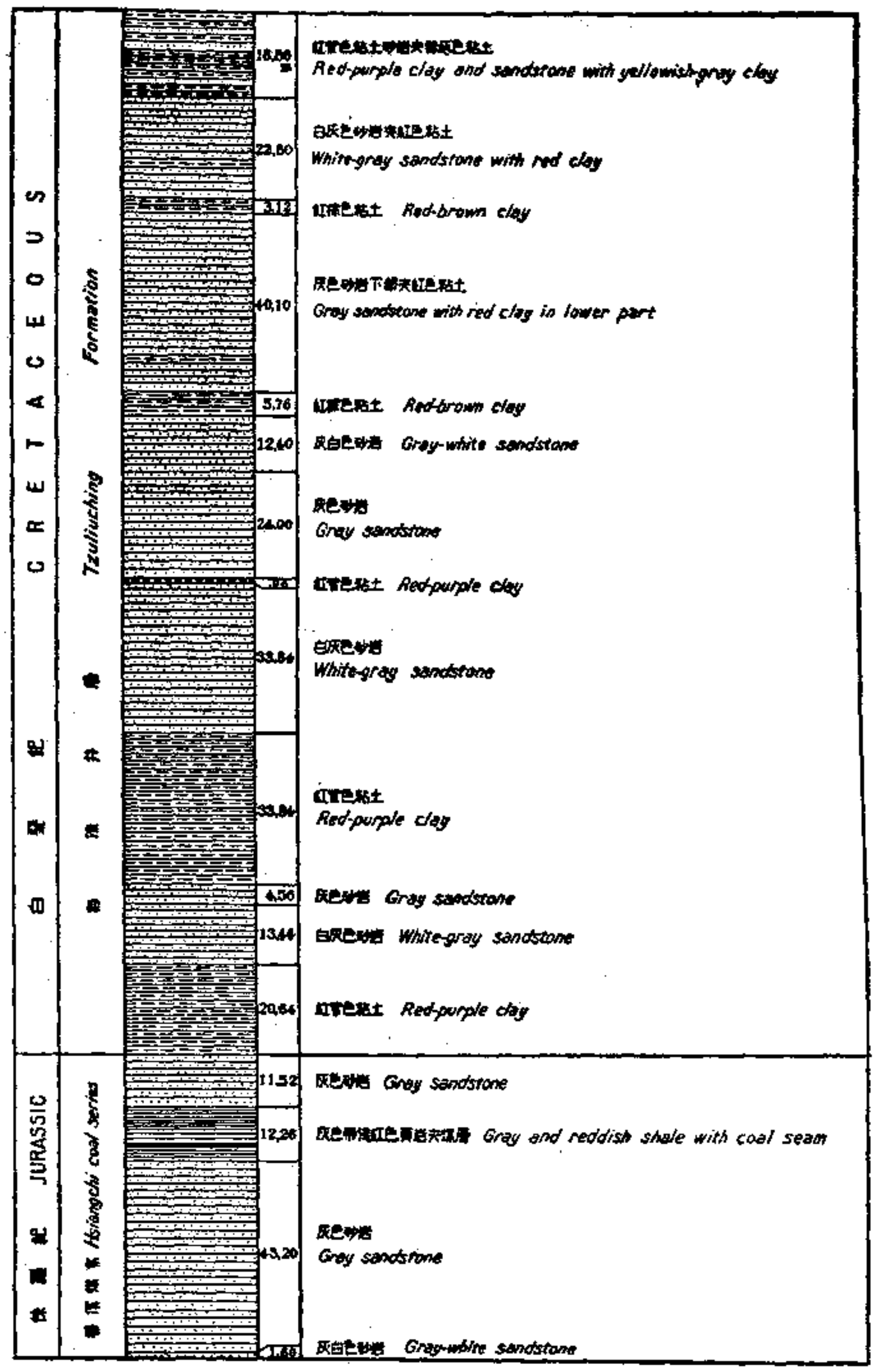

Fig. 1. Columnar section showing the well log of Fuyüching at Shunhochieh in Chienwei region.

CHIENWEI-LOSHAN SALT DEPOSITS

Location

The salt deposits are situated in the north-eastern part of the Chienwei district and the southern part of the Loshan districts. The productive localities (Pl. XVII) are numerous, and the large ones are Wutungchiao, Niuhuachi, Yangliuwan, Tzatsaotan, Hueishanching, Shunhochieh, Hungtoupo, Wangtsunchang, Mataching, Sanchiangchen, Watsatan, Chinshihching, Hoerhkan and Lijenchang on the east of the Min River and Ts'aichinchang, Kuanpangchang and Hsinchangtzu on the west of the Min River. The area in which the salt wells are scattered is large, amounting to probably more than 60 km. in length and to more than 20 km. in width. Wutungchiao and Niuhuachi which are located near the Min River are the business markets like Tzuliuching and Kungching in the Fushun-Junghsien area.

Geology

The geology of the Chienwei-Loshan area is relatively simple; the surface stratigraphy (Pl. XVII) is represented by the Tzuliuching formation in the central part, the Chiating formation in the northern part and the Jurassic coal series near the southern margin. In the environs of Motzuchang on the east and of Shihlin on the west of the Min River occurs the upper part of the Jurassic coal series, which contains white-gray and yellowish-gray sandstone and dark-gray shale with coal seams. Above the coal series is the Tzuliuching formation of the Cretaceous, which is here well developed and wide-spread. The chief constituent of the formation are red-purple clay and white-gray and yellowish coarse sandstone with yellowish-green and gray limestone about 5 meters thick containing plenty of polecypods. This limestone may correspond to the Taanchai limestone in the Fushun-Junghsien salt area though it is rather thinner here. In the vicinities of Wutungchiao, Yuchingpo and Hueishanching are exposed some yellowish-brown and gray coarse and cross-bedded sandstone and red and purple clay with thin-bedded limestone and calcareous shale, which also belong to the Tzuliuching formation. The Chiating formation which lies upon Tzuliuching formation is found to occur in the northern part of this area and to extend northward to the environs of the Loshan city (Chiating) where it is well exposed. The constituent rocks are red clay and sandstone.

As regards the suburface geology there is little information; some may be obtained from the drilling records kept by some well owners, though they may be wrong or unreliable. At Shunhochieh the well Paotungching was drilled on the surface at some yellow sandstone above the thin limestone and penetrated through some red rocks with gray rocks; the red rocks may be the red and purple clay and sandstone and the gray rocks may be the gray or white-gray sandstone interbedded with the former. They all belong to the lower part of the Tzuliuching formation, but the intercalated limestone was not noticed. The well Fuyüching was also drilled at the sandstone above the limestone and penetrated to a depth of about 302 meters. From the surface to the depth of about 234 meters were found mostly the red and gray rocks which are undoubtedly the red and purple clay and sandstone and gray and white-gray sandstone of the lower Tzuliuching formation, neither the limestone was here recorded. Below 234 meters the rocks change in colour, the gray becomes predominant and some coal is encountered; these belong to the upper part of the Jurassic coal series and the coal seam may correspond to the uppermost coal seam encountered at Motzuchang (Fig 1). The well Chinhuaching on the northeast of Niuchuachi was started to drill from some member of the Chiating formation and penetrated to a depth of about 626 meters; the upper part seem to consist almost entirely of red rocks with very few gray rocks at some horizons whereas in the lower part in addition to the red rocks there were abundant gray and white rocks; the upper part may belong to the Chiating formation and the lower part represents one part of the Tzuliuching formation, but the demarcation between them is not clear. This well has not reached the Jurassic coal series below the Tzuliuching formation with a depth of about 626 meters, if the Tzuliuching formation is estimated at from 400 to 450 meters, the penetrated part of the Chiating formation amounts to about 200 meters. The comparison of the drilling records with the surface observations shows that the subsurface stratigraphy is fairly the same as the rocks succession exposed on the surface.

The structure of the Chienwei-Loshan salt area is represented by slight undulations and low anticlines without conspicuous fault. There is a noticeable anticline which may be named Chukentan anticline with the axis lying north of Motzuchang in east-west direction (Fig. 2). It gradually diminishes toward east until totally disappearing but it extends to the west to form an elevated large anticline. On the east of the Min River the southern limb are gentle and dips at very low angles, while the northern limb has the dipping angles of about 8°. On the west of the Min River the Jurassic coal series and Triassic formations come to light and have also gentle inclination on both limbs. On the northern limb of this anticline is situated the Chienwei-Loshan salt area in which the strata dip generally to north, northwest or north-northeast at rather low angles. On the east of the salt area lies the Weiyuan-Junghsien large anticline which may also have the relation to the salt deposits here in question.

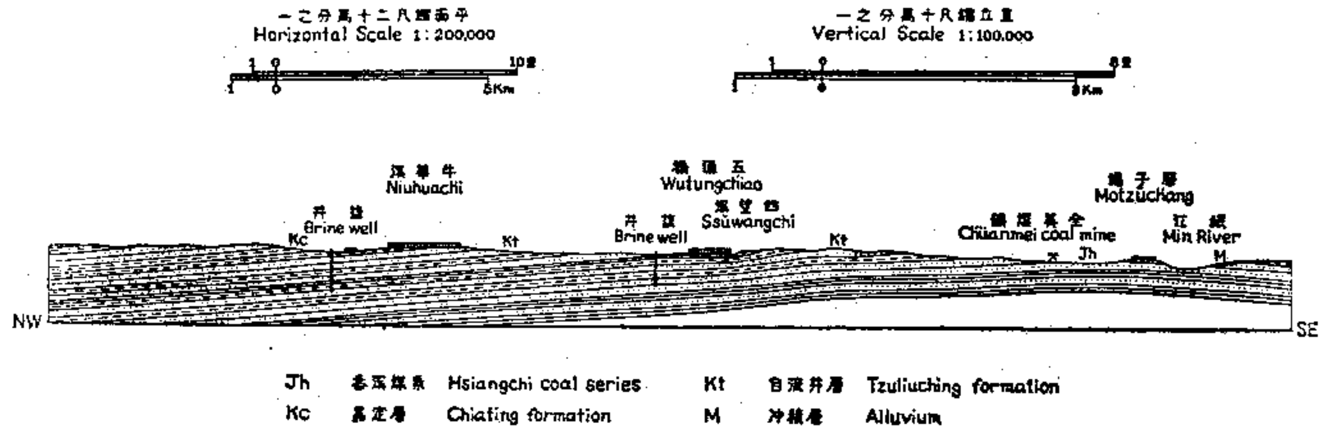

Fig. 2. Section showing the Stratigraphy and Structure of the Chienwei-Loshan Salt and Oil Area, Szechuan.

Occurrence of Salt

The brine has not been differentiated here as black and yellow, though its salinity varies according to the depths at which it is encountered. The salinity of brine usually increase downward from the surface and thus better brine is often obtained from deeper wells. The depth of wells varies from about 240 m. to more than 600 m., but this can not represent the horizons of brine, and the position of wells on the surface should be taken into account for correlation. The wells which have about the same depth but are sunken from different formations on the surface have certainly the brine of different horizon, whereas the brine from the same horizon may be encountered in wells of different depths. It is known that in the southern part of the salt area the brine is obtained from the upper part of the Jurassic coal series while in the northern part it is from the lower Tzuliuching formation. But the brine usually occurs in zones and can not be differentiated by horizons; thus in the Chienwei-Loshan salt area there are two brine zones which may contain many horizons. As regards the reservoir rocks no more reliable information has been obtained than that from some drilling records and well people; it is known that the brine is derived from the so-called "straw-white sands" which are without doubt some white-gray or gray coarse sandstones which may be found both in the Jurassic coal series and Tzuliuching formation.

Quality of Brine and Salt

The brine is different in salinity according to the depth at which it occurs. The calculation of the salinity used by the natives depends on the quantity of the pan salt produced from the brine per catty. According to the reports of various wells and salt plants the brine contains from 4 to 15 per cent salt of its amount with 8 per cent as an average. No analyses of the brine of this area have been made to show its actual composition. The salt produced is also of two kinds, namely grain salt and pan salt, according to fuel and colour it is subdivided. The analyses of salt made by Sulman and Picard are given in the following table:

Salts	NaCl	CaO	MgO	SO_3	Insoluble matter	Total
White pan salt	97.97	0.40	0.07	0.44	0.60	99.48
Black pan salt	97.90	1.00	0.53	trace	0.60	100.03

Salt Mining and Salt Making

The method of drilling wells is exactly the same as that used in the Fushun-Junghsien area, but the difference is that the wells drilled here in this area are much shallower and the drilling takes much less time. The wells vary from about 8 to 15 cm in diameter and from about 240 to more than 600 m. in depth. The drilling for a deep well may take 3 or 4 years and cost about 20,000 dollars. When the brine is encountered the bailing equipments are set up. The derrick is simply made of logs, at most wells the oxen windlass is used, but a few wells are working with the steam winding engine. The bailing tube is of the same type as that used in the Fushun-Junghsien area and formed of bamboo. No people specially carry on pipe transportation business, the well owners manage both brine wells and salt plants. Long bamboo pipes are used for transporting brine from well to salt plant, and some bamboo pumps of local type and wooden barrels are also used for this purpose. Coal is used for fuel in salt making. On the furnace are placed pans which are supported by iron plates and stone blocks cemented by mud.

The process for making grain salt and pan salt is similar to what has been described of the Tzuliuching-Kungching region. The grain salt thus produced from one pan in 2 days amounts to 300 to 500 catties. A cake of salt formed in 2 days weighs from 150 to more than 500 catties.

Salt Industry

The exact date of salt discovery in this area is not known. Existence of salt wells is recorded in the Tang Dynasty. The salt industry continued through the Sung, Yuan and Ming Dynasties and became prosperous since the early Ching Dynasty. There are more than 4000 salt wells, a big well may produce about 70,000 catties of brine per day whereas a small one produces only 100 to 200 catties, the average daily output being 3,000-4,000 catties. The salt plants number over 1300 and have more than 2000 pans. The coal is the only fuel for salt making and produced from the Shihlin, Motzuchang, Changkou and Huangtan coal fields in the Loshan, Chienwei and Pingshan districts. Each pan may produce about 7000 catties of pan salt per month and produce a little less amount of grain salt.

The price of salt is from 4.5 to 5.5 dollars per picul. The transport is done by boats or human carriers and mules. The freight varies according to consumption markets and means of transportation. The consumption area includes western Szechuan, northeastern Yunnan and eastern Hsikang. The yearly production of salt of the Chienwei-Loshan area is given in piculs in the following table:

Year	Production of Chienwei Region	Production of Loshan Region
1925	381,593.66 piculs	275,750.01 piculs
1926	406,280.91 ,,	300,764.23 ,,
1927	445,787.52 ,,	306,166.38 ,,
1928	458,787.20 ,,	320,809.09 ,,
1929	488,272.16 ,,	329,448.72 ,,
1930	546,124.91 ,,	380,750.63 ,,

CHINGYEN-JENSHOU-TZUCHUNG SALT DEPOSITS

Location

The salt deposits are scattered in the territories of the Chingyen, Jenshou and Tzuchung districts. The area in which the salt regions are situated is large with a maximum length amounting to about 140 kilometers and a maximum width to more than 100 kilometers (Pl. VIII). In the Chingyen district are the Tashuiwan, Chienfossu, Yenchingwan and Huchiatien regions, which are about 20 kilometers distant from the city, and the Wupaowan region which is about 40 kilometers NNW of the Chingyen city. In the Jenshou district are the Yangssuching region about 15 km. south of the Jenshou city, the city region and the Chungpaching region about 50 km. NNE of the city. In the Tzuchung district are the Luochuanching region about 60 km. west of the Tzuchung city and the Chinliching region about 30 km west of the city.

The Weiyuan-Junghsien range has an important significance to the distribution of the salt regions. On the north of this range is the Chingyen-Jenshou-Tzuchung salt area. On the north of this area there is again a range 800 m high which may be called the Chienyang-Jenshou range. The salt regions may be divided into two groups; one group including those near the Chingyen city, the Yengssuching region, the Luochuanching region and the Chinliching region, which are situated on the slope of the Weiyuan-Junghsien range, the other including the Wupaowan region, the Jenshou region and the Chungpaoching region which are located on the slope of the Chienyang-Jenshou range.

Geology

Although the salt area is very large, the geological conditions are rather simple. The stratigraphical formations are those common in the adjacent areas and the structural features are related to the Weiyuan-Junghsien anticline on one hand and to the fault lying along the Chienyang-Jenshou range on the other. Broadly speaking the salt area occupies but the northern limb of the Weiyuan-Junghsien great anticline, in the central part of which the Triassic limestone comes to light. On both limbs are the Jurassic coal series and the Cretaceous formations, the latter extend to this area. The Tzuliuching formation is well developed in the southern part of this area and constitutes the surface stratigraphy of the salt regions.

In the salt regions around the Chingyen city are exposed the red-purple clay and greenish and yellowish-gray sandstone, which belong to the upper part of the Tzuliuching formation and upon which rest the red clay and sandstone of the Chiating formation. Most of the salt wells are located in the Tzuliuching formation. In the Luochuanching salt region the Tzuliuching formation exposed contains chiefly red-purple clay and greenish-gray sandstone with two beds of limestone and some greenish clay. The upper limestone about 10 meters thick corresponds to the Taanchai limestone, and the lower limestone much thinner is correlated with the Tungyomiao limestone in the Tzuliuching-Kungching region.

The subsurface stratigraphy is little known. According to some drilling records, below the red rocks were found the black, gray and white-gray sandstones with coal seams which belong to the Jurassic coal series. In the Jenshou city salt region are developed the red-purple clay and sandstone and dark-brown and brown-purple micaceous sandstone with white-gray sandstone and greenish clay, which are the members of the upper Tzuliuching formation. On the east of the fault which lies along the eastern margin of the salt region are exposed the red and red-purple clay and sandstone with greenish clay and sandstone, which belong to the Chiating formation.

The major structural features consist of the Weiyuan-Junghsien dome anticline and the fault lying along the southern foot of the Chienyang-Jenshou mountain range. Most part of the salt area lies on the northern limb of the anticline, which dips generally to northwest or north at very low angles. The strata dip to NWW and NNW at angles of 4 to over 10 degrees between Chingyen and Jenshou, to N, NNW or NNE at very low angles in the Luochuanching region and to NW or NNW at angles of about 5 degrees between Luochuanching and Jenshou. At the Jenshou city a fault is found to lie in northeast southwest direction with the fault plane dipping to southeast (Pl. VIII). This is a normal fault with the Tzuliuching formation on the upthrow side and the Chiating formation on the downthrow side, on either side of the fault the strata dip generally to NNW at somewhat different angles, but near the fault the dip direction is variable and on the north of the city the strata are likely to form an incomplete anticlinal dome. It is not known how far the fault extends; but on the southern slope of the Chienyang-Jenshou range are often found the Tzuliuching formation while along the southern foot occurs the Chiating formation, if the two formations are everywhere along the southern foot of the Chienyang-Jenshou range in fault contact, at the Jenshou city is found only a part of it.

Occurrence of Salt.

The brine occurs at different horizons. In the Chingyen salt regions most of the salt wells are located at the upper part of the Tzuliuching formation at the depths ranging from 160 to 300 meters. The thickness of the Tzuliuching formation is estimated at more than 400 meters. Thus the brine does not occur down in the Jurassic coal series but is still confined to the lower part of the Tzuliuching formation. But the wells have different depths and the brine occurs at different horizons which can not be differentiated from each other, so that the brine zone here established contains many horizons, some of which may correspond to those in the Hoerhkan field of the Chienwei-Loshan area.

In the Luochuanching region most of the salt wells are located on the surface below the Taanchai limestone of the Tzuliuching formation and have their depths varying from 200 meters to over 600 meters. The part of the Tzuliuching formation below the Taanchai limestone amounts to less than 200 meters, so that the shallowest wells have entered the upper part of the Jurassic coal series and the deepest ones have reached the lower part. The wells Fuyuanching, Chaoyuanching and Hungyuanching are known to produce brine at the depths of about 529, 523 and 524 meters respectively and have the mouths situated just below the bottom of the Taanchai limestone which lies about 180 meters above the Jurassic coal series. The brine horizon thus determined occurs at the depth of 340 meters below the top of the Jurassic coal series. But the depths of wells are different, the occurrence of brine is represented by zones better than by horizons. It is known that in this region there are two brine zones, one occurring in the upper part of the Jurassic coal series and about several tens of meters below its top, the other in the lower part and less than 200 meters above the bottom of the coal series.

In the Jenshou city salt region the wells are sunken in the Tzuliuching formation, which lies at 100 meters below the Chiating formation, and are more than 230 meters in depth. The Tzuliuching formation in the Jenshou and Chingyen districts is estimated at about 500 meters, thus the brine occurs in the lower part of the Tzuliuching formation and about 170 meters above the Jurassic coal series, this horizon may lie below the Taanchai limestone.

In grouping the brine horizons in the Chingyen-Jenshou-Tzuchung area there are three brine zones; one being in the lower part of the Jurassic coal series and represented by the deep brine of Luochuanching; one in the upper part of the coal series and represented by the shallow brine of Luochuanching; one in the lower part of the Tzuliuching formation and represented by the brine of Chingyen and Jenshou.

Quality of Brine and Salt

According to salt records the brine in the Luochuanching region contains from .93 to 1.76 ounces in a catty (i. e. 6.2-11.7% salt), in the Chinliching region from .65 to 1.36, in the regions in the Chingyen district from .8 to 1.65, and in the regions in the Jenshou district from .94 to 1.36 ounces. According to the information from the brine well people the brine worked at the wells of the Yümo salt plant in the Luochuanching region has the salinity of from .7 to 1.2 ounces in a catty, at the wells of the Kaiyuan salt plant from .5-.6 ounces in shallow wells to .8-.9 ounces in deep wells, at the well Fengchuanching of the Shuncheng salt plant in the Jenshou city region about 1.2 ounces, and at the wells in the Chingyen regions from .5 to 1 ounce in a catty. The salt formed is also classified as grain salt and pan salt, the refined grain salt is the best and the gray salt is inferior.

Salt Mining and Salt Making

The depths of wells vary from about 160 meters to more than 600 meters and the diameters from 8 to 11 cm. The oxen windlass, simple wooden derrick, wooden wheels, bamboo pole, bamboo rope and bamboo bailing tube constitute all the mining equipments. The salt plants are situated near the wells, no many pipes are used for transportation. The salt making method is different in different regions. In the Chingyen and Jenshou salt regions the grain salt and pan salt are separately produced in different pans. In the Luochuanching region the grain salt and pan salt are produced in the same pan, the latter constituting the lower part.

Salt Industry

The Tzuchung salt deposits began to be worked since the Chin Dynasty and the Chingyen salt industry is known to have been prosperous in the Tang Dynasty. At present the wells in this area number more than 1,600 while the plants are about 340. The drilling expense of a well may vary from 500 to 1,000 dollars and the capital for establishing a plant is said to be from 100 to more than 200,000 dollars. The pan salt is sold at from 4.5 to 6 dollars per picul in the Chingyen-Jenshou regions and from 6.2 to 7.4 dollars in the Luochuanching and Chinliching regions; the grain salt is much cheaper, from 2.7 to 3.5 dollars per picul in the Chingyen regions and from 4.3 to 5.9 dollars in the Luochuanching and Chinliching regions.

The transportation is difficult, carriers or mules are used, at about 80 cents per 60 kilometers. The yearly production of the salt regions is given in the following table:

Year	Production of Chingyen and Jenshou regions	Production of Luochuanching and Chinliching regions
1925	87,221.17 piculs	40,160.38 piculs
1926	78,782.83 ,,	40,300.76 ,,
1927	72,012.49 ,,	38,096.58 ,,
1928	73,035.98 ,,	35,627.83 ,,
1929	67,202.55 ,,	30,818.95 ,,
1930	83,634.21 ,,	36,900.51 ,,

CHUANPEI (NORTH SZECHUAN) SALT DEPOSITS

Location

The salt deposits occur over a large area in the northern part of Szechuan and are being worked at many localities. The area covers parts of the Nanpu, Langchung, Shehung, Pengchi, Santai, Mienyang, Suining, Hsichung, Yenting, Chungchiang, Lochih and Chienyang districts and consists of 12 salt regions (Pl. XI). The Nanpu-Langchung region is the largest and includes the salt producing localities in the northern part of the Nanpu district and the southern part of this Langchung district. The Shehung-Pengchi region occupies the southeastern part of the Shehung district and the southwestern part of the Pengchi district. The Santai region includes the salt-producing localities in the southern, northeastern and northwestern parts of this district. The Pengchi region is situated in the northern and central parts of the district and separated from the Shehung-Pengchi and Pengchi-Suining regions. The Mienyang region includes the salt-producing localities in the southeastern part of this district. The Pengchi-Suining region covers the southwestern part of the Pengchi district and the western part of the Suining district. The Hsichung-Yenting region includes the salt-producing localities scattered in the eastern, northern and western parts of the Hsichung district and the northeastern part of the Yenting district. The Shehung region is situated between the Shehung city and Taihochen in the central part of this district. The Chungchiang region includes the salt-producing localities in the environs of Pangtzuchen in the southeastern part of this district. The Lochih region occupies the larger part of the district with the salt-producing localities scattered here and there especially in the central and western parts. The Chienyang region includes the salt-producing localities in the environs of Shihchiaoching and Haichingkuan in the northern part and in the vicinity of Laochunching in the western part of this district. The Nanpu-Yenting region is recently separated by the Salt administration from the Nanpu-Langchung and Hsichung-Yenting regions and occupies the western part of the Nanpu district and the central and western parts of the Yenting district.

Geology

The surface geology is entirely composed of the Cretaceous formations, the Tzuliuching formation constitutes only a small part of the Chienyang salt region while the Chiating formation is wide-spread in all salt regions above mentioned. On the northern margin of the Szechuan basin, i.e. north of Mienyang and Langchung, upon the Jurassic coal series rest the red-purple and brown sandstone and clay with conglomerate, which belong to the Tzuliuching formation. The strata dip generally to SSE, the Chiating formation follows the Tzuliuching formation and becomes mostly flat-lying and slightly undulating until reaching the salt area. In the Chienyang region in the south-western part of the area there occurs some red-brown sandstone with intercalated conglomerate which is likely to belong to the Tzuliuching formation. The Chiating formation is composed chiefly of red clay and sandstone with greenish-gray sandstone and clay, the rock characters hold good for the formation in the whole area. According to G. D. Louderback[1] from Penglaichen (Pl. X) to Shehunghsien were found red shale and sandy shale with red sandstone, green shale and reddish, gray and white sandstone, overlain by white massive sandstone, red shales and gray sandstone with red clayey sandstone. Further north from Shehunghsien to Hsichunghsien the rocks exposed are red shales and white-gray and brown sandstone. All these are the constituents of the Chiating formation.

No conspicuous structures were found by the writers who visited only a part of the area, the slight undulation and gentle inclination of strata are the only prevailing features, while in some parts the strata are flat-lying. When the strata are inclined the inclination is scarcely more than 5 degrees, so that it is difficult to define definite structure with such variable undulation. On the north of the Chienyang city the mountain Lungchuanshan, a part of the Chienyang-Jenshou range, is formed of an anticline, the northern limb of which is steeply inclined while the southern limb is gentler. The Chienyang region contains part of it. In the vicinity of the Chienyang city the strata become mostly flat-lying.

Occurrence of Salt

The wells in the vicinity of Laochunching in the Chienyang region are likely to be sunk in the middle part of the Tzuliuching formation and 100-200 meters deep, thus the brine occurs still in the lower part of the Tzuliuching formation. In this area the deepest wells are known to be about 460 meters and sunk in the middle part of the Chiating formation about 500 meters thick, so that the brine is encountered at the depth not more than 300 meters below the top of the Tzuliuching formation. The wells of moderate depths are from about 200 to 300 meters deep and thus have the brine contained in the Chiating formation. The shallow wells have the depths of about 100 meters with the brine confined in the middle part of the Chiating formation. Some wells in the Lochih region are still shallow and only from 40 to 60 meters, the brine occurs in the middle part of the Chiating formation. In summarizing the brine horizons in the Chuanpei salt area, 4 brine zones are established, namely, in descending order, that in the middle part of the Chiating formation, that in the

1 G. D. Louderback: op. cit.

lower part of the Chiating formation, and that in the upper part of the Tzuliuching formation, and that in the lower part of the Tzuliuching formation.

Quality of Brine and Salt

The brine is low in salinity and rather impure, and thus must be undertaken through filtration and concentration before boiled to make salt. The salinity here mentioned is represented by the amount of salt in the filtered and concentrated brine for a catty or in terms of Baume degrees. The brine contains from .4 to 2.2 ounces of salt per catty, i.e. from 2.7 to 13.6 per cent salt. In term of Baume degrees the original brine in different regions is from 5.75 to 13 and the concentrated brine from 11 to 20. The salt formed is also classified as grain salt and pan salt, and according to the fuel for salt making the gas, coal and firewood salts are distinguished by natives, the white grain salt is the best and the black pan salt is inferior.

Salt Mining and Salt Making

The wells are shallow and the salt plants are all in small scale. The drilling and bailing methods and tools are the same as those used in the areas above mentioned. The wells are from 40 to 460 meters deep, with the diameter from 7 to 10 centimeters. A large well may produce 60 piculs of brine per day, while a small one has an output of less than one picul.

Salt Industry

The salt industry in the Chungchiang region begun to be known since the Chin Dynasty; the Chienyang and Santai deposits are known to have been worked from the Han Dynasty; the remainder were started from the Tang Dynasty. The salt regions became prosperous in the Ming Dynasty, were well developed in the early part of the Ch'ing Dynasty, and continued to play a role in the Szechuan salt production to the present time. The wells now number more than 90,000 in total and the salt plants more than 5,000; in the Lochih region there are more than 30,000 wells, while in the Chienyang region the active wells are only 200 in number. The total salt production is about 3,000,000 piculs per year.

CHUANTUNG (EAST SZECHUAN) SALT DEPOSITS

Location

The salt deposits are situated in the eastern part of Szechuan and scattered in a large area (Pl. XI). Six salt regions are distinguished. The Chunghsien region is composed of two fields, the Yenching field being about 16 km. N of the Chunghsien city and the T'uching field about 40 km. NE of the city. The Wanhsien region is located in the vicinity of Changtanching about 50 km. S of Wanhsien city. The Yunyang region is near Yunanchen about 16 km. NW of Yunyang city. The Fengchieh region is situated about 3 km. E of the Fengchieh (Kueichow) city. The Taning region is located at 16 km. north of the Wuchi city, the brine is not bailed from wells but comes from a spring. The Kaihsien region is situated in the environs of Wentengching about 34 km. NE of the Kaihsien city.

Most of the salt regions in this area are situated in or near the Yangtze valley between Chungking and the Gorge region. The eastern margin of the great Szechuan basin is traversed by a series of foldings giving rise to mountains unlike the Chuanpei area of which the relief is very gentle. The Taning deposits occur already outside the Szechuan basin.

Geology

The writers had no chance to make personal observation on the salt regions in eastern Szechuan though they passed the Fengchieh region on steamer. However geological conditions of some regions are well known from the works by B. Willis[1] and E. C. Abendanon[2]. In the Fengchieh region the outcrops are very rare while on the hills outside the region the strata are exposed. On the west of the Fengchieh city the Jurassic coal series is wide-spread and in the Kueichow gorge east of the city the Permian limestone is fully developed. Between them there should be Triassic formations. According to E. C. Abendanon some red-brown sandstone and shale with the overlying limestone occur in the vicinity of the Fengchieh city, these are likely to be the salt-bearing beds of this region.

According to Abendanon the Yunyang region is composed of the Triassic, Jurassic and Cretaceous formations, the Cretaceous is represented by the Tzuliuching formation and the Triassic consists of limestone and calcareous shale in the upper and red-brown sandstone and shale in the lower part. The wells are situated in the red-brown beds.

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1 Bailey Willis: Research in China, Vol. I, pt. I, 1907.

2 E. C. Abendanon: La Geologie du Bassin Rouge de la Province du Se-Tchouan, 1906.

According to Willis[1] in the Taning region is well developed what he called the Wushan limestone which he assigned to the Carboniferous age. From the later research by C. Y. Hsieh and Y. T. Chao[2] in the Yangtze gorge region, the Wushan limestone is divided into Tayeh and Yanghsin limestones, the latter belonging to the Carboniferous and the former to the Permain. The brine spring is located in the Tayeh limestone. From the latest palæontological study[3], at least part of the Tayeh limestone is Triassic.

No direct information concerning the geological conditions of the Chunghsien, Wanhsien and Kaihsien regions is available. According to their position the Chunghsien and Wanhsien regions are adjacent to the central part of the Yangtze valley, which is formed of the Cretaceous formations, and may have the salt deposits in the Triassic beds as in the Yunyang region, while the Kaihsien salt deposits are situated in the low hilly region and may occur in the Cretaceous beds.

As regards the structural features most of the salt regions in this area are related to the syncline which lies in SWW and NEE direction from Fuling to Fengchieh, in the trough of which the Yangtze River runs, and which may be named the Yangtze syncline. The two limbs dip at various angles, ranging from more than 80° at farther localities from the trough to about 12° in the central part. This is a long narrow, and closed syncline. The Yunyang region is situated on the northern limb in the eastern part of the syncline. According to Abendanon[4] in the vicinity of the Yunyang city the Cretaceous beds dip to SSE at about 15°; between the city and Yunanchen where the salt deposits occur, the folds and faults affect not only the Cretaceous beds but also the Jurassic and Triassic formations; in the environs of the salt region the strata form an anticline, the southern limb is composed of the Triassic limestone and calcareous shale and the Jurassic coal series with steep inclination to south and somewhere overturned and the northern limb of the Triassic limestone, Jurassic coal series and Cretaceous beds with smaller dip angles. The wells are located

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1 B. Willis: op. cit. pp. 265-279.

2 C. Y. Hsieh and Y. T. Chao: Geology of I Chang, Hsing Shan, Tze Kuei and Patung Districts, W. Hupeh; Bull. Geol. Surv. China, No. 7, pp. 13-76, 1926.

3 C. C. Tien: Lower Triassic Cephalopoda of South China, Palæontologia Sinica Ser. B. Vol. XV, fasc. 1, p. 4, 1933.

4 E. C. Abendanon: op. cit. pp. 74-75.

on the Triassic red-brown sandstone which forms the axial part of the anticline.

The Fengchieh region is located at the eastern end of the syncline with the Triassic strata dipping generally to northwest. The Chunghsien region is situated on the northern limb in the western part of the syncline, the Cretaceous beds near the Chunghsien city dip generally to southeast, but it is not known whether the structural feature changes in the salt fields. The Wanhsien region is located on the southern limb in the middle part of the syncline, the Cretaceous beds along the Yangtze River north of the salt region dip generally to northwest.

The Taning region is situated on the northeast of the syncline and in the Wushan folded area. According to Willis[1] the anticlines and synclines were often found to occur between the Wushan city and the salt region where the folds are also developed, the brine spring is located near the axis of an anticline. The Kaihsien region is situated far north of the syncline and seems to be in the folded area.

Occurrence of Salt

In the Fengchieh region the wells are sunk in the Triassic red-brown sandstone and have the depth of about 10 m, the brine is thus contained in some sandstone of the Triassic formation. In the Yunyang region the wells are also located on the Triassic red-brown sandstone and 60 m deep, so that the brine occurs also in the Triassic sandstone. This may hold good for the brine of the Chunghsien and Wanhsien regions where the geological conditions are not exactly known. The brine in the Kaihsien region is said to come from the river bed and the source is unknown. The brine in the Taning region occurs in particular condition. According to Willis[2] the brine comes from the cavity in the Wushan limestone, i. e. in the Permian limestone, but in other parts of Szechuan the Permian system is not known to contain salt or brine. Most probably the cavity is found from the upper Wushan limestone which belongs to Early Triassic.

Quality of Brine and Salt

Whether it comes from wells or springs, the percentage of the brine is always low. According to salt records the brine contains from .19 to 1.638

1 B. Willis: op cit. p. 276.

ounces of salt in a catty, i.e., from 1.2 to 4.2 per cent salt in the Yunyang region; from .94 to 1.2 per cent salt in the Kaihsien region; and from 2.6 to 8 per cent salt in the Taning region. Only grain salt is produced. The coal salt and firewood salt are also distinguished according to the fuels used for salt making.

Salt Mining and Salt Making

The wells here are different from those in the areas mentioned above in that they are dug to form shafts large in diameter but shallow in depth. In the Chunghsien region the deeper wells are about 40 m deep and about one meter in diameter while the shallower ones are 10 to 20 m in depth and about 70 cm in diameter. On the well is placed a wooden derrick on which are hung two wooden tubs for bailing brine by hand. The brine is carried with wooden barrels to the salt plants.

In the Yunyang region the wells are about 60 m deep with the diameter of about one meter. Wooden derrick, bamboo rope and wooden tubs are used for bailing brine and the bamboo pipes for conveying it to salt plants.

In the Fengchieh region the wells are about 10 m deep and form large shafts, carriers are used to bail and convey the brine with wooden barrels from the well to salt plant.

In the Wanhsien region only one well is productive. Wooden tubs are used for bailing brine and bamboo pipes for conveying.

In the Kaihsien region the brine comes from the river bed and is led through ditches into the shafts dug on the river side. It is then pumped up to salt plants and there disposed through concentration and filtration for making salt. In all the above regions, coal is used for fuel.

In the Taning region the brine comes from the spring and stored in a pool which is called "Lungchih" (Dragon Pool) by natives. In front of the pool is placed an iron plate on which are pierced 68 holes for leading the brine through pipes into salt plants. The fuel is coal or wood.

Salt Industry

According to historical records the Chunghsien region is known to have been worked in the Han Dynasty, the Wanhsien region in the Chin Dynasty, the Fengchieh region in the Sui Dynasty, and the Yunyang, Taning and Kaihsien regions in the T'ang Dynasty. In the Chunghsien region there are now two large wells and 17 small wells, and 32 salt plants. The salt is sold at the price of 6.3-7.2 dollars per picul, the transportation fee is about a dollars for 60 km. per picul.

The only well of Wanhsien region supplies 7 salt plants. The salt price is 9.5 dollars per picul and the transportation costs 50 cents per picul from salt plants ot consumption markets.

In the Yunyang region there were 33 wells and 67 salt plants, but now only 9 wells are productive. The salt price is 4.4 dollars per picul. Transportation for 60 km. costs about 1.2 dollars per 80 catties.

In the Fengchieh region there were 4 wells and 220 pans for making salt, but now two wells are active and the pans number much less. The price of salt is 5.3 dollars per picul. The transportation cost is about 1.4 dollars per picul for 60 km.

In the Taning region, 94 salt plants are active. The price of salt is different according to the fuel used, the coal salt at 3.9-4.5 per picul while the fire-wood salt at 7-7.6 dollars.

In the Kaihsien region there were 19 wells and about 90 salt plants, but now only 4 wells and 42 salt plants are productive. The salt is sold at 6.3 dollars per picul. The transportation costs about a dollar per picul for 60 km. but about 30 cents by boat.

The yearly production of salt in piculs in this area is given in the following table:

Year	Chunghsien Region	Wanhsien Region	Yunyang Region	Fengchieh Region	Taning Region	Kaihsien Region
1925	4,189.50	176.80	280,972.80	30,547.60	147,685.82	29,810.24
1926	4,262.10	383.20	274,057.60	26,941.30	114,291.09	22,995.90
1927	4,222.10	386.80	277,058.40	25,986.18	92,814.00	24,438.70
1928	5,074.30	388.40	307,114.40	25,827.50	18,136.10	29,208.20
1929	4,594.70	293.80	287,048.00	23,432.50	58,590.30	28,426.40
1930	4,937.90	118.00	302,561.60	31,903.10	109,893.60	29,918.75

TATSU SALT DEPOSITS

This area is situated in the southwestern part of the Tatsu district, (Pl. XI), salt being produced at Lungshuichen, Wangchiachang, Shuanghoching and Yungchuanching. It is composed of low hills of the same type as those in the southern part of the Szechuan basin. A tributary of the To River passes through the area and forms the main drainage. The surface stratigraphy is about the same as in the environs of Tatsu and Jungchang where the red-purple clay and yellow-gray sandstone of the Tzuliuching formation are well developed. The wells are not deep enough to reach the lower part of the Jurassic coal series and may be confined in the Tzuliuching formation or the upper part of the Jurassic coal series.

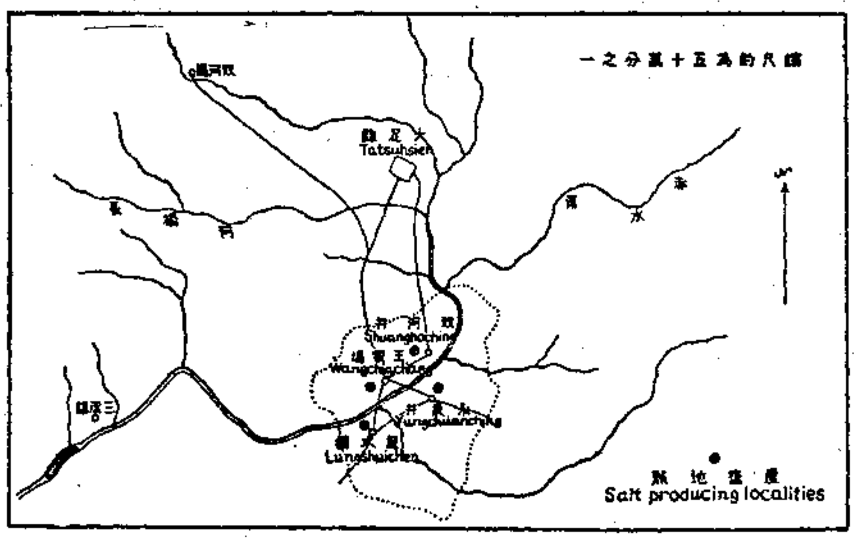

Fig. 3. Sketch map of the Tatsu Salt Region in Szechuan

According to salt records there were more than 350 wells and 37 salt plants. The commencement of the salt region is not recorded but 9 wells are known to have been worked in the Ch'ing Dynasty. The salt industry became prosperous to the present time and the production was 1,745 piculs in 1927, 1,615 in 1928, 1,305 in 1929 and 984 in 1930.

PENGSHUI SALT DEPOSITS

This area is situated in the environs of Yüshanchen northeast of Pengshui district (Pl. XI), salt being produced at Houchingchieh, Chungchingchieh and Laochingchieh. There are 6 wells and 54 salt plants. The brine contains .3-.39 ounces of salt per catty, i. e. 2-2.6 per cent salt.

The deposits are known since the T'ang Dynasty. The salt industry is now relatively small.

Year	Sale production in piculs	Year	Salt production in piculs
1925	36,573	1928	33,952
1926	35,955	1929	32,301
1927	32,421	1930	22,153

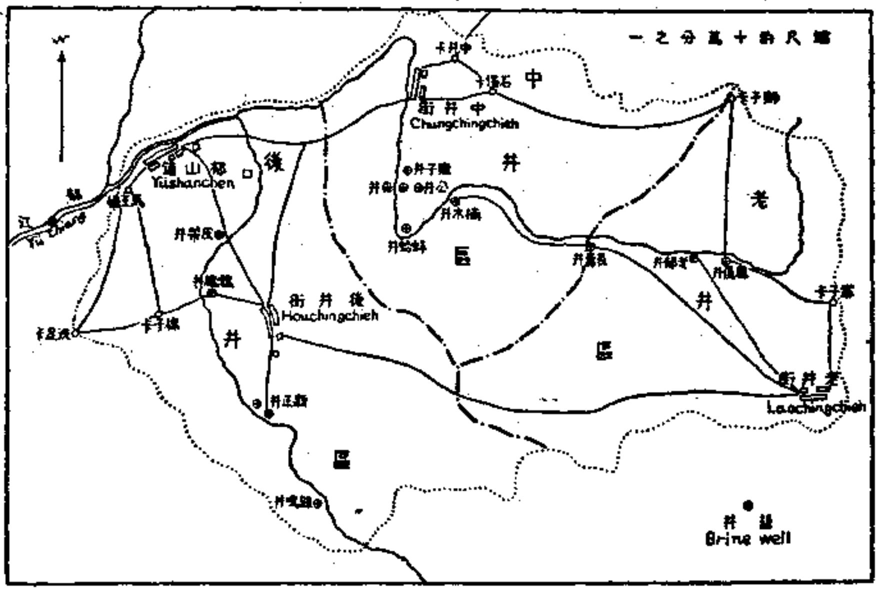

Fig. 4. Sketch map of the Pengshui Salt Region in Szechuan

YENYÜAN SALT DEPOSITS

This salt area is situated in the western part of the Yenyüan district in southwestern Szechuan and near the boundary between Szechuan and Yunnan. Two fields are included, one named Paiyenching about 22 km. W of the Yenyüan city and the other Heiyenching about 110 km. W to the city (Pl. XI). As to the geological conditions are unknown, it may be assumed that the deposits are closely related to the salt deposits in the adjacent regions in Yunnan[1]. There are 5 wells in the Paiyenching field, the deepest of which is 12 m with the size of 2.5 m × .7 m. The salinity varies from 1.5 to 6 per cent salt for Paiyenching brine and about 7 per cent for Heiyenching brine.

1 Geology of Salt deposits in Yunnan to which the Yenyuan deposits are closely related has been described of Coggin Brown as consisting of Permo-Triassic red beds from which the salt worked by underground mining.

According to historical records the salt deposits have been worked since the Han Dynasty and the industry became more prosperous from the late Ch'ing times. There are now 94 salt plants. The pans are bell shaped, from 40 cm to 1.2 m high and from 15 cm to 50 cm in diameter. The salt produced is named "hat-like salt" and sold at 8.5-9.5 dollars per picul. The transportation for 60 km costs about 1.5 dollars per picul. The yearly production is as follows:

Year	Salt production in piculs	Year	Salt production in piculs
1925	29,868	1928	38,475
1926	37,780	1929	35,813
1927	40,212	1930	37,055

Origin of the Salt Deposits in Szechuan[1]

The salt in Szechuan occurs in form of brine and rock salt, the former is wide in both geological and geographical distribution whereas the latter is only known at Tafenpao in the Tzuliuching-Kungching region, within an area of about .64 sq. km.

The origin of the rock salt are usually explained by (1) Bar theory, (2) Desiccation theory, or (3) Leaching-Supersaturation theory, but the last named is not generally accepted. Now we shall try to see which theory can be best applied to the salt deposits in Szechuan. The conditions under which the rock salt occurs are summarized for reference as follows:

(1) The rock salt occurs at Tafenfao in the lower part of the Triassic limestone, the succession is continuous without disconformity in the limestone.

1 Szechuan has been visited by several other geologists of the Survey although they had not chance to make observations on the salt occurrence so detailed as the authors of this paper. The latters' view on the origin of the salt is however not shared by majority of their colleagues. I for one believe that salt was originally contained in the Triassic at least. And nothing makes it impossible that the salt depositing condition reoccurred in more than one periods during the Mesozoic era. The meteoric water entered in the Triassic and Jurassic formations does not necessarily come through the overlying creteceous strata. That the salt is found in solid state in one place and in solution in another is due more to later condition of ground water than to the original condition of deposition. The paper is here published for the important facts which the authors have well observed and correlated. W. H. Wong.

(2) The dimensions of the rock salt are irregular and small and the total thickness varying from 2 to 5 m, outside this small area no rock salt has been encountered.

(3) The fresh water is poured from some well into underground for dissolving the rock salt, the brine thus artificially formed is bailed up again; it is said that the water poured down from one well can be bailed up from others.

(4) According to well owners the quantity of the salt produced from rock-salt brine is quite large, but it is not exhausted and the salinity of that brine does not decrease.

(5) In the Triassic limestone exposed in the region adjacent to the salt areas has never found any trace of rock salt, the formation contains mostly limestone with some marly limestone in the upper part and some calcareous shale in the lower part, which are all deep-water deposits.

When the above stated facts are taken into consideration it seems that the origin of rock salt can not be easily explained by the bar theory or desiccation theory. It seems difficult to understand the rock of such small dimensions could be formed in wide-spread marshes or lagoons or lakes in which the Triassic limestone would have been deposited. Although the leaching supersaturation is not generally accepted, the origin of the rock salt in the Tzuliuching-Kungching region may be better explained by this theory. It is thought that the rock salt was derived from the brine of the horizons which acquired increased salinity by dissolution of the salt content of the successive strata which it traversed in sinking, until reaching the supersaturated condition. At the same time there were some cavities or irregular hollows in the Triassic limestone, in which the salt was precipitated gradually to form the rock salt as now worked by artificial dissolution at Tafenpao. The localization of the Tafenpao rock salt may be explained by local occurrence of the small and irregular structure in the Triassic limestone. This is however a pure hypothesis which needs confirmation by more facts than are now available to us.

As to the question whether the brine water is of meteoric origin or connate origin, facts seem to disprove the hypothesis that the saline water is originally enclosed in the formations here concerned. The most saline brine is bailed from the limestone which does not show much porosity to hold such amount of saline water during deposition. The Jurassic coal series in which the brine occurs is of continental origin and the climate under which the coal was formed must be humid, thus it is questionable whether the saline water could occur, under such condition, in large amount to form the source of the brine which is now being worked. The lateral distribution of brines does not show their uniform presence in different formations. In many places the water which was taken up from underground at coal mines or came out from some springs in the limestone regions has never been known to be saline.

If the meteoric origin is accepted, it must be believed that the meteoric water has in passing downward through the strata dissolved out of the rock the salt which it now holds in solution. There are also some facts which are contrary to this hypothesis. The association of the dry sands with the brine bearing beds indicates that the brine has not passed through the sands downward from the surface. There are no adequate explanations of how the brine has been removed through the strata and migrated to such depths as indicated by deep brine wells.

A study of the occurrence of the brines in the Szechuan basin furnishes the data which suggest another hypothesis for explaining the origin of brine, the data are summarized in the following lines:

(1) Almost all the salt regions are situated in the area where the Cretaceous formations are well developed except some regions in eastern Szechuan, and perhaps also in Yenyüan area where the brine wells are directly sunk in the Triassic sandstone.

(2) The brines do not occur at distinct horizons but in wide zones which have also no sharp demarcation, and are likely to occur in continual succession.

(3) The depths of the brine zones probably depend upon the position of the wells on the surface; if the well is located higher in position, the horizon at which the brine occurs is also higher.

(4) The salinity of the brines increases with the depths of wells and brines, except where the gas wells are most productive and deep enough to reach the Triassic sandstone waters, while the brines in the Jurassic coal series and the Triassic limestone were derived from the underground saline water in the Cretaceous beds after sinking and concentration. But the brine in the Triassic sandstone contains only 3-4% salt and can not be regarded as the source of the brines in the Triassic limestone and the Jurassic coal series, which have

much higher salinity. The rock salt which occurs in such small dimensions as repeatedly mentioned above can also not be the source from which the salt was diffused to form the wide-spread brines. The Cretaceous less saline brine is perhaps the only source of the deeper ones.