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Original Article

Geology of the Primary Selenium Deposits in Mainland China

Jian Zhao Yin [1,2,3] Ⓛ

Abstract

Selenium deposits in mainland China are distributed across various tectonic units, including the North China Platform, Yangtze Platform, South China Geosyncline, Qinghai-Tibet Plateau, Tarim Terrane, and Tianshan and Qilianshan tectonic belts. These deposits exhibit a diverse geological background, with varying genetic types and geochemical properties. China's selenium deposits include both independent and associated/symbiotic deposits. They are classified into sedimentary, magmatic, skarn, hydrothermal, and volcanic types. Selenium deposits in the Yangtze Platform are mostly sedimentary, while those in the North China Platform are primarily hydrothermal and sedimentary. In the South China Geosyncline, selenium deposits are closely linked to igneous rocks, with hydrothermal and volcanic types dominating. The Qinghai-Tibet Plateau contains mainly hydrothermal and sedimentary selenium deposits. Other regions, such as the Tianshan tectonic belt, Tarim terrane, and Qilian Mountain tectonic belt, feature hydrothermal and sedimentary deposits. Selenium deposits have formed at varying rates throughout geological history, with the highest output occurring during the Mesozoic era. These deposits contain diverse metallogenic series, and selenium is often found alongside organic matter, sulfides, and various metal elements. Selenium content varies significantly across deposits.

Key words: Geology; primary selenium deposit; genetic type; temporal and spatial distribution; metallogenic series; mainland China

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1. Introduction

Semi-metallic selenium (Se) is a rare element considered critical by many countries. Though sharing similar chemical properties with sulfur, selenium's abundance in the Earth's crust is low, making independent selenium deposits scarce. Selenium has widespread applications in metallurgy, glass, ceramics, electronics, solar energy, chemicals, agriculture, feed, nutritional food, medicine, and other emerging industries[1-4]. As an essential trace element for humans, selenium plays a vital role in anti-oxidation, immunity enhancement, thyroid hormone regulation, detoxification, and cancer prevention. However, both selenium deficiency and excess can cause health issues, with 72% of China's land area being generally selenium-deficient.

Russia, Peru, and the United States possess the world's largest selenium reserves, accounting for 24.7%, 16.0%, and 12.3%, respectively, in 2022. China's selenium reserves have declined over time, with 15,600 tons in 2007, reducing to 6,051.8 tons in 2020 and 3,362.1 tons in 2021, before increasing to 6,000 tons in 2022[1-3].

Although China is the world's largest producer of selenium mineral products, with 1,260 and 1,300 tons in 2021 and 2022, respectively, its domestic market demand for selenium products is strong. Consequently, the output cannot meet domestic consumption demands, resulting in a significant supply-demand gap, ranging from 669 to 1,749 tons in the past decade[3-6].

This paper aims to provide a comprehensive overview of primary selenium deposits in mainland China, focusing on their geological and geochemical characteristics, genetic types, spatial and temporal distribution, and metallogenic series. By sharing this information, we hope to encourage international collaboration, analysis, and research on selenium deposits, ultimately benefitting human society through the discovery of additional selenium resources worldwide.

2. Distribution

China has researched associated and symbiotic selenium deposits within non-ferrous metal deposits since the 1950s. Selenium-containing metal deposits have been discovered in several provinces, including Hubei, Guizhou, Gansu, and Sichuan. Further associated and symbiotic selenium deposits were found in additional provinces, municipalities, and autonomous regions. Notably, independent selenium deposits, which are rare globally, were also uncovered.

Selenium deposits in mainland China are distributed across over 90 production sites in 24 provinces and autonomous regions, including Heilongjiang, Jilin, Liaoning, Inner Mongolia, Xinjiang, Gansu, Qinghai, Shaanxi, Shanxi, Hebei, Shandong, Jiangsu, Anhui, Hubei, Jiangxi, Hunan, Zhejiang, Guizhou, Sichuan, Yunnan, Guangdong, Guangxi, and Fujian.

The distribution of selenium deposits across these regions is not uniform, with concentrations in Gansu (5,831 tons), Xinjiang (2,443 tons), and Jiangxi (2,124 tons). These three provinces combined account for 57% of China's selenium reserves (Figure 1)[2-3].

While these spatial and administrative divisions provide an overview of selenium deposits, it's important to note that they are largely artificial and don't necessarily align with the geological structural units that influence the distribution of selenium deposits.

Geologically, selenium deposits in mainland China are primarily found in the margins of the North China and Yangtze Platforms, the South China Geosyncline, the Qinghai-Tibet Plateau, the Tarim Terrane, and the Tianshan and Qilianshan tectonic belts. Each of these geological structural units has unique characteristics that influence the geological, geochemical, and genetic types of selenium deposits within them, which will be discussed further in the subsequent sections.

Figure 1. Distribution of selenium deposits in mainland China (modified after Wang et al.[3])

3. Type and geology

In mainland China, most selenium deposits are associated and/or symbiotic, with the exception of the Yutangba independent sedimentary deposit in Enshi, Hubei Province. Various genetic classifications have been proposed for these deposits based on factors like industry, formation, and genesis[7-11]. Wang et al. classified Chinese selenium deposits into eight genetic types, with epithermal, skarn, and marine volcanic rock types being the most common. Other types include magmatic hydrothermal, magma detachment, porphyry, and chemical/biochemical sedimentary, and continental volcanic rock types[3,7-11].

Chinese associated/symbiotic selenium deposits consist mainly of skarn copper deposits in the Yangtze River's middle and lower reaches, magmatic copper-nickel sulfide deposits in the northwest, and sedimentary selenium deposits in Hubei and Hunan Provinces. The Yutangba deposit in Enshi, Hubei, has the highest average selenium content globally, with concentrations ranging from 0.0047% to 0.035%.

The distribution of these deposits varies across tectonic units. In the North China Platform, spanning Shanxi, Hebei, and the Inner Mongolia Autonomous Region, selenium deposits are primarily hydrothermal and sedimentary, influenced by the platform's geological history and conditions. Selenium in hydrothermal deposits is often associated with metal sulfides like copper, gold, lead, and zinc, while in sedimentary deposits, it is linked to coal-bearing strata and black shales. Selenium content varies widely, ranging from tens to hundreds of ppm.

Wang et al.[3], based on the occurrence, ore-bearing host rocks, and genesis of 92 selenium deposits in mainland China, combined with previous classification schemes and the main mineralization processes (e.g., magmatic activity, ore-bearing fluids, sedimentation), categorized China's selenium deposits into eight genetic types. Statistical analysis reveals that epithermal, skarn, and marine volcanic rock types are the predominant genetic types of selenium deposits in mainland China. Other genetic types, based on the proportion of deposits, include magmatic hydrothermal, magma detachment, porphyry, chemical/biochemical sedimentary, and continental volcanic rock types.

China's associated and/or symbiotic selenium deposits are primarily found in skarn copper deposits in the middle and lower reaches of the Yangtze River, magmatic copper-nickel sulfide deposits in the northwest, and sedimentary selenium deposits in Hubei and Hunan Provinces[2-5,10-15].

The Yutangba independent selenium deposit, located in Enshi City, Hubei Province, contains selenium concentrations ranging from 0.0047% to 0.035%, with localized highs of 0.112% to 0.54% and an average of 0.0084%. This average is 1,628 times the Earth's Clarke value for selenium[4,16-19], making Yutangba the region with the highest average selenium content in the world.

The distribution of associated and/or symbiotic selenium deposits varies across different tectonic units. A brief overview is provided below:

3.1 The North China Platform

This region, encompassing parts of Shanxi and Hebei Provinces, and the Inner Mongolia Autonomous Region, primarily hosts hydrothermal and sedimentary selenium deposits. This distribution reflects the platform's geological evolution and conditions. In hydrothermal deposits, selenium is often associated with metal sulfides such as copper, gold, lead, and zinc. In sedimentary deposits, selenium is closely linked to coal-bearing strata and black shales. Selenium concentrations in these ores vary significantly, ranging from tens to hundreds of ppm.

3.2 The Yangtze Platform

Located in southern China, this platform is a key area for selenium deposits, particularly in Hubei, Hunan, and Guizhou Provinces. The selenium deposits here are predominantly sedimentary and are closely associated with black shales, phosphorite and carbonate rocks. Selenium in these deposits is often found alongside organic matter and sulfides (e.g., pyrite), with selenium-rich layers containing concentrations of up to hundreds of ppm. Other associated elements include uranium, vanadium, and molybdenum.

3.3 The South China Geosyncline

The selenium deposits in the South China Geosyncline are primarily distributed in Jiangxi, Fujian, and Guangdong provinces in mainland China. Depending on the geological conditions of the geotectonic unit, the deposit types are mainly hydrothermal and volcanic. In hydrothermal selenium deposits, selenium is often associated with metal sulfides such as copper, gold, and silver. In volcanic deposits, selenium is naturally linked to volcanic and sub-volcanic rocks, with selenium content typically reaching hundreds of ppm.

3.4 The Qinghai-Tibet Plateau

In the Qinghai-Tibet Plateau, known selenium deposits are mainly distributed in the Tibet Autonomous Region, Qinghai Province, and some adjacent provinces. The deposit types identified so far are predominantly hydrothermal and sedimentary. In hydrothermal deposits, selenium coexists with metal sulfides such as copper, lead, and zinc. In sedimentary deposits, selenium is associated with lake sediments and evaporates. The selenium content in these ores varies significantly, ranging from tens to hundreds of ppm.

3.5 The Tarim Terrane, Tianshan and Qilianshan tectonic belts

In the Tarim Terrane, Tianshan, and Qilianshan Tectonic Belts, selenium deposits are primarily hydrothermal and sedimentary. In hydrothermal deposits, selenium is mainly associated with metal sulfides such as copper, lead, and zinc. In sedimentary deposits, selenium is linked to coal-bearing strata and black shales. The selenium content in these deposits is usually high, often reaching hundreds of ppm.

4. Geochemistry and mineralogy

Selenium has a Clarke value of 0.05 × 10-6 in the Earth's crust and typically exists in a dispersed state, making it difficult to form independent deposits[10,13-14]. More than 90% of China's selenium resources are found in associated selenium deposits, with selenium being recovered as a by-product. Selenium shares properties and characteristics with elements such as sulfur and tellurium, often forming isomorphisms or micro-grained inclusions in metal sulfides[10,13-14, 20-23].

Selenium has similar properties and characteristics to elements such as sulfur and tellurium in crystallography and geochemistry, and they are easy to form isomorphisms with each other.

Selenium exists in two main forms in metal sulfides, isomorphism, and/or micro-grained selenium mineral inclusions[1-5]. There are two categories of selenium deposits: independent and associated/symbiotic. The Yutangba deposit in Enshi, Hubei, is China's only known independent sedimentary selenium deposit. Associated/symbiotic selenium deposits are more common, primarily found in porphyry copper and copper-molybdenum deposits.

5. Time and space

5.1 Metallogenic age

According to Wang et al.'s analysis of 68 Chinese selenium deposits, selenium mineralization occurred throughout geological history, with peaks during the Proterozoic, Early Paleozoic, Late Paleozoic, Mesozoic, and Cenozoic eras. The Mesozoic saw the most selenium deposit formation, followed by the Late Paleozoic and Early Paleozoic (Figure [2])[3]. The Permian, Jurassic, and Cretaceous periods were peak selenium mineralization periods, with the Sinian, Ordovician, Silurian, and Triassic periods also contributing significantly.

The age of selenium mineralization is primarily determined by the age of selenium-bearing strata and the formation time of associated/symbiotic selenium ores. Selenium deposits exhibit a correlation between mineralization timing and spatial distribution.

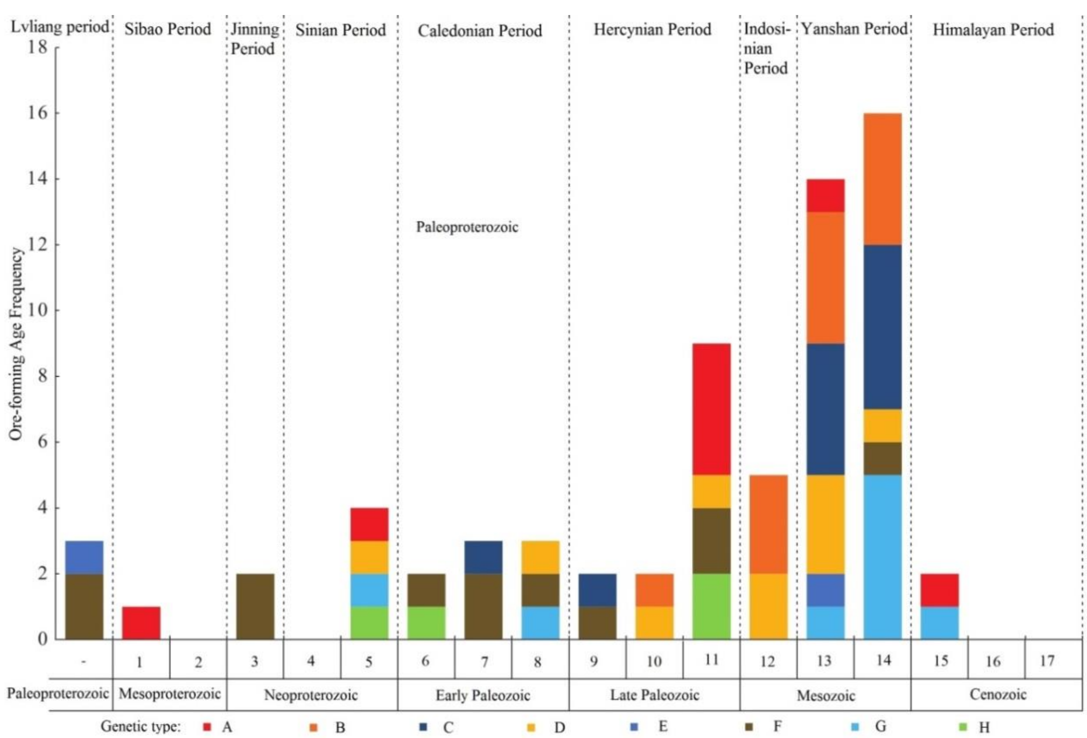

Figure 2. Genetic types and formation ages of selenium deposits in mainland China (modified after Wang et al.[3])

1. Changcheng Period; 2. Jixian Period; 3. Qingbaikou Period; 4. Nanhua Period; 5. Sinian Period; 6. Cambrian; 7. Ordovician; 8. Silurian; 9. Devonian; 10. Carboniferous; 11. Permian; 12. Triassic; 13. Jurassic; 14. Cretaceous; 15. Paleogene; 16. Neogene; 17. Quaternary. A. Magma melting separation; B. Skarn; C. Porphyry; D. Magmatic hydrothermal; E. Continental volcanic; F. marine volcanic; G. Epithermal; H. Chemical and biochemical deposition

5.2 Spatiotemporal connection

Selenium deposits in mainland China exhibit distinct spatial and temporal distribution patterns across different mineralization periods, reflecting a correlation between the timing of selenium mineralization and its geographic occurrence. The key characteristics are summarized below:

- **Proterozoic deposit**
  - **Distribution:** Primarily concentrated in the North China Platform and Yangtze Platform.
  - **Deposit types:** Magmatic, hydrothermal, and sedimentary.
- **Early Paleozoic (Cambrian) deposit**
  - **Distribution:** Focused in the Yangtze Platform, Altyn-Qilian Orogenic Belt, and Yili Plate.
  - **Deposit types:** Predominantly sedimentary and hydrothermal.
- **Late Paleozoic deposit**
  - **Distribution:** Widely scattered across the Yili Terrane, Yangtze Platform, Altyn-Qilian Orogenic Belt, North China Platform, Bayan Har-Songpan Orogenic Belt, Greater Khingan Range, and Junggar Area.
  - **Deposit type:** Magmatic, sedimentary and hydrothermal.
- **Mesozoic (Yanshanian Period) deposits**
  - **Distribution:** Broadly distributed along the western edge of the Qinling-Dabie Orogenic Belt, margins of the North China Platform and Yangtze Platform, and the Karakoram-Sanjiang Orogenic Belt.
  - **Deposit type:** Skarn and hydrothermal.
- **Cenozoic (Himalayan Period) deposits**
  - **Distribution:** Mainly localized in the Karakoram-Sanjiang Orogenic Belt and the margins of the Yangtze Platform.
  - **Deposit type:** Hydrothermal and magmatic.

5.3 Type and spatiotemporal distribution

Associated/symbiotic selenium deposits associated with other mineralization processes exhibit distinct temporal-spatial patterns:

- **Magmatic deposit**: Copper-nickel sulfide-associated selenium deposits span multiple eras:
  - **Meso-Neoproterozoic:** e.g., Pingshui copper deposit formed in the Qingbaikou Period in Zhejiang Province.
  - **Late Paleozoic to Early Mesozoic:** e.g., Xiaonanshan nickel-copper polymetallic deposit (Inner Mongolia, Middle Permian); Heishan copper-nickel deposit (Gansu, Late Devonian); Huayangchuan uranium polymetallic deposit (Shaanxi, Late Devonian).
  - **Cenozoic:** e.g., Baimazhai nickel deposit formed in Himalayan Period in Yunnan Province.
- **Porphyry deposit**: Span from the Paleoproterozoic to Cenozoic:

   - **Paleoproterozoic:** e.g., Tongkuangyu copper-molybdenum deposit in Shanxi Province.
   - **Early Paleozoic:** e.g., Duobaoshan copper-molybdenum deposit formed in Ordovician in Heilongjiang Province.
   - **Mesozoic:** e.g., Ulugtushan copper-molybdenum deposit formed in Early Yanshanian Period in Inner Mongolia.
   - **Cenozoic:** e.g., Marathon porphyry copper deposit formed in Himalayan Period in Tibet.
- **Hydrothermal deposit**: These deposits are predominantly linked to hydrothermal iron, copper, and lead-zinc systems, with formation ages spanning multiple geological epochs:
   - **Proterozoic:** e.g., Xiagaoyue lead-zinc deposit formed in Xuefeng Period in Guizhou Province; Paleoproterozoic Laoyu Dongliushui copper deposit in Shaanxi Province.
   - **Paleozoic:** e.g., Caihuagou tungsten-copper-pyrite deposit formed in early Devonian in Xinjiang.
   - **Mesozoic:** e.g., Luqu Laerma gold deposit formed in Yanshanian Period in Gansu.
   - **Cenozoic:** e.g., Wengzi silver-lead-zinc deposit formed in Himalayan Period in Yunnan.
- **Skarn deposit**: These selenium deposits are primarily associated with skarn-type copper mineralization, with ages concentrated in the Mesozoic (Yanshanian Period).
   - **Mesozoic:** e.g., Shizishan copper deposit formed in Yanshanian Period in Anhui Province.
- **Sedimentary deposit**: Sedimentary selenium deposits in mainland China include two categories: Associated/symbiotic selenium polymetallic deposits, and independent selenium deposits (rare, hosted in specific sedimentary sequences):
   - **Neoproterozoic:** e.g., Baiguoyuan silver-vanadium deposit formed in the early Sinian in Hubei Province.
   - **Early Paleozoic:** e.g., Ganziping-Wangjiazhai selenium polymetallic deposit formed in Cambrian in Tianmenshan, Hunan Province.
   - **Late Mesozoic:** This kind of deposit formed in the organic-rich siliceous rocks interbedded with high-carbon mudstone and shale, forming layered or lenticular deposits. e.g., Shuanghe selenium deposit formed in Permian in Hubei Province.

6. Discussion

Elements exhibit uneven crustal distribution due to their distinct geochemical properties, resulting in geochemical anomalies and/or zoning. Selenium follows this pattern. Selenium's crustal distribution is highly heterogeneous, with localized anomalies reflecting enrichment in specific tectonic and lithological settings. This zoning provides a critical framework for understanding selenium resource potential and targeting exploration efforts.

6.1 Selenium metallogenic belt

Selenium deposits in mainland China are predominantly distributed along the margins of the North China Platform, Yangtze Platform, Qinghai-Tibet Plateau, South China Geosyncline, Tarim Terrane, Tianshan Mountains, and Qilian Mountains tectonic belts. Based on associated/symbiotic mineral types, spatiotemporal distribution, geological settings, and regional metallogenic factors, researchers have categorized these deposits into 24 metallogenic belts[2-3,10-20].

- **Magmatic selenium metallogenic belt:** These occur along the margins of the North China and Yangtze Platforms, as well as the Altun-Qilian orogenic belt. Key belts include the western section of the North China Platform's northern margin, East Liaoning, South Qilian, Alxa, Xiaoqinling-Xiong'er Mountain, Wugong Mountain-Hangzhou Bay, and Ailao Mountain.
- **Porphyry metallogenic belt:** Distributed across the Greater Khingan Range, Karakoram-Sanjiang, North China, Yangtze, and Qinling-Dabie geological units. Notable examples include the Hailar, East Ujimchin Banner-Nenjiang, Lesser Qinling-Xiong'er Mountain, Qamdo, and Wugong Mountain-Hangzhou Bay belts.
- **Hydrothermal selenium metallogenic belt:** Widely dispersed across major tectonic units in China, including the North China Platform, Yangtze Platform, Greater Khingan Range, Bayan Har-Songpan, Altun-Qilian, South China Geosyncline, Karakoram-Sanjiang, Qinling-Dabie Mountains, Yili, and Junggar regions. Specific belts include: Wutai-Taihang, Xiaoqinling-Xiong'er Mountain, Junggar, Yili, East Ujimqin Banner-Nenjiang, North Qilian, West Qinling, Bayan Har, Yidun-Shangri-La, Middle and eastern Upper Yangtze, Western Jiangnan Paleoland, Middle-lower Yangtze River, Eastern Jiangnan Uplift, Wugongshan-Hangzhou Bay, Changning-Lancang, Yunnan-Guizhou-Guangxi, and Nanling.
- **Skarn-type metallogenic belt:** Predominantly associated with the Qinling-Dabie orogenic belt, the North China and Yangtze Platforms, and the South China geosyncline belt, and other tectonic units. Specific belts include: West Qinling Mountains, Xiaoqinling-Xiong'er Mountains, Middle-lower Yangtze River, Eastern Jiangnan Uplift, Wugong Mountain-Hangzhou Bay, and Nanling selenium mineralization belt.
- **Sedimentary metallogenic belt:** Mainly found in the Yangtze Platform, including the middle and eastern part of the Upper Yangtze and the western section of the Jiangnan paleo-land selenium metallogenic belt.

6.2 Selenium metallogenic series

Researchers have categorized known selenium deposits in mainland China into over 30 metallogenic series, establishing a comprehensive metallogenic spectrum for these deposits[2-4,7,10-11]. Building on prior studies, the author of this paper proposes the following classification of selenium metallogenic series:

• **Se-Fe-Cu-Pb-Zn metallogenic series:** mainly found in the East Wuzhumuqin Banner-Nenjiang area of the Greater Khingan Range in Northeast China. The development of this metallogenic series is related to the basic-intermediate-acidic magmatic activity of the Ordovician in the Hercynian period.

• **Se-Fe-Cu-W metallogenic series:** found in the Hailar area of the Greater Khingan Range in China, a metallogenic series related to the intermediate and acidic magmatic intrusions of the early Yanshan period.

• **Se-Cu-Ni-Co-Pt metallogenic series:** developed in the Hercynian basic-ultramafic intrusive bodies in east Liaoning, China.

• **Se-Au (Ag) metallogenic series:** spatially distributed in the northern margin of the North China Platform and the Northeast China in northern China, and the Xiaoqinling-Xiong'ershan area in the central region, i.e. the southern margin of the North China Platform.
• **Se-Fe-Cu-Mo-Au metallogenic series:** mainly developed in the southern margin of the North China Platform, and is a metallogenic series related to the shallow-ultra-shallow intrusions of the Indosinian and Yanshanian periods.
• **Se-Fe-Cu-Ni-Au-Ag-Pt metallogenic series:** developed in the Hercynian mafic-ultramafic magmatic intrusions at the southern margin and the western end of the northern margin of the North China Platform.
• **Se-Cu-Mn-P-V metallogenic series:** developed in the Junggar area, mainly in Xinjiang and other provinces in northwest China, and is a metallogenic series related to late Paleozoic sedimentation.
• **Se-Cu-Ni-Au-Fe-Mn-Pb-Zn metallogenic series:** developed in the Early Devonian (Caledonian) intermediate-basic and intermediate-acidic magmatic rocks in the Yili area of Xinjiang, northwest China.
• **Se-Cu-Ni-Au-Pb-Zn-Fe metallogenic series:** developed in the Altun-Qilian Mountains in northwest China, and is a metallogenic series related to Paleozoic submarine volcanic eruption sedimentation.
• **Se-Cu-Co-Zn-Au metallogenic series:** developed in the Qinling-Dabie Mountains in central China, and is a metallogenic series related to the deep-source magmatic intrusion of the Indosinian and Yanshanian periods.
• **Se-Au-Cu-Mo-W-Sn-Pb-Zn-Ag metallogenic series:** concentrated in Wugongshan and Yushan in Jiangxi, the middle and lower reaches of the Yangtze River, Yunnan-Sichuan-Guizhou and the eastern section of the Jiangnan uplift, and is a metallogenic series related to the acidic-acidic magmatic intrusion-eruption activities in the Yanshanian period.
• **Se-Cu (Au) metallogenic series:** concentrated in the middle and lower reaches of the Yangtze River and the Yunnan-Sichuan-Guizhou region in southern China, dominated by skarn-type copper deposits.
• **Se-Pb-Zn-Mn metallogenic series:** concentrated in the Yunnan-Guizhou-Sichuan area, and is a metallogenic series related to the Early Paleozoic carbonate formation.
• **Se-Pb-Zn-Fe-Mn metallogenic series:** concentrated in the central and eastern Yunnan-Guizhou-Sichuan area, and is a metallogenic series related to the Early Paleozoic-Permian marine-continental transitional carbonate and clastic rock formation.
• **Se-Pb-Zn-Fe-Mn metallogenic series:** concentrated in the central and eastern Yunnan-Guizhou-Sichuan area, it is a metallogenic series related to the carbonate and clastic formations of the early Paleozoic-Permian marine-continental transition phase.
• **Se-Cu-Fe-Nb-Ta metallogenic series:** developed in Jiangxi and northeastern Zhejiang, it is a metallogenic series related to the Cambrian carbonaceous siliceous mudstone.
• **Se-Cu-Au-Fe-Zn metallogenic series:** developed in the middle and lower reaches of the Yangtze River, a metallogenic series related to the development stage of the continental margin of the Caledonian cycle.
• **Se-Au-Sb-Hg-Ag-Mn metallogenic series:** mainly developed in Yunnan, Guizhou and Sichuan, a metallogenic series related to the Indosinian and Yanshanian intermediate-light acidic granites.
• **Se-Pb-Zn-W-Mo-Cu metallogenic series:** developed in the Nanling area of China, a metallogenic series related to the Yanshanian shallow-ultra-light granodiorites.

• **Se-Cu-Zn-Co metallogenic series:** developed in the Bayan Har-Songpan area of China, a metallogenic series related to the Hercynian Animaqing ophiolite formation.
• **Se-Pb-Zn-Au-Cu metallogenic series:** developed in the Yidun and Shangri-La areas of the Karakoram-Sanjiang area of China, a metallogenic series related to the Yanshanian magmatic intrusion activity.

7. Conclusions

Selenium mineralization is widespread across mainland China's diverse tectonic units. Each unit's unique geological history has led to different types of selenium deposits, resulting in distinct genetic deposit types for each tectonic unit.

Selenium mineralization has occurred throughout various geological periods in China, though its development has been uneven across this history. Selenium mineralization has primarily occurred during specific geological periods.

Different types of selenium mineralization exhibit unique temporal and spatial distribution patterns. Selenium deposits of certain genetic types are typically associated with specific geological periods and tectonic units, creating an imbalanced distribution across time and space.

Independent selenium mineralization is typically limited to particular rock types and tectonic units, while associated/symbiotic selenium mineralization is more common. In mainland China, independent selenium mineralization is predominantly found in sedimentary rocks, exhibiting a stratabound nature.

Selenium mineralization in mainland China has only been discovered in sedimentary and igneous rocks thus far, with limited evidence of selenium mineralization in metamorphic rocks. Current research has yet to identify a significant role for metamorphic rocks in selenium mineralization.

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Author contributions

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Data availability

The data that support the findings of this study is available from the author upon reasonable request.

Declaration of competing interest

The author declares that he has no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Use of AI tools declaration

The author declares that he has not used Artificial Intelligence (AI) tools in the creation of this article.

Original Article

Determining the optimal soil sample grid spacing to explore for epithermal gold deposits in a tropical wet and dry environment: an example from the La India mining district, Nicaragua

L.T.P. English[1] ©

Abstract

Soil sampling is a useful tool for the assessment of large areas of land where low sulphidation epithermal vein mineralisation is known or suspected. It provides a quantitative means of mapping out the geometry of an epithermal system and identifying potentially economic gold concentrations. In this paper gold in soil geochemistry data from the La India gold mining district in Nicaragua is used to model the soil gold signature at different sample grid spacing over known gold resources. The most cost-effective or optimal soil sample grid spacing to explore for epithermal gold deposits in this tropical wet and dry environment is identified. La India gold mining district covers a 50 km² area of fault-fill gold-silver mineralized quartz-adularia veins in western Nicaragua. The distribution of gold veins is well understood with current estimates defining a mineral endowment of over 2.3 Moz gold. The exploration data includes full coverage of the district by a 200 m by 50 m soil survey of fine-fraction B-horizon soil with ultra-trace multi-element analysis. Soil close to the gold veins is enriched in gold at trace level. Gold resources and prospects can be effectively ranked using the soil data with the larger resources correlating to broader, higher-grade soil gold anomalies. The soil gold content can be used to map-out the geometry and distribution of the epithermal vein system. In this study the soil survey data is filtered to create simulated 200 m by 200 m and 400 m by 400 m soil grids. The simulated grids are assessed against the mapped veins, surface rock chip and trench results, and known mineral resources. It is concluded that a 200 m by 200 m soil grid is adequate to discover economic vein gold deposits in the soil type found in the tropical wet and dry zone of western Nicaragua. This grid spacing provides enough resolution to map out vein trends and the overall geometry of an epithermal vein system that is exposed at surface and provides sufficient resolution to rank the gold anomalies by size and grade with confidence that the ranking will broadly correlate with associated gold occurrences. A 400 m by 400 m spaced soil sampling does appear to detect the larger deposits but will miss smaller or partially hidden deeper-seated deposits, and the spacing is too wide to provide any useful information on epithermal vein orientation or network geometry.

Keywords: soil geochemistry; gold; vein; low sulphidation epithermal; La India mining district; Nicaragua

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1. Introduction

Soil geochemistry sampling has been successfully used in the exploration and discovery of mineral deposits, including low sulphidation epithermal gold-silver vein deposits for a long time. Soil geochemistry can be used to detect these deposits either by looking for concentrations of the sought after minerals, gold and silver, or by looking for concentrations of other minerals that may be concentrated within the ore veins, the so-called pathfinder elements. If a more extensive suite of elements is analysed, then the soil geochemistry can also be used to help map the host geology and identify areas of hydrothermal alteration that may be associated with the mineralisation.

The soil samples are typically collected at regular intervals on a grid pattern across an area of interest. Several factors are considered when designing the grid pattern used in a soil geochemical survey: geology, vegetation and soil type, terrain and access, budget and time must be considered. In areas with limited soil development or where much of the soil has been covered by a thick transported cover, or restricted access then a regular grid survey may not be possible and practices such as ridge-and-spur sampling may be the best option. In areas where there is widespread soil development and reasonable access then a regular grid pattern is preferred to provide full coverage. Close-spaced samples along traverse lines perpendicular to the dominant regional structural or geological trend and/or the strike direction of any known mineralised veins in the area has been a popular practice. However, recently it has become more common to use an unbiased regular spaced grid pattern such as a square or triangular grid because it is recognised that low sulphidation epithermal vein systems at district-scale often contain a network of veins with two or more oblique strike directions. An unbiased grid pattern is more likely to detect and define the orientation of veins in any direction, whereas a set of soil traverses will bias detection and interpretation to veins that are perpendicular to the traverses and may miss veins that are parallel or at an acute angle.

Soil samples can be analysed in a laboratory, typically using a method that can detect very low concentrations of elements such as inductively coupled plasma mass spectrometry (ICP-MS). Portable X-ray fluorescence spectrometers are a cost-effective and quick alternative for the analysis for many elements, but a laboratory analysis is still required to analyse gold at the low levels of detection required to provide meaningful data.

Soil geochemical surveys are usually constrained by a budget, so once the decision has been made on the analytical technique to be used then the challenge is to design a soil survey grid that covers the area of interest using the least number of samples required to detect and preferably define the orientation of any potentially economic mineralisation.

In this paper the extensive and high-resolution soil geochemistry data that was collected over the La India mining district in Nicaragua is used as a case study to determine the most cost-efficient soil survey grid that would have been required to discover and outline the orientation of all the known potentially economic gold-silver mineralisation in the La India mining district. The existing soil database is filtered to simulate soil geochemistry surveys at different spacing. The simulations are assessed to determine how effective the soil survey is at detecting and ranking the known deposits and prospects and at defining the geometry of the known gold occurrences and vein system. The findings can be used as a guide for explorers looking for similar low sulphidation epithermal gold-silver deposits in a similar terrain and environment: moderate relief terrain with light woodland in a tropical wet and dry climate.

2. Case study-La India gold-silver mining district

The La India gold mining district in the tropical wet and dry zone of western Nicaragua has an extensive high-resolution soil geochemistry survey dataset over a low sulphidation epithermal gold-vein district which contains multiple past producing mine workings, a development-level open pit mine reserve and several potentially economic gold-silver resources (Figure 1).

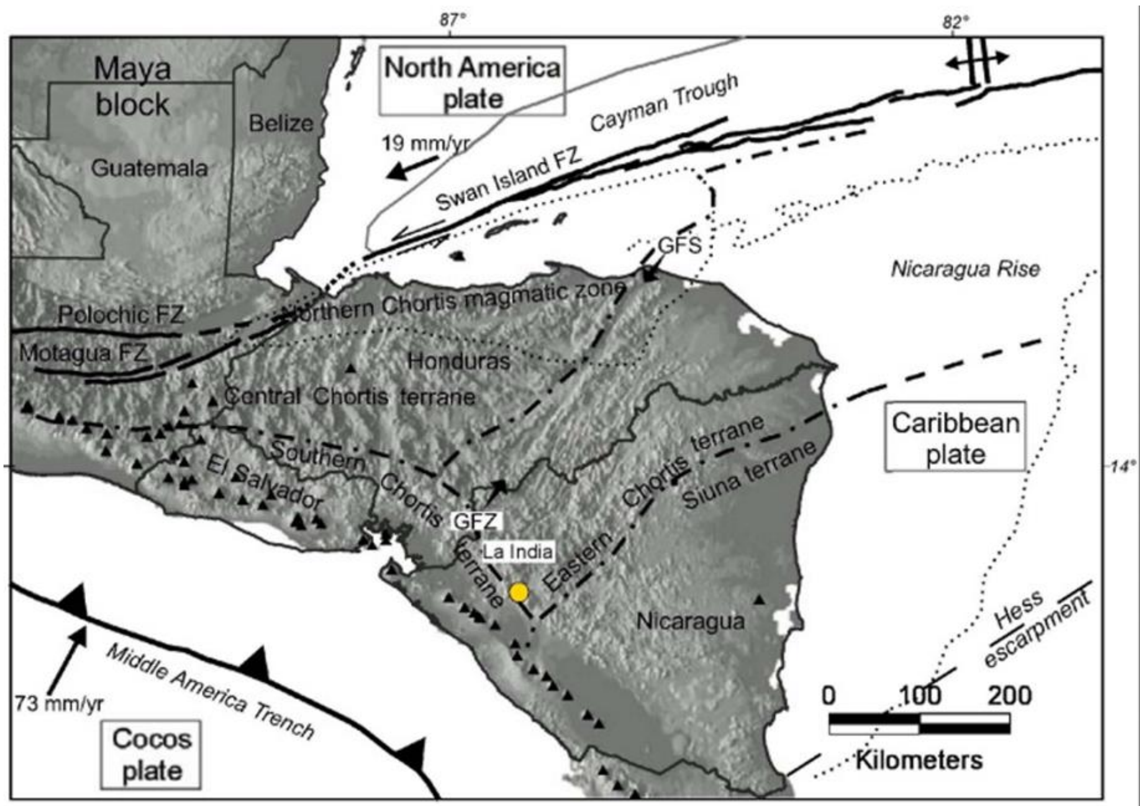

Figure 1. Location of the La India district in western Nicaragua (from Rogers et al. 2007[1])

3. Geology and mineralisation of La India Mining District

The La India gold mining district covers a 50 km² area on the western margin of a Tertiary volcanic arc that runs along the west side of Nicaragua. The district-scale gold-silver mineralisation at La India is found in two adjacent geological settings with distinct mineralization characteristics: (1) an upland area of strongly faulted felsic to andesitic volcanics where the historic mine workings are located, and (2) an adjacent downthrown graben, the Sebaco Graben, where a thick sequence of andesite is preserved overlying the felsic volcanic sequence (Figure 2). Gold mineralisation is classified as rift margin-type low-sulphidation epithermal gold-silver vein mineralization in fault and fracture-fill veins. In the historic mining area erosion has exposed the top of the high-grade epithermal zone. Minimal erosion in the Sebaco Graben means that the epithermal system is fully preserved and predominantly occurs as deep-seated, partially hidden low sulphidation epithermal mineralization locally associated with hydrothermal sinter outcrops, and also as near surface gold mineralization in a phreatic breccia pipe[2].

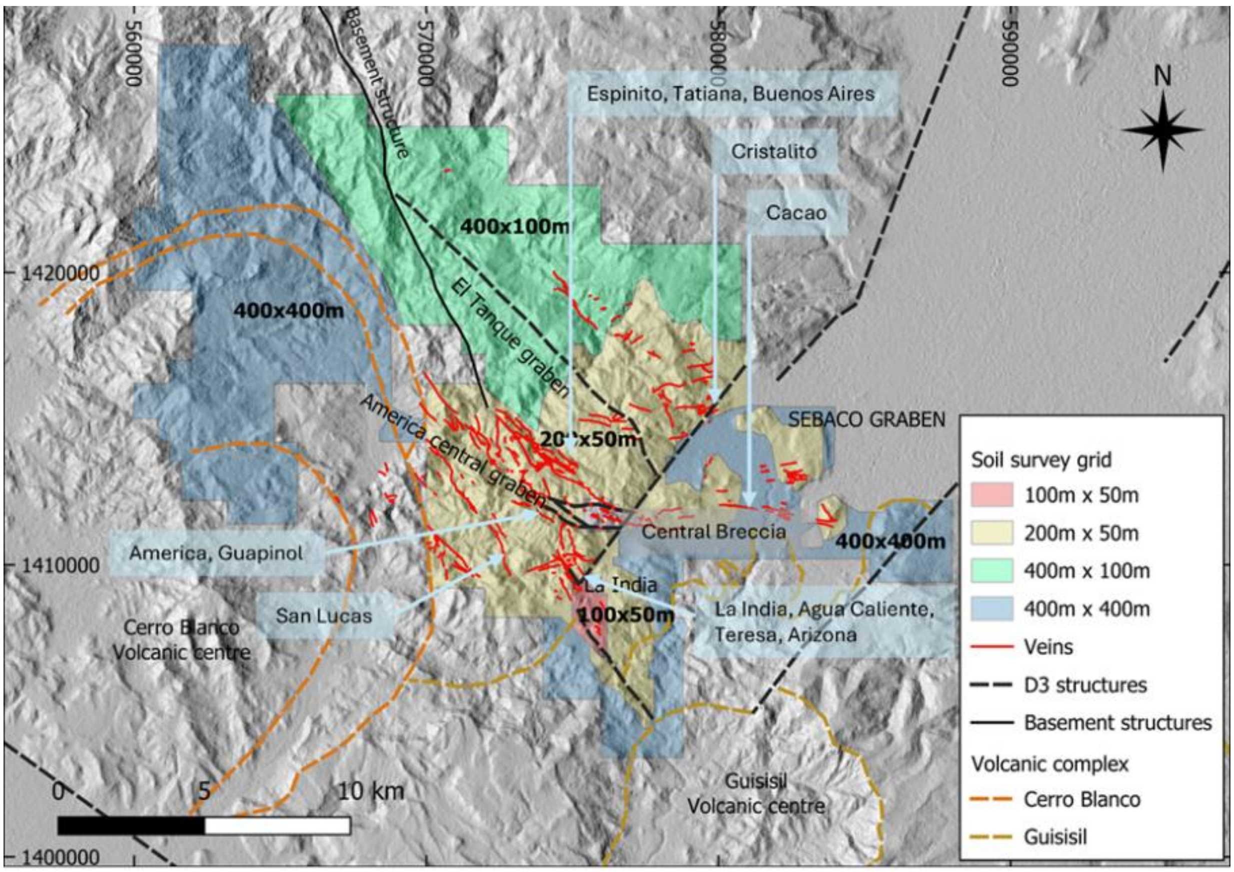

Figure 2. Map showing the soil geochemistry survey coverage at different grid spacing over La India district and the location of the main volcanic complexes and principal geological structural blocks. Digital elevation topographic model background (adapted from English et al.[2]).

Apart from the one phreatic breccia, the gold-silver mineralisation occurs in quartz veins and breccias that filled brittle faults and associated fractures and fissures. The structures containing the gold-silver mineralisation occur in at least three orientations: (1) a predominant northwest to north-northwest set; (2) secondary but locally extensive east-west, and (3) tertiary shorter and narrower northeast and north-striking veins. The gold-silver mineralisation is best developed where these structures pass through competent felsic volcanics, welded tuffs and the massive andesite, and is less well developed where the structures pass through less competent unwelded tuffs and volcanic agglomerates[2].

Historic mining records from a period of underground gold and silver mining in the mid-20th Century, and well-documented modern mineral exploration since the late 1980s has identified 110 kilometres of surficial gold-silver veins, a mineralised breccia pipe and two hidden deep-seated gold-silver veins[3]. The exploration has been well documented and provides a database of over 4,500 rock chip samples, 1776 trenches for almost 29,000 m of channel samples, and 625 drill holes for over 96,000 m of rock samples, most of which collected continuous samples of rock core, satellite-derived digital terrain models and a 280km² area airborne radiometric and magnetic geophysical surveys, and a grid of over 12,000 soil samples[2]. This extensive dataset has been used to estimate a significant mineral resource in the La India district: the current concession holders have defined a 2.3 Moz gold endowment[4].

4. Climate, landscape and soil at La India mining district

Climate and terrain play an important role in determining the degree and extent of physical and chemical gold mobilisation in soil. The La India mining district is in an area of moderate to steep relief on the western side of the Central Highlands of Nicaragua, predominantly hills and mesas ranging between 300 m and almost 1000 m altitude and some lowland plains, notably the Sebaco Plain in the east (Figure 3).

Figure 3. Left: Typical moderate relief landscape in the La India mining district which was covered by a regular grid soil geochemistry survey in 2015-2017. Right: Screening a soil sample at <3 mm mesh to sample the fine fraction in the field

The climate is characterised as tropical wet and dry (savannah) according to the Köppen system with an average annual rainfall of 1000 - 1400 mm concentrated in the six months between May and October. The temperature is relatively constant with average year-round temperatures ranging between 20°C and 30°C with cooler weather at higher altitudes.

The upland areas are a mixture of light tropical thorny forest and land cleared for pasture and seasonal crops of corn or beans. The tops of some of the hills at altitudes over 800 m support pine forests. The lowland plains are mostly cleared for pasture, apart from the flattest areas of the Sebaco Plains, beyond of the soil survey area, which are periodically flooded to cultivate rice.

In the upland areas the soil thin with a poorly developed organic horizon. The texture of the residual B-horizon which was sampled in the soil geochemistry survey is determined by the bedrock lithology: a thin sandy horizon where the bedrock is felsic volcanic, a sandy-clayey soil where the bedrock is tuff, and a thicker clayey soil which passes downward into a saprolite where the bedrock is andesite (Figure 4). Soil that has developed on thick transported deposits such as colluvial aprons at the foot of some slopes and alluvial river sediment were not sampled.

Figure 4. Left: Soil sampling thin soil horizon over weathered felsic volcanic bedrock, and (Centre:) trenches revealing the sandy soil developed over tuff and (Right:) the clayey soil over saprolitic andesite

5. Soil geochemistry data at La India mining district

This study uses a database of 12,476 soil samples that were collected on grids ranging between a close-spaced 100 m x 50 m in the historic mining zone to a wide-spaced 400 m x 400 m on outlying regions (Table 1). Samples were collected from the B-horizon, just below the organic A-horizon. Soil was collected with a clean shovel, sieved using a <3mm mesh and any organic particles removed by hand and a 750 g to 1 kg sample collected. The soil samples were then prepared at the certified Bureau Veritas Inspectorate sample preparation laboratory in Managua by drying and screening the <180 µm fraction (-80 mesh). A 200 g sample of the fine fraction was sent for analysis by aqua regia digest and 53-element suite ultra-trace level ICP-MS at the Bureau Veritas (formerly Acme) Laboratory in Vancouver, Canada. The gold value has a stated detection limit of 0.2 ppb[5].

Table 1. Summary of soil geochemistry survey grid spacing coverage in the La India mining district

Grid spacing	No. of samples	Area (km²)
50 m × 100 m	320	2
50 m × 200 m	9,257	90
100 m × 400 m	1,476	80
400 m × 400 m	1,423	140
TOTAL	12,476	312

Reviews of the soil geochemistry clearly demonstrated that the soil gold value is the most reliable indicator of gold mineralisation in the bedrock with elevated soil gold results clearly correlating with the mapped veins and supported by rock chip and trench samples collected at surface[6]. The soil gold anomalies are best developed in the upland area where the gold veins are exposed at surface (Figures 5-6). Lower gold values occur over the deeper-seated gold mineralisation in the downthrown Sebaco graben. In these areas where the residual soil has developed from rocks that were located above the level of the epithermal mineralisation then pathfinder elements such as mercury, tellurium, thallium, arsenic and antimony that are associated with the hydrothermal outflow zone above the epithermal system can be used to detect the hidden mineralisation[7]. However, at the La India district exploration for deep-seated hidden and partially hidden deposits is still at an early stage and there is not enough data available to confidently correlate the soil pathfinder element signature to deep-seated gold mineralisation. Therefore, this study only tests the use of soil gold signature as a method of discovering gold vein deposits.

6. Determining the background gold in soil value

In order to identify soil gold anomalies that are associated with vein mineralisation then it is first necessary to establish the background threshold gold value, and to choose higher threshold values to help distinguish low level dispersal of gold in soil, and low level gold occurrences from significant occurrences that may have economic potential. There are several visual and statistical methods that can be used to determine the background gold value. Commonly used methods include using the mean value plus two standard deviations[8-9], cumulative graph inflection points, probability graphs[10], arbitrarily application of the 95th percentile value. Jarva et al.[11] suggest using the upper limit of the upper whisker line (ULBL) which is based on the 25% and 75% percentile values using the formula ULBL = P75 + 1.5 × (P75 – P25). In a soil geochemistry survey that has been confined to a gold district where there is widespread dispersal and dilution of gold mineralisation in the soil away from the mineralised veins then there is considerable overlap between the background and mineralised population domains[12]. The statistical methods return a wide range of threshold values which can be useful guides to choosing the various thresholds between background, distal and proximal soil dispersion (Table 2).

Table 2. Statistical determination of the gold in soil background threshold using mean plus two times standard deviation, 95th percentile and upper limit of the upper whisker line (ULBL) methods

	No. of soil samples	Mean+2SD Au (ppb)	95^{th} percentile Au (ppb)	ULBL threshold Au (ppb)
Mining district	9578	254	37	14
All samples	12476	222	30	12

A visual analysis guided by statistics of the soil survey data covering the known mineralisation at La India district can be a more effective way of determining a background value. Pratt and Flindell[6] suggested that all the known gold veins can be detected using a 10 ppb gold background threshold (Figure 5) which is close to the statistically derived ULBL background threshold.

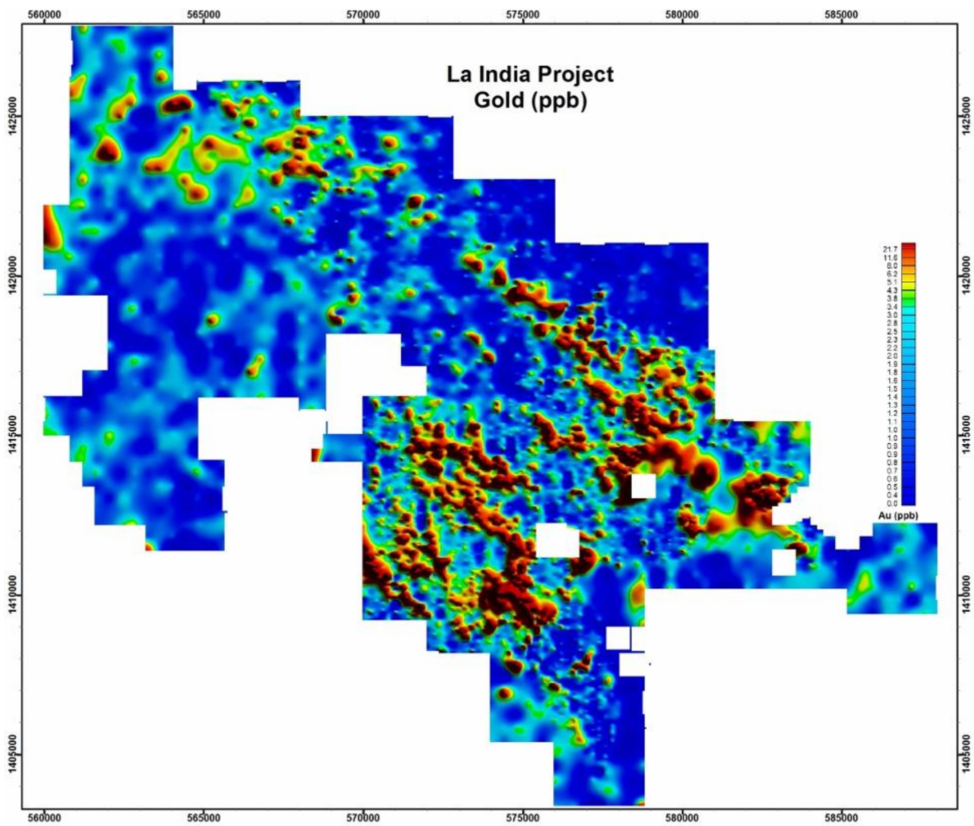

Figure 5. Gold in soil over La India mining district showing a 10 ppb background threshold (yellow-red) clearly defines all known veins (from Pratt & Flindell[6])

This is also consistent with a compilation of data from unmineralised rocks by Pitcairn[12] which suggests that a background value is typically between 0.5 and 5 ppb. Significant gold mineralisation has a higher threshold. The thirteen veins that currently support gold-silver mineral resources all have at least one sample >25 ppb gold (Figs 5-6). Plans of the soil gold values are presented here with a standardized colour coding built on a 10 ppb gold background with >25 ppb gold considered significant and >250 ppb gold a priority target (Figure 6, Table 3).

Table 3. Comparing the distribution of soil gold values for the soil database with the simulated 200 m by 200 m and 400 m by 400 m soil grids

	200 m × 50 m		200 m × 200 m		400 m × 400 m	
	No.	%	No.	%	No.	%
No. samples	9577	*100*	2407	*25*	662	*7*
<detection	6603	*68.95*	1665	*69.17*	451	*68.13*
>10 ppb Au	1651	*17.24*	424	*17.62*	111	*16.77*
>25 ppb Au	686	*7.16*	172	*7.15*	49	*7.4*
>50 ppb Au	358	*3.74*	90	*3.74*	29	*4.38*
>100 ppb Au	177	*1.85*	41	*1.7*	15	*2.27*
>250 ppb Au	61	*0.64*	10	*0.42*	4	*0.6*
>500 ppb Au	27	*0.28*	4	*0.17*	2	*0.3*
>1000 ppb Au	14	*0.15*	1	*0.04*	1	*0.15*

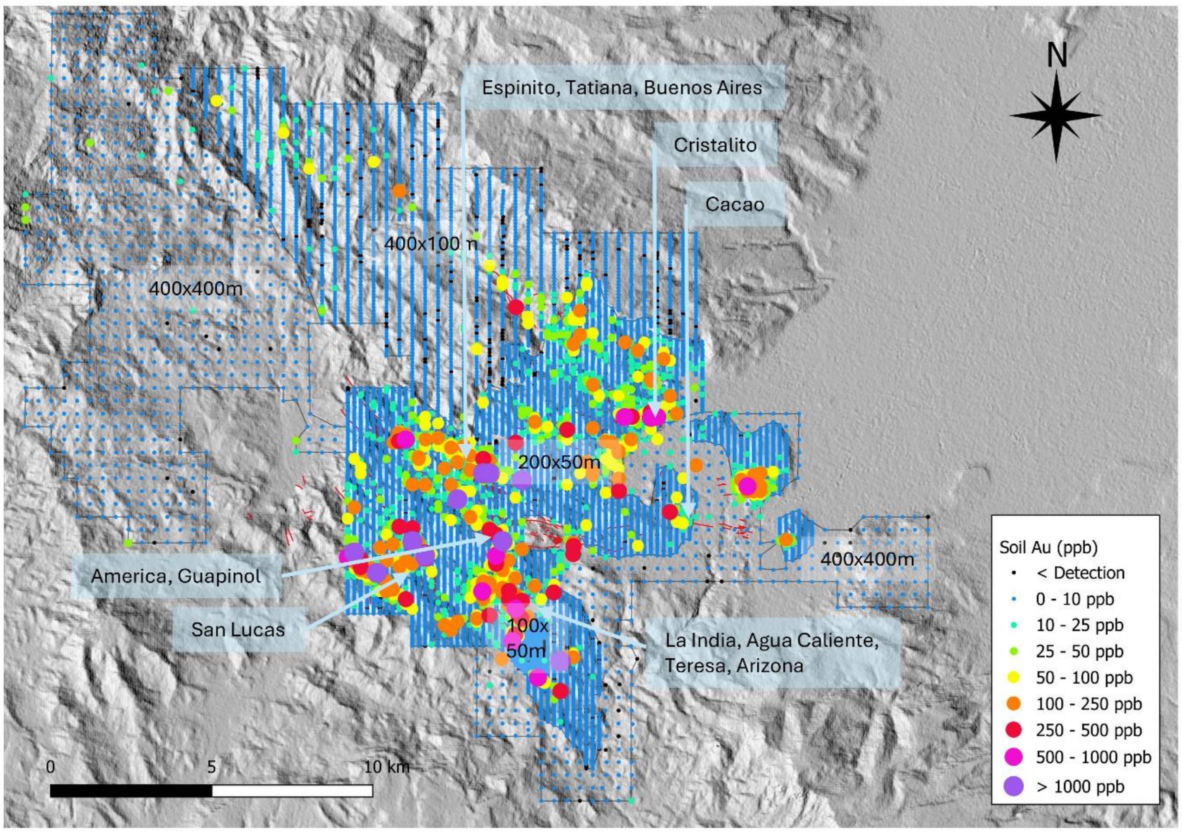

Figure 6. Soil sampling coverage over La India mining district

7. Analytical method

Soil samples in La India mining district were collected on grids ranging between 100 m by 50 m and 200 m by 50 m over the area of known gold vein mineralisation. Outlying areas beyond the known mineralisation was covered by a wider-spaced and 400 m by 400 m grid. This study aims to test the effectiveness of using an unbiased square-grid at different grid spacings over the area of known mineralisation to determine the most cost-effective sample spacing that would still have discovered all the potentially economic gold veins and still defined the geometry of the vein system. There are two unbiased square grid spacings that can be filtered out of the available data to simulate using a square grid. A 200 m x 200 m square grid can be extracted from the core 92 km² core area which covers most of the mineralisation, and a 400 m x 400 m square grid can be filtered across the entire area, including the core area.

The simulated grids were created by first creating idealised 200 m by 200 m and 400 m by 400 m grids and then filtering the La India soil data using QGIS™ geographic information software 'distance matrix tool'. The filter selects the nearest actual soil sample to each of the idealised grid locations to create the simulated grid with real datapoints, thus simulating the results of sampling on these grid spacings.

The simulated 200 m by 200 m and 400 m by 400 m soil grids were then compared with the known distribution of the gold resources, prospects and occurrences as determined by mapping, surface rock chip, trench sampling and drilling. A comparison with the effectiveness of the actual closer spaced full soil dataset was also made. The effectiveness of each simulated grid is determined by considering: (1) how many of the known resources and mineralised veins could be detected, (2) whether the soil anomalies can be ranked correctly based on the size and maximum grade of the soil anomaly, and (3) whether the orientation of the principal veins and the geometry of the vein network could be interpreted from the soil gold data.

The aim of the analysis is to determine the optimal soil grid spacing to explore for low sulphidation epithermal gold in a tropical wet and dry environment, and to provide a guide to the cut-off gold in soil value that should be considered a target for further exploration.

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8. Results

Comparison of the two simulated soil survey grids can be made within a 92 km² area covering the main mineral resource area that has been covered by both the 200 m by 200 m and the 400 m by 400 m soil survey simulations. The cost differences between the grids are considerable. Ultimately an exploration company will be considering the cost per unit area of any soil geochemistry survey and the cost is dominated by collection and analysis costs and approximately proportional to the number of samples. With 2407 samples the 200 m x 200 m simulated grid uses only 25%, and with only 662 samples the 400 m by 400 m grid has 7% as many samples as the existing 9577 close-spaced soil samples.

A summary of the gold values of the data over this area shows a similar grade distribution with 68-69% of the samples being below detection and approximately 7% of the samples over 25 ppb gold which is considered a useful detection threshold for significant gold mineralisation (Table 3).

9. Discussion

An effective soil geochemistry survey will locate all economic or potentially economic gold veins with a recognisable soil gold anomaly. The grade and extent of these gold occurrences should be indicated by the soil gold values and the size of the area of the soil anomaly. An effective soil survey will also reveal the orientation of the mineralised veins and the geometry of the vein system at a district scale, contributing valuable information to the geological interpretation of the mineralisation and guiding future exploration. The effectiveness of the 200 m by 200 m and the 400 m by 400 m soil survey simulations at fulfilling these objectives are compared and considered below.

9.1 Effectiveness at detecting known gold resources

All the current mineral resources are revealed by the current close-spaced soil survey by multiple anomalous soil values over 25 ppb gold. Applying the 25 ppb cut-off the simulated 200 m by 200 m soil grid detects all the mineral resources except for the relatively small Arizona and Espinito deposits, albeit only the larger two deposits, La India and America have multiple samples above the threshold. It is noted that both these deposits narrowly miss the cut-off and do have anomalous soil gold with soil samples of 24 and 20 ppb associated with each respectively. It is also noted that both are close to or linked to another of the larger deposits and so it is reasonable to assume the soil anomaly from the larger would have led explorers to the vicinity and that they would have been discovered.

The 400 m by 400 m soil grid has a very low discovery rate using a 25 ppb gold in soil threshold with only the two larger deposits of La India and America and two of the smaller resources, San Lucas and Agua Caliente registering. It is important to note that it is not even a reliable method to discover the larger deposits as the third largest deposit Tatiana does not make the threshold and would potentially be passed over[1] (Table 3).

9.2 Effectiveness at identifying the size of the known gold resources

The size of the deposits causing the soil anomalies can be estimated and the anomalies ranked by a combination of the size or area covered by the soil anomaly exceeding a given threshold, in this case 25 ppb gold, and by the tenure reflected by the maximum gold value.

Comparison of the 200 m by 200 m simulated soil grid with the existing close-spaced soil survey data suggests that both are equally effective at indicating the size of the deposits with La India and America providing the expected largest anomaly in both cases. San Lucas is ranked third which is higher than the resource would suggest, perhaps suggesting that this is an under-drilled target. The other resources score similarly. The only divergence from the expected order is the Tatiana deposit which appears to have a weaker than expected soil anomaly on the 200 m by 200 m grid with only one 61 ppb gold soil sample exceeding the threshold.

The 400 m by 400 m grid only appears to detect the largest deposits and misses the smaller deposits. The 400 m by 400 m grid has effectively detected and ranked the same three deposits highest, La India, America and San Lucas, but does not detect many of the others even if the detection threshold is reduced to 10 ppb gold (Figure 7, Table 4).

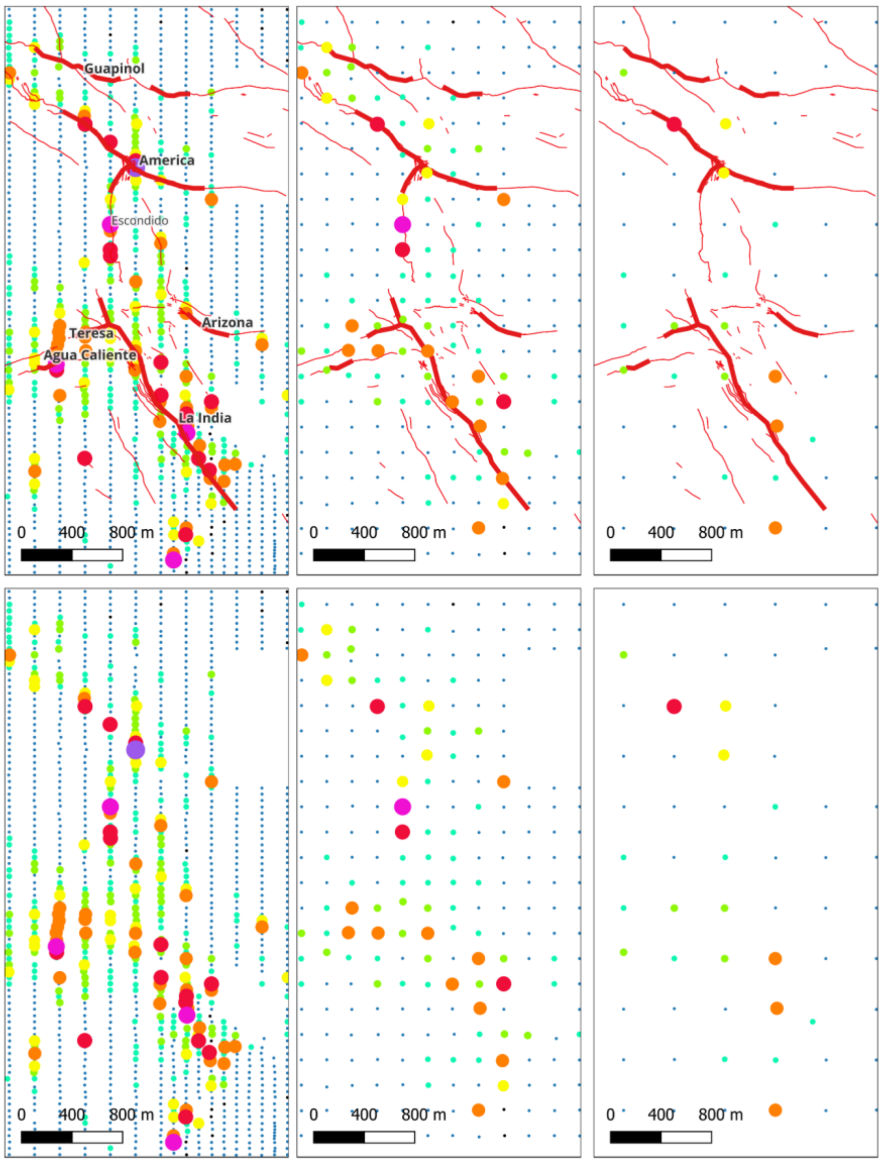

Figure 7. Map showing all the soil samples colour coded by gold content over the principal La India and America vein sets which both supported the main historic mine workings and contain the current main resource and open pit mine reserve in the La India mining district. Left: all soil data predominantly at 200 m by 50 m grid. Centre: the simulated 200 m by 200 m soil grid and (Left:) the simulated 200 m by 200 m soil grid. See Figure 6 for soil gold colour key

Table 4. Current gold endowments in the La India gold mining district with the number of associated soil samples >25 ppb gold and the maximum soil gold value for the full close spaced soil dataset and the simulated 200 m by 200 m and 400 m by 400 m soil grids

				200m × 50m	**(all data)**	**200m × 200m**		**400 × 400m**	
Deposit	**Au (kt)**	**Au (g/t)**	**Au (koz)**	**No. >25 ppb Au**	**Max Au ppb**	**No. >25 ppb Au**	**Max Au (ppb)**	**No. >25 ppb Au**	**Max Au (ppb)**
La India	11,000	3.3	1,200	52	853	15	290	5	153
America	2,300	5	360	19	1778	6	329	3	329
Tatiana	1,000	5.4	180	5	2017	1	61	0	8
Cacao	1,200	2.7	100	4	86	1	55	0	15
Guapinol	500	5.9	94	2	70	2	70	0	5
Buenos Aires	310	8.2	81	5	1458	3	58	0	4
Arizona	400	4.3	56	2	108	0	24	0	1.4
San Lucas	300	5.9	56	13	1959	4	1959	2	1959
Central Breccia	920	1.9	56	incomplete		incomplete		incomplete	
Espinito	180	8.4	49	4	112	0	20	0	10
Cristalito	180	5.5	33	9	638	2	598	0	6
Teresa	90	10.6	31	6	172	3	155	0	23
Agua Caliente	43	9	13	5	575	3	223	1	41

9.3 Effectiveness at revealing gold vein orientation and network geometry

Soil sampling can be an effective mapping tool, providing quantitative information on the spacial distribution of gold mineralisation. The trends and geometry of a vein system and information on where the gold is concentrated can not only identify mineral deposits but can also reveal vectors to mineralisation that may be hidden beneath adjacent cover or at deeper levels in the bedrock (Figure 8).

When the soil gold data is viewed on a regional scale the overall network of mineralised veins and the concentration of mineralisation at La India vein can clearly be seen in both the full dataset and the 200 m by 200 m grid. The 400 m by 400 m grid has anomalies associated with most of the key resource and prospect areas but does not provide any information on orientation or relative size of the different occurrences.

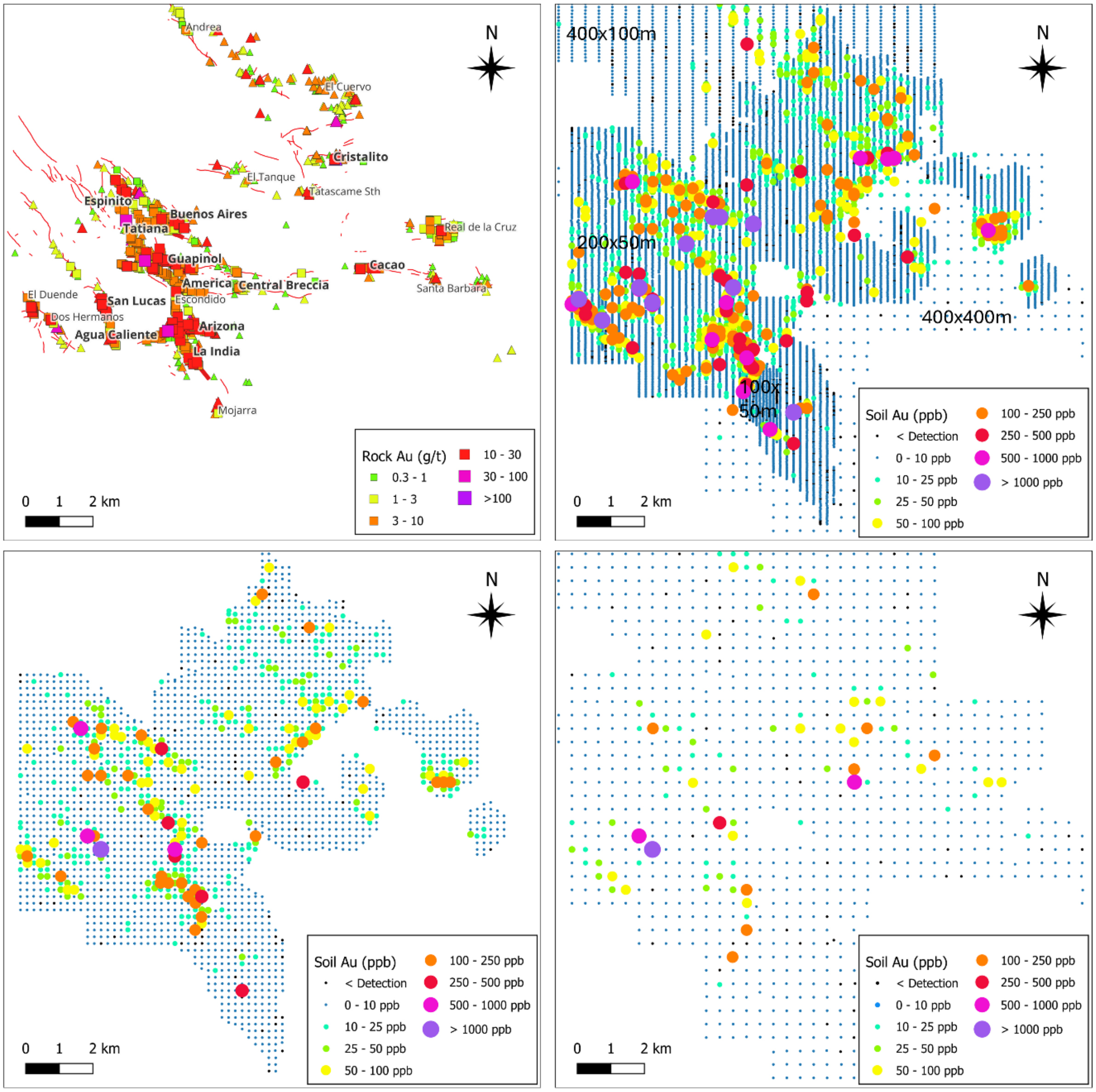

Figure 8. Top left: Mapped veins and surface rock chip and trench samples at the La India mining district, (Top right:) all soil sample data at grid spacing varying between 100 m by 50 m, 200 m by 50 m, 400 m by 100 m and 400 m by 400 m colour coded by gold content. Bottom left: Results of simulated 200 m by 200 m and (Bottom right:) 400 m by 400 m soil sample grids

10. Conclusions

The soil geochemisty data for the La India gold mining district provides a complete soil geochemistry dataset across an entire low sulphidation epithermal gold-silver district at a high resolution of 200 m by 50 m spacing. The north-south biased soil grid provides abundant data on the dominant mineralised veins which strike between east-west and northwest-southeast but does not provide good definition of a set of secondary veins that strike north-south, such as the Escondido vein which links the principal La India and

America resources. This type of biased data can lead to incomplete or incorrect interpretations of the vein geometry with the associated soil anomalies often being treated as background noise or forced into east-west interpretations.

An unbiased square grid is preferred in gold vein system such as La India where there are multiple vein directions. The existing soil dataset provides sufficient information to simulate and evaluate the effectiveness of an unbiased 200 m by 200 m and an unbiased 400 m by 400 m soil grids in a low sulphidation epithermal vein gold system in a tropical wet and dry environment. These spacings are considered reasonable for first pass regional exploration aimed at discovering low sulphidation epithermal gold vein mineralisation.

The 200 m by 200 m soil grid requires only 25% as many samples as the existing soil survey to cover the same area. A 400 m by 400 m soil grid would require approximately 9% as many samples. Both simulated grids represent significant cost savings for any exploration company.

Analysis of the simulation suggests that a 200 m by 200 m soil grid is (1) adequate to discover economic vein gold deposits in the soil type found in the tropical wet and dry zone of western Nicaragua. (2) A 200 m by 200 m soil grid will provide enough resolution to map out vein trends and the overall geometry of an epithermal vein system that is exposed at surface. (3) A 200 m by 200 m soil grid provides sufficient resolution to rank the gold anomalies by size and grade with confidence that the ranking will be broadly correlate with the size and grade of the associated gold occurrences.

A 400 m by 400 m spaced soil sampling successfully detects the larger gold deposits but will miss smaller or partially hidden deeper-seated deposits. The spacing is too wide to provide any useful information on epithermal vein orientation or network geometry. It could be considered as a first pass exploration to identify areas of interest, but there would be value in undertaking infill sampling at 200 m by 200 m, or possibly closer spacing to allow the system to be traced and targets ranked.

Soil geochemistry surveys at closer than 200 m spacing in this geology and environment will provide better information, but it is cautioned that it is unlikely to add significant information, and it may be more cost-effective to direct resources to exploration work that will locate and sample the in situ ore such as rock chip sampling, trenching or drilling.

It is important to note that this study only considers the soil gold signature. The optimal grid spacing for other pathfinder elements or to use the soil as a lithology and alteration mapping tool may be different. However, as the gold is a relatively immobile element and in vein systems is constrained to a relatively narrow geological structure then it is reasonable to expect that the effective soil signature of more mobile elements distributed in broadly distributed lithologies and alteration halos would be achieved with wider spaced grids.

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Author contributions

L.T.P.E. contributed to the data collection, compilation and interpretation and wrote the paper. V.H.G. and C.R.P. contributed to the data collection and interpretations.

Data availability

Data sets generated during the current study and internal company reports referenced in this paper are available from the corresponding author on reasonable request, but restrictions apply to any data used in these studies which was collected for exploration, mineral resource evaluation and mine feasibility studies under license, and so are not publicly available. The referenced internal company and consultant reports on the geology and soil geochemistry and data referring to mineral resource estimates are available on the website of the current owners of the mining concessions at www.metalsexploration.com.

Declaration of competing interest

The author declares that he has no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Use of AI tools declaration

The author declares that he has not used Artificial Intelligence (AI) tools in the creation of this article.

Original Article

An open letter to the Geological Society of China

Lisheng Zhang [1] ©

Abstract

In a letter to Guofeng Hua, Xiaoping Deng and Yi Fang, dated January 11, 1978, T. K. Huang claimed to have proposed focusing on the North China Plain, Songliao Plain, Ordos Basin (namely, the Shaanxi-Gansu-Ningxia Basin), and Sichuan Basin as key areas for petroleum exploration based on his continental origin of petroleum theory. He asserted that his proposal led to the discovery of the Songliao and North China Oilfields. However, evidences from various sources, including resolutions from the first and second working conferences of petroleum reconnaissance, C. Y. Hsieh's 1955 report, and T. K. Huang's 1957 report, contradict these claims, indicating that they are unfounded. Furthermore, T. K. Huang did not identify the range of petroleum reconnaissance nor provide strategic selection for petroleum reconnaissance areas, nor did he offer an optimistic assessment of China's petroleum prospects. Although T. K. Huang contributed significantly to the discovery of the Daqing Oilfield, it is untrue that his work was free from theoretical constraints or single-handedly altered the perception of China's petroleum potential. Despite T. K. Huang's passing, his fraudulent behavior should be exposed, condemned, and not praised. Efforts by entities such as the Geological Review, Geological Society of China, and Professional Committee for the History of Geological Sciences to conceal the controversy surrounding the theory of continental origin of petroleum guiding petroleum exploration must be addressed by the Society's leadership.

Keywords: T. K. Huang; a letter; the theory of continental origin of petroleum; the discovery of the Songliao and North China Oilfields; the lie; the Geological Society of China

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致中国地质学会的公开信

张立生

摘要

黄汲清 1978 年 1 月 11 日致华国锋、邓小平和方毅的上书信声称，他 1955 年依据他的陆相生油理论，“提出了把华北平原、松辽平原、鄂尔多斯盆地（即陕、甘、宁盆地）和四川盆地作为‘普委会’找油的四大重点地区。‘普委会’采纳了我的建议，并很快做了部署，开展了工作”，从而发现了松辽和华北油田。地质部第一次、第二次石油普查工作会议的决议，谢家荣 1955 年 3 月在全国地质会议上所作题为“一九五四年普查检查工作中的几个问题”的报告，黄汲清 1957 所作报告《对我国含油气远景分区的初步意见》、竺可桢先生 1957 年 5 月 26 日的日记都无可辩驳地证明：这是不折不扣的谎言。黄汲清既没有指出过石油普查的方向，也没有提供过石油普查的战略选区。他 1950 年代对中国石油远景没有乐观的评估。虽然黄汲清对大庆油田的发现也有重要贡献，但所谓黄汲清突破理论束缚，摘掉中国“贫油”帽子，没有一点点道理。虽然黄汲清先生已经过世多年，但他弄虚作假的行为，应当予以揭露和谴责而绝不应当唱赞歌。中国地质学会所属《地质论评》和地质学史专业委员会，压制不同意见，竭力掩护陆相生油理论指导石油普查发现大庆油田的谎言应该受到谴责，应当引起学会领导的重视与问责。

关键词: 黄汲清；上书信； 陆相生油理论； 发现松辽和华北油田； 谎言； 地质学史专业委员会； 压制不同意见

中国地质学会，许大纯理事长，韦延光秘书长，各位理事：

大庆油田发现历程中的地质科学工作问题，在中国闹腾了几十年，在中国地质界可谓人尽皆知。经过长期的努力，现在已经查明，所谓陆相生油理论指导石油普查，从而发现大庆等油田，是不折不扣的谎言。

黄汲清在 1978 年 1 月 11 日上书华国锋、邓小平、方毅的信中声称，他 1977 年 6 月 14 给邓小平的信“没有反映存在于地质界的一个重大问题，即我国东部的大油田（包括大庆、胜利、大港、长庆等油田）到底是怎么发现的。这主要是考虑到这个问题直接牵涉到我个人的历史作用，而我不想为个人争荣誉”，“现在看来，不把这个问题反映出来，不说清楚，在地质界真正落实党的‘双百’方针，充分调动地质战线广大人员的社会主义积极性是有很大困难的。”[1]

黄汲清在信中说“长期以来在地质系统有少数领导同志不执行百家争鸣方针，压制不同学术观点，在我国东部油田的发现上弄虚作假，不顾事实地胡乱吹嘘”[1]，“我国大庆等东部油田的普查和发展与地质力学的理论无关，这是事实”1，宣称：“作为一个社会主义中国的科学工作者，我只有坚持科学真理的义务，而没有容忍谎言的权

力。”“我深感有责任响应党中央的号召，有责任把地质界的这个重大问题反映给您们。”[1]

但声称“只有坚持科学真理的义务，而没有容忍谎言的权利”“不想为个人争荣誉”的黄汲清，却有过之而无不及地“在我国东部油田的发现上弄虚作假，不顾事实地胡乱吹嘘”他自己：制造了他“依据陆相生油理论”提出了“找油的四大重点地区”的建议，以陆相生油理论指导石油普查，发现大庆油田的谎言。他说：

“我国东部几大油田普查工作是 1955 年初在当时地质部普查委员会（简称‘普委会’）的直接主持下开始进行的，当时我作为‘普委会’的主要负责人之一，提出了把华北平原、松辽平原、鄂尔多斯盆地（即陕甘宁盆地）、四川盆地作为‘普委会’找油的四大重点地区。‘普委会’采纳了我的建议，并很快做了部署，开展了工作。我的建议是根据‘陆相生油’理论（这一理论是我国地质学家潘钟祥教授和我在四十年代初期分别提出和发展起来的）和我的大地构造观点并结合我国多年来的地质工作实践而提出的。这一历史事实是‘普委会’广大干部、技术人员都知道的。在此之后，我又编制了《我国含油气远景分区图》”，把上述四大地区用橙红色明确圈出，并于 1957 年 3 月 8 日在全国石油普查会议上，配合这张大型挂图，作了题为《对我国含油气远景分区》的学术报告。“普委会”及下属松辽普查大队经过 1955、1956、1957 三年的工作，……从而完全证实了松辽平原的含油远景（华北平原和其他地区在以后几年也相继被证实有含油远景）……我谈这些并不是宣扬我个人，而是因为这一科学历史事实被篡改了[1]。

真实的历史是：

一、在 1955 年开始在全国范围内进行大规模的石油普查之前，先后指出中国东北大平原下可能有油的地质学家有：阮维周[2]、翁文波[3]、谢家荣[4-9]、李春昱[10]、孙健初[11]、高振西[12]、李四光[13]、以及援华的苏联专家[14-15]，但没有黄汲清。其中尤其值得提到的是谢家荣指出的：“东北还没有发现的矿产，最重要的是石油，……日本人在锦州和扎赉诺尔二区对于石油的钻探，虽然没有成功，却是很有理由的，我们将来还应该继续做，并且要扩大范围，彻底钻探”，“从区域方面讲，我们将来的测勘工作，要特别注意北满，因为北满到现在为止，还是一个处女地，……中生代煤田炭分的特低；和沥青的产生（如扎赉诺尔），可能有发现油田的希望”[5]，以及“要特别注意海相的第三纪或中生代地层。在华北、华东、甚至东北的广大平原下，已有种种迹象指出有广大海水侵入的可能。如果不谬，那末，含油的希望就很大了。所以这些地区应作为可能油区而予以密切注意。”[6]

1950 年代，华夏大地上还弥漫着“中国贫油”的雾霾，中国究竟是“有丰富的石油”，还是“真正的贫油”？谢家荣的回答是：“中国肯定是有油的，并且其储量一定是相当丰富的”“可以推测它的分布是很广泛的”[9]，只要将各大含油盆地的储油层和圈闭类型研究清楚，“只要钻探能赶得上地质工作，我想许多巨大新油田的跟踵发现，是在意料之中的”[16]；李四光的回答是：中国的石油资源是丰富的[17]；黄汲清的回答是“如果我是一个投机政客，何妨拍拍胸膛说：‘中国的石油资源丰富的很，只要你给我足够的人力、物力、财力，我保证在十年八年之内，找到一批大油田。’但是作为一个实事求是的科学工作者，我不能这样讲。”“我若是随心所欲地、完全不考虑后果地作

出答复，那将是一种犯罪。”“因此，我没有直接采用‘是’或‘不是’的方式回答问题，而是委婉地、可以说是绕圈子的办法把问题摆出来，让陈副总理自己考虑”去！[1 & 18]

1950 年代，在刚刚获得新生的华夏大地上，在即将开展全国范围的石油普查的前夜，应该到什么地方去找油？回答这个问题的是谢家荣的《中国的产油区和可能含油区》[9] 和李四光的《从大地构造看我国石油资源勘探的远景》[13]，而不是根本就不存在的所谓黄汲清的“大胆设想”[19-20]。

谢家荣的《中国的产油区和可能含油区》将中国的含油区域分为三大类 20 个区 [9]，1950 年代的石油普查战略选区无一例外都是它指出的地区；李四光的《从大地构造看我国石油资源勘探的远景》将中国可能的含油气分为 4 个区含 10 多个地区 [13]，1950 年代的石油普查战略选区大多也是它指出的地区。黄汲清至少在 1956 年第二次石油普查工作会议结束之前，没有只言片语提到过中国东部平原的石油远景，没有指出过中国找油的方向，也没有提供过石油普查的战略选区。

二、根本就没有黄汲清在 1955 年“提出了把华北平原、松辽平原、鄂尔多斯盆地（即陕甘宁盆地）、四川盆地作为‘普委会’找油的四大重点地区”这回事，也就更没有所谓“普委会采纳了”他的建议“并很快做了部署”这回事。

1955 年的石油普查项目是在第一次石油普查工作会议期间，在谢家荣和黄汲清主持下，经过专家们集体讨论决定的，会议的讨论结果是由黄汲清向部务会议汇报的 [17-18]。没有任何理由将专家们的讨论结果说成是黄汲清自己的意见。

经专家们讨论后，按照当时可能组织起来的力量，第一次石油普查工作会议决议：组成 5 个石油普查大队即新疆石油普查大队、柴达木石油普查大队、鄂尔多斯地台石油普查大队、四川盆地石油普查大队和华北平原石油普查大队，分赴新疆的准噶尔盆地和吐鲁番盆地、青海柴达木盆地、鄂尔多斯地台、四川盆地和华北平原等 5 个地区进行工作 [21]，而不是黄汲清“建议”的 4 个（华北平原、松辽平原、鄂尔多斯盆地、四川盆地）。其中没有松辽平原；松辽平原的工作是“在会议结束之后”，黄汲清“与谢家荣一道专门提出”的 [22]，由黄汲清出面授意苏云山起草“松辽平原石油地质踏勘设计任务书”[23]，由谢家荣、黄汲清修改了该任务书 [24]，谢家荣并且“亲自起草了”“关于松辽平原石油地质踏勘工作方法”[23,25]。松辽平原项目哪里是什么黄汲清作为重点地区提出的？并且会议结束后提出的松辽平原项目不是普查，而只是地质踏勘；稍微有点地质常识的人都清楚，一个地质情况不明、尚需进行踏勘的地区是根本不可能作为重点普查区的。

在第一次石油普查工作会议（1955-01-20 至同年 02-11）闭幕近 20 天后，1955 年 3 月 1 日，普查委员会技术负责人之一、总工程师谢家荣在 1955 年全国地质会议（2 月 22 日至 3 月 17 日在北京举行）上所作题为“一九五四年普查检查工作中的几个问题”的报告中，明确指出：“以后数年的石油普查工作应集中力量在准噶尔、柴达木、塔里木及河西走廊的四大盆地之中。华北、松辽及华东平原中亦有产油希望，应予注意。在四川应注意川西川中各区，并应着重天然气的开发及利用”[26]。这里根本没有黄汲清提出四大重点地区建议的影子。哪来的普委会采纳了他的建议并且还“是‘普委会’广大干部、技术人员都知道的”？

明明黄汲清没有指出过石油普查的方向，没有提供过石油普查的战略选区，明明1955 年的石油普查项目是经过专家们集体讨论决定的，1956 年新增的石油普查项目也是在第二次石油普查工作会议期间经专家们讨论决定的 [27]，有人却宣称，“《中国的产油区和和可能含油区》代表谢先生的思想，《从大地构造看我国石油资源勘探的远景》代表李先生的思想”，但是黄汲清“是中国最顶层的地质学家，是地质大师”，“在工作思路上，他不会受别人影响”，“他不会轻易地根据别人的观点来部署工作”，“作为普委的技术负责人，黄先生部署全国石油普查的思想与他们并不相同”，“黄先生部署全国石油普查，一是根据他的陆相生油理论”，“二是他的大地构造理论”[28]。就是说，1950 年代的石油普查是黄汲清一人根据他的陆相生油理论部署的，不关别人什么事！！！

三、所谓黄汲清 1955 年提出了“找油的四大重点地区”，并没有任何可考的证据，因为它根本就不存在。为了要“留下”“证据”，只好在黄汲清 1957 年在第三次石油普查工作会议（石油地质专业会议）上的报告《对我国含油气远景分区的初步意见》上动手脚。

中央档案馆藏黄汲清《对我国含油气远景分区的初步意见（提纲）》一共 14 页 [29]，其中根本就找不到所谓将鄂尔多斯、四川、华北平原、松辽平原作为找油的四大重点地区的蛛丝马迹。

1993 年《黄汲清石油地质著作选集》出版，其中收入了经黄汲清“审阅定稿”的《对我国含油气远景分区的初步意见》。比较中央档案馆的原件，它增加了一个“结束语”，正是在这个“结束语”中出现了“在 4-5 年以内将鄂尔多斯、四川、华北平原、松辽平原作为重点是正确的”[30]。此外还加了一个“后记”，其中说：“报告由作者的助手任纪舜和华北石油普查大队主任地质师孙万铨作记录，此处发表的大部分照抄了任的记录，只有一小部分照抄了孙的记录。为了使词句通顺易懂，做了少数几处文字上的修正，绝不影响内容。”还说他在会议上使用的、已经丢失的 1:300 万中国含油气远景分区挂图上“各种不同含油气远景区的分别一目了然，松辽平原、华北平原、四川和鄂尔多斯四大地区特别引人注目。”[30] 也就是他在上书信中说的“我又编制了《我国含油气远景分区图》，把上述四大地区用橙红色明确圈出。”

当然，报告提纲与正式报告不可能完全相同，后者应该更为详细。但是，竺可桢先生 1957 年 5 月 26 日听了黄汲清先生的同名报告之后的日记却无可辩驳地证明，黄汲清心目中最有远景的地区是准噶尔盆地，华北、松辽是排得很后面的，根本就没有所谓四大重点地区：

“晨六点起。九点和尹主任至北京饭店，听地学组论文报告。孟宪民《华南地区金属矿床的分布规律》……次黄汲清讲对我国含油气远景分区。说从他看来目前所开河西老君庙每年出四十万吨，是小矿区，要和苏联 Baku 相比得年出千万吨，目前准噶尔盆地有此希望，克拉玛依看来这区可出百万吨，然尚系估计数字。次为四川油田，川东、川西、川南统有希望。柴达木也有希望，但尚难估计。次则谓华北、华东和松辽平原能够得第三纪海相即有希望。谢家荣《若干地区油气普查勘探意见》，认为……” [31] 。

而且，即使到了大庆油田发现 3 年之后的 1962 年，黄汲清也仍然认为中国含油气地区最有远景的 4 个地区是：准噶尔盆地、塔里木盆地、柴达木盆地和四川盆地[32]（亦见本刊本期第 429-461 页张立生的另一篇文章：“正本清源 还历史本来面目--对杨丽娟关于黄汲清与中国石油普查两篇文章的质疑”），也证明根本就没有黄汲清 1955 年提出所谓找油的四大重点地区这回事。

四、关于《对我国含油气远景分区的初步意见》是到松辽平原找油的依据

黄汲清的上书信将其 1957 年的报告《对我国含油气远景分区的初步意见》说成是到松辽平原找油的依据，没有任何道理。

1950 年代石油普查的战略选区完成于 1956 年第二次石油普查工作会议。《对我国含油气远景分区的初步意见》是在 1955 和 1956 两年工作所得成果的基础之上作的，将其说成是 1955 年到松辽平原找油的依据就有如说女儿生了母亲一样的荒唐。

因此，曾经的李四光秘书郑明焕、周国钧同志 1979 年 5 月 4 日致信中国科协代主席周培源等驳斥黄汲清的上书信说[33]：

“在写上封信之后，我们又见到黄先生一九七八年一月写的一封信。他说松辽平原的找油工作，是根据他的建议开展的。我们查阅了地质部档案，未见片纸只字有关黄先生建议去松辽平原找油的记录；查阅了黄先生解放前后，公开发表有关石油方面的文章，没有一篇提到松辽平原；二十多年来，除黄先生本人之外，我们也没有听到第二个人这样说过。我们见到唯一的一篇文字材料，是黄先生自己提供的，据说那是他一九五七年三月八日做（作）的学术报告的记录，题目是《对我国含油气远景分区的初步意见》。在这个记录中，确实把松辽平原列为我国‘含油及可能含油区域’之一。但这是在李四光同志提出到松辽平原找油三年之后；人民日报在社论中把松辽平原列为我国可能含油远景区一年之后；当黄先生做（作）这个报告时，地质队在松辽平原进行找油工作已进行两年了。尽管如此，但较他以前鼓吹“中国贫油论”，总算是个进步，也是值得欢迎的。但要把它作为地质部去松辽平原找油的证据，那就未免把马车栓在马的前头了。”

五、黄汲清在上书信中声称他提出四大重点地区是依据他的陆相生油理论，并为普委会“采纳”，一样是谎言：

1955 年第一次石油普查工作会议的决议说[21]：

华北平原是中生代以来的下沉地带，新生代的泥沙堆积甚厚，其中可能有海相沉积和产生石油的有机质，又由于喜马拉雅运动的发生，较老的平原沉积可能曾遭受到轻微褶皱，因此，华北平原是可能产生石油的。

地质部普查委员会“关于第一次石油普查工作会议的报告”更是这样写道[34]：

华北平原冲积层的底部可能有海相沉积和轻微的褶皱以及产生石油的有机物质，近年地质工作及群众报矿都不断发现有油气苗。故华北平原底部很可能储有有工业价值的油气藏，如确属实，则其意义将异常巨大。

1956 年第二次石油普查工作会议的决议说[27]：

广阔的松辽平原的大地构造轮廓与华北平原相似，是一个晚近的下沉地带，其中堆积着很厚的新沉积。包括白垩纪地层以及第三纪和第四纪的疏松沉积，其中可能有含油岩系。

很显然，石油普查工作会议的决议所反映的正是前述谢家荣 1952 年文章的观点[6]，根本没有什么依据陆相生油理论去华北平原找油的影子。

实际上，中央档案馆藏黄汲清《对我国含油气远景分区的初步意见（提纲）》中的白纸黑字是[29]：松辽平原南部平原法库以南，海相第三纪很可能存在，值得进一步普查，北部平原南部的东部已发现海相第三纪（松花江统）。关键性问题是：（1）加紧进行物探，划分平原的构造单元，（2）配合浅钻研究中新生代地层，特别注意松花江统的海相第三纪，（3）海侵似不可能从苏联方面进侵，而是从渤海北来，因此应该在彰武一带用深浅钻证实海相第三纪的存在。

华北平原东部第一凹陷，可能有第三纪海相沉积，关键问题是 4 个，其中第 4 个是：研究有无海相第三纪沉积：首先在德州一带和汤阴、浚县以东用浅深钻追踪。江苏平原与华北平原关系。海滨沉积深度问题。

因此，前述郑明焕、周国钧同志 1979 年 5 月 4 日的信驳斥黄汲清的上书信说[33]：

“黄先生在信中还说，一九五五年，他是根据‘陆相生油理论’，建议去松辽平原找油的，可是黄先生自己提供的一九五七年三月八日的报告记录稿，却做了一个相反的回答。在这个报告里，黄先生的观点恰好相反，他认为松辽平原可能存在海相第三纪，所以才值得进行普查的。”

于是，经黄汲清“审阅定稿”出版的《对我国含油气远景分区的初步意见》便干脆将报告中的“海相第三纪很可能存在，值得进一步普查”“修正”成了“通顺易懂”的“可以存在海相第三纪，应进一步做普查工作”[30]，并且将报告中上述所有标为黑体字的部分、即所有有关海相第三系的文字（包括江苏平原的“海滨沉积深度问题”）“修正”（删除）得一干二净[30]，再也看不见了（见张立生：《正本清源 还历史本来面目--对杨丽娟关于黄汲清与中国石油普查两篇文章的质疑》图 4），以便掩盖其当年将松辽与华北平原的含油气远景与海相第三系联系在一起的史实，毁灭其 1955 年以陆相生油理论为依据提出所谓四大重点地区是谎言的证据。但历史岂是“修正”（删除）得了的？

前述竺可桢日记中“华北、华东和松辽平原能够得第三纪海相即有希望”则将黄汲清当年将华北、松辽与华东平原的含油气远景与海相第三系联系在一起的史实表述得十分的简洁与透彻。

六、陆相生油理论最早是谢家荣在 1929 年，而不是潘钟祥在 1941 年、黄汲清在 1943 年提出的。黄汲清 1943 年的 Report on Geological Investigation of Some Oil-Fields in Sinkiang（《新疆油田地质调查报告》）说的是“在新疆见到的许多石油都是非海相成因的。因为世界上许多大油田的石油都是海相成因的，还因为迄今所知陆相石油在世界石油工业中无足轻重，所以很显然，如果此非海相说得以证实的话，

那就不应过于夸大新疆各油田的远景。尽管我们可以在天山山麓带发现和开发有经济价值的重要油田，但却很难指望发现像巴库和马拉开波那样的大油田”[35] “虽然我们无意夸大新疆油田的远景，但是将来在天山山麓带和前山带及其它有利地区，很有可能发现与独山子油田同样大小或甚至更大的油田”，但“除非发现较深较好的含油层，独山子油田将只能是一个小油田。”[35]

黄汲清从 1943 年的《新疆油田地质调查报告》之后到 1955 年开展全国石油普查的十年多的时间内没有发表过一篇石油地质的文章，从 1944 年到 1977 年的 34 年间没有发表过一篇包含有陆相生油理论论述的文章。从 1955 年开始石油普查到大庆油田发现的差不多五年时间里，侯德封 [36-37]、潘钟祥 [38]，特别是谢家荣 [6-7,9 & 39-44] 发表了大量有关陆相生油的论述，但黄汲清先生没有发表过一篇包含有陆相生油论述的文章。

此外，“自大庆油田发现以后，就存在生油岩是陆相还是海相的争论，因为在含油岩系中发现了可以生活在海里的鱼类和瓣鳃类。在华北、苏北、江汉和三水等盆地的下第三系中，也发现了有孔虫等能够生活在海里的生物化石，同时还有海绿石，部分层中的化学特征（如硼含量、锶钡比）也与陆相不同，而与海相接近。因而又发生了下第三系含油层的生油岩是陆相还是海相的争论问题。”[45]。但从大庆油田发现起直到 1978 年 1 月黄汲清发出上书信止的 18 年间，既没有看到黄汲清对大庆油田的海相陆相之争发表过什么意见，也没有见到黄汲清论述过陆相生油理论问题。

但是，在经过海相陆相的长期争论，最终认为大庆油田是陆相生油之后，在当年与他一起指导石油普查的谢家荣与世长辞 11 年多和李四光逝世几近 7 年之后，黄汲清突然“想起”了他 1943 年的报告，在 1978 年 1 月的上书信中谎称是他依据陆相生油理论提出找油的四大重点地区，去松辽和华北平原找油的，并为此不惜犯大忌，去涂改其 1957 年的报告《对我国含油气远景分区的初步意见》，删除其中将我国东部平原的含油远景与海相第三系联系在一起的文字。所谓陆相生油理论指导松辽平原和华北平原石油普查抑或陆相生油理论指导大庆油田发现的说法由此产生。在中国学术界发生的那一场旷日持久的争论——地质力学理论发现大庆油田说与陆相生油理论指导发现大庆油田说之争也由此发生。黄汲清因此获得了“何梁何利优秀奖”，由此中国地质学会设立了黄汲清青年地质科学技术奖。

一位地质大师，一边口中念念有词“我只有坚持科学真理的义务，而没有容忍谎言的权力”，“我不想为个人争荣誉”，一边编造以陆相生油理论为依据，提出找油的四大重点地区的谎言，一路走来竟然取得如此光鲜亮丽的“辉煌”成绩，令人惊叹不已。而在我们屡次指出大庆油田不是在陆相生油理论指导下发现的之后 [46-49]，他们竟没有丝毫的反思与收敛，反而借纪念诞辰日的机会，在中国学术界的殿堂上集宣扬此谎言之大成，大肆鼓吹和宣扬这段虚假历史，如此下去，怎么向历史和子孙后代交代？

2024 年黄汲清诞辰 120 周年，有人借机精心策划，假非地质专业、更不了解大庆油田发现历程中的地质科学工作的年轻学者杨丽娟之笔，在《地质学报》上发表《探矿找油六十载：黄汲清与中国石油天然气的普查勘探》[19]，在《中国科学报》上发表《黄汲清院士：突破理论束缚，摘掉“中国贫油”帽子》[20]，大肆鼓吹和宣扬黄汲清以陆相生油理论指导石油普查，发现大庆油田，突破理论束缚，摘掉中国“贫油”帽子

的虚假历史，将发现大庆油田的功劳归功于黄汲清一人。为揭露这种虚假历史宣传，维护历史真相，本人撰写了《正本清源 还历史本来面目--对杨丽娟关于黄汲清与中国石油普查两篇文章的质疑》，于 2024 年 6 月投书《地质学报》编辑部。两个月后，它称《地质学报》不刊登争鸣文章，建议改投《地质论评》。8 月改投《地质论评》后，最终到 2025 年 2 月被《地质论评》编辑部以包括了对"学者"的道德评价为由封杀 [50]。文章提交至 2024 年 10 月 31 日举行的中国地质学会下属的地质学史专业委员会举行的第 32 届学术年会，竟然也被地质学史专业委员会拒绝收入会议的《论文汇编》（同期提交给《地质论评》和地质学史专业委员会第 32 届年会的另外一篇论文，也因揭露所谓黄汲清提出四大重点地区的谎言而被他们封杀、并被拒绝收入《论文汇编》）。

总之，只准州官放火，不许百姓点灯。有人要坚决维护"黄汲清以陆相生油理论指导石油普查发现大庆油田"的谎言，绝对不能让维护历史真相的文章问世。

中国地质界"百花齐放、百家争鸣"的方针何在？在中国地质学会过往 102 年的历史中何曾发生过这样的咄咄怪事？

黄汲清本是中国一代地质大师，对我国地质学的诸多领域，尤其是在大地构造学、区域地质学、生物地层学、地质制图学方面贡献卓著。他是我国二叠系研究的开拓者、中国历史大地构造学的奠基人、中国地质图类编绘事业的重要开拓者。他作为一位石油地质学家，和他曾经的师长谢家荣一道指导了 1950 年代中国的石油普查，对大庆油田的发现也有重要贡献。因此他在我国地质界曾经享有崇高的威望。他本应运用他的威望，尊重历史，实事求是，正确反映大庆油田发现历程，作科学道德的楷模。然而他却趁着当年石油普查的主要当事人谢家荣、李四光都已经过世的"大好时机"，凭借他的显赫地位，在给中央领导的上书信中弄虚作假，一手制造了依据他的陆相生油理论提出找油的四大重点地区，发现大庆油田的骗局；绝口不提当年和他一起指导石油普查的谢家荣的名字，将发现大庆油田的功劳归功于他自己，丧失了一位科学家应该具备的基本品德，突破了一个科学家的道德底线，令人极为惋惜和遗憾。正是由于他的这般操作，导致了中国学界和社会关于大庆油田发现真相旷日持久的争论，一定程度上严重地败坏了学术风气和社会风气。

真正的历史是重要的。古今中外的先贤和思想家们，对此有着很精辟的论述。以史为鉴，可知兴替。大庆油田发现历程中的地质科学工作问题，在中国地质界乃至中国学术界发生了长达半个多世纪的争论，谎言与史实的较量，叹为观止。尊重历史，还历史本来面目，是我们后辈应尽的责任。虽然黄汲清先生已经过世多年，但他弄虚作假的行为，应当予以揭露和谴责而绝不应当唱赞歌。我们应当尊重史实，还历史本来面目，而不应该像《地质论评》和地质学史专业委员会所做的那样，竭力为歪曲历史的谎言提供掩护，这违背了学术研究的真实性和严肃性。学会所属期刊与地质学史专业委员会压制不同意见，掩盖这一重大历史真相的行为同样应该受到谴责，应当引起学会领导的重视与问责，以杜绝类似事情的再次发生。期盼学会能为公开"存在于地质界的一个重大问题，即我国东部的大油田（包括大庆、胜利、大港、长庆等油田）到底是怎么发现的"的真相，还历史本来面目贡献一份力量。

祝中国地质事业在未来的岁月里蒸蒸日上，为建设社会主义的伟大祖国做出更大的贡献。

顺致

崇高的敬礼！

成都地质矿产研究所研究员、85 岁翁 张立生

2025 年 3 月 16 日（乙巳年二月十七）于成都高新西区

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Author contributions

Lisheng Zhang contributed to the data collection, compilation and interpretation and wrote the paper.

Data availability

Data sets generated during the current study and internal reports/files referenced in this paper are available from the corresponding author on reasonable request, but restrictions apply to any data used in these studies.

Declaration of competing interest

The author declares that he has no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Use of AI tools declaration

The author declares that he has not used Artificial Intelligence (AI) tools in the creation of this article.

Original Article

Is hydrogen a silver bullet in fighting climate change and recent trends in hydrogen technologies

You-Zhi Tang[1] ©

Abstract

This review article is not intended to audience that is specialized in the research and development as well as deployment of hydrogen technologies. Rather, it is for those who are in the fields of commercialization, investment and applications of new technologies, working in areas relevant to climate change and energy policies, as well as those who have a general interest in hydrogen energy. While hydrogen holds a bright future in reducing carbon emission and mitigating climate change, it is only one of the valid means among an integrated and diverse set of solutions. As part of the current effort for energy transition, hydrogen offers zero emission provided that the electricity used for generating hydrogen is from green sources. In the domain of producing green hydrogen, alkaline electrolysis (AE) currently dominates industrial applications thanks to its lower costs and reasonable efficiency, while it is expected proton exchange membrane (PEM) will pick up pace from 2030. Anion exchange membrane (AEM) is relatively new and may hopefully combine some of the advantages of both AE and AEM. However, each technology has its niche based on the application's specific requirements, such as cost sensitivity, purity needs, and operational flexibility. Producing hydrogen from biomass, including waste materials, is an area of active research and development and several technologies have been explored or under development for harnessing hydrogen from such resources. Manufacturing and applying more efficient and powerful electrolysers at lower costs is the way to go. While storing and shipping hydrogen in containers with hydrogen in a compressed gaseous or cryogenic liquified form remain the primary ways, solid-state storage of hydrogen is getting more and more attention, with metal hydrides such as MgH_2, $TiFeH_2$, $NaAlH_4$, etc. getting close to full commercial applications. Dissolving hydrogen in organic solvents or converting it into ammonia, is a direction of on-going research. With a proper way for safe and low-cost storage of hydrogen in large scale, hydrogen as an energy carrier is a great candidate for grid balance. Although hydrogen can be used as a fuel directly such as with an internal combustion engine (ICE) or gas turbine, as well as used as a chemical reagent such as a reductant in steel making or as feedstock in a variety of industrial processes, a lot of attentions is paid to the use of hydrogen with fuel cells (FC). Current focuses on FC are reducing costs, adapting to harsher working conditions, enhancing flexibility and durability, increasing fuel types, finding more applications and scaling up. It is expected that the hydrogen industry will continue to attract large capital inflows in 2025 and beyond to achieve a low-carbon transition for energy-intensive sectors. Hydrogen infrastructures are being developed all over the world, with China seemingly leading the way. Transporting hydrogen by pipeline is important for developing a hydrogen economy, and demonstration projects are currently underway in many countries.

Key words: hydrogen; a silver bullet; climate change; recent trends; hydrogen technologies; review

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1. Introduction

Climate science since its inception in the late 18th and early 19th centuries has evolved from rudimentary observations to empirical extrapolations or speculative predictions, further to a sophisticated understanding of Earth's climate systems. Today, climate science is a robust field characterized by advanced computational models, extensive datasets, and a high level of scientific consensus on climate change[1].

The IPCC's Sixth Assessment Report (AR6), highlight several critical aspects of current climate understanding, with the following two key points:

• **Global warming trends:** Average global temperatures have risen significantly, with 2020 being one of the hottest years on record. The past decade has been the warmest in the historical record[2].

• **Attribution of climate change:** There is a high level of confidence that human activities, particularly the burning of fossil fuels and deforestation, are the primary drivers of recent global warming. The IPCC AR6 report states that it is "unequivocal" that human influence has warmed the atmosphere, oceans, and land[2].

The AR6 Report further predicts the profound effects of climate change on ecosystems, human health, and economies, and calls for strategies and measures to mitigate climate change by reducing greenhouse gas emissions and adapting to its unavoidable impacts[1-2]. Transformation to renewable energy sources, enhancement in energy efficiency, and developing adaptive infrastructure are normally considered some of the most effective means and hydrogen is sometimes called the ultimate clean energy as it has zero emission of pollutants[3-4].

Hydrogen is a chemical element with an atomic number of 1 and listed as the first on the Periodic Table of Elements. Therefore, it is called the Number 1 Element. Hydrogen is also an energy carrier that will certainly make an important and decisive contribution to the global energy transition and lead to a significant reduction in greenhouse gas (GHG) emissions over the coming decades. It is estimated that 60% of GHG emission reductions in the last phase of the energy transition could come from renewables, green hydrogen and electrification based on green energy development[5].

Hydrogen can substantially contribute to global decarbonization efforts, especially in sectors difficult to electrify directly. It is considered a game-changer in fighting climate change as it possesses certain advantages with some of the examples listed below:

• **Zero emissions at point of use:** Hydrogen fuel cells emit only water, making them ideal for decarbonizing transport sectors such as heavy-duty vehicles, ships, and aircraft, where battery-electric solutions face limitations in range or payload[6].

• **Energy storage and grid balancing:** Hydrogen as a flexible energy carrier is useful for storing surplus renewable energy and providing backup power for intermittent renewable sources. Hydrogen energy storage and grid integration are becoming important technologies for efficient energy generation and decarbonization, addressing the unpredictability of renewable sources like wind and solar[7].

• **Industrial decarbonization:** It offers a viable pathway to reduce emissions from difficult-to-electrify industries such as steelmaking, chemical production, cement manufacturing and oil refinery[6]. Hydrogen can be used as fuel, feedstock and reagent in many industrial processes for decarbonization.

In the past 5 to 10 years, many governments around the world have been actively developing strategies and plans to promote hydrogen. Notably, EU published its hydrogen strategy in July

2020[8], and Australia (first in 2019 and updated in 2024)[9], Germany (first in 2020 and updated in 2023)[10], Chili (November 2020)[11], Canada in December 2020 announced their National Hydrogen Strategy[12]. Japan, South Korea, Saudi Arabia, and India are all among those having an aggressive hydrogen plan[13]. China is making remarkable progress and is emerging as a global leader in hydrogen technology and infrastructure. The country is placing significant strategic emphasis on hydrogen as part of its energy transition and decarbonization plans. Its aggressive push positions it not just to meet domestic energy transition needs but potentially to become a global hydrogen powerhouse, influencing technology standards and supply chains worldwide[13-15]. However, hydrogen should be viewed as part of an integrated and diverse set of solutions, rather than a single, ultimate solution to climate change, as there are challenges that limit the role of hydrogen:

• **Cost and fnfrastructure:** Production (in a green way), storage, transport and distribution of hydrogen is still costly, requiring substantial investments in electrolysers, infrastructure, and renewable electricity generation[13]. The lack of hydrogen refueling stations is one of the examples of stumbling blocks in hydrogen applications in the transportation sector.

• **Energy efficiency concerns:** Hydrogen production and conversion involve energy losses; thus, direct electrification may be more efficient and economically sensible for many applications[16].

• **Technology maturity and safety:** Technical challenges and safety issues around hydrogen storage and transportation remain, especially concerning large-scale adoption[17].

In general, hydrogen technology holds significant promise in the fight against climate change but cannot be considered a Silver Bullet. The term "silver bullet" normally refers to a simple and seemingly magical solution to a complex or difficult problem. The expression originates from folklore, where a silver bullet is often the only weapon that can kill a werewolf or other mythical creatures, symbolizing a direct and effortless way to end a formidable challenge. Apparently, the climate issue has far more complexity and the challenge is much more overwhelming, and there is no quick fix. Hydrogen could only be one critical component in a broader strategy that must also include renewable energy, cleaning and decarbonization of primary energy, electrification, energy efficiency, smart grid, behavioral changes, adaption, etc.

2. Major applications of hydrogen for carbon reduction

With its advantages of zero emission and high energy density, hydrogen energy is being widely used in transportation, industry, energy storage and low-altitude economy, effectively promoting the realization of carbon reduction goals.

Figure 1 provides a breakdown of the areas of hydrogen applications[18]. It includes both new and existing applications currently responsible for 60 per cent of the world’s energy- and process-related emissions.

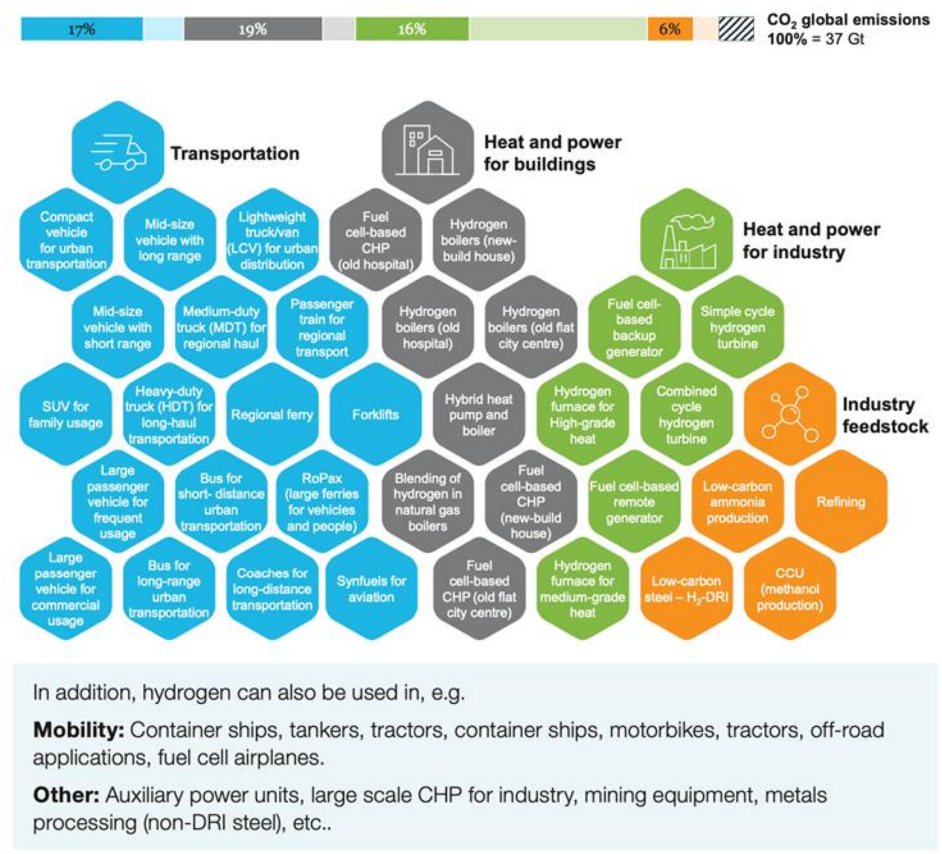

Figure 1. Overview of hydrogen applications[18]

For simplicity, our following discussion on using hydrogen for decarbonization will target on three sectors: transportation, industry, and energy storage and grid balance.

2.1 Decarbonization of the transportation sector

Hydrogen has the potential to meaningfully reduce GHG emissions in the transportation sector. It can particularly offer benefits to the heavy-duty transportation sector applications (i.e., long-haul trucks, locomotives, ships, etc.) where current battery technology might not yet be suitable for certain transportation modes (e.g., the necessary battery weight would be too substantial). Hydrogen passenger vehicles, heavy-duty freight trucks, buses, and even hydrogen trains and drones have gradually moved from demonstration to large-scale application. However, integrating fueling infrastructure for hydrogen into current local and national roadways will take some time.

2.2 Key industrial applications of hydrogen

Hydrogen is increasingly recognized as a key player in reducing carbon emissions across various industrial sectors. Its applications are diverse, from traditional roles in refining and chemical production to innovative uses in steelmaking and concrete production. The shift to low-carbon hydrogen, especially green hydrogen produced from renewable energy sources, offers significant potential to reduce industrial carbon emissions. This type of hydrogen does not produce carbon emissions at the point of use and can be integrated into existing industrial processes with minimal changes to infrastructure. Only a brief review is given in this paper on the industrial applications of hydrogen relevant to reducing carbon emission.

2.2.1 Steel making

Hydrogen can replace coal in steel making, where hydrogen is primarily being explored as a chemical reduction agent rather than just as a fuel. Traditionally, coal or coke is used in steel production to remove oxygen from iron ore, which is necessary to produce metallic iron. Hydrogen can perform this same function—when it reacts with iron oxides (FeO), it reduces them to iron metal and produces water as a byproduct instead of carbon dioxide, which is typically generated when carbon (coal/coke) is used.

The application of hydrogen as a reducing agent is a key part of creating what's termed "green steel." This process significantly reduces carbon emissions associated with steel production, aligning with global efforts to decrease industrial carbon footprints and combat climate change. This innovative use of hydrogen could transform the steel industry and contribute significantly to decarbonization efforts. *The Future of Hydrogen* well describes the use of hydrogen for reducing carbon emissions from this sector[4].

2.2.2 Cement and concrete production

Hydrogen is also being explored as a means to reduce emissions in the production of concrete. This process is traditionally very carbon-intensive due to the energy required. Using hydrogen as a part of the fuel mix can help decrease the carbon footprint of this essential building material.

2.2.3 Ammonia and methanol production

These are two of the largest industrial uses of hydrogen. Ammonia is crucial for fertilizer production, and methanol is used widely as a chemical feedstock. Both processes can benefit from using "green" hydrogen produced via renewable energy sources, reducing the carbon emissions associated with these industries.

2.2.4 Oil refining

Hydrogen is essential in refining processes, especially for removing sulfur from crude oil to make cleaner fuels. Some 38 MtH_2/yr, or 33% of the total global demand for hydrogen (in both pure and mixed forms), is consumed by refineries as feedstock, reagent and energy source[4]. Transitioning to hydrogen produced from low-carbon sources can further reduce emissions in this sector.

2.3 Energy storage and grid balance

Hydrogen can also store energy for long periods of time. As additional renewable electricity such as that wind and solar technologies is added to the grid, hydrogen could be used to help balance intermittent supply with varying demand. Being an energy storage medium, hydrogen energy can effectively absorb the surplus electricity of intermittent renewable energy, realize the decarbonization and stable operation of the power system through hydrogen energy storage technology.

2.4 Challenges and future prospects

These applications of hydrogen not only show the potential for hydrogen to significantly reduce carbon emissions but also highlight the ongoing need for investment and innovation in hydrogen technologies to make these opportunities viable at scale.

The main challenges for hydrogen use include the high costs of green hydrogen production and the need for significant infrastructure investments. However, with technological advancements and increased government and industry support, hydrogen is poised to play a crucial role in the global transition to a low-carbon economy. The report *Path to Hydrogen Competitiveness* provides a good analysis on the costs of producing, distributing and using hydrogen and the trends in reducing these costs[18].

3. Recent trends in hydrogen technologies

As more favourable policies have been promoted or are being developed in various countries, investment into this industry is increasing and the industrial chain is constantly improving. Importantly, hydrogen energy technology is gradually maturing, and it is entering into the stage of large-scale commercial application. 2025 may become the turning point for the development of the global hydrogen energy industry[13].

The hydrogen industrial chain is mainly consisted of 1) hydrogen production by various means; 2) hydrogen storage, transportation and distribution; and 3) hydrogen utilization / end uses. Figure 2 is an illustration covering the whole hydrogen value chain from production to application[19].

From the viewpoints of the industry and investment community, the current hydrogen energy technology and market progress are mainly manifested in the following aspects.

3.1 Production (green, blue, grey, turquoise hydrogen)

There are different ways to produce hydrogen. Examples include production from renewable energies through electrolysis of water, steam reforming of biomethane and pyrolysis of biogenic feedstocks (green hydrogen) and natural gas through steam reforming with (blue hydrogen) and without (grey hydrogen) the sequestration and storage of CO_2 by CCUS - Carbon Capture, Utilization and Storage[20].

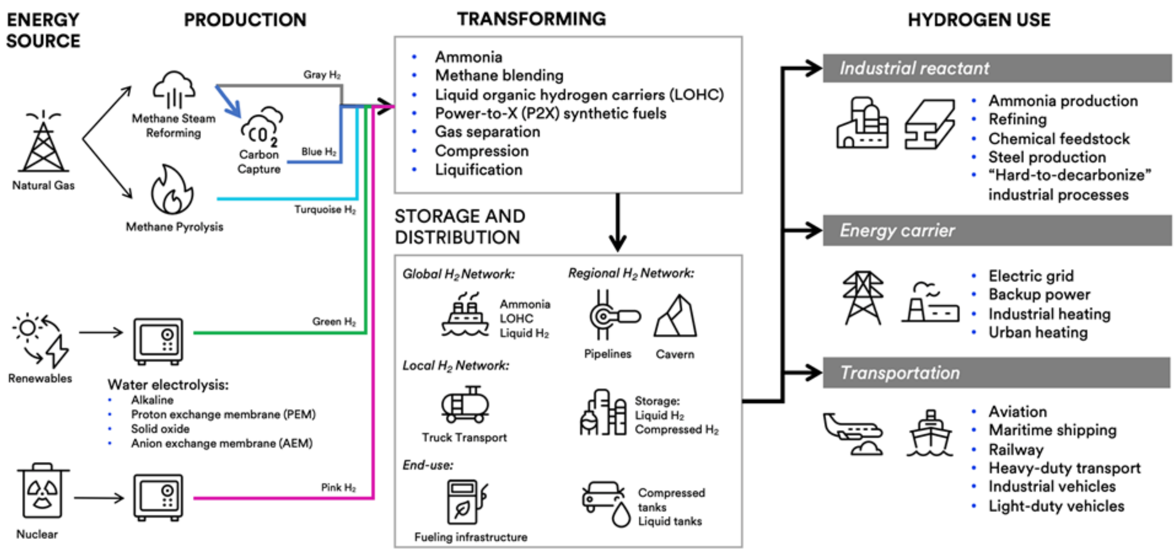

Figure 2. Hydrogen value chain[19]

According to Singh[21], around 92% of hydrogen (by value) in 2022 was grey hydrogen, underlining global dependence on this carbon-intensive production process. It was expected by 2035 low to zero-carbon emitting blue and green hydrogen are to pick up pace and comprise about 22% of total hydrogen production.

It is obviously and necessarily that green hydrogen needs to gradually replace grey hydrogen (hydrogen produced from fossil fuels without removing CO_2). While the concept of making hydrogen from water by electrolysis has long been known, recent breakthroughs have been made in electrolysis efficiency, scale and cost control. In 2025, the market demand is trending towards higher power electrolysers, and the requirements for the electro-hydrogen coupling performance of products will be significantly increased[15].

In this review, discussion on the production of hydrogen from natural gas or methane by means of steam reforming[22] and other ways of producing grey and blue hydrogen is not included. Rather, we will focus on green hydrogen production.

3.1.1 Electrolysis for green hydrogen production

Recent advancements in hydrogen production technologies, particularly the two conventional means, i.e. Alkaline Electrolysis (AE) and Proton Exchange Membrane (PEM) electrolysis, have focused on improving efficiency, reducing costs, and scaling up production to meet the growing demand for green hydrogen[15].

- **Alkaline electrolysis (AE):** Alkaline electrolysis is a very well-established technology that uses two electrodes separated by a porous diaphragm and a liquid alkaline solution as the electrolyte[23-24]. The electrolyte solution allows hydroxide ions (OH-) to be transported from the cathode to the anode with hydrogen being generated on the cathode side and oxygen produced on the anode.

The concept has been known for a long time, and many readers might have done such an experiment in a high school lab. In fact, AE systems have been commercially available for many years. This technology is considered as extremely efficient, reliable, and cost-effective. Capacity can stack in the MW range but drawbacks include using corrosive liquid electrolytes, operation at low current densities and low pressures as well as gas crossover. Traditional alkaline electrolysers operate with efficiencies from 70% to 75%, with about 25% of the renewable energy for producing green hydrogen wasted.

- **Proton exchange membrane (PEM) electrolysis:** PEM electrolysis[23-24] uses pure water and a solid polymer electrolyte instead of a liquid solution. The electricity splits the water into hydrogen and oxygen. Hydrogen protons pass through the membrane, combining with electrons to form H2 gas on the cathode side.

  PEM electrolysers are well suited for use with volatile renewable energy sources thanks to their fast ramp-up/down capabilities and their wide dynamic operating range. No corrosive electrolyte is involved, and they operate at high current density which speeds up the breakdown of the water molecule, ultimately affecting production price. Finally, a small footprint and compact system design is a benefit for many on-site industrial applications.

- **Anion exchange membrane (AEM):** AEM electrolysis is an emerging technology for hydrogen production that utilizes a semipermeable membrane to conduct hydroxide ions (OH^-), facilitating the electrolysis of water into hydrogen and oxygen gases[25]. This method offers several advantages over traditional electrolysis techniques:

  - Cost-effective catalysts: Unlike Proton Exchange Membrane (PEM) electrolysis, which requires expensive noble metal catalysts like platinum and iridium, AEM electrolysis operates in an alkaline environment. This allows for the use of more abundant and affordable transition metal catalysts such as nickel, iron, cobalt, manganese, and copper.
  - Mild operating conditions: AEM electrolysis can function using pure water or mildly alkaline solutions (0.1–1M KOH/NaOH), reducing the risks associated with handling highly concentrated alkaline solutions required in traditional alkaline water electrolysis.
  - Reduced gas crossover: The membrane's selective ion conductivity minimizes the mixing of hydrogen and oxygen gases, enhancing both the efficiency and safety of the electrolysis process.

  While AEM electrolysis presents significant advantages, challenges such as membrane durability and ionic conductivity remain. Ongoing research focuses on enhancing membrane stability at higher temperatures and in alkaline environments to extend the operational lifespan of AEM electrolysers. Continued advancements in this field are expected to further reduce costs and improve the efficiency of green hydrogen production, contributing to global decarbonization efforts.

Overall comparison of AE, PEM and AEM: When comparing the advantages and disadvantages of Alkaline Electrolysis (AE), Proton Exchange Membrane (PEM), and Anion Exchange Membrane (AEM) methods for green hydrogen production, several key factors like cost, efficiency, operational requirements, and application suitability come into play (Table 1)[26-27].

Table 1 reflects general trends and performance metrics which can vary based on specific technological advancements and manufacturer-specific designs. Each technology has its niche based on the application's specific requirements, such as cost sensitivity, purity needs, and operational flexibility. However, AE will remain the dominant technology probably until 2030 due to its lower cost, and new technologies may pick pace from 2030.

Table 1. Comparison of AE, PEM and AEM

Feature	Alkaline Electrolysis (AE)	Proton Exchange Membrane (PEM)	Anion Exchange Membrane (AEM)
Cost of Equipment	Lower due to less expensive materials	Higher due to precious metal catalysts	Moderately low, uses cheaper materials
Operational Costs	Higher due to corrosion issues	Higher due to need for pure water	Lower than PEM, higher than AE
Efficiency	Moderate	High	Lower than PEM, but improving
Hydrogen Purity	High	Very high, suitable for sensitive applications	Lower than PEM, may not suit all applications
Ease of Use	Good, but handling of caustic electrolytes	Best, with rapid response to power changes	Good, less sensitive to impurities
Maturity	Most mature, widely used commercially	Commercially established, but less than AE	Emerging, with ongoing development
Durability	Good, but can be affected by corrosion	Lower due to membrane and catalyst degradation	Potentially better than PEM
Integration with Renewables	Moderate, less responsive to power fluctuations	Excellent, can handle rapid fluctuations	Good, improving with technology

3.1.2 Other emerging hydrogen production technologies

Producing hydrogen from biomass, including waste materials like garbage, is an area of active research and development, offering a sustainable alternative to fossil fuel-based hydrogen production. Several technologies have been explored to harness hydrogen from such resources.

- **Gasification:** Gasification involves thermochemically converting organic materials, such as biomass or municipal solid waste, into synthesis gas (syngas), a mixture primarily composed of hydrogen, carbon monoxide, and carbon dioxide. This process occurs at high temperatures (typically above 700 °C) in an oxygen-limited environment. The resulting syngas can be further processed to separate hydrogen for use as a clean fuel or chemical feedstock. For example, Sierra Energy has developed the FastOx gasifier[28], which can convert nearly any type of waste into syngas without producing ash or other contaminants that need to be landfilled. This system operates at extremely high temperatures (around 2000 °C) and is modular, allowing for scalability.

- **Microbial electrolysis cells (MECs):** MECs utilize electrogenic microorganisms to decompose organic matter, releasing electrons and protons. By applying a small external voltage, these protons are reduced to form hydrogen gas[29]. This bioelectrochemical approach allows for the conversion of waste biomass into hydrogen with higher energy efficiency compared to traditional water electrolysis. The efficiency of hydrogen production depends on the organic substrates used, with lactic and acetic acid achieving efficiencies of up to 82%.

- **Photofermentation:** Certain photosynthetic bacteria can convert organic substrates into hydrogen through photofermentation, a process that requires light[30]. For instance, the bacterium *Rhodobacter sphaeroides* can transform small molecular fatty acids into hydrogen. This method leverages the metabolic pathways of these bacteria to produce hydrogen under illuminated conditions.

- **Plasmalysis:** Plasmalysis employs plasma technology to dissociate compounds like methane or wastewater into hydrogen and other byproducts[31]. For example, methane plasmalysis can efficiently produce hydrogen and elemental carbon without emitting carbon dioxide. Similarly, wastewater plasmalysis can recover hydrogen from pollutants such as ammonium or hydrocarbon compounds, simultaneously purifying the wastewater.

- **Turquoise hydrogen production:** Turquoise hydrogen refers to hydrogen produced through methane pyrolysis, a process that thermally decomposes methane (the primary component of natural gas) into hydrogen gas and solid carbon without emitting carbon dioxide (CO_2)[32].

  In methane pyrolysis, methane (CH_4) is subjected to high temperatures, typically around 900 °C, in the absence of oxygen. This thermal decomposition yields hydrogen gas (H_2) and solid carbon (C):

  $CH_4 \rightarrow C + 2H_2$

  The solid carbon byproduct can be utilized in various industrial applications, such as manufacturing carbon black, which is used in products like tires, inks, and batteries.

  Turquoise hydrogen production is considered environmentally favorable because it avoids CO_2 emissions associated with traditional hydrogen production methods, such as steam methane reforming. Additionally, the solid carbon produced can serve as a valuable industrial commodity, potentially offsetting production costs.

  Several companies are advancing methane pyrolysis technologies to scale turquoise hydrogen production. However, challenges remain, including achieving energy efficiency, managing the solid carbon byproduct, and integrating renewable energy sources to heat the reactors.

In summary, turquoise hydrogen presents a promising pathway for low-emission hydrogen production, leveraging existing natural gas infrastructure while minimizing greenhouse gas emissions.

3.2 Advances in hydrogen storage and distribution

Traditionally, hydrogen is stored in compressed gaseous form in tanks or cylinders, or in a cryogenic liquified form. As hydrogen is very light, the former way requires very high pressure and / or a large volume. It is therefore bulky and less safe for storage and transportation. The latter means requires freezing hydrogen to -253 °C and keeping it at this extremely low temperature, creating challenges for handling[33].

Advancements in materials and methods led to some new technologies in hydrogen storage. This article will not discuss the two conventional ways for hydrogen storage, i.e. in compressed gaseous and cryogenic liquified forms, and will try to look into the relatively new means for storage.

3.2.1 Solid-state storage of hydrogen

Solid-state hydrogen storage technologies have been the focus of extensive research due to their potential to safely and efficiently store hydrogen for various applications[34-35]. These technologies primarily involve the absorption or adsorption of hydrogen onto or into solid materials, offering advantages over conventional gas or liquid storage methods. Followed is an overview of the key solid-state hydrogen storage technologies.

- **Metal hydrides**

Metal hydrides are compounds formed by the reaction of hydrogen with metals, resulting in materials capable of reversibly storing hydrogen[36]. They are categorized into three main classes:

  - **Intermetallic hydrides:** These hydrides, such as $LaNi_5H_6$ and $TiFeH_2$, exhibit fast kinetics and moderate hydrogen storage capacities. They are often used in stationary storage and fuel cell applications.
  - **Complex hydrides:** Examples include sodium alanate ($NaAlH_4$) and lithium borohydride ($LiBH_4$), which offer higher hydrogen storage capacities but typically require catalysts to facilitate hydrogen release.
  - **Lightweight hydrides:** Materials like magnesium hydride (MgH_2) provide high gravimetric hydrogen storage but require high temperatures for hydrogen desorption. For instance, MgH_2 contains 7.6 wt% hydrogen but requires temperatures above 300 °C for hydrogen release.

Magnesium hydride has garnered attention due to its high hydrogen storage capacity (7.6 wt% theoretically). However, its practical application is limited by the high desorption temperature required to release hydrogen. Research efforts are focused on reducing this temperature through methods such as nanostructuring and doping with catalysts. For example, nano-engineered Mg-Ti-V composites have demonstrated reduced desorption temperatures, enhancing their suitability for fuel cell vehicles.

Alanates, such as lithium alanate ($LiAlH_4$) and sodium alanate ($NaAlH_4$), are complex hydrides that have been extensively studied for hydrogen storage. $LiAlH_4$, for instance, has a theoretical hydrogen capacity of 10.5 wt% and undergoes dehydrogenation in multiple steps. While these materials offer high hydrogen content, challenges remain in achieving practical desorption temperatures and kinetics. Strategies like ball-milling and catalyst addition have been employed to enhance their performance.

Palladium can absorb hydrogen at room temperature, forming palladium hydride (PdH_x). This material can absorb up to 900 times its own volume of hydrogen, making it a subject of interest for hydrogen storage. However, the high cost of palladium limits its widespread application.

Sodium silicide (NaSi) reacts exothermically with water to produce hydrogen gas and sodium silicate. This reaction has been utilized in hydrogen generation technologies, offering a method for on-demand hydrogen production. However, practical challenges, such as handling and reaction control, need to be addressed for widespread application.

Hydrogen spillover refers to the migration of dissociated hydrogen atoms from a metal catalyst to a support material, enhancing hydrogen storage in materials like metal-organic frameworks (MOFs) and carbon-based materials. This mechanism has been explored to improve the hydrogen storage capacity of various materials, although the exact mechanisms and efficiency are subjects of further research.

In summary, solid-state hydrogen storage technologies encompass a variety of materials and mechanisms, each with its own set of advantages and challenges. Ongoing research aims to optimize these materials to achieve practical hydrogen storage solutions suitable for various applications.

3.2.2 Others

• **Formic acid as a hydrogen carrier:** Formic acid has been established as an effective hydrogen storage medium[37]. Its liquid state at room temperature and non-toxic properties makes it ideal for safe storage and transportation.

• **Mechanochemical storage solutions:** Innovations in mechanochemical processes have led to the development of hydrogen storage using readily available salts. This method offers a potential solution to the challenges of hydrogen storage, providing a safe and efficient means of storing hydrogen in powder form[38].

• **Advancements in LOHC technology:** Liquid organic hydrogen carriers (LOHCs) are organic compounds that can absorb and release hydrogen through chemical reactions, serving as storage media for hydrogen[39]. In 2020, Japan established the world’s first international hydrogen supply chain between Brunei and Kawasaki City utilizing toluene-based LOHC technology. Additionally, Hyundai Motor has invested in developing stationary and on-board LOHC systems, indicating a growing interest in this storage method.

• **Ammonia:** Ammonia has long been a chemical associated with hydrogen. It is in the recent years viewed as a viable option for hydrogen storage and transport, especially for long-distance transport where direct hydrogen methods face challenges[40]. However, the overall sustainability and efficiency of using ammonia as a hydrogen carrier depend on overcoming the challenges associated with its production, handling, and dissociation. Ammonia as a hydrogen-rich molecule is also finding direct applications as a fuel or precursory material of hydrogen in some scenarios of hydrogen utilization. These topics seem worthy of a separate article to discuss.

3.2.3 Transporting hydrogen by pipeline

In addition to transporting/shipping hydrogen in a storage tank, either as compressed gas, liquid, solid-state or in one of the forms discussed in the previous section, use of pipeline offers the best economy for large scale and lang-range transport of hydrogen[41-42].

Currently, transporting hydrogen via pipeline is an evolving area in the field of energy infrastructure, with developments primarily aimed at creating a more sustainable and efficient energy system. Here are some key updates on the progress:

- **Infrastructure conversion and expansion:** Some existing natural gas pipelines are being tested and modified to transport hydrogen. This includes blending hydrogen with natural gas to leverage existing infrastructure while reducing carbon emissions. In Europe, for instance, several projects are underway to test the feasibility of converting natural gas pipelines to hydrogen[43]. China's Hydrogen into Ten Thousand Homes project is another good example[44].
- **Dedicated hydrogen pipelines:** New projects are also focusing on building dedicated hydrogen pipelines, especially in regions heavily invested in hydrogen as a key part of their energy transition. For example, the European Hydrogen Backbone (EHB) proposes a hydrogen network spanning several countries, aimed to be operational by 2040[45].
- **Technological and material advances:** Research continues into improving the materials used in pipelines to handle hydrogen's unique properties, such as its propensity to cause embrittlement in traditional steel and welds. New alloys and composite materials are being developed to improve safety and efficiency.
- **Regulatory and safety standards:** There is ongoing development in regulatory frameworks to ensure safety, efficiency, and interoperability of hydrogen transport via pipelines. This includes setting standards for purity, pressure, and mixture ratios when blended with natural gas.
- **Economic and policy support:** Governments in potential hydrogen hubs like the European Union, Australia, and parts of the US are supporting these initiatives through subsidies and policy frameworks to encourage investment in hydrogen infrastructure.

These efforts are part of a broader strategy to integrate hydrogen as a major component of a low-carbon energy system, facilitating large-scale storage and distribution of renewable energy.

3.3 Fuel cell advancements and cost-reduction trends

Hydrogen fuel cell technology has seen considerable progress in recent years, driven by both industry and academia seeking cleaner and more efficient power generation. It has further matured, and the performance, reliability, and durability have been significantly improved, leading to the rapid expansion of hydrogen energy vehicles and commercial applications[46]. Below are some key areas of advancement and notable trends.

3.3.1 Improved catalysts and reduced platinum usage

- Lower platinum-group metals (PGM) content: One of the main cost drivers of Proton Exchange Membrane (PEM) fuel cells is the platinum catalyst. Research efforts have focused on reducing or even replacing platinum—through alloyed catalysts (e.g., platinum-cobalt) or entirely platinum-free options (e.g., iron-nitrogen-carbon catalysts) - to lower costs and increase production feasibility[47].
- **Durability enhancements:** New catalyst formulations are engineered to be more resistant to oxidation and degradation, extending the overall lifetime of the cell and improving performance under a wide range of operating conditions[48].

3.3.2 Advances in membrane and materials science

- **High-temperature PEM fuel cells:** Traditional PEM cells operate efficiently in the 60–80 °C range. New high-temperature PEM fuel cells (operating up to ~120 °C) improve tolerance to carbon monoxide (CO) and reduce the complexity of cooling systems[49].
- **Ion-exchange membranes:** Ongoing development of membranes that offer higher proton conductivity at lower humidity helps maintain performance even in challenging environments. Improved polymers (such as perfluorinated sulfonic acids with modified structures) increase both efficiency and durability[50].

3.3.3 Solid oxide fuel cells (SOFCs) gains

- **Lower-temperature SOFCs:** While SOFCs typically operate at 600-1000 °C, there is a push to develop "intermediate" temperature versions (~500-700 °C). These lower operating temperatures reduce thermal stress, allow for cheaper materials, and facilitate faster start-up times[51].
- **Flexible fuel options:** SOFCs can use various fuels—natural gas, biogas, hydrogen, or even ammonia-making them attractive for stationary power applications. Recent demonstrations have shown robust operation on ammonia, a potential carbon-free fuel for shipping or backup power[15, 52-53].

3.3.4 Scale-up and manufacturing innovations

- **Mass production of PEM stacks:** Automotive manufacturers (e.g., Toyota, Hyundai) continue to refine production lines to produce fuel cell stacks at higher volumes and lower cost. Standardized designs and automated processes are lowering the per-kilowatt cost[15 & 54].
- **Modular and compact systems:** Companies are introducing smaller, more modular PEM fuel cell units aimed at logistics applications (like forklifts, warehouse vehicles) and at backup-power markets for data centers and telecommunications15.While SOFCs typically operate at 600-1000 °C, there is a push

3.3.5 Market expansion to heavier transport and infrastructure

- **Trucks and buses:** Fuel cell electric trucks and buses are increasingly on the roads in Asia, Europe, and North America. Improved cell performance and hydrogen storage systems are helping address driving-range and refueling-time constraints[55].
- **Maritime trial:** Projects exploring hydrogen or ammonia fuel cells for ships and ferries, especially for short-sea shipping or inland waterways, are ongoing. Zero-emission vessels are being designed around solid oxide or PEM-based powertrains[15 & 56].
- **Aviation trial:** While batteries dominate small electric aircraft, companies are experimenting with hydrogen fuel cell powertrains for regional aircraft, with the aim of balancing weight, range, and refueling considerations[15 & 57].

3.3.6 Hydrogen infrastructure and policy support

- **Green hydrogen boom:** Rapid expansion of electrolyser capacity (for green hydrogen generation) and policies supporting hydrogen infrastructure bolster fuel cell deployment in both mobility and stationary power[8-13, 34 & 45].
- **Refueling infrastructure growth:** Countries like China, Germany, Japan, the U.S., and South Korea are investing heavily in hydrogen stations to support fuel cell electric vehicles - pushing technological improvements in hydrogen compression, storage, and dispensing[6,18 & 58].

3.3.7 Digital optimization and system integration

- **Real-time monitoring and control:** Advances in sensors and data analytics help optimize fuel cell operation. Software-based "virtual sensors" and digital twins improve performance predictability, system longevity, and maintenance scheduling[15].
- **Hybrid systems:** Fuel cells are increasingly being paired with battery systems to balance peak loads, handle transient power demands, and optimize overall efficiency. Such hybrid configurations are now common in bus fleets and certain industrial applications[59].

In summary, recent fuel cell technology developments revolve around reducing material costs (particularly platinum), improving durability, scaling manufacturing, and adapting to new fuels (like ammonia). Policy momentum toward decarbonization and green hydrogen production is accelerating fuel cell adoption in both transportation (trucks, buses, ships, and potentially aircraft) and stationary power (backup power, microgrids). As more countries commit to hydrogen infrastructure, we can expect further cost reductions, performance gains, and commercial deployments in the near future.

3.4 Hydrogen infrastructure

The construction of hydrogen refueling stations, hydrogen pipelines, hydrogen storage facilities and other infrastructure has been accelerated, effectively solving the bottleneck of hydrogen energy utilization. China's boom in the promotion of hydrogen fuel cell vehicles is generating increasing demand for hydrogen refueling stations (HRS), which has resulted in them being included in government plans and regulations. According to Interact Analysis, 30 provinces and municipal cities across China issued government policies and plans covering the development of HRS. Of these, 29 local governments outlined 2025 targets for the construction of HRS, totaling more than 1,200 sites, which is more than the current global total[60].

Also, China's "Hydrogen into Ten Thousand Homes" project has achieved remarkable progress. It is a significant national project designed to integrate hydrogen energy into daily life and industrial use across the country. The initiative, launched by China's Ministry of Science and Technology in collaboration with the Shandong provincial government, aims to demonstrate the comprehensive use of hydrogen energy in industrial parks, community buildings, and transportation systems, thereby fostering a hydrogen-powered society[44].

A key component of this initiative involves blending hydrogen with natural gas to supply energy via pipelines to residential, commercial, and industrial users. This showcases the versatility of hydrogen as an alternative energy source that can be integrated into existing energy infrastructures. The initiative also includes the construction of hydrogen fueling stations, such as the one built by Air Products in Shandong Province, which supports the refueling of buses and trucks and signifies a move towards green transportation solutions[61].

Hygreen Energy, a global leader in hydrogen technology and electrolyser manufacturing, has announced the successful delivery of a 25-megawatt electrolyser system to Huadian Weifang Power Generation Co., Ltd., comprising five 5-megawatt electrolyser stacks, each capable of producing high-purity hydrogen at 99.999% levels. This marks the largest hydrogen production initiative in the region to date. The system represents a significant step in scaling up hydrogen production and integrating green hydrogen into power and industrial applications[62].

The project underscores China's commitment to reducing carbon emissions and promoting renewable energy use, aligning with the country's broader environmental goals, including the 14th Five-Year Plan and the '30•60' decarbonization targets, i.e. carbon emission peaking by 2030 and reaching carbon neutral by 2060. The integration of hydrogen technologies in Shandong, recognized for its strategic hydrogen roadmap and development plan, exemplifies the region's leading role in hydrogen energy innovation within China[44].

4. Discussion

In the area of green hydrogen production, AE and PEM remain the major tools while AEM is emerging. R&D and innovation of other means for producing hydrogen from organic matter is current underway with promising results. Larger and more efficient electrolysers and better coupling with renewable energy will lower the cost of green hydrogen.

Storage and transport of hydrogen seems to present more challenges to the industry, but new developments in solid-state storage using metal hydride as well as progress in hydrogen pipelines provide encouragements to the hydrogen community.

Fuel cell technologies are improving steadily and finding more and more scenarios of applications.

In the author's opinion, the hydrogen industry is turning matured particularly in producing and utilizing hydrogen, while in the areas of storage and transportation/shipping of hydrogen more improvements and innovations are required.

In the eyes of the investment community, hydrogen energy is an important strategic investment area in the global energy transition, and the market potential is huge. KPMG's Energy Transition Investment Outlook notes that hydrogen technology has become one of the key areas attracting large amounts of capital[13]. With policy promotion and technological maturity, it is expected that the hydrogen industry will continue to attract large capital inflows in 2025 and beyond to achieve a low-carbon transition for energy-intensive enterprises.

Despite the rapid development of the hydrogen energy industry, it still faces many challenges such as cost control, technological competition, and fierce market competition. In the future, the hydrogen energy industry needs to further reduce the cost of hydrogen production, improve the reliability and safety of technology, build a reasonable business model, and truly achieve stable growth and long-term sustainable development of commercial scale.

6. Conclusions

As an important path for energy transition and carbon reduction, hydrogen energy technology has made remarkable technological progress, expanded application scenarios, and continued to grow the industry and market scale. However, it also faces many challenges in terms of technology, cost and market. The industry and investment institutions are actively participating in the layout, and the prospects of the hydrogen energy industry are worth looking forward to. Before artificial, controlled nuclear fusion for power generation becomes a commercial reality, hydrogen remains a strong option in our package for energy transition and combating climate change.

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Data availability

The data that support the findings of this study is available from the author upon reasonable request.

Declaration of competing interest

The author declares that he has no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Use of AI tools declaration

The author declares that he has not used Artificial Intelligence (AI) tools in the creation of this article.

Original Article

Correct the source and restore the original appearance of history

——Questions about Lijuan Yang's two articles on T. K. Huang and China petroleum exploration

Lisheng Zhang [1] ©

Abstract

Lijuan Yang’s two papers on T. K. Huang and oil-gas reconnaissance in China during the 1950s acknowledge the theory of continental origin of petroleum, which was proposed by Zhongxiang Pan in 1941 and T. K. Huang in 1943. Yang asserts that the *Report on Geological Investigation of Some Oil-Fields in Sinkiang* established the concept that "oil generated in continental strata could form economically significant oil fields."Yang argued that T. K. Huang confidently suggested that the Songliao and North China continental basins could form large oil fields. Yang emphasized that T. K. Huang's assertion that "Mesozoic and Cenozoic large continental basins are the primary targets for oil exploration," particularly focusing on four promising areas: Sichuan, Ordos, Songliao, and North China basins. According to Yang, the theory of continental origin of petroleum served as the theoretical foundation for Songliao and North China oil exploration. Yang attributed the discovery of the Daqing oilfield primarily to T. K. Huang and claimed that T. K. Huang surpassed theoretical limitations and challenged the notion that China was oil-poor. However, these assertions contradict historical facts.

Keywords: T. K. Huang; Daqing oilfield; theory of continental origin of petroleum; theoretical basis; four key areas searching for oil; be completely at odds with historical facts

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正本清源 还历史本来面目

——对杨丽娟关于黄汲清与中国石油普查两篇文章的质疑

张立生

摘 要

杨丽娟博士关于黄汲清与中国石油天然气普查勘探的两篇论文认定陆相生油论是潘钟祥在1941 年和黄汲清在 1943 年首先提出的，说黄汲清 *Report on Geological Investigation of Some Oil-Fields in Sinkiang* 认为陆相生油"可以形成具有重大经济价值的油田"，称黄汲清大胆设想"松辽和华北陆相盆地也可以形成大油田"。杨文还称黄汲清强调"中新生代大型盆地是主要的找油对象"，"在各大盆地的石油普查中，黄汲清特别关注四川、鄂尔多斯、松辽、华北四大盆地"4 个最有远景的地区，陆相生油理论是松辽、华北石油普查的理论基础。杨文将从松辽平原石油地质踏勘到大庆油田发现历程中的地质科学工作主要归功于黄汲清，宣称黄汲清突破理论束缚，摘掉了"中国贫油'帽子"。事实上，所有这些都完全违背了历史事实。

关键词: 黄汲清；大庆油田； 陆相生油论； 理论基础；陆相盆地；四大重点地区；违背历史事实

关于本文：本文为"老科学家学术成长资料采集工程●谢家荣学术成长资料采集"项目的部分成果（项目编号：2013-K-Q-XH07）。本文在作者于 2024 年 10 月提交给中国地质学会地质学史专业委员会第 32 届年会的同名论文基础上修改而成。

作者简介：张立生，男，1940 年生。原国土资源部成都地质矿产研究所研究员，1966 年中国地质科学院矿床学研究生毕业，长期从事矿床地质、地球化学和地质学史研究。

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1. 前言

大庆油田发现真相的争论已经持续几十年了。

这几十年争论的焦点集中在两个问题上：一是大庆油田是否是按照李四光的地质力学理论"到新华夏构造体系的坳陷带找油"发现的？二是大庆油田是否是在陆相生油理论的指导下进行工作而发现的？

作者 2010 年依据当年公开发表的文字和中央档案馆的原始档案资料，否定了按照李四光"到新华夏构造体系的坳陷带找油"发现大庆油田的说法 [1]。在此前后，作者还用大量资料论证了大庆油田不是在陆相生油理论的指导下发现的 [2-4]。

但是，人们假装没有看见已经披露的大量史料，采取"你说你的，我说我的"方针，或者继续宣扬地质力学理论发现大庆油田，或者继续宣称陆相生油理论指导石油普查发现大庆油田。前者的代表有《大庆油田发现真相: 中国独创理论不容抹杀》[5] 和三卷集的《中国地质科学发展史》[6]，后者的代表则有《从天山之麓到松花江畔》[7] 和杨丽娟 2004 年的两篇文章 [8-9]。

2024 年，为纪念黄汲清先生诞辰 120 周年，杨丽娟博士于 3 月和 4 月，先后在《地质学报》和《中国科学报》上发表《探矿找油六十载：黄汲清与中国石油天然气的普查勘探》[8] 和《黄汲清院士：突破理论束缚，摘掉"中国贫油"帽子》[9]（以下简称杨文）。两篇文章认为：1、陆相生油论是潘钟祥和黄汲清在 1940 年代提出的；2、黄汲清 1943 年的 *Report on Geological Investigation of Some Oil-Fields in Sinkiang*[10] 认为陆相生油可以形成"有重大经济价值的油田"；3、黄汲清"大胆"设想松辽和华北陆相盆地也可以形成大油田；4、黄汲清特别关注松辽、华北、四川、鄂尔多斯这 4 个"最有远景的地区"；5、陆相生油论是指导松辽、华北石油普查的理论基础；6、黄汲清强调"中新生代大型盆地是主要的找油对象"。杨文还这样叙述大庆油田的发现历程：黄汲清作为普委的技术负责人，授意苏云山起草"松辽平原石油地质踏设计及任务书"并亲自修改……松基三井喷出大量原油，大庆油田宣告发现。因此，杨文认为：是黄汲清突破理论束缚，摘掉了"中国贫油"的帽子。

本文就杨文上述内容提出质疑，以正本清源，还历史本来面目。

2. 对杨文中陆相生油论最早提出者的质疑

杨文认为，"陆相生油论应分别为潘钟祥和黄汲清等独立提出"[8]。这不是真实的历史。

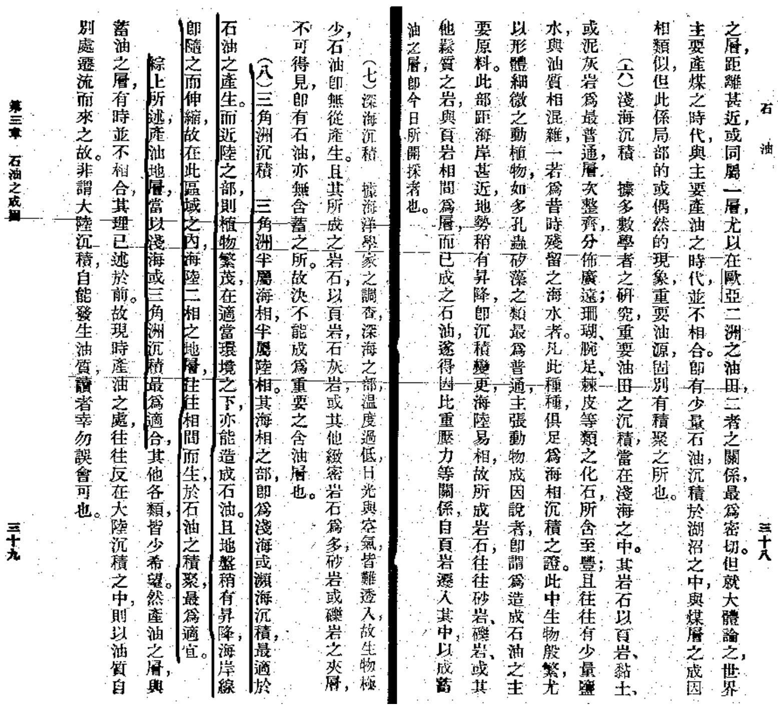
中国地质学家中最先指出中国西北的陆相地层中有石油生成的当为翁文灏 [11-12]，其次有谢家荣 [13-16]、王竹泉和潘钟祥 [17]。

但中国最早的陆相生油论出自谢家荣笔下 [3,18]。胡社荣指出："在我国目前所出版的一些书（包括百卷本中国全史）或文章中，作者们普遍认为，中国陆相生油理论为潘钟祥、黄汲清两位先生率先提出，甚至是黄汲清提出。根据目前的资料，这种说法很有值得商榷的地方。"[18]。他进而明确指出，如果说"翁文灏对唯海相生油论提出了疑问，还不足以说明陆相生油理论已经明确提出的话，那么谢家荣的论述，应该说是非常明确、丝毫无差的了。"胡社荣大段引用了谢家荣在《石油》一书中关于内陆湖沼相、沼泽相

和近海三角洲相能够生成石油的论述后指出：“因此，我们说，我国学者在 1934 年已经提出了陆相生油论”[18]。“至少我们可以得出，在中国，明确提出陆相地层能够生油观点的，是谢家荣，而不是目前许多文章、书上所描写的那样 [18]。

需要指出的是，胡社荣所引用的是谢家荣 1934 年版的《石油》，现在我们已经找到了谢家荣 1929 年版的《石油》。经核对，这两个版本的《石油》的内容是完全一样的。因此，应该说，早在 1929 年，谢家荣就已经从理论上论述了陆相地层生油的问题。所谓中国陆相生油论是黄汲清、潘钟祥率先提出的说法是不对的。他们的陆相生油论文章，出现在谢家荣陆相生油论之后十年还多。

必须指出的是，谢家荣 1929 年的《石油》不仅明确指出陆相地层能够生油，而且将浅海相与三角洲相相提并论，明确指出二者为最适合产油的地层（图 1）[14]：“三角洲半属海相，半属陆相。其海相之部，即为浅海或濒海沉积，最适合于石油之产生。而近陆之部，则植物繁茂，在适当环境之下，亦能造成石油。且地盘稍有升降，海岸线即随之而伸缩，故在此区域之内，海陆二相之地层，往往相间而生，于石油之积聚，最为适宜。”……“综上所述，产油地层，当以浅海或三角洲沉积最为适合。”


石油　三十八

之層，距離甚近，或同屬一層，尤以在歐亞二洲之油田，二者之關係，最爲密切。但就大體論之，世界主要產煤之時代，與主要產油之時代，並不相合。卽有少量石油，沉積於湖沼之中，與煤層之成因相類似，但此係局部的或偶然的現象，重要油源，固別有積聚之所也。

（六）淺海沉積　據多數學者之研究，重要油田之沉積，當在淺海之中。其岩石以頁岩、黏土、或泥灰岩爲最普通，層次整齊，分佈廣遠；珊瑚、腕足、棘皮等類之化石，所含至豐；且往往有少量鹽水，與油質相混雜，一若爲昔時殘留之海水者。凡此種種，俱足爲海相沉積之證。此中生物殷繁，尤以形體細微之動植物，如多孔蟲矽藻之類最爲普通，主張動物成因說者，卽謂爲造成石油之主要原料。此部距海岸甚近，地勢稍有昇降，卽沉積變更，海陸易相，故所成岩石，往往砂岩、礫岩、或其他鬆質之岩，與頁岩相間爲層，而已成之石油，遂得因比重壓力等關係，自頁岩遷入其中，以成蓄油之層，卽今日所開採者也。

（七）深海沉積　據海洋學家之調查，深海之部，溫度過低，日光與空氣，皆難透入，故生物極少，石油卽無從產生。且其所成之岩石，以頁岩、石灰岩、或其他緻密岩石爲多，砂岩或礫岩之夾層，不可得見，卽有石油，亦無含蓄之所。故決不能成爲重要之含油層也。

（八）三角洲沉積　三角洲半屬海相，半屬陸相。其海相之部，卽爲淺海或瀕海沉積，最適於石油之產生。而近陸之部，則植物繁茂，在適當環境之下，亦能造成石油。且地盤稍有昇降，海岸線卽隨之而伸縮，故在此區域之內，海陸二相之地層，往往相間而生，於石油之積聚，最爲適宜。

綜上所述，產油地層，當以淺海或三角洲沉積最爲適合，其他各類，皆少希望。然產油之層，與蓄油之層，有時並不相合，其理已述於前。故現時產油之處，往往反在大陸沉積之中，則以油質自別處遷流而來之故。非謂大陸沉積，自能發生油質，讀者幸勿誤會可也。

第三章　石油之成因　三十九

图 1. 谢家荣 1929 年《石油》一书中关于三角洲沉积适于石油产生与积聚的论述

Figure 1. C. Y. Shieh's 1929 book *Petroleum* on deltaic deposits favorable for formation and accumulation of petroleum

还必须指出的是，松辽与华北、渤海湾、周口、南阳、江汉、苏北等盆地的含油层系中都有海相化石和海相沉积发现 [19-23]。因此，中国东部各油田（除奥陶系中的古潜山油田外），事实上产于濒海三角洲沉积中。

3. 对潘钟祥、黄汲清陆相生油论认为陆相生油“可以形成具有重大经济价值的油田”的质疑

尽管有上述胡社荣和作者的文章指出，谢家荣早在 1929 年就提出了陆相生油理论。但由于非常明显的原因，所谓“陆相生油理论应分别为潘钟祥与黄汲清独立提出”的观点，在当今中国学术界仍然是绝对主流。经过几十年反反复复的宣扬，潘钟祥 1941 年在 *Non-marine origin of petroleum in North Shensi, and the Cretaceous of Szechuan, China*（《中国陕北和四川白垩系石油的非海相成因》）[24] 和黄汲清等 1943 年在 *Report on Geological Investigation of Some Oil-Fields in Sinkiang*（《新疆油田地质调查报告》）[10] 中先后提出的陆相生油论，其内容在中国学术界广为人知，此不复赘。但他们文章中的下面几段很重要的文字，却是很多人不愿意提起以至于基本上已经被人忘却了的（黑体字是本文作者所标）：

潘钟祥文章中关于陕北油田的结论 [24]：“陕西的油看来不可能是从海相地层中运移来的，这表明，这种油是在陕西系中生成的，具有陆相（河流和湖泊）的成因。**考虑到油苗小、许多井是干井和推断油是非海相成因的，该油田可能没有什么商业价值**。但该油田中的确有油，并且已经生产了少量的油。如果能够找到有利于石油聚积的良好构造，或许还是有可能获得少量石油产量的。遗憾的是，有利的构造非常少。”

关于四川油田的结论 [24]：“从前面的讨论来看，石油沟和达县的油苗和蓬莱镇的油非常可能来自自流井石灰岩，而自流井石灰岩，如同淡水的双壳类 *Unio* 和 *Cyrena* 所表明的，是湖成的。此外，**这种白垩纪的油可能没有商业价值**。”

但鉴于美国科罗拉多西北 Powder Wash 油田的产量大，潘钟祥文章认为，在特殊情况下，陆相生成的油可以具有商业价值 [24]：“因为世界上几乎所有的油田都是海相成因的，所以毫不奇怪，大多数地质学家都认为，石油不可能在淡水沉积物中生成。但科罗拉多西北的 Powder Wash 油田产量大，作者相信是非海相成因的。陕北的石油显然是非海相成因的，四川白垩系的油也可能来自淡水沉积物——自流井石灰岩。从上述证据来看，很明显，在特殊情况下，石油也能够从淡水沉积物中生成，并且可以具有商业价值。”

黄汲清等的 *Report on Geological Investigation of Some Oil-Fields in Sinkiang* 之“新疆石油地质概要”在讨论“生油层”时说的则是 [10]：

“From[1] the foregoing description and discussion it appears that we advocate a non-marine origin for many of the oil types found in Sinkiang. Since oils from the great fields of the world are of marine origin and since continental oil, so far as known, plays an insignificant role in world oil industry, it becomes evident that, if the non-marine theory proves to be true, the prospects for the Sinkiang oil-fields should not be too much exaggerated. We can hardly hope to find a Baku or a Maracaibo in the Piedmont Belts of the Tienshan, though economically important fields may be discovered and exploited there.”

本文将其翻译如下（黑体字是本文作者所标）[2]：

[1]原文这里为 Form，显系印刷错误，应为 From。

[2]黄汲清等人 1943 年的《新疆油田地质调查报告》原文用英文写成，1947 年由地质调查所出版。1993 年出版《黄汲清石油地质著作选集》时，由编者将其译成中文收入其中。编者将这段英文译为：“根据以上的描述和讨论，看来我们可以提出，新疆的石油是非海相成因的。由于世界上许多大油田的石油都是海相成因，加之陆相石油至今所知

"根据以上的描述和讨论，看来我们可以提出，在新疆见到的许多石油都是非海相成因的。因为世界上许多大油田的石油都是海相成因的，还因为迄今所知陆相石油在世界石油工业中无足轻重，所以很显然，**如果此非海相说得以证实的话，那就不应过于夸大新疆各油田的远景。尽管我们可以在天山山麓带发现和开发有经济价值的重要油田，但却很难指望发现像巴库和马拉开波那样的大油田。"**

黄汲清等所撰 *Report on Geological Investigation of Some Oil-Fields in Sinkiang* 的"结论"这样说 [10]（第一段中的黑体字是本文作者所标，第二段中的黑体字是 1993 年中文版的编者所标）：

"独山子油田现已开发，有极好的位置，产出的原油质量优良。加之油田构造很适于储油,且适于大规模的开发。遗憾的是，已知的油砂一般薄而不规则，浅井（600-700 米）日产量十分有限。**除非发现较深较好的含油层，独山子油田将只能是一个小油田**……"

"虽然我们无意夸大新疆油田的远景，但是将来在天山山麓带和前山带及其它有利地区，**很有可能发现与独山子油田同样大小或甚至更大的油田。**"

这意思再明确不过了：如果新疆的油田是陆相生油的，就不应该过分夸大新疆油田的远景；陆相生油可以形成有经济价值的重要油田--像独山子那么大的油田或比之更大的油田（但除非发现较深较好的含油层，否则独山子油田将只能是一个小油田，而所谓"较深较好的含油层"应该是指海相二叠系的含油层），但却很难指望形成像巴库或马拉开波那样的大油田。

显然，*Report on Geological Investigation of Some Oil-Fields in Sinkiang* 中并没有杨文所说的陆相地层"可以形成具有重大经济价值的油田"[8-9] 的说法。

4. 对所谓黄汲清的"大胆"设想的质疑

杨文称："如果中国西部的陆相盆地可以形成有经济价值的油田，那么中国东部的陆相盆地，例如华北盆地和松辽盆地也可以形成同样的油田。"黄汲清的这一"大胆"设想无疑是从理论上突破了'中国贫油论'的束缚。"[8-9]

黄汲清在大庆油田发现前的哪篇文章或者哪个报告里有过这样的"大胆"设想呢？没有。黄汲清没有写过有此内容的文章，也没有作过有此内容的报告，根本就没有过此所谓"大胆"的设想。

历史的事实是：尽管到 1950 年代，中国的地质学家们已经非常重视陆相生油理论，认为"陆相生油在中国是很重要的" "陆相不仅能生油而且是大量的"[25] "来自陆相沉积本身的油源是占有一定的重要地位的，而且远景很大"[26] "大陆的沼泽相或湖泊相沉积也能生油"，"内陆相沉积的本身也能生油"[27]，"陆相生油的学说在理论上是没有困难的"[28]"大陆沉积生油的理论在我国是应该予以很大的考虑的"[29]。

在世界石油工业中尚未起到重要作用，因而如果此非海相成因理论得以证实的话，那么新疆各油田的远景评价就没有言过其实。我们在天山山麓带尽管可能发现和开发有相当经济价值的重要油田，但却难以希望发现像巴库和马拉开波那样的大油田"（黄汲清石油地质著作选集，第 82 页）。作者认为，《黄汲清石油地质著作选集》中这段中译文欠妥，故将此段英文重新翻译于本文中，并列出原文，请读者加以比较和鉴别。

早在 1952 年，谢家荣就指出："要特别注意海相的第三纪或中生代地层。在华北、华东、甚至东北的广大平原下，已有种种迹象指出有广大海水侵入的可能。如果不谬，那么，含油的希望就很大了。所以这些地区应作为可能油区而予以密切注意。"[30]

谢家荣还指出，"从地形的研究（李希霍芬，克雷洛夫）和天津深水井中夹有海相化石层的事实来看，华北平原下发现海相第三纪的可能性是很大的。最近南京古生物研究所研究长春附近发现的蚌壳类及介形虫化石指出一部分可能是海相的，因此我们已有足够的根据来寻找华北平原下海相第三纪的储油层。"[28]。在松辽平原上，"长春街道中打钻发现第三纪含介形虫化石的灰质砂岩，最近研究还有海相化石。含油的希望与华北平原相似。"[31]

这是谢家荣的论述。但这并不仅仅是谢家荣一个人的意见。1954 年 10 月 29 日，作为燃料工业部石油管理总局顾问的谢家荣，应邀在燃料工业部石油管理总局向苏联专家介绍中国东部平原[32]（图 2）。参加的专家有：戈鲁丝、柯尔波夫、彼得洛夫、尼基金、柯特列夫斯基、魏盖林。翻译：窦炳文。记录：张传淦。参加者：职若愚、翁文波、张传淦。联系人：邱振馨。

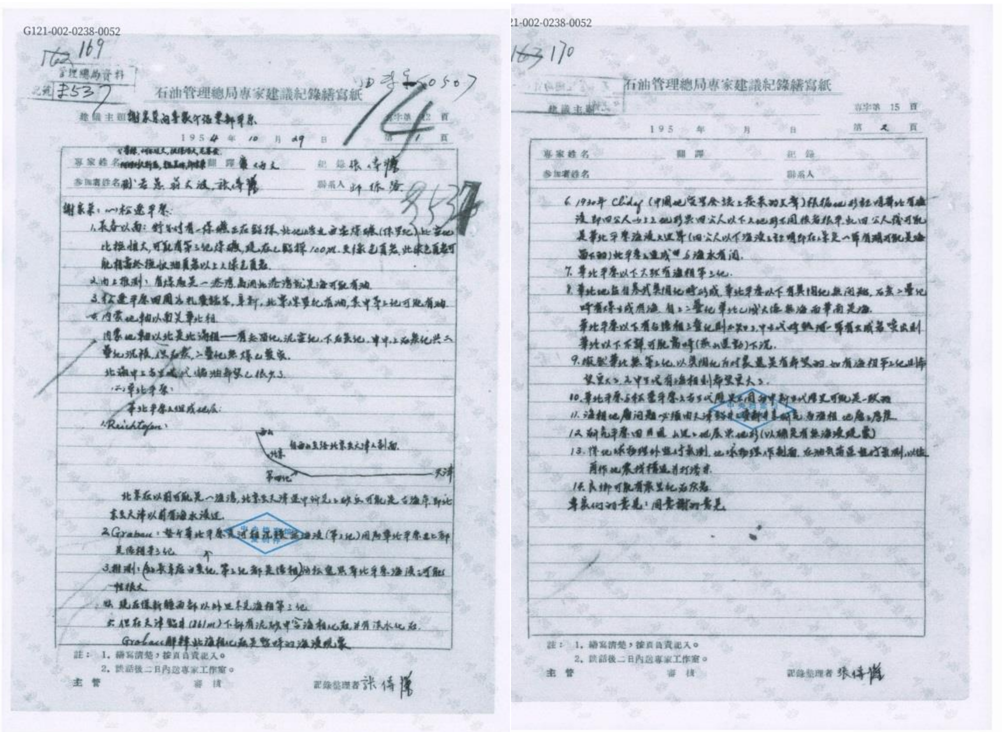


图 2. 谢家荣向（苏联）专家介绍（中国）东部平原的档案资料

（中央档案馆资料，档号：G121-002-0238-0052。中国科学院自然科学史研究所胡阳东提供）

Figure 1. Archival materials on C. Y. Shieh's introduction on the Eastern Plains to Soviet experts (the Central Archives, archival code: 196-6-050-1. Provided by Yangdong Hu from the Institute for the History of Natural Sciences, CAS)

以下是图 2 谢家荣介绍资料的具体内容照录：

（一）松辽平原

1、长春以南：舒尔付有一煤矿正在钻探。此地靠近西安煤矿（侏罗纪）。此盆地比抚顺大，可能有第三纪煤矿，现在已钻探 100 m，至绿色页岩。此绿色页岩可能相当于抚顺油页岩以上之绿色页岩。

2、由上推测：有煤，应是一港湾。离开此港湾就是海。可能有油。

3、松辽平原四周，如扎赉诺尔，阜新，北票，侏罗纪有油。其中第三纪可能有油。

4、内蒙地轴以南是华北相。

内蒙地轴以北是北满相——有志留纪、泥盆纪、下石炭纪、中上石炭纪与二叠纪沉积，但石炭二叠纪无煤，已变质。

北满中上古生代储油希望已很少了。

（二）华北平原

华北平原之组成地层

1、Richthofen（李希霍芬）：自西山经北京至天津之剖面

北京在以前可能是一海湾。北京至天津途中所见之沙丘可能是古海岸，即北京至天津以前有海水浸过。

2、Grabau（葛利普）：整个华北平原是河相沉积，无海侵（第三纪），因为华北平原上都是陆相第三纪。如长辛店白垩纪、第三纪都是陆相。

3、推测：松辽与华北平原海侵之可能性很大。

4、现在除新疆西部以外还未见海相第三纪。

5、但在天津钻井（861 m）下部有泥砂中含海相化石，并有淡水化石。

Grabau 解释此海相化石是暂时的海侵现象。

6、1930 年 Clidof [3]（中国地质学会志上发表的文章）根据地形证明华北有海侵，即四公尺以上之地形与四公尺以下之地形不同，后者很平。此四公尺线可能是华北平原海侵之边界（四公尺以下海侵之证明即在保定一带有湖，可能是海留下的）。此平原之造成与海水有关。

7、华北平原以下大致有海相第三纪。

[3]谢家荣在这里说的 1930 年发表在《中国地质学会志》上的文章，有可能不是 1930 年而是 1932 年，作者不是 Clidof，而是德国人 Von W. Credner（威廉·克勒脱纳），文章题目是 Das Kräfteverhätlnis Morphogenetischer Faktoren und Ihr Ausdruck im Formenbild Südost-Asiens（亚洲东南部地形研究），载《中国地质学会志》第 11 卷第 1 期，页 19-34。

8、华北地台自寒武奥陶纪时形成。华北平原以下有奥陶纪无问题。石炭二叠纪时有煤生成，有海。自上二叠纪华北已成大陆，无海面，而华南是海。

华北平原以下有否陆相三叠纪则不知了。中生代时，热河一带有火成岩喷出，则华北以下不详，可能当时（燕山运动）下沉。

9、纵然华北无第三纪，以奥陶纪为对象还是有希望的。如有海相第三纪则希望更大了，如中生代有海相，则希望更大了。

10、华北平原与松辽平原之古生代历史不同，而中新生代历史可能是一致的。

11、海相地层问题必须由天津钻井之资料来研究，为海相地层之厚度。

12、研究平原四周山边之地层与地形（以确定有无海侵现象）。

13、除地球物理外进行气测，地球物理作剖面，在油气苗区进行气测，以后再作地震找构造，并打浅井。

14、良乡可能有震旦纪石灰岩。

与会专家们的意见：同意谢的意见。

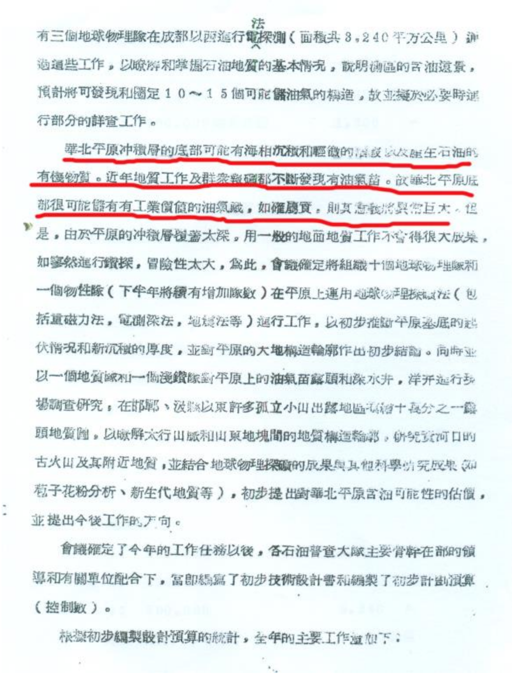
谢家荣在这里介绍中国东部平原时，认为在松辽与华北平原下可能存在海相第三系，指出**如有海相第三纪则希望更大了，如中生代有海相，则希望更大了**。而专家们都同意谢家荣的意见。

这正是当年决定到松辽平原和华北平原进行石油普查的依据。这有当年留下的档案资料为证（黑体字是本文作者所标）：

“华北平原是中生代以来的下沉地带，新生代的泥沙堆积甚厚，**其中可能有海相沉积和产生石油的有机物质**，又由于喜马拉雅运动的发生，较老的平原沉积可能曾受到轻微褶皱，因此华北平原是可能产生石油的。”[33]

“华北平原冲积层的底部**可能有海相沉积**和轻微的褶皱以及产生石油的有机物质。近年来地质工作及群众报矿都不断发现有油气苗。故华北平原底部很可能储有有工业价值的油气藏，**如确属实，则其意义将异常巨大**。”[34]

“广阔的松辽平原的大地构造轮廓**与华北平原相似**，是一个晚近的下沉地带，其中堆积着很厚的新沉积。包括白垩纪地层以及第三纪和第四纪的疏松沉积，其中可能有含油岩系。”[35]


有三個地球物理隊在成都以西進行電法探測（面積共3,240平方公里）通過這些工作，以瞭解和掌握石油地質的基本情況，說明該區的含油遠景，預計將可發現和圈定10～15個可能儲油氣的構造，故並擬於必要時進行部分的詳查工作。

華北平原冲積層的底部可能有海相沉積和輕微的變質或改造生石油的有機物質。近年地質工作及群眾報礦都不斷發現有油氣苗。故華北平原底部很可能儲有有工業價值的油氣藏，如確屬實，則其意義將異常巨大。但是，由於平原的冲積層覆蓋太深，用一般的地面地質工作不會得很大成果，如冒然進行鑽探，冒險性太大，為此，會議確定將組織十個地球物理隊和一個物性隊（下半年將續有增加隊數）在平原上運用地球物理探礦方法（包括重磁力法，電測深法，地震法等）進行工作，以初步推斷平原基底的起伏情況和新沉積的厚度，並對平原的大地構造輪廓作出初步結論。同時並以一個地質隊和一個淺鑽隊對平原上的油氣苗露頭和深水井，洋井進行現場調查研究，在邯鄲、汲縣以東許多孤立小山出露地區編繪十萬分之一露頭地質圖，以瞭解太行山脈和山東地塊間的地質構造輪廓，研究黃河口的古火山及其附近地質，並結合地球物理探礦的成果與其他科學研究成果（如孢子花粉分析、新生代地質等），初步提出對華北平原含油可能性的估價，並提出今後工作的方向。

會議確定了今年的工作任務以後，各石油普查大隊主要骨幹在部的領導和有關單位配合下，當即編寫了初步技術設計書和編製了初步計劃預算（控制數）。

根據初步編製設計預算的統計，全年的主要工作量如下：

图 3. 地质部普查委员会《关于第一次石油普查工作会议的报告》中的华北平原

Figure 3. The North China Plain in *the Report on the First Petroleum Survey Working Meeting of the oil Reconnaissance*, the Reconnaissance Committee, the Ministry of Geology, PRC

这是两次石油普查会议和地质部普查委员会对松辽平原和华北平原的提法。难道黄汲清当年不赞成这些提法，而有另外的什么“大胆”设想？

那就让我们看一看经过 1955 和 1956 两年的地质工作，获得了大量新的资料后的 1957 年，黄汲清在其《对我国含油气远景分区的初步意见（提纲）》[36] 的真实版本中，是怎样论述松辽平原与华北平原的含油气远景的（黑体是本文作者所标）：

华北平原：……**可能有第三纪海相沉积。关键问题是**：……（4）**研究有无海相第三纪沉积。**

松辽平原：南部平原法库以南，范围很小。有三个超过 3 000 公尺的凹陷及其间的隆起。**海相第三纪很可能存在**，值得进一步普查。

北部：……南部被双辽隆起分为东西二部，**东部已发现海相第三纪（松花江统）**……关键性问题是：（1）加紧进行物探，划分平原的构造单元，（2）配合浅钻研究中新生代地层，**特别注意松花江统的海相第三纪，**（3）**海侵似不可能从苏联方面进侵，而是从渤海北来，因此应该在彰武一带用深浅钻证实海相第三纪的存在。**

历史就这样清清楚楚地记载着：黄汲清乃至到了 1957 年还将松辽平原与华北平原的含油气远景与海相第三系联系在一起的。显然，根本不存在什么“大胆”设想，也根本看不到根据陆相生油理论到松辽平原和华北平原找油的影子。

必须指出，黄汲清 1978 年 1 月上书华国锋、邓小平、方毅之后 [37]，曾经的李四光秘书郑明焕、周国钧同志，就曾于 1979 年 5 月 4 日致信“全国科协代主席周培源同志并其他领导同志”时指出 [38]：

黄先生在信中还说，一九五五年，他是根据‘陆相生油理论’，建议去松辽平原找油的，可是黄先生自己提供的一九五七年三月八日的报告记录稿，却做了一个相反的回答。在这个报告里，黄先生的观点恰好相反，他认为松辽平原可能存在海相第三纪，所以才值得进行普查的[4]。

于是，到 1993 年出版《黄汲清石油著作选集》时，收入该书的《对我国含油气远景分区的初步意见》中的华北平原和松辽平原的叙述便干脆将原报告中的“**海相第三纪很可能存在，值得进一步普查**”改成了“**可以存在海相第三纪地层，应进一步做普查工作**”[38]，并且将其余所有上述标为黑体字的文字即有关华北平原、江苏平原和松辽平原海相第三纪的文字删除得一干二净（图 4）。

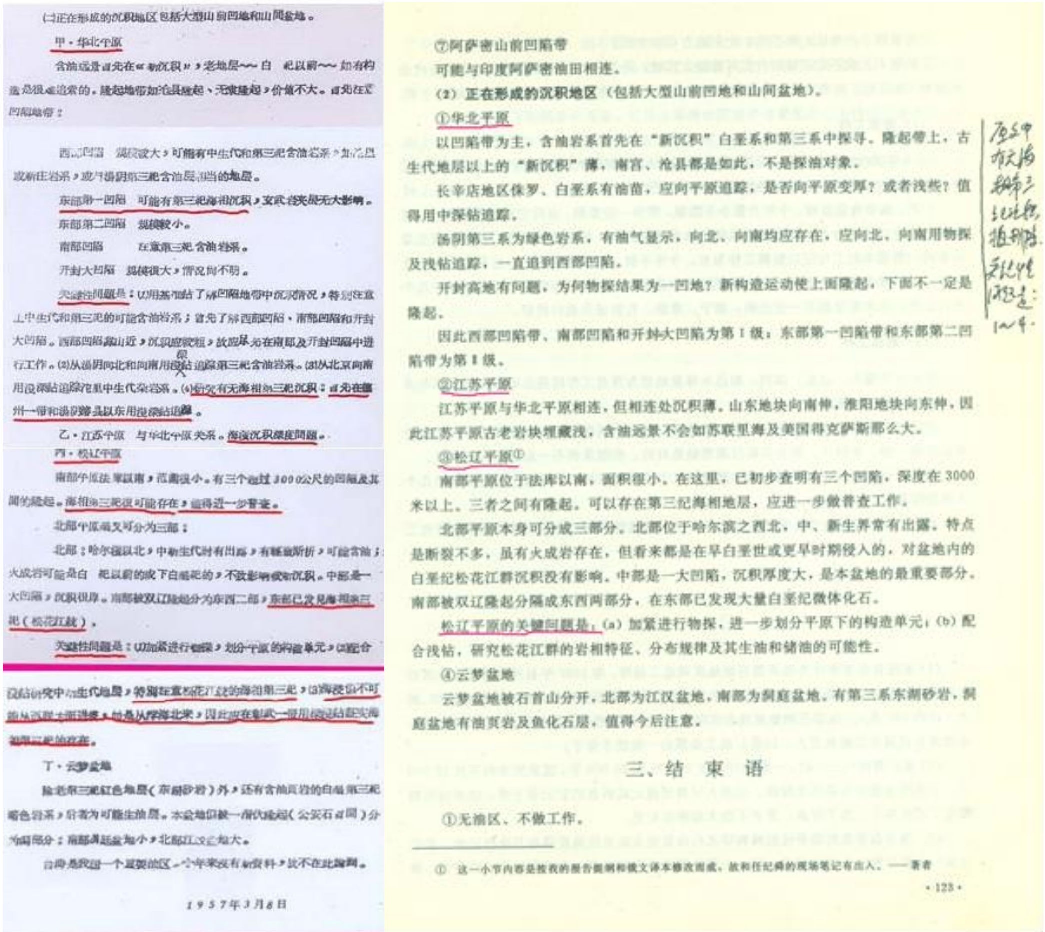


图 4. 中央档案馆所存 1957 年资料（左）[35] 与 1993 年收入《黄汲清石油著作选集》中的黄汲清《对我国含油气远景分区的初步意见》[38] 中关于华北平原、江苏平原与松辽平原（右）同一叙事的文字对比

Figure 4. Comparison of deletions and changes in T. K. Huang's descriptions of the oil and gas potential of the North China Plain, Jiangsu Plain, and Songliao Plain in 1957 (left) and 1993 (right)

[4] 郑明焕、周国钧 1979 年 5 月 4 日给全国科协代主席周培源同志并其他领导同志的信. 中央档案馆，全宗号 196，目录号 27，案卷号 14，序号 9。

但是，历史终究是历史，是“删除”不了的，因为没有人能够删除保存在中央档案馆里的文字。不仅如此，当年听过黄汲清报告的也还另有其人。请看竺可桢先生 1957 年 5 月 26 日的日记 [39]：

晨六点起。九点和尹主任至北京饭店，听地学组论文报告……次黄汲清讲对我国含油气远景分区。说从他看来目前所开河西老君庙每年出四十万吨，是小矿区，要和苏联 Baku 相比得年出千万吨，目前准噶尔盆地有此希望，克拉玛依看来这区可出百万吨，然尚系估计数字。次为四川油田，川东、川西、川南统有希望。柴达木也有希望，但尚难估计。次则谓华北、华东和松辽平原能够得第三纪海相即有希……

“华北、华东和松辽平原能够得第三纪海相即有希望”！哪里有什么“大胆”设想呢？

还必须指出，到 1994 年，黄汲清在临终前的口述访谈中如是说 [41]（黑体是本文作者所标）：

松辽盆地方面，当时我们知道东西很少，第一，松辽盆地是在大兴安岭隆起带的东面形成的一个凹陷带，布利斯道本一八六几年就提出大兴安岭隆起、松辽盆地中间是个大断层，兴安构造线，松辽盆地是大兴安岭前面一个凹陷带。大兴安岭隆起是侏罗、白垩、第三纪隆。第二，在松辽盆地的东南边，过去日本人有少数报道说那个地方出现**松花江群**勘探（原文如此--张立生注）凹陷，以砂页岩为主，分布很广，它们可能是白垩纪的，**但是陆相地层，没有看到海相**。过去谭锡畴、王鸿桢他们调查嫩江地带的地质，发现在大兴安岭前面，嫩江上游，嫩江西的地层是陆相的砂岩地层，可能白垩纪第三纪的沉积， 也是相当普遍，相当厚。**这两个地层当时说的都是陆相的，不是海相的。不过不要紧，我们有陆相生油论嘛**，陆相也可以有生油层，也可以形成油田。当然有海相就更好了。

我当时的这个意见，是从葛利普和我们自己结合中国人、日本人的零星观察得出的一个不同的意见，所以决定要在这一地区进行石油普查，特别是松辽盆地、华北盆地。

“松辽盆地方面，当时我们知道东西很少”。这是真话。既然知道东西很少，那凭什么将松辽盆地列为“四大重点地区”之一呢？可见那是没有的事。黄汲清 1957 年的报告明明白白地说“**东部已发现海相第三纪（松花江统）**”“**特别注意松花江统的海相第三纪**”，“**海侵似不可能从苏联方面进侵，而是从渤海北来，因此应该在彰武一带用深浅钻证实海相第三纪的存在**”[36]，可到了 1994 年，却说松花江群（统）“**是陆相地层，没有看到海相**”“**当时说的都是陆相的，不是海相的。不过不要紧，我们有陆相生油论嘛**”[41]。

怎么可以这样对待历史呢？

5. 对黄汲清特别关注四大重点地区的质疑

杨文说：1957 年黄汲清的报告“在各大盆地的石油普查中，黄汲清特别关注四川、鄂尔多斯、松辽、华北四大盆地”，“在展示中国含油远景分区图时，他特意将松辽、华北、四川、鄂尔多斯四大盆地作为重点远景区用醒目的深橙红色圈出，说明这是四个最有远景的地区。”[8-9]

说黄汲清 1957 年的报告“特意将松辽、华北、四川、鄂尔多斯四大盆地作为重点远景区用醒目的深橙红色圈出”[8-9]，是为了与所谓黄汲清 1955 年提出找油的四大重点地区相呼应，用以说明其“真实性”。

但我们还是要说：那是根本没有的事。

黄汲清在 1978 年的上书信中说，他 1955 年以陆相生油理论为依据提出了找油的四大重点地区 [42]。但根本就没有这回事。关于此点，作者在 2018 年提交给中国地质学会地质学史专业委员会第 28 届年会和中国科学技术史学会 2018 年度学术年会的论文《回归历

史，是谓不朽--大庆油田发现真相争论的总结与述评》[43]中，有近 1 万字的详尽论述，并将相关文字收入到了《谢家荣年谱长编》[44]中，此不复赘。

本文只做如下的补充：

黄汲清在 1956 年 5 月即第二次石油普查会议闭幕 3 个月后（第二次石油普查会议 1956 年 2 月在北京举行），写过一篇《准噶尔和柴达木盆地的构造特征及其含油远景》（未曾发表），后于 1993 年收入《黄汲清石油地质著作选集》，其中说到了当时中国寻找石油天然气的主要对象和重点地区，原文如下（黑体字是本文作者所标）[45]：

加里东和华力西构造带，包括天山、南山、昆仑山和秦岭在内，由于褶皱剧烈，且往往遭受区域变质，对含石油和天然气来说，它们与广大的前寒武纪结晶片岩区域一样，是没有或很少价值的。这些区域占全国面积三分之一强。西藏大部分地方是强烈褶皱和岩浆活动地带，只有它的西部褶皱比较轻微，中生代和新生代海相沉积含油气的可能性较大。剩下来不足二分之一的面积是当前寻找石油和天然气的主要对象。这包括三种不同的大地构造类型：（1）地台区域，主要是华北地台，扬子地台和广西地台；（2）华力西褶皱带里的山间地块和山前凹地，主要是准噶尔地块，塔里木地块以及它们的山前凹地，还有河西的南山山前凹地；（3）后燕山运动的沉降区域，主要是华北平原、华东平原和松辽平原。解放以来，我们在这些区域做了不少的普查工作和**几个重点地区的钻探工作**。中苏石油公司在准噶尔的工作做得比较深入，在塔里木盆地也作了部分普查。**目前的普查和钻探集中在**准噶尔、柴达木、河西走廊、鄂尔多斯地台、六盘山、四川盆地和华北平原。

从中可以看出，直到 1956 年，黄汲清还将准噶尔、柴达木和河西走廊置于位列前三的重点地区，也佐证黄汲清所谓 1955 年提出华北、松辽、鄂尔多斯、四川四大重点地区不是事实。

下面的资料更可以确凿地证明，说 1957 年“黄汲清特别关注四川、鄂尔多斯、松辽、华北四大盆地”，“他特意将松辽、华北、四川、鄂尔多斯四大盆地作为重点远景区用醒目的深橙红色圈出，说明这是四个最有远景的地区”，是根本就没有的事。

1、前述竺可桢 1957 年 5 月 26 日的日记说明，在 1957 年的黄汲清眼里最有远景的地区是准噶尔盆地，但所谓“特意”“用醒目的深红色圈出的”“四个最有远景的地区”中却根本没有准噶尔盆地。不仅如此，从竺可桢的日记看，华北、华东、松辽地区，在 1957 年的黄汲清眼里是排得很后面的，根本谈不上所谓“四大重点地区”。

2、直到 1962 年，黄汲清也还认为，准噶尔盆地是最有远景的地区。请看黄汲清 1962 年的论述[46]（黑体字是本文作者所标）：

根据大地构造和含油气地层的特点，中国含油气区和可能含油气区可作如下分类：

（1）中间地块及其边缘坳陷含油气区：准噶尔、塔里木、柴达木。

（2）华力西褶皱系中、后期山前坳陷及山间坳陷含油气区：吐鲁番哈密坳陷、河西走廊坳陷。

（3）地台上晚古生代及三叠纪海相地层含油气区：四川、贵州、广西、鄂尔多斯。

（4）地台上大型陆相中、新生代坳陷含油气区：四川、鄂尔多斯、松辽坳陷区、华北坳陷区。

（5）地台及地槽褶皱期后的中小型山间盆地含油气区：青海民和、辽西阜新、广西田阳等。

（6）地槽边缘坳陷含油气区：台湾。

根据现有普查和勘探资料，**考虑到含油气远景**，我们认为上述**各类含油气区的重要性依次是**（1）、（4）、（2）、（6）、（3）、（5）。

按此论述，上述 6 类含油气区和可能含油气区按其“含油气远景”的重要性排在前四位的是：准噶尔、塔里木、柴达木、四川。这就是说，即使五年之后，即大庆油田发现 3 年之后的 1962 年，在黄汲清看来，准噶尔依然是最有远景的含油气区，松辽、华北、鄂尔多斯的含油气重要性或含油气远景也还排不到前四位，也还不在所谓“四个最有远景的地区”或所谓“四大重点地区”之列。其实，黄汲清这篇文章对各含油气远景分区的排序和他 1957 年《对我国含油气远景分区的初步意见》报告中的排序基本上是一致的，准噶尔盆地始终都是放在第一位的。

6. 对陆相生油理论指导松辽、华北石油普查的质疑

杨文称：“中国东部的陆相盆地，例如华北盆地和松辽盆地也可以形成同样的油田”，“进而奠定了在第一轮中国石油普查中，把大型陆相沉积盆地摆在石油普查战略方向的理论基础。”[8-9] 换句话说，就是陆相生油理论是松辽、华北石油普查的理论基础。

前述谢家荣关于松辽平原、华北平原下可能存在海相第三系的论述、第一次、第二次石油普查会议的决议及地质部普查委员会《关于第一次石油普查会议的报告》以及黄汲清 1957 年报告中将松辽平原、华北平原与江苏平原的含油远景与海相第三系联系在一起的事实已经足以说明，根本就不存在陆相生油理论指导松辽平原、华北平原和江苏平原石油普查的事。

那么，所谓陆相生油理论指导松辽平原、华北平原石油普查的说法是从哪里来的呢？让我们回顾历史。

6.1 1944-1954 年间黄汲清没有发表过石油地质研究的文章，更没有指出过石油普查的方向，也没提出过石油普查的战略选区

查黄汲清从 1943 年的 *Report on Geological Investigation of Some Oil-Fields in Sinkiang* 之后到 1954 年的十年多时间内，没有发表过一篇有关石油地质的文章。查看《黄汲清年谱》[42] 可以得知，这十年多时间里，黄汲清主要的工作是研究中国的大地构造、撰写其代表作《中国主要地质构造单位》、某些地区的区域地质调查、特别是编制百万分之一和三百万分之一中国地质图，少有石油地质的研究[5]。

杨文说：“1946 年夏，黄汲清赴北京主持《中国地质学会志》和《丁文江先生地质调查报告》的出版工作，同时兼任北京大学地质系教授。其间有机会搜集和阅读日本地质工作者撰写的各种地质矿产报告，其中关于石油地质和石油勘探的研究，特别是东北三省的油苗调查报告和阜新煤田的石油勘探报告引起了黄汲清的注意，让他进一步思考在华北和东北寻找石油和天然气的可能性。”[8-9]
说黄汲清说 1946 年东北三省的油苗调查报告和阜新煤田的石油勘探报告引起了他的注意，让他进一步思考在华北和东北寻找石油和天然气的可能性”，有证据吗？论文？日记？或者工作日志？没有，没有任何可考的证据。
下面是黄汲清自己在 1991 年说的 [47]：

[5]黄汲清 1948 年向第 18 届国际地质大会提交了《中国的油田地质》论文，但未见发表。在第 18 届国际地质大会出版物 Section E The Geology of Petroleum 中，只见到黄汲清文章的题目 Huang,T.K, Geology of the oilfields of China，但连摘要都没有。1950 至 1954 年黄汲清写过几篇有关四川石油的简报等，也未曾发表。

我于 1946 年夏来北京，主持《中国地质学会志》和“丁文江先生地质调查报告”的出版工作，同时兼任北京大学地质系教授。得有机会搜集和阅读日本地质工作者出版的和未出版但已编成的各种地质矿产报告，其中一部分是有关石油地质和石油勘探的。特别是东北三省的油苗检查报告和阜新煤田的石油勘探报告，引起我的注意，从而促使我考虑在华北和东北寻找石油和天然气的可能性。1946 年元旦前后，清华大学地质系负责人孟宪民教授邀请我到校作学术演讲。由于事隔多年，讲演的内容大部已忘却了，但是还依稀记得，我主要讲中国大地构造，兼及中国找油远景，并简略地谈到在华北平原和东北平原找油的可能性…… 令人遗憾的是，我的讲演没有记录下来，更没有在任何刊物上发表。我的简单日记本，解放前的，经过“文化大革命”，大部都有已毁掉，也无法查对。

但三年后，即 1994 年，黄汲清又有了另外的说法：

我记得在 1956 年阳历过年的时候，清华大学地质系的负责人孟宪民教授，请我到清华大学地质系去作一个学术报告，我记得当时我主要谈的是中国石油远景的问题，其中也谈到在华北平原、松辽平原找油的可能性，可惜我没有把这个学术报告写成文章发表。最近我又查了一下清华大学的《清华日报》，看有没有记载黄汲清谈过什么问题，结果 1956 年《清华日报》还没有恢复印刷，到 1957、58 年才恢复了印刷，所以我对这个问题谈的话在现有的文献资料里查不出来，我自己也没有保存这个记录，所以这个东西不能算，没有可考的证据 [41]。

两次“回忆”，时隔三年。说的都是元旦前后应孟宪民之邀到清华大学作报告这回事。一次回忆说是主讲大地构造，兼及华北、松辽找油，一次回忆又说是主讲中国石油远景问题，谈到华北、松辽找油的可能性。一次回忆说是 1946 年，一次回忆又说是 1956 年。问题是：究竟是哪一年？是 1946 年？还是 1956 年？若说是 1956 年，其时孟宪民根本就不在清华大学（孟宪民已经于 1952 年离开清华大学到地质部工作）；若说是 1946 年，可又说他去查 1956 年《清华日报》有没有恢复印刷，显然又对不上。这样的“回忆”文字，显然根本就不具采信价值。

1955 年开始了大规模的、全国性的石油普查。到哪些地区去进行石油普查？这个问题显然是非常重要、非常紧迫和现实的问题。

本文作者曾经指出，“1954 年，在全国进行大规模石油普查的前夜，中国地质界有两篇重要文献发表。这两篇重要文献，一篇是谢家荣 1954 年 6 月或 7 月发表在《石油地质》第 12 期上的《中国的产油区和可能含油区》，另一篇是李四光的《从大地构造看我国石油资源勘探的远景》。这两篇文献发表在地质部按照中央的决定负责全国石油普查的前夜，对于指导石油普查的战略选区有着极其重要的意义”[1,48]。因为 1950 年代最终选定进行石油普查的地区**无一例外**都是谢家荣《中国的产油区和可能含油区》指出的地区，**大多数**也都是李四光《从大地构造看我国石油资源勘探的远景》指出的地区。

可有人不认可这样的历史事实，说：

按照张立生的说法，这两篇文章对指导石油普查的战略选区有着极为重要的意义，这是他的看法，而我觉得他这种说法并不符合实际。为什么呢？我是这样看的，作为普委的主要技术负责人，他不是普通的技术人员，也不是只了解自己专业的一般技术人员，他是中国最顶层的地质学家，是地质大师。他有自己的独立见解，对中国的大地构造，对中国的区域地质、石油地质，都曾进行过大量深入的调查研究。……他不会轻易地根据别人的观点来部署工作。“中国的产油区和和可能含油区”代表谢先生的思想，“从大地构造看我国石油资源勘探的远景”代表李先生的思想。但是作为普委的技术负责人，黄先生部署全国石油普查的思想与他们并不相同。黄先生是根据他自己对中国大地构造和中国石油地质的基本认识来部署的，在工作思路上，他不会受别人影响。……据我了解，当时黄先生部署全国石油普查，一是根据他的陆相生油理论，这是他的理论基础，是他在新疆石油调查实践的结果；二是他的大地构造理论 [49]。

1950 年代的**石油普查项目明明是在谢家荣、黄汲清主持下，经过专家们集体讨论决定的** [50]，并且是由黄汲清“代表普委向部务会议汇报最后讨论结果的”[47-50]，但在协助审阅杨文初稿的任纪舜眼里，中国 1950 年代的石油普查乃是黄汲清这位地质大师一个人部署的，不关别人什么事。谢家荣怎么说，李四光怎么说，或者还有别的其他什么人怎么说，那都没有任何价值，黄汲清大师一个人说了算！但是，黄汲清根据他的陆相生

油理论和大地构造理论，指出过石油普查的方向了吗？提出过到哪些地方去找石油了吗？没有。黄汲清并没有依据他的理论指出过石油普查的方向，也没有提供过石油普查的战略选区。这是没有办法改变的历史。这有黄汲清自己的话为证 [41]（黑体是本文作者所标）：

下面谈一下全国石油天然气普查的方向问题怎么提出来，这是个重要问题。谢家荣先生在 1952 年的《地质学报》第 32 卷第 3 期 219 到 231 页里头，发表了题为《从中国矿床的若干规律提供今后探矿方向的意见》的文章，文章里说“应特别注意海相的第三纪后中生带地层在华北、华东甚至东北的广大平原下，已有种种迹象指出有广大海侵的可能，如果不谬的话，那么含油的希望就很大了，所以这些地区包括东北作为可能的油区而给予密切的注意”[6]。李四光先生在 1954 年中央燃料工业部石油管理总局的内部刊物《石油地质》16 号上发表了一篇文章，题目是《从大地构造看我国石油资源勘探的远景》……而我自己在这期间发表过什么意见？没有。我记得在 1956 年阳历过年的时候，清华大学地质系的负责人孟宪民教授，请我到清华大学地质系去作一个学术报告……其中也谈到在华北平原、松辽平原找油的可能性……这个东西不能算，没有可考的证据。所以上面谈的关于在中国找石油的地区，特别华北平原、松辽平原是不是也可以找油，名见经传的，就只有谢家荣、李四光的文章，谢家荣谈得比较明确，时间在李四光之前。

到松辽平原和华北平原找油，根本就不是黄汲清提出来的。这是无法改变的历史事实。

6.2 从 1955 年到 1959 年大庆油田发现，黄汲清没有发表过讨论述陆相生油理论的文章

1950 年代，特别是从 1955 年开始石油普查到大庆油田发现的差不多五年时间里，侯德封 [26,51]，潘钟祥 [25]，特别是谢家荣 [27-31,52-55] 发表了大量有关陆相生油的论述。但在此期间，黄汲清先生却没有发表过一篇包含有陆相生油论述的文章。黄汲清在第一次、第二次石油普查会议上的报告，没有触及陆相生油理论问题，而在第三次石油普查会议上的报告《对我国含油气远景分区的初步意见》，也只是在谈及评价准则时泛泛地谈及陆相生油问题（而且我们读到的是 1993 年经过“整理”后的所谓记录稿），且将松辽平原、华北平原与江苏平原的含油远景与海相第三系联系在一起。黄汲清 1955 年 3 月发表过一篇《鄂尔多斯地台西缘的大地构造轮廓和寻找石油的方向》[56]，1956 年 5 月写过一篇《准噶尔和柴达木盆地的构造特征及其含油远景》[45]，但未曾发表。这两篇文章都收录在 1993 年出版的《黄汲清石油著作选集》中，其中都没有对陆相生油理论的论述。

6.3 1959-1977 年间，黄汲清没有发表过论述陆相生油理论的文章

此外，“自大庆油田发现以后，就存在生油岩是陆相还是海相的争论，因为在含油岩系中发现了可以生活在海里的鱼类和瓣鳃类。在华北、苏北、江汉和三水等盆地的下第三系中，也发现了有孔虫等能够生活在海里的生物化石，同时还有海绿石，部分层中的化学特征（如硼含量、锶钡比）也与陆相不同，而与海相接近。因而又发生了下第三系含油层的生油岩是陆相还是海相的争论问题”[19]。

但从大庆油田发现起直到 1978 年 1 月黄汲清发出上书信止的 18 年间，既没有看到黄汲清对大庆油田的海相陆相之争发表过什么意见，也没有见到黄汲清论述过陆相生油理论问题。

[6]这段话与谢家荣文章的原文（本文第 435 页）有出入。但黄汲清的原文如--本文作者张立生注。

6.4 陆相生油理论指导松辽和华北石油普查、发现大庆油田的来源

上述的叙述充分证明，从 1944 到 1977 年底总共长达 34 年的时间里，黄汲清没有发表过论述陆相生油的文章，到华北平原和松辽平原找油也不是黄汲清提出的，并且直到 1957 年，黄汲清还将松辽平原与华北平原的含油远景与海相第三系联系在一起。

可是到了 1978 年 1 月，在大庆油田发现 18 年多之后，在当年与他一起主持石油普查的谢家荣逝世十多年之后，李四光逝世将近 7 年后，在经过长期的海相陆相争论，确定大庆油田是陆相生油之后，黄汲清"忘记"了他在石油普查工作会议上的报告是怎样将松辽平原与华北平原的石油远景与海相第三系联系在在一起的，突然"想起"了他 1943 年的 *Report on Geological Investigation of Some Oil-Fields in Sinkiang*，决定发出上书信，在揭露"用李四光同志地质力学理论找到大庆等油田的不符事实"[42]、"我国大庆等东部油田的普查和发展与地质力学的理论无关，这是事实"[42] 的同时，绝口不提当年和他一起主持石油普查的谢家荣，称他 1955 年"作为'普委会'的主要负责人之一，提出了把华北平原、松辽平原、鄂尔多斯盆地（即陕甘宁盆地）、四川盆地作为'普委会'找油的四大重点地区。'普委会'采纳了我的建议，并很快做了部署，开展了工作。我的建议是根据'陆相生油'理论（这一理论是我国地质学家潘钟祥教授和我在四十年代初期分别提出和发展起来的）和我的大地构造观点并结合我国多年来的地质工作实践而提出的。"[42]

正是由于黄汲清上书信在否定李四光地质力学理论找到大庆油田的同时，说是他按照他的理论提出松辽平原等四大找油的重点地区，并且还说普委会还"采纳"了他的建议，"做了部署"，所以在其后进行的"大庆油田发现过程中的地球科学工作"评奖过程中，主持评奖工作的人对李四光与黄汲清谁排第一的问题大伤脑筋，为此钱三强先生专门到黄汲清家里拜访，征求他的意见。对此，黄汲清当场表示，李四光是部长，又是普查委员会主任，还是李四光排第一为好。黄汲清的"谦让"，让钱三强如释重负，当即向黄汲清鞠了一躬，说："谢谢你，为我们解决了一个大难题。"[57]

接下来就是舆论登场，相继有了何建明"献给'中国石油之父'黄汲清院士"的《科学大师的名利场》、《"中国石油之父"与大庆油田》和《大庆油田发现真相》的问世。由此，华夏大地上便回荡着陆相生油理论发现大庆油田的呼喊，黄汲清"亲自布下松辽平原石油普查计划"，"黄汲清的陆相生油理论是实现大庆油田发现的重大突破的最基本和惟一可信的理论依据"[58] 的声音不绝于耳。由此，黄汲清获得了"何梁何利优秀奖"。由此中国地质学会设立了黄汲清青年地质科学技术奖。

这就是所谓陆相生油理论指导松辽平原和华北平原石油普查，发现大庆油田的来源。

历史不应该、不能够是这样书写的。

7. 对大庆油田发现过程中地质科学工作叙事的质疑

7.1 无本之木、无源之水的叙事

杨文这样叙述从松辽平原地质踏勘到大庆油田发现的历程 [8-9]：

第一次石油普查会议后，作为普委的技术负责人，黄汲清将松辽盆地作为重要遗留课题，授意苏云山查阅资料，起草"松辽平原石油地质踏勘设计任务书"，并亲自修改，后由普委下达东北地质局（中国地质

科学院，1998）。1955 年 8 月，由韩景行等组成的踏勘组开始了松辽盆地的石油普查……1956~1957 年间，地质部加强了松辽盆地的地面地质和物探工作，了解白垩系地层层序，某些构造特征以及可能的含油岩系。到 1958 年初已初步断定松辽盆地是一个远景很大的含油盆地……

1959 年春节期间，地质部副部长何长工主持召开重要会议，时石油部部长余秋里、石油部副部长康世恩等参加会议……9 月 26 日松基三井喷出大量原油，证实了松辽盆地是具有经济价值的大型含油地区。时值国庆十周年的大喜日子，石油工业部决定将这个改变中国石油工业落后面貌的大油田命名为“大庆油田”。

按照杨文的上述叙事，读者所能得出的结论只能是：不是别人，是黄汲清独自一人部署了松辽平原石油地质踏勘。

杨文上述从松辽平原地质踏勘到大庆油田发现的叙事，除了黄汲清外，还提到了韩景行、李奔、吕华、何长工、余秋里、康世恩等人，就是没有谢家荣和其他地质学家什么事。

此乃大谬。这是歪曲历史的叙事。

述说松辽平原找油历程，避开 1955 年之前中外地质学家对松辽平原含油可能性的论述，不可思议。因为“象松辽盆地这样的掩盖地区，又无油气苗，开展石油普查工作，主要是根据地质理论推断作出决定的” [59]。

历史不应该忘记，阮维周 [60]、翁文波 [61]、谢家荣 [30,52 & 62-65]、孙健初 [66]、高振西 [67]、李四光 [68] 等人对东北地区找油前景的地质理论推断，尤其是谢家荣的论述与推断。历史也不应该忘记苏联专家“松辽平原，这个地区无疑值得予以极大的重视，并应开展普查，对最有意义的构造进行详查”[69-70] 等论述。没有他们的论述与推断，就根本不会有 1955 年松辽平原的石油地质踏勘。因为黄汲清至少在 1956 年第二次石油普查工作会议闭幕之前没有关于松辽平原找油的只言片语。

只写黄汲清授意苏云山起草“松辽平原石油地质踏勘设计任务书”，不交代松辽平原石油地质踏勘的依据，松辽平原石油地质踏勘就成了无本之木，无源之水。那是贪众科学家之功为黄所有。

7.2 没有理由“忘记”谢家荣也审查、修改了“松辽平原石油地质踏勘设计任务书”

其次，就“松辽平原石油地质踏勘设计任务书”本身，杨文也“忘记了”不该忘记的历史：黄汲清终于在临终前“想起”来谢家荣也审查、修改了“松辽平原石油地质踏勘设计任务书”[41]。“忘记”谢家荣也审查、修改了“松辽平原石油地质踏勘设计任务书”，没有任何道理。作者在 2015 年就曾经指出过这一点 [4]，但协助审阅杨文的任纪舜这次还是“忘记”了。

7.3 没有理由“忘记”的“关于松辽平原石油地质踏勘工作方法”

当年的亲历者吕华、苏云山告诉世人：“谢家荣还亲自起草了‘关于松辽平原石油地质踏勘工作方法’，于 8 月 29 日发给东北地质局”[71-72] 我们今天能够知道这个历史事实，要感谢吕华和苏云山两位先生，因为直到 1994 年黄汲清离开人世的差不多 40 年间，黄汲清对此事从没有透露过一个字。杨文从“松辽平原石油地质踏勘设计任务书”写到大庆油田发现的叙事，理应提到此事，但没有。

7.4 松辽平原石油地质踏勘是谢家荣与黄汲清共同部署的

作为地质部普查委员会常委、总工程师 [73] 的谢家荣，与松辽平原石油地质踏勘有没有关系？或者说，谢家荣在松辽平原石油地质踏勘中起了什么作用？这是任何谈论松辽平原石油地质踏勘的文字都绕不开的话题，但杨文在关于大庆油田发现历程的叙事中却根本予以回避。

黄汲清和谢家荣是普查委员会的技术负责人，那么人们自然会问：在第一次石油普查会议没有将松辽平原列入计划之后，在黄汲清去找苏云山，授意他起草任务书之前，黄汲清有没有和谢家荣在一起讨论过松辽平原的事？因为黄汲清告诉我们 [47]：

刘毅、谢家荣、李奔、吕华和我就在这几间房子和年轻的技术人员一道工作。从另一方面来看，普委这样一个只有几间房子的"小家庭"倒有一个优点。刘、谢、黄、李、吕等人天天办公，天天见面，有什么需要商议的事，随时可以你找我，我找你，乃至开个小会都非常方便。

并且，任纪舜还告诉我们："要特别强调的是，在普委工作期间，黄、谢这两位地质大师合作非常好，他们相互尊重，共同为中国的找油事业出谋划策，是不分彼此的。"[49]。

作者完全相信，黄汲清和任纪舜的上述说法是百分之百真实的。

由此我们可以断定，在知道没有将松辽平原列入计划之后，谢、黄两位先生在一起商定，必须到松辽平原进行石油地质踏勘，以了解其含油气的前景，决定由黄汲清出面找苏云山起草"松辽平原石油地质踏勘设计任务书"，由谢家荣自己亲自起草"关于松辽平原石油地质踏勘的工作方法"（苏云山和吕华两位都用了"亲自起草"这四个字）。

虽然黄汲清自己承认，他没有提出过石油普查的方向，没有指出过石油普查的战略选区，华北平原和松辽平原的石油普查是谢家荣和李四光等提出的，但考虑到黄汲清说过："1954 年 12 月到 1955 年 1 月 20 日，即地质部在北京召开第一次石油普查工作会议以前，**这一段时间中，谢家荣和我为了准备提出找油的方向与任务，曾经多次交谈，讨论，互通情报……两人也同意必须在华北平原和松辽平原进行普查……**"[47]（黑体是本文作者所标）。

而且，翁文波更是明明白白地写道（黑体是本文作者所标）："1955 年，第一次石油普查工作会议除部署了几个大盆地的工作外，**在会议结束之后，黄教授与谢家荣一道专门提出了松辽平原的找油工作及其方向和工作方法**，并坚持当年布置普查勘探工作。"[74]

事实上，如上所述，谢家荣也审查和修改了"松辽平原石油地质踏勘设计任务书"，并且亲自起草了"关于松辽平原石油地质踏勘工作方法"。

因此，有非常充足的理由认为，松辽平原石油地质踏勘是谢家荣和黄汲清共同部署的，而没有任何理由认为是黄汲清一人所为。

然而，尽管协助审阅杨文初稿的任纪舜读过上述黄汲清和翁文波的文字，但他显然不认可。

十年前，在与审阅杨文初稿的任纪舜进行了"多次磋商"[7] 之后，黄汲清女儿黄洁生这样说 [75]：

黄汲清对不能派队伍开展松辽平原的普查深感焦虑，于是，他在自己的职权范围内指示青年地质学家苏云山起草了《松辽平原石油地质踏勘设计任务书》……12 月中旬踏勘任务圆满完成并取得重大成果，丰富的资料完全证实了黄汲清的正确预见……

1955 年全国石油普查工作会议没有将松辽平原列入普查任务。黄汲清在他职权范围内及时补救并部署了这一任务，设计了踏勘路线，由普委向东北地质局下达了《松辽平原石油地质踏勘设计任务书》，使松辽平原踏勘在当年就得以迅速展开，为大庆油田的发展迈出了关键的第一步。

在松辽平原未被纳入 1955 年普查计划后，黄汲清敢于坚持并亲自部署了当年松辽平原的踏勘，正是他深邃的地质理论和丰富的实践经验的集中体现。

在松辽评原踏勘任务的提出、设计、部署上黄汲清起着主导作用，他的思路就是指导松辽平原踏勘的思路，其中陆相生油理念和陆相沉积盆地占有重要地位。

历史怎么可以这样书写？

8. 对“黄汲清强调中、新生代大型盆地是主要的找油对象”的质疑

杨文称“黄汲清强调中、新生代大型盆地应是主要的找油对象”[8-9]。必须指出，黄汲清在大庆油田发现之前，没有在任何场合讲过或写过所谓“中新生代大型盆地是主要的找油对象”。杨文没有也列不出任何有关的证据来证明这一点。据杨丽娟博士说，他是引用任纪舜的《从天山之麓到松花江畔》[76]。换句话说，所谓“黄汲清强调中新生代大型盆地是主要的找油对象”，是任纪舜“研究”出来的成果而并非黄汲清自己的主张。

其实，任纪舜“研究成果”的原意还不止于此。他的原话是“黄先生更强调在大型盆地的中新生代地层中找油；谢先生更侧重于在古生代海相地层中找油” “黄先生更强调中国的大型陆相盆地，谢先生更强调在海相地层中找油。”[48] 其用意乃在据以说明：凡是已经找到油气的地方，就都是黄汲清主张的，没有或尚未找到油气的地方，就都不是黄汲清而是谢家荣主张的。

对此，作者在《是雪泥鸿爪，还是舞文弄墨--再论大庆油田不是在陆相生油理论指导下发现的（读任纪舜黄洁生《从天山之麓到松花江畔》笔记）》中用了近 6 千字的篇幅予以辩驳[4]，兹不复赘。

9. 讨论

9.1 黄汲清对发现大庆油田的贡献

黄汲清先生是中国地质界的大师之一，他对中国地质事业的贡献是巨大的。作者在“是雪泥鸿爪，还是舞文弄墨”一文的结束语中曾经写过一段话来评价黄汲清先生对发现大庆等油田的贡献[4]，本文照录如次：

黄汲清先生是一位国内外著名的大地构造学家和石油地质学家。上世纪 50 年代，他作为地质部普委常委，与谢家荣先生等一道，为中国的石油地质普查，为石油普查勘探战略的重点东移和大庆油田的发现，做出了重大贡献。作者在《中国石油的丰碑--纪念谢家荣教授诞辰 110 周年》中，依据史实评价了黄汲清先生对中国石油勘探战略重点东移和大庆油田发现的贡献，指出：他 1942 年就已经改变 1938 年“中国贫油论”的观点，认为中国石油“可达到自给自足之境”；他 1957 年的《对我国含油气远景分区的初步意见》虽然不是在石油普查战略选区时提出的，但它对于分析整个中国的含油气远景也是有帮助的，也为后来

的石油勘探战略重点东移提供了理论支持和依据，从而为石油勘探战略重点东移做出了贡献；黄汲清先生是三年石油普查的实施者和组织者之一，在 1955 年第一次石油普查会议前后和会议期间，为在全国开展大规模的石油普查工作做了大量的组织工作，在会议期间和谢家荣先生一道主持了石油普查战略选区的讨论，确定了 1955 年的石油普查项目，在第一次石油普查会议后，黄汲清先生和谢家荣先生一道"专门提出了松辽平原的找油工作及其方向和工作方法，并坚持当年布置普查勘探工作"，修改了项目设计书，为石油普查勘探战略重点东移和大庆油田的发现做出了重要贡献。会议闭幕后的最初三个月中，包括黄汲清先生在内的普委常委们在北京商谈工作计划，研究各工作地区的资料，制定和讨论各工作地区的设计，与苏联专家讨论石油地质，与有关各工作区的同志谈工作方法，在从 5 月 22 日到 12 月初的半年多时间里，与谢家荣先生等一起不辞辛劳，奔赴从新疆到四川的各个工作地区，在野外亲自指导，亲自示范，言传身教；亲自实地考察，发表对各个工作地区的具体意见，具体指导各个工作地区的找油工作，给各个工作地区从事实际工作的人作出了榜样，谢家荣、黄汲清先生等地质学家的辛劳和汗水和广大石油地质人员的辛勤劳动换来的成果催生了石油勘探战略重点东移，加速了大庆油田在 1959 年的发现。

黄汲清先生是一代地质大师，他为中国地质学的发展，包括为大庆油田的发现，做出了不可磨灭的贡献。任何人都不能否认这一点。我们没有任何理由忘记黄汲清先生为大庆油田的发现所做的一切。但是，对他的评价也要实事求是，也要依据历史资料说话。既不能不实地贬低，也不能不实地抬高。任何与历史事实相抵触的东西都应当摈弃。

9.2 黄汲清和谢家荣的中国石油远景观

所谓摘掉"中国贫油"的帽子，无疑起码应该有对中国石油远景的乐观估计。黄汲清对中国石油远景的估计有一个发展的过程，这很自然。1938 年，黄汲清发表《钻探四川油田之我见》，其开篇为"中国境内是否有发见大规模油田之希望"，其中说："世界上最重要之油田，大多数均与所谓大内斜构造有关，并且多半与阿尔布士造山运动有关。……中国除少数地域外，阿尔布士运动不显著，大内斜构造亦不多见，天山，阿尔泰，昆仑，祁连山，秦岭等，虽均可视作远古时代之大内斜地带，但均受剧烈的造山运动之影响，大内斜构造自中生代以来已不存在（昆仑山应除外），良好之油田构造，无法生成于其间。由此看来，中国境内似无发见大规模油田，如巴古油田，波斯油田，加利弗尼亚油田之希望。即以小规模之油田而论，其有希望之地带亦不甚多。"[77] 熟悉中国贫油论的人大多知道此段名言。

但当然，不应当纠住这段话不放，因为事物是发展的。四年后，即到 1942 年 12 月，可以认为，黄汲清已经不再是上述观点。这一年，黄汲清在《石油资源之分布》一文中说："现在每年汽油产量至少可达 1 万余吨，抵战前输入十分之一（单以汽油为例），今后尚可继续增产。且现在未开发之油田尚多，未开采之油母页岩亦广，此固有待于吾国地质学人的详细调查、研究。一旦至抗战结束之后，增加机器，大量开采，收回抚顺，自炼页岩，则吾国石油前途，虽不及美、苏，但亦可达到自给自足之境也。"[78]

对于 1942 年的这个"亦可达到自给自足之境"的含义，黄汲清在 1991 年给了一个解答，全文如下[47]：

1956 年 1 月初，可能是元旦前后（具体日期记不得了），陈云副总理电告普委，让黄汲清去中南海谈话……陈云同志……随即说出如下的一段话（大意）：人们都说"中国贫油"，但石油是工业的命脉，没有石油如何能建成现代化的工业国家？所以我们要有两种打算：一种是有丰富的石油，那当然很好；一种是真正贫油，那我们不得不走人造石油的道路。中国的煤炭资源在世界各国名列前茅，我们可以走煤炼油的道路嘛。您对这一问题有什么想法？

说老实话，对中国是否要搞煤炼油的问题，我还没有认真考虑过。从间接获得的消息，中央已派煤炼油专家赵宗燠赴锦州筹备……另一方面早在 1942 年我就发表文章说，中国的石油资源可以自给自足。面对陈副总理，我必须马上回答他的问题，怎么办呢？如果我是一个投机政客，何妨拍拍胸膛说："副总理同志，中国的石油资源丰富的很，只要你给我足够的人力、物力、财力，我保证在十年八年之内，找到一批大油田。"但是，作为一个实事求是的科学工作者，我不能这样讲。我虽然说过石油可以自给的话，这

只是一种估计，更确切地说，是一种猜测。今天，当国家领导人把这样的国家大事向我征求意见，我若是随心所欲地、完全不考虑后果地作出答复，那将是一种犯罪。因此，我没有直接用"是"或"不是"的方式回答问题，而是委婉地、可以说是绕圈子的办法把问题摆出来，让陈副总理自己考虑。

有人将黄汲清先生 1942 年的这种"估计"或"猜测"说成是"有史以来中国人第一次站在战略高度，对中国石油前景所作的最乐观也是最贴切的展望和评估"[75]。真是笑话。作者认为，黄汲清的这段话告诉我们，他的"中国的石油资源可以自给自足"的含义"只是一种估计，更确切地说，是一种猜测"，而不是根据中国地质条件进行的科学评估。陈云副总理征求的意见是：究竟是"有丰富的石油"，还是"真正的贫油"？他却不作正面回答，而是绕圈子，"把问题摆出来，让陈副总理自己考虑"。显然，这是一种无奈的回答。由此应该认为，黄汲清直到 1956 年对中国石油资源远景的答案必定是"心中没底"，"信心不足"，根本谈不上乐观的。

那么，所谓黄汲清"突破理论束缚，摘掉'中国贫油'帽子"究竟从何说起呢？

真正对中国石油前景做出"最乐观也是最贴切的展望和评估"的是谢家荣[27]：

中国肯定是有油的，并且其储量一定是相当丰富的……中国的四周，都有油田。如果说被包围在中间的这块大陆，没有石油，除非它是一块前寒武纪的古陆，或是为各种火成岩和结晶变质岩所组成的杂岩区，否则就无从理解说它没有油。事实证明，我们的大陆，包含有许多地槽，许多盆地，它曾经过复杂的地质历史，沧海桑田，山脉起伏，以至地面上出露了大片的沉积岩层，造成了很多显著的构造，因之，我们可以断定中国有油，并且可以推测它的分布是很广泛的。

在黄汲清"委婉地、可以说是绕圈子的办法把问题摆出来，让陈副总理自己考虑"之后 4 个月，即 1956 年 5 月，谢家荣指出[79]（黑体是本文作者所标）：

储油层的确定和圈闭类型的研究，在目前石油勘探工作方在开始的中国尤其具有关键性的意义，为了迅速发现足够的新油田以满足国家的要求，必须对此问题尽先研究，迅速予以解决。如果这两个重要问题，在各重要含油盆地中都已研究清楚，则我们的勘探对象即已确定，**只要钻探能赶得上地质工作，我想许多巨大新油田的跟踵发现，是在意料之中的**。

历史已经证明，谢家荣并不"是一个投机政客"。

9.3 提出松辽平原可能有油的地质学家中没有黄汲清，部署松辽平原石油地质踏勘也不是他一人所为

所谓摘掉"中国贫油"帽子，其标志应该就是大庆油田的发现。作者在《论大庆油田发现真相》 的导言中写过这样一段话："大庆油田的发现惊天动地，在人民共和国社会主义建设的历史上，有着极其重大的意义。它的发现凝聚了以王铁人为代表的工人阶级，从普通地质人员到谢家荣、李四光、黄汲清等大科学家的地质科学工作者，从基层领导到何长工、余秋里、康世恩等部长们的领导干部的心血，是他们，在以毛主席为首的党中央领导下，发扬艰苦奋斗、自力更生的伟大精神谱写出的不朽篇章。他们中的每一个人都为大庆油田的发现贡献了自己的一份力量，因而都有一份属于他们自己的功劳，将大庆油田的发现归功于某一个人是完全不正确的。"[80] 同样的道理，将摘掉"中国贫油"的帽子归功于某一个人自然也是完全不正确的。而将摘掉"中国贫油"的帽子归功于黄汲清，更是无论如何也说不过去，没有任何道理的。

黄汲清为大庆油田的发现做出了重要贡献，这是毋庸置疑的。但最先指出松辽平原和华北平原可能有油，提出到松辽平原和华北平原去找油的不是黄汲清，而是谢家荣、李四光和其他人等及苏联专家。否认或回避这点，是完全不可接受的。松辽平原石油地质踏勘是发现大庆油田的野外地质工作程序的起点，但把松辽平原石油地质踏勘的

部署归功于黄汲清一个人的企图注定不会成功，松辽平原石油地质踏勘的部署是谢家荣、黄汲清共同进行的。至于将大庆油田的发现归功于黄汲清陆相生油理论的指导，说是黄汲清突破了理论束缚，摘掉了“中国贫油”帽子，更是完全违背历史事实。

9.4 大庆油田的发现丰富了陆相生油理论，而不是陆相生油理论指导了大庆油田的发现

潘钟祥 1941 年指出陕北的油田是河流和湖泊相的，可能没有什么商业价值，四川的白垩纪的油是湖成的，可能没有商业价值；但在特殊情况下，陆相石油可以具有商业价值。黄汲清等人 1943 年的 *Report on Geological Investigation of Some Oil-Fields in Sinkiang* 依据新疆油田石油地质调查所得资料，提出了新疆的石油是非海相成因的，提出了多期生油的观点，这是值得肯定的，但不能因此否定谢家荣 1929 年就提出了陆相生油论的史实，宣称黄汲清和潘钟祥才是中国陆相生油理论的提出者，没有道理。*Report on Geological Investigation of Some Oil-Fields in Sinkiang* 的结论是[10]：新疆的石油是非海相成因的，因而不应该过分夸大新疆各油田的远景；陆相生油可以形成有经济意义的重要油田--像独山子那么大的油田或比之更大的油田；除非发现较深较好的含油层（即海相二叠系油层），否则独山子油田将只能是一个小油田，但却很难指望形成像巴库或马拉开波那样的大油田。并非杨文和另外一些人所说的黄汲清当年得出了陆相生油可以形成“具有重大经济价值的油田”的结论。

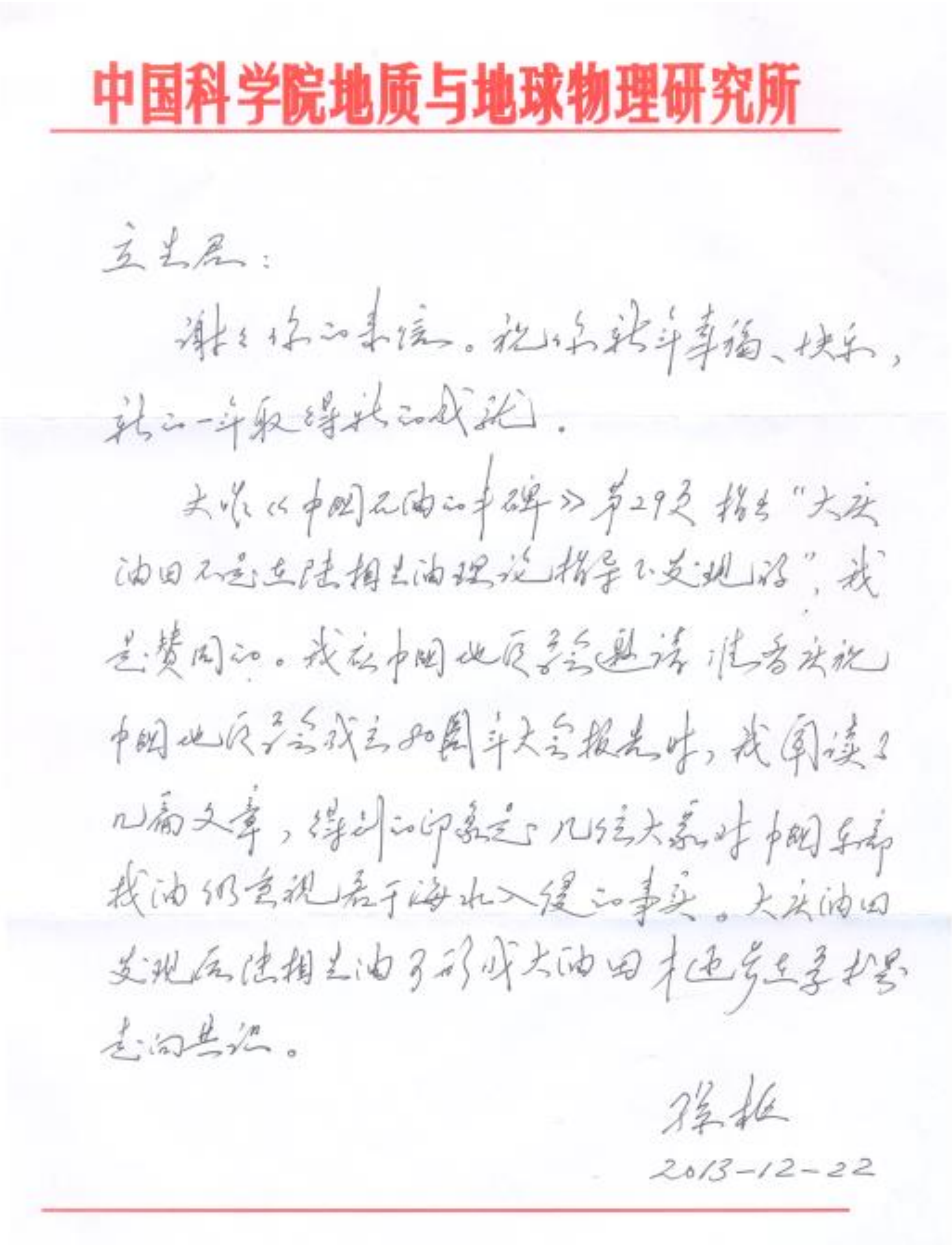
有人嘲笑说：“地质找矿的发现事例，有许多是有运气的成分，但总不能说大庆油田的发现是谢家荣先生海相生油论指导的胜利吧”[5]。这是一个石油地质外行的话。因为虽然大家都寄希望于海相第三系，但是正如谢家荣在石油普查一开始就指出的：“在实际找油工作中，我们所注意的是含油气的层系，更重要的是储油层，而不是生油层，但从生油层的观点来研讨普查区域内含油的可能性，对全面了解问题方面还是有好处的。”[54] 虽然大家都寄希望于海相第三系，但在实际工作中注意的是含油气的层系，尤其是储油层和圈闭类型的研究。最后当储油层和圈闭类型研究清楚，钻探发现大庆油田之后，经过大量的工作，发现并不是海相第三系，而是白垩纪和第三纪的濒海三角洲沉积，从而认定大庆油田是陆相生油的。这就是实践丰富了理论：以前认为，陆相生油只能形成像独山子那样的或比独山子大的油田，但形成不了巴库那样的大油田；大庆油田的发现正式宣告，陆相生油可以形成大油田——这才是真正的历史，而不是所谓陆相生油理论指导了大庆油田的发现。

正如胡社荣指出过的[18]：

> 在我国，真正建立和完善及指导我国石油勘探的陆相生油理论，是在大庆油田发现以后（近来有人认为，大庆油田的白垩系中有海相地层，提出对其生油理论有重新认识之可能的看法），是广大石油地质工作者共同努力的结果。

也正如已故中国科学院院士孙枢先生指出的[81]（图 5）：

> “大庆油田不是在陆相生油理论指导下发现的”，我是赞同的。我应中国地质学会邀请准备庆祝中国地质学会成立 80 周年大会报告时，阅读了几篇文章，得到的印象是，几位大家（当时）对中国东部找油仍重视若干海水入侵的事实。大庆油田发现后陆相生油可以形成大油田才逐步在学界走向共识。



中国科学院地质与地球物理研究所

立志君：

谢谢你的来信。祝你新年幸福、快乐，新的一年取得新的成就。

大作《中国石油的丰碑》第29页指出"大庆油田不是在陆相生油理论指导下发现的"，我是赞同的。我应中国地质学会邀请准备在庆祝中国地质学会成立80周年大会报告时，我阅读了几篇文章，得到的印象是：几位大家对中国东部找油仍重视着于海水入侵的事实。大庆油田发现后陆相生油可形成大油田才逐步在学术界走向共识。

孙枢

2013-12-22

图 5. 孙枢先生 2013 年 12 月 22 日致本文作者的信

Figure 5. Letter from Mr. Shu Sun to the author of this article on December 22, 2013

9.5 谢家荣对中国石油地质的主要贡献

作者在《谢家荣：现代中国地质科学的拓荒人--纪念中国地质学会成立 100 周年》中，用了 2600 字的篇幅概述了"中国石油地质学的先驱与功臣"谢家荣对中国石油地质学和中国石油大发现所做的贡献 [65]。概括起来说，除了进行中国第一次石油地质调查（1921），发表第一篇石油地质调查报告《甘肃玉门石油报告》（1922），编著中国第一本石油地质专著《石油》（1929），进行中国第一次石油储量计算（1937），最早指出黑龙江和热河可能有油 [62]、并最早将找油目标指向今大庆地区 [63]，反反复复指出松辽和华北可能有油外 [27,30,52 & 64,]，谢家荣还解决了一系列中国石油地质的重大问题：

- 在中国最早从理论上阐述陆相生油问题，并指出，"三角洲半属海相，半属陆相。……在此区域之内，海陆二相之地层，往往相间而生，于石油之积聚，最为适宜。"[14] "富于生物之海相（浅海）地层或海陆混合之海湾或三角洲地层，于石油之产生，最为适宜。"[16] 松辽油田与华北油田事实上就产在濒海三角洲的地层中。1950 年代谢家荣对陆相生油理论进行了大量、艰苦的探索 [3]。
- 发表指导 1950 年代石油普查的纲领性文献《中国的产油区和可能含油区》，指出"中国肯定是有油的，并且其储量一定是相当丰富的"，"推测它的分布是很广泛的"，"内陆相沉积的本身也能生油"，将中国的含油远景区分为三大类 20 个区 [27]。中国 1950 年代石油普查最终确定的战略选区全部都是谢家荣在此文中指出的。
- 率先批判"油在西北"之说 [62]，最早提出"依据地质理论，并为解决中国石油问题计，我们应该扩大范围，在中国各地普遍探油"[82]，在 1955 年全国石油普查刚一开始就制定了石油普查正确的战略方针："在全国含油区和可能含油区内进行大规模的全面的地质普查是十分必要的 [54]。
- 制定了中国石油普查勘探的正确的战术方针："储油层的确定和圈闭类型的研究，在目前石油勘探工作方在开始的中国尤其具有关键性的意义"，"如果这两个重要问题，在各重要含油盆地中都已研究清楚"，"只要钻探能赶得上地质工作"，"许多巨大新油田的跟踵发现，是在意料之中的。"[79]
- 在反复强调要纠正"油在西北"之说的偏向的同时，还屡次指出必须纠正只注意中新生代陆相砂岩储油层及背斜构造的偏向，要同样注意西北以外的许多可能的油区，要研究从古生代到新生代的可能储油层，包括海相碳酸盐储油层以及除背斜构造以外的各种圈闭 [28-29,79 & 82-83] 。
- 率先提出石油勘探战略重点东移的思想。早在 1956 年 5 月就提出："我们不但要在西北广大地区以往曾做过相当工作的如柴达木、准噶尔等地区内进行勘探，还要在尽管了解还不很够但交通较便、开发较易的地区内进行工作，俾可收事半功倍之效。"[79] 并在 1957 年重申："为达到第二个五年计划所要求的储量，则必须发现几个大的新油区，而为了要使一部分的新油区，能在此期限内投入生产，获得产量，我们不但要在西北广大地区已证实的油田内进行工作，还要在交通较便，开发较易的地区内，加速勘探，俾可收事半功倍之效。"[29]

9.6 尊重历史，敬畏历史，是科学工作者的道德底线

科学家应该是老实人，应该说真话。1950 年代松辽平原和华北平原的石油普查，不是在陆相生油理论的指导下进行的。大庆油田的发现并非陆相生油理论指导的结果。恰恰相反，包括谢家荣、黄汲清在内，当年从事松辽平原和华北平原石油普查的人们，是寄希望于海相第三系的，这有当年石油普查会议的决议和谢家荣、黄汲清等人的文章和报告以及地质部第一次和第二次石油普查工作会议的决议为证。将当年报告中“不合时宜”的文字删除掉，并不能改变历史。

黄汲清 1978 年 1 月的上书信，在揭露所谓“地质力学理论指导发现大庆油田”不实的同时，本应该指出当年与他一起指导石油普查的谢家荣对中国石油地质的上述贡献，哪怕只是关于松辽平原找油的部分。如果是这样，在中国学术界发生的那一场旷日持久的争论--地质力学理论发现大庆油田说与陆相生油理论指导发现大庆油田说之争，一场双方都站在空中楼阁上的争论根本就不会发生。令人非常遗憾的是，黄汲清的上书信竟然连谢家荣的名字都不提。那场争论发生了。

黄汲清从 1943 年的 *Report on Geological Investigation of Some Oil-Fields in Sinkiang* 之后到 1978 年初的 30 多年间，包括他和谢家荣一起指导 1950 年代石油普查的几年时间在内，没有关于陆相生油的论述（而谢家荣等人在此期间有大量的论述），甚至没有提到过他的 *Report on Geological Investigation of Some Oil-Fields in Sinkiang*（虽然 1993 年版的《黄汲清石油地质著作选集》中的《新疆油田地质调查报告》提了一句，但可疑），而经过海相陆相的长期争论（也没见黄汲清对此争论发表过意见），最终认为大庆油田是陆相生油之后，在谢家荣和李四光都已经辞世多年之后，他突然想起了他 1943 年的报告，在上书信中称是他依据陆相生油理论提出找油的四大重点地区，去松辽平原找油的。所谓陆相生油理论指导松辽平原和华北平原石油普查抑或陆相生油理论指导大庆油田发现的说法由此产生。

这是一代地质大师黄汲清的悲剧，可叹！

科学工作者必须有历史敬畏感，绝不能篡改或伪造历史。这是一切科学工作者，尤其是自然科学工作者的道德底线，一条绝对不可逾越的红线。历史是严肃的，只有尊重历史，才能得到历史的尊重。想要嘲弄历史的人，最终只能被历史嘲弄。

9.7 尊重权威，不能迷信权威

对于学术上的权威，我们应当尊重，尊重知识，尊重科学。这不应该含糊。但是，不能迷信权威，以为权威的言论全都是真理。有的时候，对待权威的言论，还得认真做方方面面的分析，多问几个为什么？以求甚解，同时防止上当受骗。黄汲清当年在上书信中谎称他依据陆相生油理论提出找油的四大重点地区，之所以在中国学术界被广泛接受，在中国新闻界被广泛传播，就是因为迷信权威，以为权威所言都是真经，以至于至今仍然有人竭力维护它，真是害人不浅，教训深刻。

在纪念黄汲清诞辰 120 周年的时候，之所以会出现上述杨丽娟的两篇文章也是因为迷信权威，以为权威所言都是真理。

作者真诚地希望，为了中国地质事业的健康发展，再也不要发生这类事了。

9.8 提倡争鸣，反对鸵鸟政策和压制不同意见

作者 2011 年在《中国石油的丰碑》的"自序"中这样说过："涉足这个领域不到两年后，我惊奇地发现：所谓依据李四光的地质力学理论到新华夏沉降带找油、发现大庆油田，所谓用陆相生油的理论找到大庆油田，闹的沸沸扬扬，却原来都是根本没有的事，而当年对中国石油地质贡献最大的谢家荣先生却基本上被人忘却了。这，真算得是中国科学技术史上的奇观了。"[84]

十多年过去，在中国学术界，至少在中国地质学界，伴随出现了另一种奇观，那就是尽管已经披露出了大量的证据，既有当年公开发表的文字，也有大量档案资料，证明所谓依据李四光的地质力学理论到新华夏沉降带找油、发现大庆油田，所谓用陆相生油的理论找到大庆油田，都是根本没有的事，但是，无论是"依据李四光的地质力学理论到新华夏沉降带找油、发现大庆油田"的主张者，还是"依据陆相生油的理论找到大庆油田"的维护者，他们大多采取鸵鸟政策，装着"没有看见"已经披露出来的大量史实，不予理睬，他们原来怎么讲，现在照样怎么讲。他们大多掌握着当今中国学术界的话语权，他们有随时发表文章的方便。他们显然相信只要不断重复，他们讲的就一定会成为真理。这是中国地质学家的一股歪风。例如赵文津先生，读到了我送给他的《论大庆等油田的发现与李四光的地质力学理论无关》后，就装着没有看见我送给他的文章，发表了《大庆油田发现真相: 中国独创理论不容抹杀》。在他写这篇文章时，旁边的同志就曾提醒他，《论大庆等油田的发现与李四光的地质力学理论无关》披露了大量资料，他直率地说："不理他"，照样按照原来的调门儿写。2022 年出版的长篇巨著《中国地质科学发展史》[6]的作者以及该书主编之一的赵腊平，在 2024 年 10 月发表的《"帽子"是这样摘掉的--李四光的新华夏系与国内大型油田的发现》[85]，采用同样的手法，对李四光先生亲自改正和补充过的 1954 年 3 月 1 日的报告稿视而不见，继续宣扬国家地质总局调查组造假的文字，坚信只要坚持不懈地重复，谎言就一定会成为真理。这不是科学的态度。对于已经披露出的资料，如果说的有道理，就应该接受，如果说的没有道理，就应该据理反驳。不同的观点要敢于交锋，而不是永远保持平行线，各说各的。真理是越辩越明的。杨文的发表说明，"依据陆相生油的理论找到大庆油田"的维护者，也与"依据李四光的地质力学理论到新华夏沉降带找油、发现大庆油田"的主张者一样采取鸵鸟政策。作者不赞成这样的态度。作者希望他们认真对待作者的文章已经披露的事实，如果它们的确是对的，就应该接受，如果它们真正是错的，就不必宽容，拿出真实、过硬的资料来批驳它们，目的只有一个，那就是还历史的本来面目。也希望相关的学术期刊，容得下不同观点的文章，给持不同观点的文章以发表的机会，不论涉及到什么样的人物，只要它们是摆事实、讲道理，论点清楚，论据真实且充分的，就给它们以面世的机会。

10. 结论

从上面的叙述中，我们可以得出下面的结论：

陆相生油论是谢家荣在 1929 年，而不是潘钟祥在 1941 年和黄汲清在 1943 提出的。

潘钟祥的陆相生油论认为陆相生油一般没有商业价值，特殊情况下可以形成有经济价值的油田。黄汲清的陆相生油论认为陆相生油可以形成有经济价值的重要油田--像独山子那样的油田或更大的油田，但难望形成巴库那样的大油田，没有陆相生油“可以形成具有重大经济价值的油田”的结论。

黄汲清从来没有过松辽盆地和华北盆地可能有重要油田的大胆“设想”。

黄汲清 1955 年依据陆相生油理论提出找油的四大重点地区的说法不实。1950 年代松辽平原和华北平原的石油普查不是依据陆相生油理论进行的。

所谓黄汲清特别关注松辽、华北、四川、鄂尔多斯四个最有远景的重点地区的说法违背历史事实，直到 1962 年，黄汲清仍然认为准噶尔盆地是最有远景的。

最早认为松辽平原和华北平原可能有油，提出到松辽和华北找油的不是黄汲清，而是谢家荣、李四光等众多中国地质学家和苏联专家。

松辽平原石油地质踏勘的部署是谢家荣、黄汲清共同进行的而不是黄汲清一人所为。

所谓黄汲清强调中、新生代大型盆地应是主要的找油对象不实。

不是陆相生油理论指导松辽平原石油普查，发现了大庆油田，而是大庆油田发现以后，陆相生油可以形成大油田才逐渐成为共识。陆相生油理论的完善并指导我国石油勘探是大庆油田发现以后的事。

说黄汲清突破理论束缚，摘掉中国“贫油”帽子，完全违背历史事实，没有一点点道理。

致 谢

本文写作过程中得到诸多专家的鼓励、帮助与指教，作者谨向他们表示由衷的感谢。他们是：中国地质科学院地质研究所浦庆余研究员，上海社会科学院历史研究所张剑研究员、浙江中控研究院徐义亨高级顾问，原国土资源部西安地质矿产研究所冯益民研究员、原国土资源部成都地质矿产研究所杜光树教授级高级工程师、中国地质调查局成都地质调查中心王高明副研究员、四川省核地质调查研究所张运昌高级工程师、西南民族大学覃影副教授、中国第二历史档案馆刘鼎铭研究馆员、全国地质资料馆李晨阳教授级高级工程师、于瑞洋教授级高级工程师和商云涛高级工程师、中国矿业大学（北京）梁汉东教授、四川省峨眉市水利电力局张铸林高级工程师、中国地质图书馆张尔平高级工程师、中国地质博物馆伍美茹研究员、中国科学院大学人文学院胡晓菁高级工程师以及中国科学院自然科学史研究所硕士研究生胡阳东同志。

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Author contributions

Lisheng Zhang contributed to the data collection, compilation and interpretation and wrote the paper.

Data availability

Data sets generated during the current study and internal reports/files referenced in this paper are available from the corresponding author on reasonable request, but restrictions apply to any data used in these studies.

Declaration of competing interest

The author declares that he has no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Use of AI tools declaration

The author declares that he has not used Artificial Intelligence (AI) tools in the creation of this article.

Book Review

No. 9 Bingmasi, Beiping, the cradle and source of modern science and technology in China

——The monograph *No. 9 Bingmasi: A Historical Study of the Former Site of the Geological Survey of China* was published

JZ Yin[1,2,3] Ⓛ

Abstract

This article reviews the book *No. 9 Bingmasi: A Historical Study of the Former Site of the Geological Survey of China* in a relatively comprehensive manner, especially the first generation of Chinese scientists who were eager to save the country through science in this courtyard. Their vivid figures are so real and vivid, and their lofty ambitions are so lofty. The reason why this first scientific institution in Chinese history has achieved great success is not only due to the first generation of Chinese geologists who combined Chinese and Western knowledge, but also inseparable from the participation and great help of geologists from developed countries all over the world. Inclusiveness, freedom, openness, equality and mutual assistance are the foundation of the success of this scientific research institution.

Key words: No. 9 Bingmasi; Beiping; China Geological Survey; the first Chinese scientific institution; a combination of Chinese and Western cultures; freedom and openness; equality and mutual assistance

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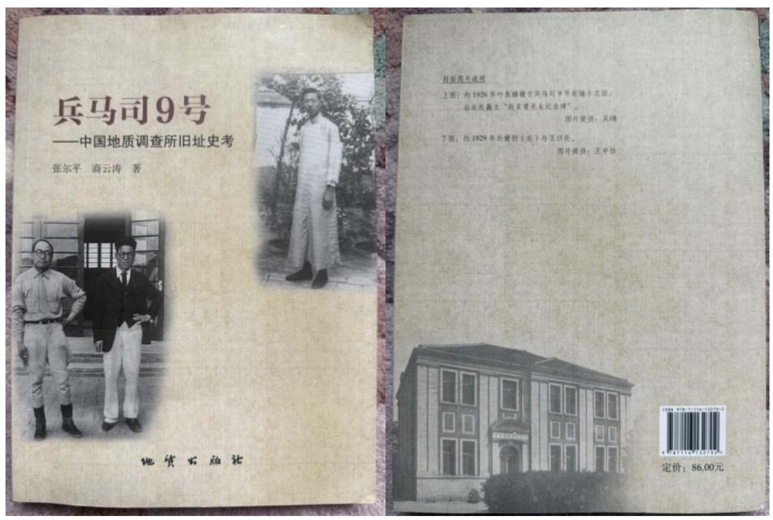
1

One day, a friend who came to visit me saw the Chinese version of *No. 9 Bingmasi: Historical Research on the Former Site of the Geological Survey of China* on my desk and exclaimed: Where did you get the detective novel?
I answered with some doubt: Where can I find detective novels? I haven't read this kind of novel for many years.
My friend picked up a book from the desk and handed it to me, saying: This one, *No. 9 Bingmasi*.
I took the book and reminded him with some sarcasm: You'd better put on your glasses and read the subtitle "-- Historical Research on the Former Site of the Geological Survey of China" which is much smaller than the main title.
So he found his glasses and put them on, and then he said to himself as if he suddenly realized something: Oh, it turns out to be *No. 9 Bingmasi: Historical Research on the Former Site of the Geological Survey of China*. If you don't look carefully, you may really ignore the subtitle.



a b

Figure 1. Cover (a) and back cover (b) of the book *No. 9 Bingmasi: A Historical Study of the Former Site of the Geological Survey of China*[1]
Cover image: L. F. Yih photographed the small garden on the east wall of No. 9 Bingmasi in circa 1926 (above), C. C. Sun (left) and Y. L. Wang (below) in circa 1926; back cover image: The library of the China Geological Survey at No. 9 Bingmasi, completed in 1921

Then he put the book back on the desk with some disappointment and said: I thought so; it turns out to be a book in your major. It's boring.
This friend who specializes in computers is not in the earth science industry, but he loves to read novels, especially detective suspense novels. So I can understand what he said about "boring".
Because I am very familiar with him, I picked up the book and told him: Don't say it's boring, and don't underestimate this book. Don't you like Chinese history and traditional culture? Most of the origins or beginnings of modern Chinese science and technology, or the masters, who first

introduced modern scientific and technological knowledge from the West to China, are the protagonists of this book. Therefore, don't underestimate the No. 9 courtyard of Bingmasi in the old Peking City. Because there were once masters gathered here, and there were people coming and going, but there was no layman, and almost everyone was well-versed in Chinese and Western learning. In addition, many internationally renowned scientists who helped China develop geological sciences displayed their talents here. Later, for a long time, most of the Chinese earth scientists came out of here.

Without their arduous and hard work, there would be no scientific and technological development and civilization in mainland China. This is the historical truth and the former glory of No. 9 Bingmasi.

2

After hearing my simple explanation, my friend suddenly became interested: Really? Come on, tell me in detail.

Figure 2. Members of the Geological Society of China, founded in 1922, took a group photo in front of the library of China Geological Survey at No. 9 Bingmasi
From left to right in the front row: H. T. Chang, V. K. Ting, W. H. Wong, H. T. Lee, Y. C. Sun and P. L. Yuan; J. G. Andersson (first row, left), A. W. Grabau (first row, right); T. I. Loo, C. Y. Hsieh, C. Li and Duo Yang in the second and third rows

I told him: Let me make it short. Modern Chinese science originated in the Republic of China, a seemingly short 38-year period. But don't underestimate this period: short but colorful, warlords fighting but open, free and inclusive. This period can be called the second "Spring and Autumn Period and Warring States Period" in Chinese history, and it is the second great period that truly practiced "let a hundred flowers bloom and a hundred schools of thought contend." Countless flashes of freedom from various schools of thought emerged in this period like mushrooms after rain. Because of the unprecedented all-round openness and freedom of thought and speech, countless aspiring young people went to study in many developed countries overseas, and discovered the huge gap between China and developed countries, and initiated China's democracy and science movement, and then introduced Western advanced science, technology and democratic concepts to China, thus bringing about all-round innovation and progress in

China. Among them, the most systematic and successful one is the establishment and development of the China Geological Survey, China's first scientific institution in the true sense. The survey produced V. K. Ting, the academic leader of the Republic of China, the founder of Chinese earth science, and the true father of Chinese geology. It also produced Dr. W. H. Wong, the first Chinese doctor in geology, who graduated from the University de Louvain in Belgium. Dr. Wong was also one of the pioneers and founders of China's geological cause. The other founder was H. T. Chang. Of course, there was also C. Y. Hsieh, who created many firsts in Chinese and even the world's geology, and T. K. Huang and C. Y. Lee, who later became famous in the Chinese geological community, and almost all the first and second generation geologists in the modern Chinese geological community.

Of course, J. S. Lee, who has been a prominent figure in the geological community of mainland China since the early 1950s and has been almost completely independent, has also left his few footprints here, which were left when he occasionally came here for meetings. His main place of activity was not at No. 9 Bingmasi, but at the Institute of Geology of the Academia Sinica, which he presided over.

In addition, Lu Zuofu, a big industrialist who almost gave up all his profits and transferred almost all important universities, scientific research institutions and military industries in northern China to the southwest of the rear area through the Yangtze River in order to fight the war, not only stayed here, but also actively donated money to support the construction and development of the China Geological Survey. Of course, in addition to Mr. Lu, many celebrities and dignitaries at that time almost all set foot here and actively donated money and materials to build this first real scientific institution in China's history.

Figure 3. Chinese and foreign scholars from the China Geological Survey took a group photo in Zhoukoudian, Fangshan, Beijing around 1930

From left: W. C. Pei, H. S. Wang, K. M. Wang, C. C. Young, B. Bohlin, D. Black, P. T. de Chardin, G. B. Barbour

The China Geological Survey was not only initiated and established by several overseas returnees or “sea turtles”: Chinese who have studied overseas and returned to China, who combined Chinese and Western learning, but also internationalized from the very beginning, that is, directly connected with the international community. In other words, all the most cutting-edge results in geology from around the world were almost seamlessly transmitted to China, an ancient oriental country, in real time. As a result, the institute had a high starting point and soon became the most successful scientific research institution in China at that time. It was these “sea turtles” and geologists from all over the world who led and effectively guided the initial research work of the China Geological Survey.

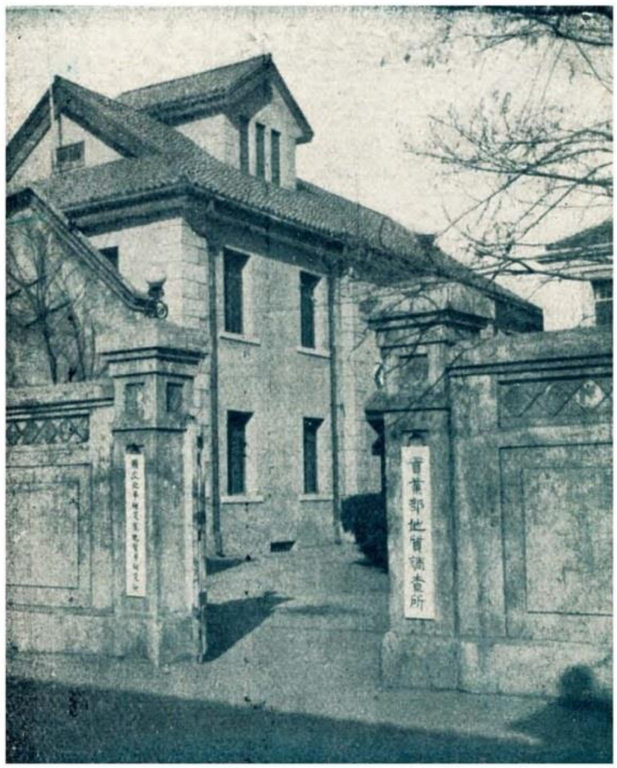


Figure 4. The gate of the China Geological Survey at No. 9 Bingmasi in the late 1920s
The building inside the gate is the West Building, which is very familiar to the colleagues of the Geological Survey

At the same time, the China Geological Survey attaches great importance to the training of the younger generation. Many students trained by the Institute were sent to developed countries such as Europe and the United States for further studies, and were entrusted with important tasks after returning to China. Later, they became the backbone and mainstay of various aspects of geoscience. Several generations of geologists, such as V. K. Ting, W. H. Wong, T. K. Huang, Tsan-Hsbun Yin and C. Y. Lee, all studied abroad and obtained relevant degrees. A large number of professional talents in the Institute also have the experience of further study and investigation abroad. This enables them to have a clear understanding and comprehensive understanding of international academic progress and the gap between China and the international geological community, and to absorb the experience and guidance of foreign experts in their work.

Figure 5. Group photo of some classmates from the Institute of Geology in 1915
From left: T. I. Loo, L. F. Yih, Yuanmo Hsu, T. C. Chow, K. W. Hsu, T. O. Chu, C. C. Liu, H. T. Lee, C. Y. Hsieh, Zhixin Chao; Note: The Institute of Geology was a short-lived geological training institution before the establishment of the China Geological Survey. Most of its graduates entered the China Geological Survey

Figure 6. Group photo of some teachers and students of the Institute of Geology in 1916
Front row, from left: W. H. Wong, H. T. Chang, V. K. Ting; middle row, from left: P. Y. Tung, T. O. Chu, T. C. Chow, H. T. Lee, H. C. T'an, K. W. Hsu, C. C. Wang; back row, from left: Zhixin Chao, L. F. Yih, Yuanmo Hsu, T. I. Loo, C. Li, C. C. Liu

It must be said that the fact that the China Geological Survey actively invited foreign scholars to join the institution at its inception was an important factor in its rapid development and rapid acquisition of international academic reputation. In other words, freedom, openness and tolerance are one of the important factors for the success of the institute.

Since the 1910s, the Ministry of Agriculture and Commerce of the Republic of China or its subordinate Mining Administration has successively hired more than a dozen foreign geologists and paleontologists to work in China. Through them, the Geological Survey has received strong support from foreign foundations for its field and related research. These foreign scholars either work in China for a short period of one or two years, or conduct research in the institute for more than 20 years. Some foreign scholars were already world-renowned scientists before coming to

China, and therefore have a certain authority and academic influence in the geological community. They cooperated sincerely with the Geological Survey, either taught at the Institute of Geology, or worked as technicians at the Geological Survey, or led young geologists to conduct surveys, or held multiple positions. They helped China build its own geological research team from scratch, founded a high-level academic journal, participated in the establishment and presided over the institute's Cenozoic and Soil Research Laboratories, etc., and played an important role in the construction and development of China's geological cause[1].

Figure 7. Group photo of teachers and graduates of the Paleontology Group of the Department of Geology, Peking University in 1923
Front row, from left: Y. C. Sun, S. K. Lee, A. W. Grabau, C. Ho, L. Wang; Back row, from left: C. C. Young (second), K. M. Wang (third), T. F. Hou (fourth), Hishchih Chang (fifth)

Among the foreign scholars who have cooperated with the China Geological Survey, in the 1910s, there were Friedrich Solger (1877-1965) from Germany, Swedish geologists Andersson J. G. Andersson (1874-1960), Eric Nystrom, mineral geologist F. R. Tegengren (1884-1980), paleobotanist Thore Gustaf Halle (1884-1964), Canadian scholar Davidson Black (1884-1934), etc. In the 1920s, there were American geologist Amadeus William Grabau (1870-1946), Vice President of the French Geological Society and paleontologist Pierre Teilhard de Chardin (1881-1955), Austrian paleontologist Otto Zdansky (1894-1988), Swedish paleontologist Birger Bohlin (1899-1990), Scottish geologist George B. Barbour (1890-1977). In the 1930s and 1940s, there were German anthropologist Franz Weidenreich (1873-1948), American soil scientists R. L. Pendleton and James Thorp (1896-1984); and Japanese geologist Morita Hijiri who joined in the 1940s.

Figure 8. J. G. Andersson, a Swedish geologist who worked at the China Geological Survey in the early days

Scholar Han Qi pointed out in his discussion of the scientific cooperation between V. K. Ting and W. H. Wong and other foreign scholars[2]: In the short period of more than 20 years from the establishment of the Geological Survey to the outbreak of the Anti-Japanese War, the China Geological Survey established close ties with the Swedish Museum of Natural History, the Swedish Far Eastern Museum, Uppsala University, the American Museum of Natural History, the French Institute of Human Paleontology and other institutions in the field of research related to China. There was both cooperation and competition among scholars from various countries, which jointly promoted the development of Chinese geology and gradually realized its localization. These foreign experts introduced and applied the latest international academic achievements to China's geological research, providing Chinese geological colleagues with an international research perspective.

…

Hearing this, my friend sincerely sighed: I didn't expect that China's modern scientific career originated here. In this case, please allow me to take this book back and study it carefully.

I am very happy that my friend has come to his senses, and I agree that he can take this book back and read it slowly, hoping to spread the truth about the scientific origin of China's career through him and his own friends.

At the end of the gathering that night, my friend happily took the book home.

3

Because of ideological issues, after 1950, the geological community in mainland China only knew one person and only promoted one person and one geological theory, namely S. K. Lee and his so-called geomechanics. There was no V. K. Ting, the real founder and Lee's mentor, nor W. H. Wong, another important founder of Chinese geology, Lee's colleague, and C. Y. Hsieh, an outstanding geologist, and other former people from the China Geological Survey. This tendency of Lee to dominate the geological community in mainland China has not completely disappeared.

This shows the stubbornness of the ideology that completely abandons facts.

Nevertheless, with the increasing development of communication technology and the unstoppable international exchanges brought about by it, the historical data about the China Geological Survey and its founder have become more objective and fair. The era of only Lee and his theory has finally come to a heavy end, although the negative traces are still obvious and stubborn. The most commonly used and famous search website in mainland China, "Baidu", introduces V. K. Ting, the founder of Chinese geology, as follows:

Figure 9. A small gathering of elites from the China Geological Survey in the early 1930s
W. H. Wong (first from left), A. W. Grabau (third from left), V. K. Ting (first from right), C.Y. Hsieh (fourth from right)

V. K. Ting (1887-1936), a native of Taixing, Jiangsu, China, was a famous scholar and one of the important leaders of the academic community during the Republic of China. He was known as the father of Chinese geology, a geologist, social activist, educator, one of the most influential figures in the history of Chinese science and culture, and the founder of China's geological cause[3-4]. He made unique contributions in the fields of geology, geography, cartography, anthropology, eugenics, history, archaeology, paleontology, zoology, philosophy, minority linguistics, and the compilation of ancient Chinese scientific and technological documents. He was a typical encyclopedic figure. Ting founded and led China's geological work, founded the Geological Society of China, and was also a pioneer of modern cartography in China. His contribution and influence on Chinese geology are unparalleled. Ting was a versatile person. He also had a high level of attainment in literature, and his poems were highly praised.

Ting entered a private school when he was young, and went to Japan and Britain to study when he grew up. He graduated from the University of Glasgow in 1911 with a double diploma in zoology and geology. After returning from studying abroad, he conducted geological surveys in Yunnan, Guizhou and Sichuan at his own expense, laying the foundation for China's geological science research. He was hailed as the Xu Xiake of the 20th century. After that, he taught courses such as physiology, English and chemistry at Nanyang Middle School in Shanghai. In 1913, he served as the head of the Geology Section of the Mining Administration of the Ministry of Industry and Commerce. Later, he joined hands with H. T. Chang to establish the Geological Research Institute of the Ministry of Agriculture and Commerce of the Republic of China and served as its director. He resigned from the post of director in 1914. In 1916, he established the China Geological Survey of the Ministry of Agriculture and Commerce and served as its director. After resigning from the post of director of the Geological Survey in 1921, he served as honorary director and general manager of Beipiao Coal Mine for about 5 years. In 1922, he presided over the first preparatory meeting of the Geological Society of China. In 1923, he was elected as the second president of the Geological Society of China. In the spring of 1929, he served as the honorary director of the Cenozoic Research Laboratory of the Geological Survey. In 1931, he became a professor of geology at Peking University. On January 5, 1936, he died young due to coal gas poisoning during an inspection at the Tanjiashan Coal Mine in Hunan. Ting was a perfect combination of multiple roles, including a professional scientist, an organizer of scientific undertakings, and a disseminator of scientific ideas. Ting's expertise in science and good at doing things was not only reflected in his organization and management of scientific undertakings in China's early years, but also in his colorful and legendary experiences later. As the founder of Chinese geology, Ting not only laid the foundation of Chinese geology, but also charted the path for its healthy development. In the early days of China's geological undertakings, Ting played the role of a "politician in the academic world" to the fullest. He founded China's earliest and most successful specialized geological education institution, the Institute of Geology, and founded China's earliest geological survey institution and also China's earliest scientific research institution, the China Geological Survey. Under Ting's leadership, Chinese geology achieved outstanding results and gained a world reputation as early as the 1920s[3-7].

Figure 10. Inauguration ceremony of Qinyuan Fuel Research Laboratory of China Geological Survey, No. 9 Bingmasi, October 1930

A. W. Grabau (seated right), C. Y. Hsieh (second from right, the first director of the Fuel Laboratory), Duan Xing (third from right), H. S. Wang (third from left); also included W. H. Wong, S. G. King and his wife (donors of the Fuel Laboratory), Davidson Black and G. B. Barbour, etc.

Hu Shi, the most famous scholar in modern China and another academic leader, said that Ting was "a most glorious and capable good man, a great man who was born to get things done, to lead people, to train talents, and to establish academics."[5].

Ssu-nien Fu (Sinian Fu), a famous scholar in modern China and another academic leader, commented on Ting: I think Ting is indeed the representative of the best and most useful Chinese in the new era. He is the highest essence produced in the process of Europeanization of China, a high-powered machine fueled by scientific knowledge, a person who obliterates subjectivity, serves academics, society, and the country, and serves the progress and happiness of the public[5-6].

The second person who made the greatest contribution to the establishment and development of Chinese geology is none other than W. H. Wong (1889-1971). According to relevant data[1,7-9], Wong was born in a gentry and merchant family in Ningbo, Zhejiang. He studied in Belgium in the late Qing Dynasty and majored in geology. He later received a doctorate in science from University de Louvain and returned to China in 1913. As a famous scholar in the Republic of China and one of the most famous geologists in early China, Wong made pioneering and outstanding contributions to many aspects of Chinese geological education, mineral exploration and development, earthquake research, etc. He was China's first doctoral student in geology, the author of China's first *Geology Lecture Notes*, the first Chinese scholar to write *China Minerals*, the compiler of China's first colored national geological map, the first Chinese scholar to examine earthquake hazards and publish a monograph on earthquakes, one of the founders of the first *China Mining Minutes*, the first geologist to represent China at the International Geological Congress, the first Chinese scholar to systematically and scientifically study China's mountain ranges, the first scholar to classify Chinese coal according to its chemical composition, the originator of the world-famous Yanshan Movement and related magmatic activities and metal deposit formation theories, and the leader of the organization that developed China's first oil field. Wong served as a director of the private Jiaozuo Institute of Technology (now China University of Mining and Technology and Henan Polytechnic University), and served as a scholar in the National Government, in charge of mining resources and production during the War of Resistance. By earning foreign exchange from the export of China's unique mineral products such as tungsten ore, he strongly supported China's war of resistance during World War II.

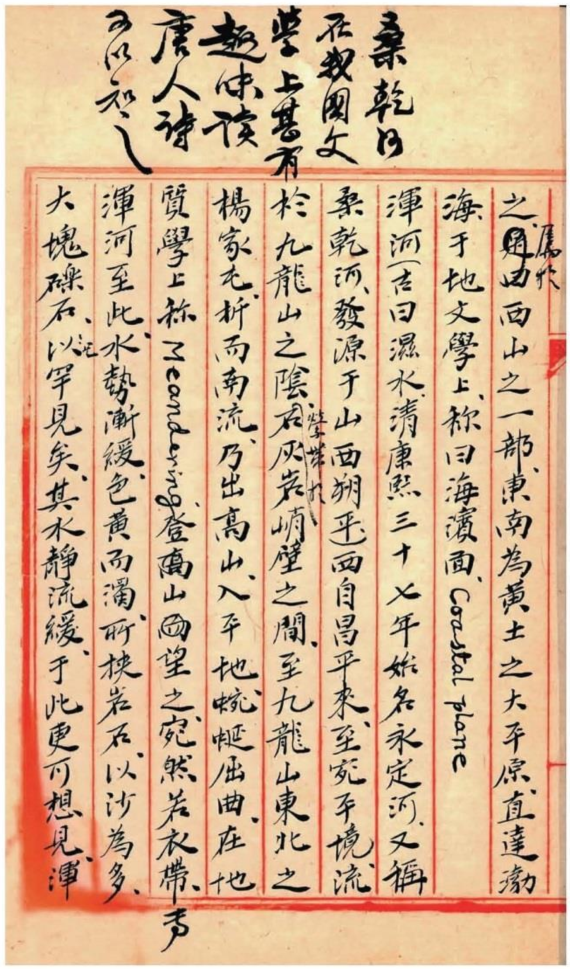
Wong was the highest-ranking and most tortuous person among the "scholars-turned-politicians" in China during the 1930s and 1940s. As an outstanding geologist and pure scholar, he once served as the premier of the Nationalist government, truly second only to the president.

In 1935, Chiang Kai-shek appointed himself as the Premier of the National Government, and Wong as the Secretary General of the National Government. In 1937, Wong became the Minister of Economy, in charge of China's wartime industrial production and economic construction during the War of Resistance. In 1945, Wong was elected as a member of the Central Committee of the Kuomintang and served as the Vice Premier of the National Government, but resigned in 1947. In June 1948, Wong was invited by Chiang Kai-shek to serve as the first Premier of the National Government after the Constitution was enacted, but his cabinet resigned in November of the same year. At the beginning of the following year, Chiang Kai-shek stepped down, and Wong became the Secretary General of the Presidential Office of Acting President Zongren Li in February. In May of the same year, Zongren Li's peace talks with the Chinese Communist Party failed, and Wong resigned as the Secretary General and fled to France. In the same year, Wong was elected as the first academician of the Academia Sinica. In his later years, he returned from overseas with the intention of resuming his geological research as a scholar, but he was unable to

fulfill his long-cherished wish to continue his geological research. In the end, he died in depression as a nominal member of the CPPCC. He died in the same year as S. K. Lee, who had been in great glory since 1950.
It is worth mentioning that Wong's second son, Xinhan Weng, died heroically in 1944 as a pilot of the Kuomintang Air Force. After the outbreak of the Anti-Japanese War, other dignitaries sent their children abroad to enjoy wealth and glory, but Wong, a high-ranking official with direct access to the highest level, sent his son to the front line as a pilot. Xinhan Weng received training in India and returned to Yunnan, China to perform missions. Once when he was returning from a mission in a bomber, he accidentally saw a Japanese barracks and attacked it. As a result, the plane ran out of fuel and crashed on a high mountain in Yunnan[7-9].

Figure 11. In front of Jiufeng Seismic Station of the China Geological Survey in Beiping in the early 1930s
From left: C. Y. Hsieh, H. T. Chang, Kaiye King, Shaofang King, Shaotang King, W. H. Wong and S. P. Lee

The third person who played a practical role in the founding of China's geological cause was H. T. Chang, who was older than Ting and Wong. According to Baidu[10], Chang (1877-1951) was a geologist, geological educator, expert in the history of geological science, a pioneer in the cause of Chinese scientific history, and one of the founders of modern Chinese geology. Chang and Ting jointly founded the Geological Research Institute of the Ministry of Agriculture and Commerce of the Republic of China, a geological training class, and cultivated the first batch of geologists for China. Many of them later became the main force of China's early geological work. Chang studied the knowledge of ancient Chinese books on paleontology, minerals, rocks and geological minerals from the perspective of modern geological science, and successively wrote works such as *Shi Ya* （*On Rocks*） and *Gu Kuang Lu* (*Ancient Mining Records*), which pioneered the study of the history of Chinese geological science. Chang participated in the establishment of the Geological Society of China and served as the first president. He was a master of the Chinese geological community.



桑乾河在我國文學上甚有趣味讀唐人詩可以知之

屬於之周西山之一部、東南為黃土之大平原、直達渤海、于地文學上、称曰海濱面、Coastal plane
渾河(古曰濕水、清康熙三十七年始名永定河、又稱桑乾河、發源于山西朔平、)西自昌平來、至宛平境、流於九龍山之陰、石灰岩峭壁之間、至九龍山東北之楊家屯、折而南流、乃出高山、入平地、蜿蜒屈曲、在地質學上称Meandering、登南山回望之、宛然若衣帶、乃
渾河至此水勢漸緩、色黃而濁、所挾岩石、以沙為多、大塊礫石、以罕見矣、其水靜流緩、于此更可想見渾

Figure 12. Part of *the Geological Report near Mentougou* compiled by outstanding student L. F. Yih in 1915

There is a comment from teacher H. T. Chang: "The Sanggan River is very interesting in Chinese literature, which can be seen from reading Tang Dynasty poems"

After passing the examination for the title of scholar (*Xiucai*, one who passed the imperial examination at the county level) in 1899, Chang was invited to be a private school teacher for several years. In 1905, he went to Japan to study at government expense and entered the Third High School in Kyoto, Japan. In 1911, he returned to China after receiving a bachelor's degree from the Department of Geology, Faculty of Science, Tokyo Imperial University, and began to work. In September 1911, he went to Beijing to take the examination for overseas students and won the title of *Gezhi Jinshi* (*Jinshi*, a candidate who passed the palace examination) with the highest score. Ting, who had studied geology in the UK, was also on the same list. Chang was immediately hired as a geology lecturer in the Agricultural Department of the Imperial

University of Peking, and thus became the first Chinese to teach geology in a university. In 1912, the Provisional Government of the Republic of China was established in Nanjing, and Chang served as the head of the Geology Department under the Mining Administration of the Ministry of Industry. During this period, he drafted an article entitled *Private Discussion on Geological Survey of China*, emphasizing the importance of geological work to arouse the attention of the whole nation. At the end of the article, a brief for the establishment of a geological research institute was attached, with the intention of training young people. After hard work, the Geological Research Institute was officially established in Beijing in 1913, with Chang as the director. Although it is called the Institute of Geology, it is actually the earliest specialized school of geology in China. After that, Chang devoted all his efforts to cultivating geological talents. After the students trained by the Institute of Geology graduated in 1916, the China Geological Survey, which was established at the same time as the institute, expanded its scale. Chang then became the head of the Geological Section of the Geological Survey and engaged in comprehensive research on geology and minerals. In 1922, under the active advocacy of Chang and others, the Geological Society of China was established at the beginning of the year, and Chang was elected as the first president. This academic group played a very important role in the development of China's geological cause. In 1928, Chang gave up the field geological survey due to illness and decided to resign from the Geological Survey. After that, Chang wrote books and articles behind closed doors, and wrote many papers covering many fields of geology. In 1946, Chang was hired as an editor for the National Compilation and Translation Bureau in Nanjing, and moved from Shanghai to the Nanjing Geological Survey to concentrate on writing.

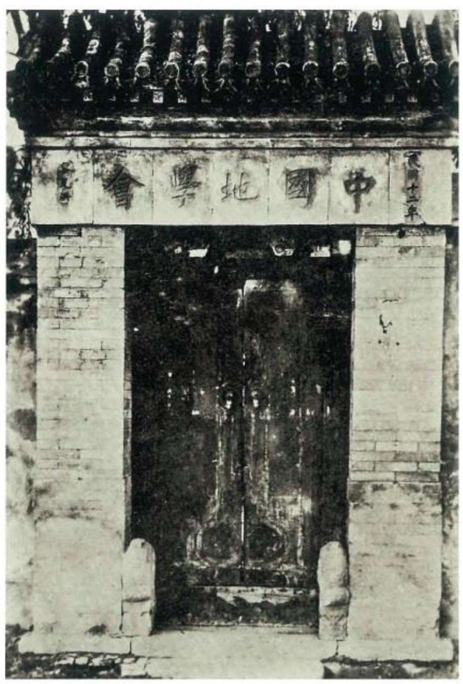


Figure 13. The gate of the Chinese Geoscientific Society at No. 11 Beiheyan, Houhai, Beijing in 1924
The plaque was inscribed by Yuanhong Li, who was known as the "Rock of the Republic" in the history

4

In 1949, T. K. Huang, the late leader of the former China Geological Survey, summarized China's geological survey and research work in this way[11]: In the 50 years before the establishment of the Republic of China, China's geological research was "monopolized" by foreigners. After the Republic of China, Chinese scholars began to become the main body of China's geological research. Under the demonstration and influence of foreign scholars, the work of the China Geological Survey gradually deepened, the research level was rapidly improved, and the research strength became mature. They continued to publish their results in various academic journals and seminars, attracting widespread attention from the geological and scientific communities. This group became the main force in many different disciplines of geology. Many of them, with their profound academic background, played an organizing and leading role in many academic institutions later.

Figure 14. During the geological trip to the 16th Annual Meeting of the Geological Society of China held in Chongqing in about 1940
T. K. Huang (squatting); from left: C.Y. Hsieh (third from left, holding a hat in his right hand), S. Chu (right behind T. K. Huang, holding a hat in his left hand), C. Y. Lee (standing in the middle behind C. Y. Hsieh and S. Chu), W. K. Kuo (left behind S. Chu, wearing a checkered scarf), T.O. Chu (front, second from right)

From the beginning of training geological talents, the China Geological Survey has successfully carried out foreign scientific cooperation and hired many foreign scientists to participate in the guidance of work. Among them, J. G. Andersson was one of the earliest to come to China and achieved outstanding results. Huang pointed out in 1948[11]: In addition to assisting Mr. Chang and Mr. Ting in establishing the Institute of Geology and the Geological Survey, Andersson, a mining consultant in the early Republic of China, also worked hard to investigate China's geological mineral resources. The famous Hsuan-Lung type hematite deposit was discovered under the leadership of Andersson. In terms of pure geological research, Andersson made the greatest contribution to the study of the Cenozoic era, and his discoveries in archaeology are particularly commendable. In 1916, the work of the Geological Survey started. Before and after this, the iron ore resource investigation and Yangshao cultural relics excavation led by Andersson were one of the outstanding achievements of the cooperation between foreign scholars and the Geological Survey[1]. On July 17, 1922, the Geological Survey held a grand opening ceremony for the library and exhibition hall in the conference room of the No. 9 Bingmasi. President Yuanhong Li of the Republic of China attended and spoke. After the meeting, everyone visited the exhibition hall at No. 3 Fengsheng *Hutong* or alleyway, which exhibited the "Andersson Collection of Human Stone Tools and Pottery Exhibition Room".

Figure 15. Yangshao pottery and its description exhibited in the exhibition hall of the China Geological Survey in the 1920s

As Western industrialization had a more and more profound impact on China, China, which had begun to industrialize, had a growing demand for coal and iron. For this reason, in 1910, Jian Zhang, a top-ranked industrialist, proposed “the cotton and iron policy” and served as the Minister of Agriculture and Commerce in the early years of the Republic of China. In 1914, the Ministry of Agriculture and Commerce invited Andersson to serve as the Chinese government's mining policy consultant. In early 1916, the Ministry of Agriculture and Commerce established the Geological Survey Bureau, with Y. O. Chang, the director of the Mining Administration, concurrently serving as the director, and Andersson, a consultant, and Ting, a senior geological engineer, serving as the deputy directors of the bureau. Although Ting was actually in charge, he relied heavily on Andersson, a well-known scientist.

At the beginning of his work in China, Andersson proposed to investigate the iron ore deposits throughout China as a basis for the development of various industries. The central government deeply agreed with his idea, and all the staff in the institute also worked hard to serve the public and cooperated. Therefore, a team consisting of three Swedes was formed, namely Andersson, the hired technician of the Geological Survey Institute, Professor Nystrom of Shanxi University, and Tegengren, a mineral geologist of the Swedish Geological Survey. They investigated, tested and evaluated a large number of mineral deposits. After the exhibition of students' achievements of the Geological Institute in July 1916, the exhibition hall initially set up four exhibition halls, including coal and iron exhibition halls, which were divided into coal mines (listed by major mining areas) and iron mines (listed by types). According to relevant data in 1925, the coal and iron exhibition halls of the exhibition hall had 230 types of coal specimens totaling 1,041 pieces, and 256 types of iron ore specimens totaling 354 pieces. In 1917, Tegengren's contract expired and he returned to Sweden, but he still used his spare time to study China's iron ore deposits. Andersson compiled all the new data and made important additions based on his own geological surveys of ore deposits in Zhili (*Hebei* now), Shandong, Jiangsu, Anhui and Hubei. In 1919, W. H. Wong serialized "Iron Ore Notes" in the *Agricultural and Commercial Gazette*, recording the composition, ore formation and reserves of domestic iron deposits. From 1921 to 1923, *Geological Bulletin Type A* published two volumes of *China Iron Ore Records* written by Tegengren, which collected many achievements of Swedish scholars and personnel of the Geological Survey. It is a masterpiece of China's early research on the mineralization and distribution of ore deposits.

Tegengren wrote in the book: Thanks to the cooperation of Chinese colleagues in the Geological Survey, this work was carried out vigorously, and it took almost two full years to carry out iron ore exploration throughout China. In this book, a large number of important survey reports of these Chinese colleagues are published for the first time.

Figure 16. A group photo of some staff members of the Peking Research Institute of the Geological Survey in April 1930

Front row from left: W. H. Wong, □, Emile Licent, Shu-hua Li, G. Bouillard, Sven Hedin (1865-1952) and P. T. de Chardin; Back row including: H. T. Chang, Jean Jérome Augustin Bussiere, K. H. Hsu, T. C. Chow, etc.

In this regard, C. Y. Hsieh later commented[1]: "Since the publication of Tegengren's *Chinese Iron Ore Records*, the geology, distribution and reserves of iron deposits in China have been systematically recorded. Its rich collection and detailed description make it a truly unprecedented masterpiece."

This is a great era of brilliant stars, prosperity and harmony. It is also a beautiful era in which a large number of elites compete with each other, support and help each other in the courtyard of No. 9 Bingmasi. In addition to the leaders Ting, Wong, Chang and Hsieh mentioned above, there are countless talented geologists who have since become famous in the Chinese geological community, such as C. Y. Hsieh, T. K. Huang, C. Y. Lee, Y. C. Cheng, T. O. Chu, T. I. Loo, H. T. Lee, L. F. Yih, C. Lee, K. W. Hsu, C. C. Wang, H. C. T'an, T. C. Chow, C. C. Liu, C. C. Young, T. H. Yin, S. F. Sheng, Y. S. Chi, W. C. Pei, Y. C. Cheng, S. P. Lee, Z. C. Chow, T. Fang, L. Wang, Y. C. Sun, C. C. Tien, T. F. Hou, S. S. Yob, S. Chu, S. C. Chang, P. Kao, K. Chen, Y. L. Wang, N. Chin, M. S. Chen, L. P. Chia, C. C. Yu, Hishchih Chang, P. L. Yuan, C. Y. Wang, K. H. Hsu, H. S. Wang, K. L. Fong, K. M. Wang, S. C. Chien, C. H. P'an, L. C. Ch'ang, Chingchang Biq, K. C. Hsu, Y. Hsiung, V. C.Juan, T. Y. H. Ma, L. C. Li, Y. T. Ma, Y. Wang, Kungtow Y. King, Y. T. Nan, C. C. Pai, H. C. Sze, T. S. Liu, C. Chu, C. C. Chang, M. N. Bien, H. L. Ching, Chia-Lin P'an, K. C. Hou, W. Y. Chang, C. S. Kao, L. T. Yeh, T. C. Sun, H. D. Wang， T. I. Young， Yueh-Yen Lee， P. C. Wang， M. Hu ， S. H. Li， K. Y. Yen……

Figure 17. Grabau and students from the Department of Geology at Peking University in 1930

Of course, there are also talented geologists such as Y. T. Chao, who was killed by bandits during field geological surveys, Y. S. Ma, a female geologist who was fluent in five languages, T. Y. Hsu and K. Chen. Regarding these geologists who died young, another article will be dedicated to mourning and commemorating them!

Grabau was a German-American. He graduated from the Massachusetts Institute of Technology in 1896 and entered Harvard University the following year to receive his doctorate. He served as a lecturer and professor of paleontology and geohistory at Columbia University. He wrote major works such as *Principles of Stratigraphy*, *Standard Fossils of North America* (co-authored), and *Geology*. In August and September 1919, Ting, the founder of Chinese geology who was traveling in the United States, invited Grabau to work in China. A year later, Grabau came to Beijing as promised and served as the director of the Paleontology Research Laboratory of the Geological Survey. He also served as a professor in the Department of Geology of Peking University, taking on the teaching tasks of three courses: geohistory, paleontology, and comparative European and American stratigraphy. When Grabau talked about the textbooks he

wrote, he did not read them word for word, but started to speak fluently and freely, which was very vivid and exciting. At that time, China was in turmoil, the government was in financial difficulties, and Peking University owed wages several times. Grabau had to consult doctors frequently because of his leg disease, so his situation was very difficult.
Due to the constant war in China in 1930, Y. L. Wang, the assistant who helped Ting sort out the field data, was basically unable to travel, so he went to Peking University to study paleontology and stratigraphy with Grabau after work. In the next three or four years, as long as he did not go out, Y. L. Wang continued to study with Grabau.
Later, when recalling the scene of taking classes with Grabau, Y. L. Wang described it like this: He had a leg disease and could not walk. He had to use a chair to carry him to the podium during class, and then sit on a rotating chair and use a long bamboo pole to point at the hanging charts and explain. He had extensive knowledge and spoke eloquently. Every year, the materials he taught were supplemented with new materials, so there was no repetition. His tireless attitude of teaching and cherishing the newcomers made me admire him with all my heart.

Figure 18. On the way to the 16th International Geological Congress held in Washington, D.C. in 1933
Front row from left: Swedish geologist Nils G. Horner, Ting and Grabau; Back row from left: Chardin and Grabau's secretary Alice Woodland

T. K. Huang, a leading figure of the China Geological Survey in the late Republic of China, later recalled that paleontology is the basis of stratigraphy, and stratigraphy is the basis of all branches of geology. In the early days of the Geological Survey, there was no real paleontologist in China. With the joining of Grabau, a famous geologist and paleontologist, the Geological Survey immediately established a paleontology research laboratory and appointed Grabau as the director. At that time, the paleontology research laboratory of the Geological Survey was still the first of its kind, and it occupied an important page in the history of Chinese science. Grabau went to eastern Hebei to conduct field geological surveys as soon as he arrived in Beijing. In his first year in China, he published a paper on the fauna of the Kaiping Basin in the *Geological Report* of the Geological Survey. At the same time, Grabau and Andersson actively assisted Ting in planning the publication of the *Chinese Paleontology* and wrote the first two volumes of the invertebrate paleontology section (1922). Thanks to the joint efforts of these predecessors, the *Chinese Paleontology* quickly became an international leader.

Figure 19. Group photo of some teachers and graduates of the Department of Geology of Peking University in 1928
Front row from left: S. G. King, T. Yang, H. T. Lee, A. W. Grabau, L. Wang, Y. T. Chao; Back row from left: C. Y. Lee, Cengwei Yang, S. Chu, and T. K. Huang

Grabau's student T. K. Huang later recalled: Mr. Grabau was full of energy in the laboratory and worked day and night. He was eloquent and tireless in teaching. Because of his appeal, many young people wanted to become paleontologists and put the heavy responsibility of studying Chinese strata and paleontology on their shoulders. Grabau's profound knowledge and teaching charm attracted many young students to follow him. By the early 1930s, China's paleontologists were talented and paleontological research was flourishing. The first few generations of paleontological talents in China were carefully trained and guided by Grabau, such as Y. T. Chao, who was good at brachiopods and Carboniferous strata, C. C. Young and W. C. Pei, who were good at Cenozoic and ancient vertebrate fossils, H. C. Sze, who studied paleobotany, and C. C. Tien, Y. S. Chi and Jie Xu, etc.
Y. C. Sun commented on Grabau: The reason why the status of geology in Chinese science is not backward is actually due to the great contributions of Chinese paleontology and stratigraphy, including the research results published in the *Chinese Paleontology* and the *Bulletin of the Geological Society of China*. Most of the work was done by Grabau himself and his disciples.

Figure 20. Grabau in the west wing of No. 58 (now No. 6) Bingmasi Hutong on February 19, 1946
About a month later, on March 20, A. W. Grabau died at the age of 76. This is the last picture left by his students when they visited him

In 1925, Grabau initiated the establishment of the Beijing Natural History Society, which attracted important biologists and some geologists from Beijing and abroad to join, especially foreign scholars, forming a scientific group centered on Grabau. This shows the great influence of Grabau at that time. In 1934, S. K. Lee, the director of the Department of Geology of Peking University, went to the UK to give lectures, and Grabau served as the acting director of the Department of Geology of Peking University. During this period, he negotiated many times to apply for various equipment and funds for the newly built Geological Museum of Peking University, and the Geological Department was able to move to the Songgongfu Geological Museum in the summer of 1935.

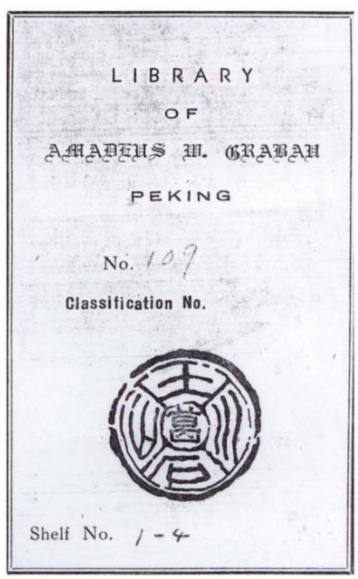


Figure 21. A. W. Grabau's personal library book stamp in the late 1930s
According to Grabau's will, all his books and maps were donated to the Geological Society of China. These books are now a valuable collection of the China Geological Library

Grabau was already a well-known scientist in the United States and was called a "living library" by his peers. He had his own library. At that time, his books were numbered and had a diamond-shaped blue seal, which read "Private Library of Amadeus W. Grabau, Columbia University, New York City". When he took office, he brought these private collections to Beijing. In the early 1930s, Grabau donated part of his private library's collection to the Geological Society of China, which was collected in the South Building of No. 9 Bingmasi. From 1933 to 1937, the society spent a total of 500 yuan on fire insurance for the donated pictures and books by Grabau.

In February 1937, the 13th Annual Meeting of the Geological Society of China was held in Meeting Room No. 9 of Bingmasi. The participants approved the emblem designed by Chang, Hsieh, C.C. Young, and Grabau. There are five deformed Chinese characters on the emblem: earth, stone, mountain, water, and China. The Chinese character *Zhong* represents China and can also represent the Geological Society of China. The four Chinese characters on the four sides represent the most important geological phenomena. Grabau asked someone to redesign the Grabau's seal (Figure 21) based on the emblem of the society, which was used in his private library in Douyacai Hutong. Each of his books has a number and shelf number, which shows his cherishment and meticulous management of books. As a founding member of the Geological Society of China, Grabau witnessed and supported every step of the society's growth. This seal carries the deep feelings of this old foreign scientist for the Geological Society of China.

As soon as the July 7 Incident broke out, Wong, the chief representative of the Chinese delegation attending the 17th International Geological Congress in Moscow, called Hongfen Sun, the director of the China Education and Culture Foundation, and asked him to help protect Grabau's personal safety. At the same time, Wong called T. C. Chow, the director of the Geological Survey, and asked him to provide strong assistance for the expenses needed for Grabau and Hsieh to travel from Peking to Nanjing.

Figure 22. A. W. Grabau, sketched by Swedish geologist Sven Hedin in 1930

After Peking University moved south, Grabau had to stay in Peking to continue writing due to leg disease. The Japanese army once wanted to occupy the Peking branch of the Geological

Survey. Grabau sat in a wheelchair, holding the American flag and shouting anti-war slogans, lying at the gate to prevent the Japanese army from entering. Grabau sympathized with and supported the efforts of the Chinese intellectual community to fight the national crisis together, and his students and colleagues in the rear also kept thinking about him.

After the July 7 Incident, Grabau was forced to stay in Beijing and guard his books in Douyacai Hutong because he was unable to walk. He could not bear to leave and worked hard to compile his masterpiece *On the Vicissitudes*. He received a gift of US$1,000 from the Geological Society of America as the cost of this work. From 1940 to 1941, Minister of Economic Department Wong and Director of the Geological Survey Tsan-Hsbun Yin wrote to Hengde Hu, President of Peking Union Medical College Hospital, twice, hoping to arrange for Dr. Grabau to go to the southwest rear area and were willing to pay all related expenses. However, various objective factors forced Grabau to stay in the bustling city of Peking and persist in his writing.

After the outbreak of the Pacific War in 1941, Grabau was transferred from his residence in Xicheng, Peking to the British Embassy in Dongjiaomin Lane. In July 1945, on the eve of the victory of the War of Resistance Against Japan, T. K. Huang recorded his concern for his teacher Grabau: He has been trapped in Peking for many years and his life is very difficult. I hope he will be liberated in the near future and meet us all. After Japan surrendered, C. C. Wang and W. C. Pei from the Peking Branch went to visit Grabau and found that he was in a very difficult situation. In December 1945, they moved Grabau to the west wing of the Geological Exhibition Hall for better care.

On March 20, 1946, Grabau died at the age of 76. Grabau's last words were: I wish to be buried in the Geological Museum of Peking University. After the Peking University Council, which was still in Kunming at the time, learned about it, it decided to follow Mr. Grabau’s last words? On March 26 and April 27, several academic groups and geological research institutions in Kunming and Beibei, Chongqing, respectively held memorial services to mourn this geologist with an internationalist spirit. On June 2, Mr. Grabau's ashes were buried in front of the Geological Museum of Peking University in Songgongfu, and a foundation stone was erected. All of Mr. Grabau's books, periodicals and maps were donated to the Geological Society of China in accordance with his will. The Society asked the Peking Branch to accept Mr. Grabau's last letter on behalf of the Society, and asked the Peking Branch of the Geological Survey to temporarily keep it.

Grabau has written many books and taught tirelessly, and he enjoys a high reputation in the scientific community. In March 1925, C. Y. Wang, a student of Grabau when he taught at Columbia University in the United States and then president of the Geological Society of China, proposed to establish the "Grabau Medal of the Geological Society of China" and took the lead in donating 600 yuan. To this end, the Council of the Geological Society of China seconded and agreed to pass 7 award rules. Among them, Article 2 is: The Grabau Medal is awarded every two years, and the Geological Society of China awards it to those who have made important research results or great contributions to Chinese geology or paleontology.

The first Grabau Medal in 1925 was awarded to Grabau himself. At the 4th Annual Meeting of the Geological Society of China held in May 1926, Wong awarded and delivered a speech on behalf of President C. Y. Wang, commending Grabau for his outstanding contributions to Chinese geology and paleontology. The Grabau Medal was awarded from 1925 to 1937 before the outbreak of the Anti-Japanese War, and was awarded 7 times. It was stopped during the Anti-Japanese War. After Grabau's death in 1946, the medal was awarded twice more until the Kuomintang withdrew from the mainland. The Grabau Medal had a great influence in the academic community and was the highest award in the Chinese geological community at that time.

Figure 23. Y. S. Chang and Y.L. Chen, couple, beside the Grabau Monument at the exhibition hall of the Beijing Branch of the China Geological Survey in 1947
Y. S. Chang and Y. L. Chen graduated from the geology department of Peking Normal University in the mid-1940s and continued to work in geology after graduation

On Grabau's 60th birthday in 1930, Chang, Ting, Wong, Hsieh, S. K. Lee, C. H. Chu, L. F. Yih, and Y. C. Sun jointly sent a congratulatory telegram to Mr. Grabau. One paragraph in the telegram expressed the common feelings of colleagues: "Since you came to China, we have always regarded you as one of us, forgetting that you are a foreigner. We know that in your heart, your love for science is strong enough to transcend race and nationality." In May 1936, the Soviet Paleontological Society nominated Grabau as an honorary member of the society. In November of the same year, the National Academy of Sciences of the United States awarded Grabau the Mary Clark Thompson Medal in recognition of his immortal contributions to geology and paleontology, and awarded him the medal in April of the following year. Grabau did not go to the United States to receive the award. In his reply to the National Academy of Sciences of the United States, he emotionally recounted the development of the Geological Society of China, the China Geological Survey, and the Department of Geology of Peking University from small to large, and finally to remarkable achievements. Grabau also predicted: "The scientific study of natural history has become a kind of intellectual study in China. As it begins to develop, those of us who have witnessed its prosperity and made some contribution are confident that in the future, Chinese scientists will gradually make achievements in geology, paleontology, biology and archaeology, which will make important contributions not only to their own country but also to world science."

In 1947, the Chine Geological Survey erected the "A. W. Grabau Memorial" in front of the Geological Exhibition Hall at No. 58 (now No. 6) Bingmasi Hutong, which became a landscape for scholars to admire. The monument is divided into two parts. The upper part is an imitation of the ancient Egyptian obelisk that was popular during the Republic of China period, with an inscription in official script. The lower part is a three-layer square split base. The upper layer of the base is engraved with a 21 cm × 20 cm rectangular picture frame on the front, and a side-by-side line drawing of Grabau painted by Sven Hedin for him on his 60th birthday in 1930 (Figure 22). The middle layer of the base is engraved with his English name and date of birth and death. Mr. Grabau's ashes were buried in front of the Geological Museum of Songgongfu, Peking University.

In 1948, C. C. Young wrote on the second anniversary of Grabau's death: Recalling Grabau's residence in Douyacai Hutong, Beiping many years ago, it has become a cultural center in Beiping, with constant visitors every day. Among them were his superiors, his students, his colleagues, his fellow geologists and paleontologists, as well as biologists, anthropologists and geographers who were not from the same field but were also scientific workers. No matter who came, Grabau was always in high spirits. No matter who asked for advice, he always gave careful guidance, with a spirit of preaching. Whether it was chatting or discussing academic matters, it was all in a friendly atmosphere.

Figure 24. The stone tablet of "Geological Survey Library Record" published in 1921
It is noted that: President Li (donated) 1,000 yuan

In the late 1950s, the building and rockery at No. 6 Bingmasi Hutong were demolished, and the relevant departments of the Ministry of Geology moved Mr. Grabau's monument to the east wall of No. 9 Bingmasi Hutong opposite, adjacent to the monument of Y. T. Chao. The two monuments coexisted in one corner, which also satisfied the mutual appreciation between the master and the apprentice.

It is extremely regrettable that the two monuments were destroyed at the same time during the "Cultural Revolution of China". Grabau's grave in front of the Peking University Geological Museum also suffered a similar fate. In 1982, Peking University re-erected Grabau's tombstone in Yanyuan. In June 2006, the China Geological Museum transported the fragments of the two monuments of Y. T. Chao and Grabau to the warehouse for preservation.

Wong once recalled the teacher-student friendship between Grabau and Y. T. Chao, two outstanding scientists: After his teacher Mr. Grabau came to China, he cultivated many

paleontological talents, and the one who made the greatest contribution to research, Grabau said that Mr. Zhao was second to none and regarded him as the loveliest and respected young man.
All these pioneers of Chinese geology left their heroic figures and youthful footsteps in Courtyard No. 9 Bingmasi during their lifetime. They are still so vivid today, and therefore have been mentioned in this book to a greater or lesser extent.

5

In October 1928, Wong published "A Commemorative Speech on the 10th Anniversary of the Geological Survey", reviewing the history of establishing academic journals since 1919: "The proposal of the China Geological Survey of China was founded in 1911, and the publication of geological illustrations began in 1919. In the past ten years, the Institute has published *Geological Bulletin*, *Geological Reports*, *Paleontology*, and other single volumes, with a total of more than 50 volumes printed." The professional journals of the Geological Survey focus on international academic exchanges and introduction of achievements and the use of foreign languages is the basis for mutual communication. The *Geological Bulletin* founded in 1919 and the *Geological Reports* A, B and C published in 1920 all focus on using Western languages: mainly publishing English papers by foreign experts, a few French and German papers, all with Chinese translations or abstracts. Chinese papers by domestic scholars are accompanied by English abstracts. There are also scholars like Wong who publish papers in French and English, with Chinese attached. This kind of editorial requirement or academic norm enables Chinese scholars to stand on the platform of international communication, master foreign languages without neglecting them due to daily work, and understand the progress of the international frontier of geoscience to improve the research level of the group, which is very beneficial to the cultivation of scientific talents.

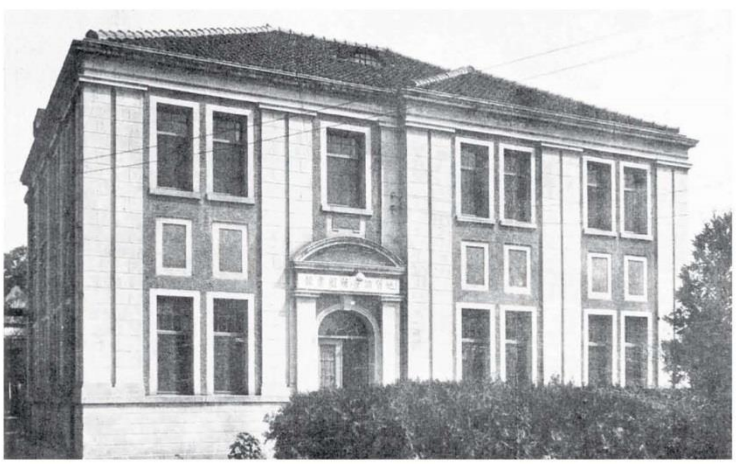


Figure 25. The China Geological Survey Library at No. 9 Bingmasi, completed in 1921

In 1922, the Geological Society of China was established in the conference room of the China Geological Survey. The academic research of the Geological Survey was based on the society, and widely attracted Chinese and foreign scholars in the geological field, as well as people in the mining, railway and metallurgical fields. The academic atmosphere was free and active. In that year, the number of members increased from 26 to 62, including 21 foreign scholars. The society also recommended foreign geologists and paleontologists as corresponding members. The society used English as the conference language.

"In the early days of modern geology in China, it was necessary to strengthen international exchanges and expand international influence. The Geological Society of China held an academic conference every year. These conferences were always attended by Western scholars, and even scholars from China were specially invited to attend the conference to report. Therefore, it was imperative to use English as the conference language."[1]

With the establishment of the Society, the national English geological journal *Bulletin of the Geological Society of China* was launched. The papers of the journal are mainly in English, with two catalogs in English and Chinese, and one volume is published each year. When the Geological Survey moved to Nanjing in 1935, the three editors-in-chief of the 14 volumes of *Bulletin of the Geological Society of China* were all from the Geological Survey, namely V. K. Ting, L. F. Yih and W. H. Wong. No. 9 Bingmasi is not only the Society's clubhouse, but also the editorial office and distribution office of the journal. There is no doubt that the Geological Survey has made outstanding contributions to expanding the influence of the Society and promoting the internationalization of academic exchanges.

The Geological Survey tried to align its academic journals with international standards in terms of language and writing. "The goal of geological journals at this time is the internationalization of academic exchanges. On the one hand, it needs the support of Western author groups, and on the other hand, it also needs to promote the research results of China to the world." In 1922 and the following two years, the Geological Survey established the English version of "Chinese Paleontology" A, B, C and D, and in 1937, it established a new paleoanthropology special issue "Chinese Paleontology New D". In this group of journals, with Grabau, Halle, Zdansky and other foreign scholars as the pioneers, high-level papers by scholars from various institutions and universities in China followed closely and were published one after another, and soon became the main force in Chinese paleontological research.

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In 1931, H. T. Chang said when talking about the research of Chinese paleontology: the progress of Chinese stratigraphy "really benefited greatly from paleontology... The researchers were centered on Dr. Grabou, the chief technician of the Peking Geological Survey, and his students and friends followed closely behind, learning from each other and achieving more and more results. The *Chinese Paleontology* published by the Peking Geological Survey is divided into four types: A, B, C, and D. More than 40 volumes have been published, most of which were independently completed by Chinese paleontologists." It quickly became a famous journal in the international geological community.

No. 9 Bingmasi not only preserves the figures of many heroic Chinese heroes of that time, but also many of China's internationally renowned geological theories that are still used today, such as the Yanshan Movement founded by Dr. Wong, and even many (if not all) of the firsts in Chinese geology, all of which took place in this small courtyard that was once the focus of the Chinese and international community but is now very dilapidated.

Before the outbreak of the full-scale war of resistance against Japanese aggression in China in 1937, the Geological Survey had achieved scientific research results that attracted the attention of the international geological community after 20 years of development and accumulation. The Chinese academic community commented: "Among all the scientific research undertakings in my country, geology and paleontology are the most internationally renowned and the most significant in terms of achievements. Geological research centered on the Peking Geological Survey, with the cooperation of the Central Research Institute, Guangdong and Guangxi and the geological survey of various provinces, has achieved outstanding results in the national geological mapping, mineral and rock surveys, theoretical research and practical applications of paleontology, soil, fuel and earthquake. Among them, the discovery of the "Peking Man" fossils is particularly precious and has made great contributions. Some people say that China's achievements in geological research have surpassed Japan and can even catch up with the world. This may not be false."[1] In 1930, the famous patriotic industrialist Zuofu Lu visited the Geological Survey at No. 9 Bingmasi and met with Ting and said: "I have traveled a lot in the south and north, and it is rare to see a successful cause. Today at the Geological Survey, I finally see the great achievements you have made. Several scholars led some young people to conduct geological surveys in various places, and then came back to study here. How many places in China can do serious things like this?"

In March 1936, President Yuan-pei Tsai of the Academia Sinica published an article commenting that the Geological Survey "truly enjoys the reputation of China's first scientific research institution"[12].

Suh Hu (Hu Shih) wrote in his book commemorating Ting, who died young: "The glorious history of the Geological Survey itself is an important part of China's scientific history... The Geological Survey founded and developed by Ting and his friends became a world-renowned pure science center in a very short time."

Chi-Sun Yeh, the father of Chinese physics, said at the 25th anniversary celebration of the establishment of the Geological Survey in December 1941: "In 1916, the Chinese began to study geology themselves, which means that the Chinese began to study natural science. Geology has achieved such a satisfactory result in 25 years, and it has its own development process and reasons. If other sciences want to achieve the same level of development as geology, they must learn from the struggle methods and efforts of the China Geological Survey in the past 25 years."

Yes, in just over 20 years, the China Geological Survey has created many firsts in the history of modern Chinese science and technology, especially in the history of earth science[13-16], which is worthy of the Chinese people's eternal pride. Regarding the countless firsts in geology created by Mr. C. Y. Hsieh alone, I have already discussed them in several articles, such as *A complete chronicle of Chia Yung Hsieh (C. Y. Hsieh) and his life and works*[13], *Finally, the complete eight-volume Collected Works of Chia Yung Hsieh is published*[14], and *Who Discovered the Largest Oilfield in China*[15]. Interested readers can search and read the relevant articles, and I will not go into details here.

Before the Geological Survey moved to Nanjing in 1935, No. 9 Bingmasi was the academic center of Chinese geology. This courtyard is very famous in the scientific community at home and abroad because it has produced many great scientists and achieved outstanding achievements.

6

I once wrote in my book review of *Less Words but Earnestly Practice--My Father Chuangan Zhang*[17]: I almost cried when I read about the simplicity and purity of traditional Chinese intellectuals in that golden age, especially their great patriotism and love for the country and the nation.

The reason why the Republic of China is considered one of the few golden ages in Chinese history is that Chinese intellectuals at that time could focus on scientific research without having to worry about various political movements that would make people tremble with fear or even lose their lives, let alone being criticized, thrown into prison, or even forced to commit suicide or be killed.

Although in terms of objective material conditions, China at that time was extremely poor and backward, and field investigations could only rely on primitive means of transportation such as camels, donkeys, horses and ox carts, and most of the time they had to rely on their own two legs and two hands. At the same time, scientists in developed Western countries had already driven cars to conduct field geological surveys and research.

Figure 26. C. C. Sun (first from right), Y. L. Wang (second from right), and Mrs. C.C. Sun (first from left) with Honglie Sun (center) on their way from Nanjing to Chongqing in the 1930s

What is even more valuable is that despite the extremely difficult times, the deep friendship between people at that time, like brothers and sisters, caring for each other and taking care of each other, is also touching and memorable. What is particularly important is that the friendship between the generations at that time was not temporary, but lasted for a lifetime and lasted until death.

For example, the book mentions that after the genius geologist Y. T. Chao was unfortunately killed by bandits while on a field trip in Yunnan, China. The China Geological Survey acted quickly and made proper arrangements for his wife and children, so that they could survive without worries and the children could grow up healthily and receive a good education.

After Mr. Ting, the founder of the China Geological Survey died of gas poisoning while inspecting coal mines in Hunan, his close friend Dr. Wong kept his word and took on all the living expenses of Mrs. Ting. Even after 1949, when Wong had no actual job and normal income in the mainland and was extremely depressed, he still did his best to help Mr. Ting's widow, Ms. Shi.

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The book *No. 9 Bingmasi: A Historical Study of the Former Site of the Geological Survey of China* was published by the Geological Publishing House in Beijing in September 2022. The authors are Ms. Erping Zhang and Mr. Yuntao Shang. In addition to the concise preface written by Academician Honglie Sun, the son of Mr. C. C. Sun, one of the pioneers of petroleum geology in China (Figure 26), the author's concise postscript, a relatively detailed index and the "Extended Data List" as an appendix, the book mainly consists of the following six chapters:

- Chapter 1 The First Cornerstone (including three sections);
- Chapter 2 China's First Modern Scientific Institution (including six sections);
- Chapter 3 Scientific Contributions (including six sections);
- Chapter 4 Architecture and Stone Carving (including three sections);
- Chapter 5 Peking Branch (including five sections); and
- Chapter 6 Protecting the Old Site (including two sections).

The book has a total of 247 pages and 270,000 Chinese characters.

It must be said that the main purpose of this book is to strongly call on the relevant government departments to clear out the No. 9 Bingmasi Courtyard, which has been occupied by residents for many years since 1949, to repair this important historical relic and properly protect and utilize it. Of course, while recalling the great historical significance of this small courtyard, this book also deeply reflects the social outlook, political ecology, human relations and other aspects of China in the 1920s-1940s, that is, the so-called a glimpse reveals the whole leopard.

This book excavates and verifies historical materials in detail, the text is vivid and beautiful, the pictures are thought-provoking, and the story is readable. It is a good book worth collecting.

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Author contributions
JZ Yin contributed to the data collection, compilation and interpretation and wrote the paper.

Data availability

The data that support the findings of this study is available from the author upon reasonable request.

Declaration of competing interest

The author declares that he has no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Use of AI tools declaration

The author declares that he has not used Artificial Intelligence (AI) tools in the creation of this article.