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# Analysis of the systematic conservation of China's petroleum industrial heritage: a case study and analysis of the petroleum industrial heritage in Daqing

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**Abstract**

After a century of development, China's petroleum industry has introduced numerous and various petroleum industrial heritage elements, which collectively embody the value and significance of China's petroleum industrial heritage. Currently, all levels of government departments are trying to protect petroleum industrial heritage, but only limited heritage types and elements of the petroleum industry are included in official conservation lists, which is not conducive to the systematic conservation of China's petroleum industrial heritage. To achieve the systematic conservation of China's petroleum industrial heritage, this study introduced a global petroleumscape research method, taking the petroleum industrial heritage of China's Daqing Oil Field as the research object, and conducted a typological and spatiotemporal historical analysis of all the heritage elements in this oilfield. The results revealed that the current conservation of China's petroleum industrial heritage focuses on the industrial remains formed by the flow of petroleum materials but rarely on the remains formed by the flow of petroleum capital. Additionally, some common characteristics were observed in the overall spatiotemporal pattern of the petroleum industrial heritage, and these characteristics are closely related to the spatial distribution of petroleum resources, oilfield development strategy, dimension of urban areas, and urban development mode. Finally, this paper highlights several future research topics on the subsequent systematic conservation of China's petroleum industrial heritage and provides some reference value for the future systematic conservation of China's petroleum industrial heritage.

**Keywords** petroleum industrial heritage, global petroleumscape, systematic conservation, typology, spatiotemporal pattern, Daqing, China

## 1 Introduction

China is one of the first countries in the world to have discovered and utilised oil and natural gas (Fang 2019). The petroleum industry started at the end of the 19th century (Liang and Liu 2003) and entered a period of comprehensive and rapid development after 1949. Accordingly, numerous large oilfields with a complete range of petroleum industries, including geological exploration, drilling and construction, oil field development, refining and chemical industry, transportation, and machinery manufacturing, have been developed. For example, the Karamay (1956), Daqing (1959), Shengli (1962), and Dagang (1964) oilfields were established as the petroleum industries in China developed. These large oilfields cover all sectors of the production chain of the petroleum industry; form special oil technology, work systems, and community living patterns; and preserve a

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series of petroleum industry-related heritage resources of historical, technical, social, and cultural value.

By 2021, petroleum industrial heritage sites in eight oilfields in China were included in the national industrial heritage conservation list (China Association for Science and Technology, National Academy of Innovation Strategy, and Urban Planning Society of China 2018, 2019; Ministry of Industry and Information Technology of the People's Republic of China 2018, 2019, 2020) (Table 1). Each of these oilfields consists of multiple heritage elements involving various technological processes (Fig. 1), such as petroleum exploration, development, transportation, and processing. These elements collectively embody the outstanding value of the petroleum industrial heritage of an oilfield. Thus, we believe that the integration of all relevant heritage elements into a holistic interpretation of a comprehensive oilfield's petroleum industrial heritage is necessary to improve the perception of the integrity of petroleum industrial heritage. Accordingly, a systematic conservation study of petroleum industrial heritage from a holistic perspective of heritage conservation is required to determine whether there is a certain correlation among these heritage elements, if these elements jointly embody some characteristics, and what conservation methods should be adopted in the future.

The global petroleumscape, an overarching concept defined by Carola Hein, is defined as the space that petroleum inhabits all over the world. Hein (2018, 2021) believes that the physical and financial flows of oil create different spatial layers (physical, representational, and everyday practices) globally, which come together to form an overarching landscape. This concept provides us with a crucial way of thinking and an approach to interpreting petroleum industrial heritage in a holistic manner.

The research scope of the global petroleumscape covers almost all the elements of petroleum industrial heritage, including tangible heritage and intangible heritage, and provides an approach for the systematic conservation of petroleum industrial heritage. At the international level, some researchers, oil companies, and government agencies have devoted combined efforts to preserving petroleum industrial heritage using this approach. For example, (Aldera 2020) interpreted the Italian petroleum industrial heritage by comparing seven layers of the spatial petroleumscape incorporated into the architectural characteristics of refineries, gas stations, office buildings and motels. Her research provided the basis for the future transformation of the Italian petroleum industrial heritage. Hein et. al. (2021) explored the petroleum history of Dunkirk, France, and the importance of the role of port city regions in the establishment, continuity, and imaginary of the petroleumscape. This research revealed the challenges in former petroleum sites that had not been fully documented and demonstrated how petroleum industrial heritage can be reused in the future by analysing design proposals for a postoil Dunkirk. Hein (2018) illustrated the creation of the port and the shaping of the entire Randstad by the headquarters, retail, infrastructure, and ancillary buildings of oil companies by analysing the temporal and spatial history of the petroleum industry footprint in Rotterdam and the Hague. Gerlodi and Pessina (2021) reported that power stations are one of the spatial elements of the global petroleumscape in Italy and expanded the elements of the petroleum industrial heritage by including power stations. The concept of the global petroleumscape was created and developed as a holistic approach to systematically investigate petroleum industrial heritage from multiple perspectives.

Currently, numerous Chinese scholars have investigated the conservation of petroleum industrial heritage. Additionally, all levels of government departments are now including petroleum industrial heritage in conservation lists, including the national industrial heritage conservation list, provincial key heritage conservation lists (e.g., Shandong Province key heritage conservation units list, Liaoning Province key heritage conservation units list, and Heilongjiang Province key heritage conservation units list; Shandong Province People's Government 2015, Liaoning Province People's Government 2023, Heilongjiang Province People's Government 1999, 2007, 2015), and municipal key heritage conservation lists (e.g., Daqing industrial heritage conservation list, and Yumen key heritage conservation units list; Daqing Municipal People's Government 2006, 2009, Yumen Municipal People's Government 2020). Over the years, scholars have mainly discussed the typological composition (Sun 2018, Liu 2022) and conservation methods (Ye 2020; Liu 2022) of petroleum industrial heritage. In addition, local government departments and oil enterprises have introduced conservation strategies for petroleum industrial heritage as a part of the future development demands of cities (Yanchang County Tourism Department 2011, Yumen Municipal People's Government 2022).

However, current conservation studies in China consider only the heritage elements formed during the flow of petroleum materials that are directly related to the petroleum industry while ignoring the heritage elements formed during the flow of petroleum capital. Consequently, only limited heritage elements of the petroleum industry in the Chinese context have been explored, and this is not conducive for the systematic conservation of China's petroleum industrial heritage.

Therefore, to enhance the systematic conservation of China's petroleum industrial heritage, for the first time, this study applied the concept of the global

**Table 1** List of China's petroleum industrial heritage sites (national level)

| No | Name | Geographic location | Construction time | Status | Core items (Heritage elements) | Date of inclusion |
|---|---|---|---|---|---|---|
| 1 | Miaoli Oil Field | Gongguan Town, Miaoli County, Taiwan Province | 1877 | Taiwan Oil Field Exhibition Hall | The first oil well (Maioyi well), oil extraction machine, trolley ropeway, etc | 2018 |
| 2 | Yanchang Oil Field | Yanchang County, Shanxi Province | 1907 | In service | Yanyi well, Qilicun oil refinery, Qilicun No. 1 well and Qilicun No. 3 well, Yanshen No. 1 exploratory well, three major petroleum geology education and teaching practice sites of Yanchang Petroleum, the cave dwelling of oil factory worker He Yannian, guest house for Soviet experts | 2018 |
| 3 | Yumen Oil Field | Yumen City, Jiuquan City, Gansu Province | 1938 | In service | Liaojunmiao; Laojunmao No. 1 well; Xiheba cave dwelling, expert building, cultural palace; Wang Jinxi memorial hall; living community for workers, etc | 2018 |
| 4 | Dushanzi Oil Field, Karamay Oil Field | Karamay City, Xinjiang Uygur Autonomous Region | 1909 | In service | First oil well site of Xinjiang, Karamay No. 1 well, Hero 193 well; Sino-Soviet Petroleum Co., Ltd. Dushanzi workers' children school site, Dushanzi Petroleum Club and office site of Sino-Soviet Petroleum Co., Ltd., etc.; Heiyoushan cellar, 101 cave dwelling house, site of the first set of distillation still in Dushanzi; production plant of petroleum machinery industry, asphalt mound and monument, Beiwu 40 drilling rig, field geological survey transcripts and other archival materials | 2018/ 2021 |
| 5 | Daqing Oil Field | Daqing City, Heilongjiang Province | 1959 | In service | Discovery well in Daqing Oil Field (Songji No. 3 well), the iron man well (Saertu No. 55 well); complete oil exploration, extraction, storage and transportation, refining and production facilities; former headquarters site of Daqing petroleum campaign; living community for workers; a large number of historical data, experiencers | 2018 |
| 6 | Qinghai Oil Field | Lenghu Town, Haixi Prefecture, Qinghai Province | 1955 | In service | Dizhong No. 4 well; office and living area sites; No. 4 cemetery; Qinghai Oilfield Exhibition Hall (Dunhuang) | 2019 |
| 7 | Shengli Oil Field | Dongying District, Dongying City, Shandong Province | 1961 | Educational base | Hua No. 8 well, Ying No. 2 well, Tuo No. 11 well; archival materials such as video materials (oral histories) | 2020 |
| 8 | Dagang Oil Field | Binhai New Area, Tianjin | 1964 | Educational base | Gang No. 5 well; drill bits and toolboxes, pipe pliers and sample buckets used during the North China petroleum exploration campaign; drill core of Gang No. 5 well; historical files | 2019 |


**Fig. 1** Some Petroleum industrial heritage in China. **A** Yangyi well in Yangchang Oil Field. **B** Laojumiao No. 1 well in Yumen Oil Field. **C** Qilicun oil refinery in Yanchang Oil Field. **D** 101 Cave dwelling house in Karamay Oil Field (Source: the author)

petroleumscape to the conservation research of China's petroleum industrial heritage. Taking petroleum industrial heritage in Daqing as a typical case, based on field research, documentation and oral data, this study qualitatively and quantitatively analysed the typological and spatiotemporal pattern characteristics of petroleum industrial heritage in Daqing and discussed the relevant factors affecting these characteristics. To this end, the existing problems in the heritage types and heritage element conservation of China's petroleum industrial heritage were identified, and future research areas in the follow-up systematic conservation of China's petroleum industrial heritage were highlighted.

## 2 Research method

The global petroleumscape, a layered physical and social landscape, is reinforced over time by human behaviour, and it links urban and rural spaces, culture and nature, and the material and immaterial (Hein 2021).

Hein divided the global petroleumscape into three layers based on the way oil and funding flows: spatial, representational, and daily petroleumscapes. Each layer of the petroleumscape contains multiple spatial elements that interconnect to form a multilayered overall landscape (Hein 2018, 2021) (Fig. 2).

The spatial petroleumscape is a layered study of the physical space of petroleum that aims to overcome the segmented, monodisciplinary, and localised approach to the petroleum spaces. It divides physical space into seven layers (industrial, retail, administrative, infrastructural, ancillary, architectural, and philanthropic layers), with each layer exhibiting specific characteristics that are distinct in their function, location, land use, scale, typology, urban and architectural form, and financial impact but are effectively a part of one spatial system (Hein 2021).

The industrial petroleumscape, including elements such as drilling platforms, refineries, oil depots, and oil-fuelled thermal power plants, is connected under a single, extended spatial entity and is a truly global space (Hein 2021).

The retail petroleumscape refers to the distribution network of petroleum products, of which gas stations are an important element (Hein 2021). The administrative petroleumscape, consisting of the headquarters, offices, and research centres of oil companies, covers the spatial elements of the management and R&D sectors (Hein 2021). The ancillary petroleumscape refers to diverse structures (e.g., streets, housing, leisure facilities, or even entire cities) that are required for the functioning of the petroleum industry but are not directly related to the physical or financial flows of petroleum (Hein 2021). The spatial extent of the ancillary petroleumscape is relatively broad.

Infrastructure petroleumscapes, architecture petroleumscapes, and philanthropy and state welfare refer to the infrastructure landscapes required by the petroleum

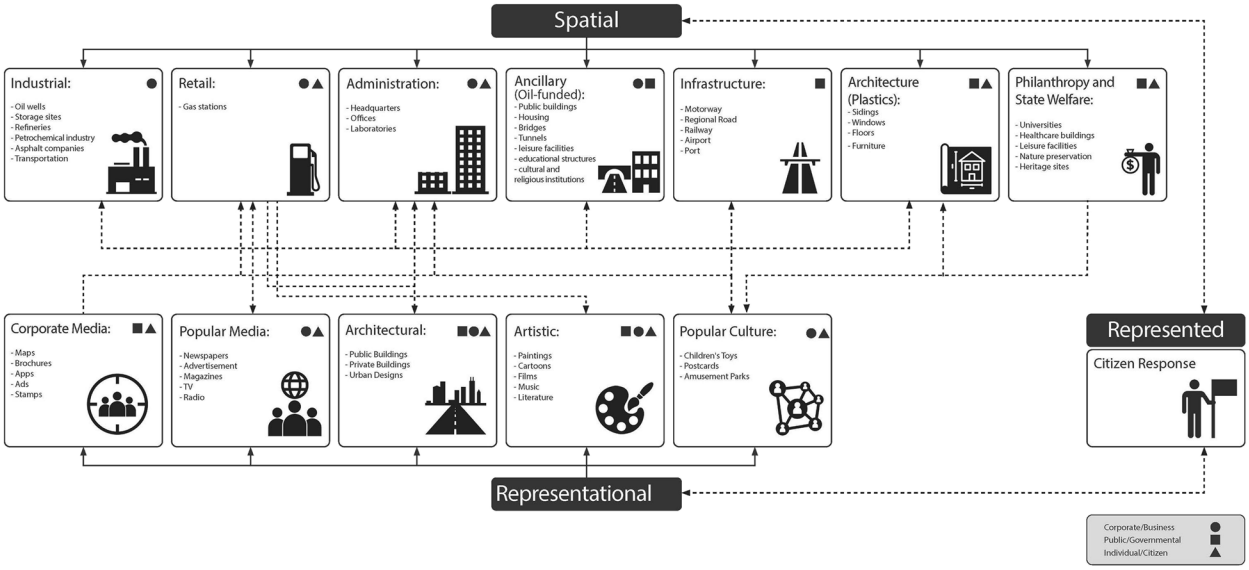


**Fig. 2** The hybrid, multiple, shifting, and uneven ways in which many actors collaborate to create the global petroleumscape (Source: Carola Hein 2021)

industry (roads, railroads, ports), the architectural landscapes created by designers and architects using plastic (furniture, windows, walls, and even entire buildings), and the landscapes formed by the social investments of oil actors in health, education, culture, and heritage (hospitals, universities, exhibition halls) (Hein 2021). Notably, the petroleum industrial heritage in Daqing does not involve these three types of landscapes.

The representational petroleumscape concept explores ways in which corporate and national actors advertise the spaces and uses of petroleum and in which public media and private actors, such as artists architects, and agents of popular culture, influence perceptions of the spatial petroleumscape (Hein 2021). It is a narrative approach to all the physical spaces associated with petroleum, including art, literature, film, advertising, and magazines (Aldera 2020).

The global petroleumscape can be considered to cover all heritage elements of petroleum industrial heritage, including tangible and intangible heritage. In particular, the spatial petroleumscape provides a comprehensive system that can be referenced for the study of the tangible heritage of the petroleum industry. Moreover, the global petroleumscape model constructed by Hein revealed a strong correlation between spatial and representational petroleumscapes, suggesting that the intangible heritage of the petroleum industrial heritage should be protected together with the spatial place where it is generated. This point is also reflected in our typological analysis of the petroleum industrial heritage of Daqing. In summary, the global petroleumscape provides an approach for the systematic conservation of petroleum industrial heritage.

## 3 Overview of the petroleum industrial heritage in Daqing

### 3.1 Overview of the Daqing Oil Field

The Daqing Oil Field, located on western Heilongjiang Province and the northern Songnen Plain, has an oil-bearing area of more than 6,000 square kilometres. It is the general name of 52 proven oil and gas fields in the Daqing Placanticline and its periphery and in the Hailar-Tamysag Basin (Compilation Committee of *Daqing Oil Field Annals* 2009). The Daqing Oil Field is the largest oilfield in China and a typical representative of the 'terrestrial facies of petroleum theory' (i.e., the production of oil from continental strata basins) (Qiu and Gong 1999).

In the early days of the People's Republic of China, Chinese oil production could only meet 25% of domestic demand owing to the underdevelopment of the country's oil industry and the uncertainty surrounding oil resources (by 1952) (Fang 2019). To address this, from 1953 – 1959, the central government organised oil workers to conduct surveys in the northwest and eastern regions and in Sichuan (Daqing Local Chronicle Office 2017). These studies revealed the presence of an extensive amount of oil in the Songliao Plain in 1959 – 1960. In September 1959, industrial oil was drilled from the third benchmark well in the Songliao Basin (i.e., Songji No. 3 Well), marking the birth of the Daqing Oil Field (Daqing Local Chronicle Office 2017).

After more than 60 years of development, the Daqing Oil Field has become a large, comprehensive oilfield with complete petroleum industry functions, including exploration and development, engineering technology, engineering construction, equipment manufacturing, and oilfield chemical work. By the end of December 2021, the Daqing Oil Field had produced a cumulative total of 2.463 billion tons of crude oil, accounting for nearly 40% of China's onshore oil production during this period (National Development and Reform Commission 2022). The construction of the Daqing Oil Field laid the foundation for China's oil self-sufficiency (China National Petroleum Corporation 2012) and transformed China's oil industry. In addition, it is an important part of China's modern petroleum industry history.

### 3.2 Overview of the petroleum industrial heritage in Daqing

Among the eight oilfields on the List of China's Petroleum Industrial Heritage, the Daqing Oil Field has the largest number and richest types of petroleum industrial heritage (Table 1) involving petroleum technological processes, such as extraction, storage, transformation, and transportation. By 2021, a total of 26 Daqing petroleum industrial heritage sites were included on the national (4), provincial (5) (Heilongjiang Province People's Government 1999, 2007, 2015), and municipal (21) (Daqing Municipal People's Government 2006, 2009) key cultural relic protection lists. The main forms of petroleum industrial heritage include the remains of remains production and living facilities, such as facility and equipment groups, buildings and structures, industrial areas, and workers' villages (Fig. 3), among which approximately 75% of the heritage sites are still in normal use.

This research involved collecting relevant historical documents from local government agencies, archives, and historical exhibitions. To achieve reliability and data efficiency, we organised and analysed the basic information of 21 heritage sites after eliminating from consideration sites with unclear information.

Therefore, this research involved collectively analysing the typological features of 21 heritage sites using the global petroleumscape method. Subsequently, the characteristics of the spatiotemporal pattern of petroleum industrial heritage in Daqing were investigated using GIS spatial analysis, superposition analysis, and statistical


**Fig. 3** Daqing's Petroleum industrial heritage. **A** Saertu No. 55 well. **B** No. 2 Cluster Well Production Platform. **C** Gandalei house in Hongqi Village. **D** Songji No. 3 well site. **E** Petaohua Oil Refinery Site. **F** Xingshugang No. 66 well (Source: the author)

analysis, and the related factors affecting these characteristics were analysed. The purpose of the research was to interpret Daqing's petroleum industrial heritage from the perspective of the systematic conservation of petroleum industrial heritage and to provide a typical and valuable case study for the future systematic conservation of China's petroleum industrial heritage.

## 4 Analysis of the systematic conservation of Daqing's petroleum industrial heritage

### 4.1 Typological characteristics of Daqing's petroleum industrial heritage: heritage dominated by the flow of petroleum materials

Based on the classification defined by the global petroleumscape notion, this study analysed the typological characteristics of petroleum industrial heritage in Daqing (Fig. 3). To this end, the petroleum industrial heritage in Daqing was divided into tangible and intangible heritage, in which the tangible heritage was classified as a spatial petroleumscape and the intangible heritage was classified as a representational petroleumscape.

The typological analysis of the tangible petroleum industrial heritage in Daqing was conducted based on the seven layers of the spatial petroleumscape. The tangible heritage consisted of three layers (industrial, ancillary, and administrative petroleumscapes), and the tangible heritage of the petroleum industrial heritage in Daqing was classified into three types based on the three layers: industrial, ancillary, and administrative petroleum heritage (Fig. 4).

Among these three heritage layers, industrial petroleum heritage accounts for the largest number, including 14 heritage sites, equating to 67% of the total tangible heritage. These sites mainly consist of exploration wells, oil wells, oil depots, refineries, and other heritage elements. This indicates that the current tangible heritage conservation of petroleum industrial heritage in Daqing focuses on sites and relics directly related to the extraction, production, storage, and processing of petroleum (i.e., the industrial footprint formed during the flow of petroleum materials).

In terms of the seven layers of the spatial petroleumscape, the Daqing industrial heritage conservation list lacks four types of petroleumscapes: retail (gas stations), infrastructure (roads, railways, and ports), philanthropy and state welfare (universities, hospitals, and leisure facilities), and architecture petroleumscapes. Increased attention should be devoted to sites and relics closely related to the flow of petroleum capital.

A review of historical documents and field surveys revealed that many remains of the petroleum industry (extant) with heritage value formed in the flow of petroleum capital have not been included in conservation lists. The Tongliao-Ranghulu Railway (1964), an important

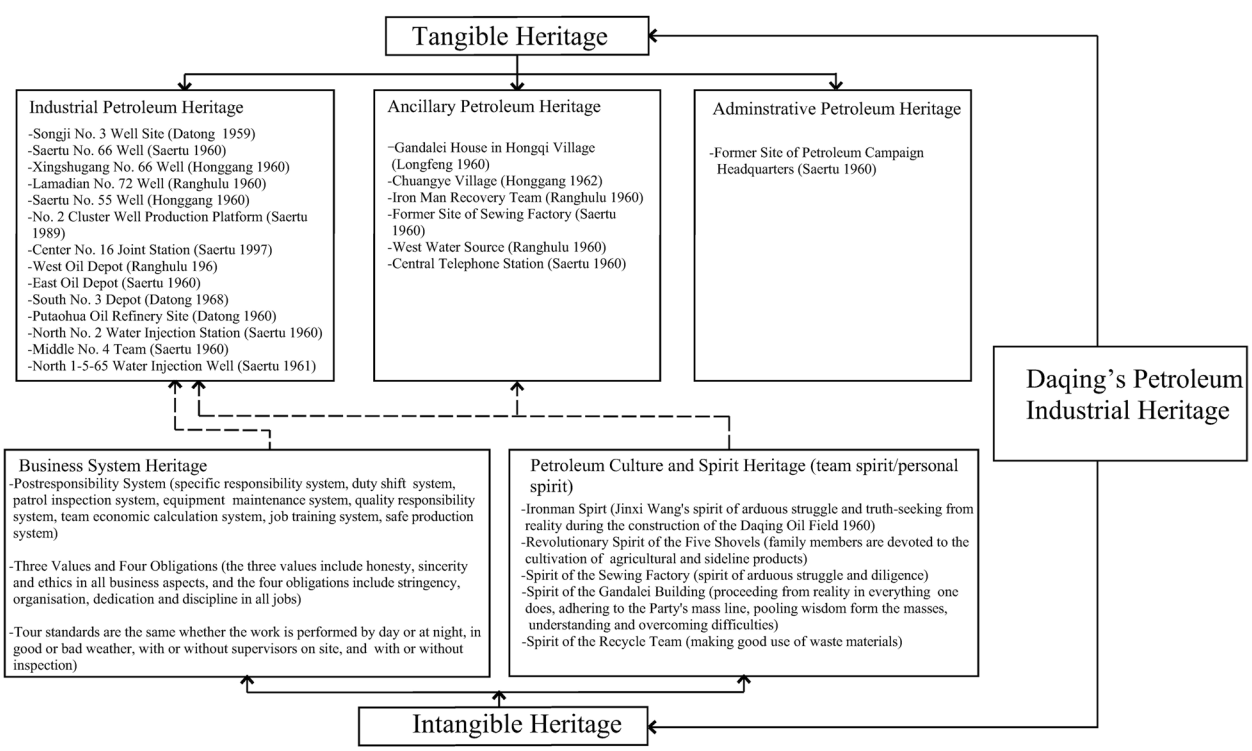


**Fig. 4** Typological analysis of Daqing's petroleum industrial heritage (Source: the author)

transport line for the construction of the Daqing Oil Field; Northeast Petroleum University (1960) (formerly known as the Daqing Petroleum Institute), a key national university for training talent for the construction of the Daqing Oil Field; and the Longfeng Thermal Power Plant (1961), the first thermal power plant built in the Daqing Oil Field (extant), can be used as heritage elements to compensate for the missing types of petroleum industrial heritage.

In addition, the petroleum industrial heritage conservation list in Daqing contains a certain amount of intangible heritage, mainly involving the petroleum enterprise system, as well as petroleum culture and spirit. There is a relationship between intangible heritage and the heritage elements of the petroleum production chain and ancillary heritage: the 'job responsibility system' (*gangwei zeren zhi* 岗位责任制) and North No. 2 water-injection station (Fig. 5-A); the 'Three values, four obligations' (*san lao si yan* 三老四严) and Zhong IV Crew (Fig. 5-B); the 'four the sames' (*si ge yiyang* 四个一样) and North No. 8 Crew's 5-65 water-injection well; the 'revolutionary spirit of the five shovels' (*'wu ba tieqiao naogeming' jingshen* '五把铁锹闹革命'精神) and Chuangyezhuang (Fig. 5-C); 'the spirit of the sewing factory' (*fengrenchang jingshen* 缝纫厂精神) and the site of the old sewing factory; 'the spirit of the gandalei house' (*'gandalei' jingshen* '干打垒'精神) and the site of Hongqi Village's gandalei house; 'the spirit of the recycle team' (*huishoudui jingshen* 回收队精神) and the iron man recycle team; and 'the iron man spirit' (*tieren jingshen* 铁人精神) and Saertu No. 55 well. These types of tangible heritage were selected for the heritage protection list owing to their 'intangible' value and significance.

Therefore, the intangible heritage of the petroleum industry in Daqing can be regarded as a way to describe the tangible heritage, which reflects the common values of oil enterprises and oil workers at that time, and can be classified as a representational petroleumscape. As Smith reported, 'heritage is intangible, and as a cultural process, its values and significance are the real objects of heritage protection and management' (Smith, 2020).

In terms of the representational portion of the global petroleumscape, the intangible heritage of petroleum industrial heritage in Daqing mainly reflects the narrative of the national agencies and oil enterprises on petroleum industrial heritage but lacks narratives from the public perspective, such as the narration of petroleum industrial heritage in popular culture. Unlike the intangible types of industrial heritage defined in the Dublin Principles of the International Committee for the Conservation of Industrial Heritage (TICCIH 2011), the intangible petroleum industrial heritage in Daqing does not indicate the technical know-how of the petroleum industry, the culture and art of petroleum, or community culture. Although terms such as 'community' and 'extensive historical materials' have been mentioned in the national conservation list, these concepts have been generalised practically and need to be refined to indicate specific aspects.

By analysing historical documents on petroleum in Daqing, we have identified numerous remains that can be protected as intangible heritage elements, such as drilling technology, water injection technology, and oil extraction technology developed independently by the oilfield; posters and poems showing the petroleum industry production process; and the settlement pattern of the 'integration of workers and peasants' (gongnong jiehe) (Compilation Committee of *Chinese National Human Geography* 2016) developed during the early years of the oilfield's construction (early urban construction).

The analysis of the typology of petroleum industrial heritage in Daqing revealed that the conservation of China's petroleum industrial heritage is currently mainly concerned with tangible heritage, particularly the industrial sites and relics formed during the flow of petroleum materials and directly related to petroleum production. The remains formed during the flow of petroleum capital are weakened. When compared to the global petroleumscape, the industrial heritage of Daqing is still missing


**Fig. 5** Daqing's petroleum industrial heritage (intangible heritage, tangible heritage). **A** Job responsibility system and North No. 2 water-injection station. **B** 'Three values, four obligations' and Zhong IV Crew. **C** 'Revolutionary spirit of the five shovels' and Chuangyezhuang (Source: the author)

several heritage types and elements. Owing to the lack of the systematic conservation consciousness of China's petroleum industrial heritage, many important remains have not been protected in time, which has negatively affected the holistic understanding of the area's petroleum industrial heritage.

### 4.2 Holistic characteristics of the spatiotemporal pattern of the petroleum industrial heritage in Daqing

The 21 petroleum industrial heritage sites in Daqing investigated in this study were formed in different periods and are distributed across various spatial regions. We thus asked whether they bear common and unique spatiotemporal characteristics, which factors affected these characteristics, and which factors were the most impactful. The analysis of these questions will directly affect the future systematic conservation methods and conservation strategies used in relation to the petroleum industrial heritage in Daqing. Therefore, this paper takes all heritage sites as a whole to conduct a historical analysis of the spatial and temporal pattern characteristics and further explore the correlation factors that may affect the spatial and temporal pattern characteristics.

#### *4.2.1 Relatively concentrated construction period for Daqing's petroleum industrial heritage: 1959 – 1963*

The construction of the Daqing Oil Field can be divided into four periods: the petroleum campaign period (1959 – 1963), the period of rapid rise (1964 – 1975), the period of high and stable production (1976 – 2002), and the period of sustainable development (2003 to present) (Party History Laboratory of Daqing Municipal Committee of CPC 2009). Based on these four periods, this study conducted a statistical analysis on the types and construction dates of the petroleum industrial heritage in Daqing to develop a temporal distribution diagram (Fig. 6).

The temporal distribution diagram revealed that the construction dates of the petroleum industrial heritage in Daqing were distributed among the first three development stages, that is, the period of the petroleum campaign (1959 – 1963), the period of rapid rise (1964 – 1975), and the period of high and stable production (1976 – 2002). Specifically, 18 heritage sites were constructed during the period of the petroleum campaign (1959 – 1963); these sites included various heritage types such as the petroleum industry production chain, ancillary heritage, and administrative heritage. Therefore, the distribution of the heritage is characterised as being temporally concentrated and having diversified typologies.

The temporal concentration of petroleum industrial heritage in Daqing was mainly affected by the following three aspects:

The first aspect was the development and construction of oilfields during the Daqing petroleum campaign (1959 – 1963), which was a very important period in the development of the petroleum industry and coincided with the early period of the construction of New China. In 1959, the Ministry of Petroleum Industry of the People's Republic of China discovered the Daqing Oil Field. Subsequently, from 1960 to 1963, the Ministry of Petroleum Industry concentrated all the sectorial power on the

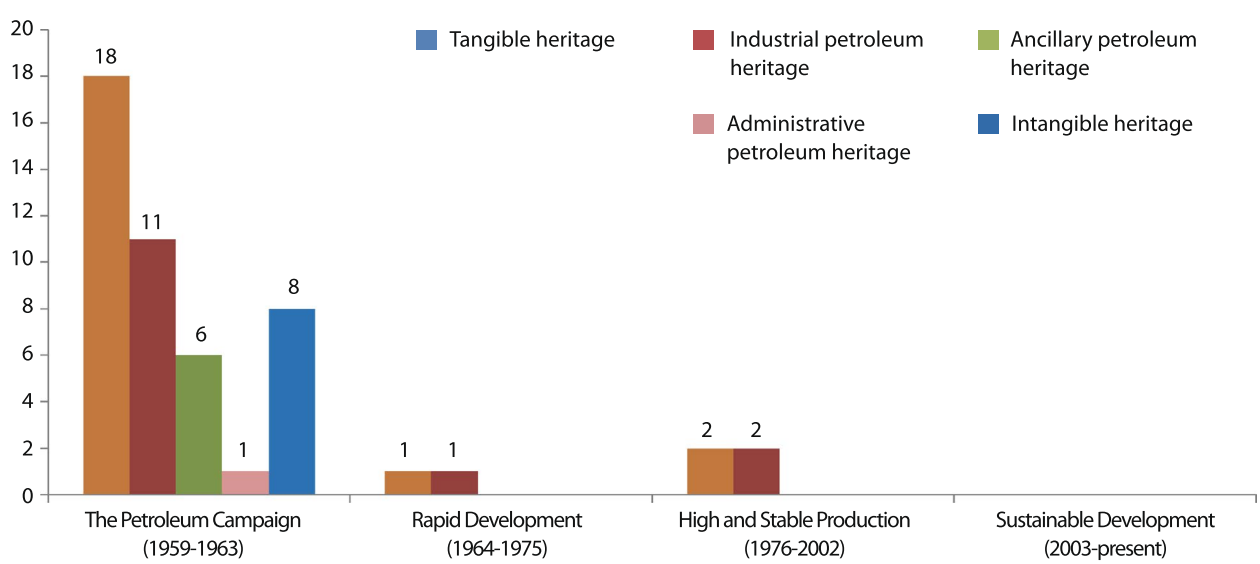


**Fig. 6** Construction period diagram of Daqing's petroleum industrial heritage (Source: the author)

launch of the famous Daqing petroleum campaign. By the end of 1963, the annual output of crude oil in the Daqing Oil Field accounted for 67.8% of China's total output of crude oil, with profits and depreciation totalling RMB 1.07 billion yuan, which laid the foundation for China's oil self-sufficiency (China National Petroleum Corporation 2012) and transformed China from an oil importer to an oil exporter (in 1962, China exported crude oil to foreign countries for the first time; Daqing Local Chronicle Office 1988). Thus, the Daqing petroleum campaign became a milestone in the history of China's petroleum industry.

The second aspect was the impressive development speed in the early stage of Daqing Oil Field construction (1959 – 1963). To rapidly identify the reserves of the oilfield, produce crude oil as soon as possible, and overcome the site's limited oil production capacity, the Daqing Oil Field adopted a development strategy of 'exploring, constructing and producing'. Consequently, this facilitated the development of a comprehensive oilfield with various types of petroleum industry facilities in three and a half years (Daqing Local Chronicle Office 2017).

The third aspect was the country's urgent need for oil. This triggered the devotion of oil enterprises and oil workers to the development and construction of oilfields with great enthusiasm and a strong sense of responsibility. Accordingly, common and shared values were formed within local communities. In addition, oil enterprises rapidly developed various important working systems, such as the 'job responsibility system', 'four the sames', and 'three values, four obligations', to achieve efficient and safe production. Moreover, oil workers and their families were also actively involved in the oilfield construction and life support network, and a large number of hard workers and families emerged and were rewarded as having a 'revolutionary spirit of five shovels' (for the families of oil workers), 'the spirit of the sewing factory' (for the families of oil workers), and 'the spirit of the recycle team' (for oil workers). These reward mechanisms and the shared values they implied are a significant part of the area's intangible heritage.

#### *4.2.2 Scattered spatial distribution characteristics of Daqing's petroleum industrial heritage*

To explore the characteristics of the spatial pattern of industrial heritage in Daqing, this research involved conducting a statistical analysis of heritage types and spatial regions. To this end, GIS was adopted to perform multiple overlay analyses of the heritage sites and basic maps of the city's municipal districts, the spatial distribution of petroleum resources, and the evolution of urban form.

The statistical analysis of the spatial distribution of the Daqing petroleum industrial heritage sites revealed that the 21 heritage sites are distributed across the city's municipal districts (Saertu District, Ranghulu District, Longfeng District, Honggang District and Datong District) with a quantitatively decreasing trend from north to south. Specifically, Saertu District has the largest number of heritage sites (10 heritage sites), covering three types of tangible heritage (Fig. 7).

To comprehensively interpret this characteristic of the spatial pattern of petroleum industrial heritage in Daqing, we conducted a correlation analysis based on the

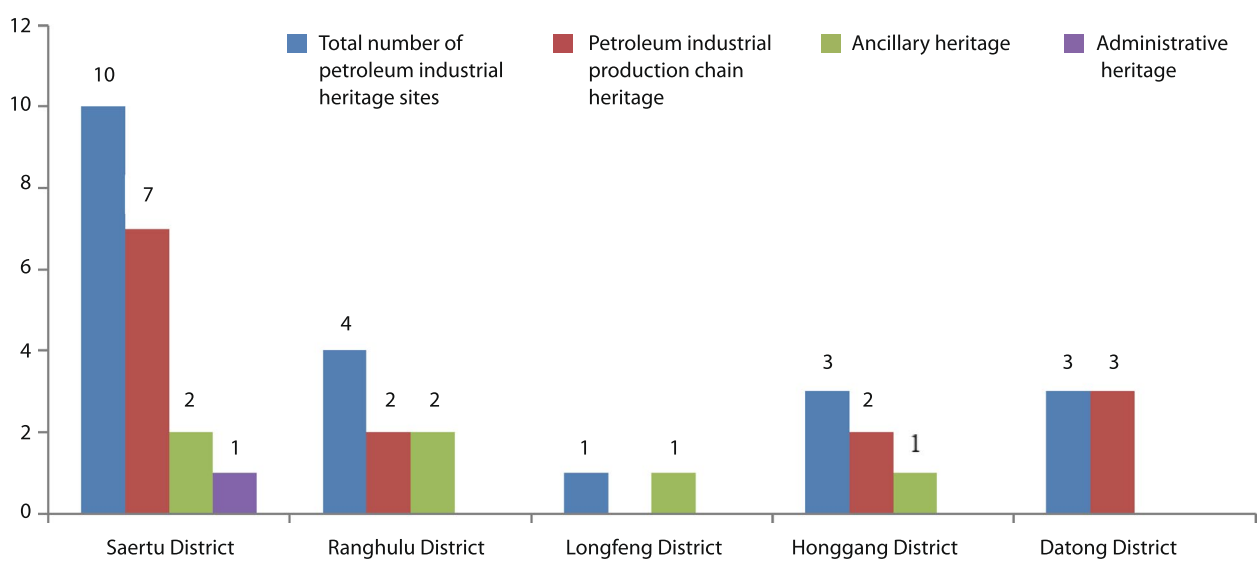


**Fig. 7** Spatial distribution diagram of Daqing's petroleum industrial heritage (Source: the author)

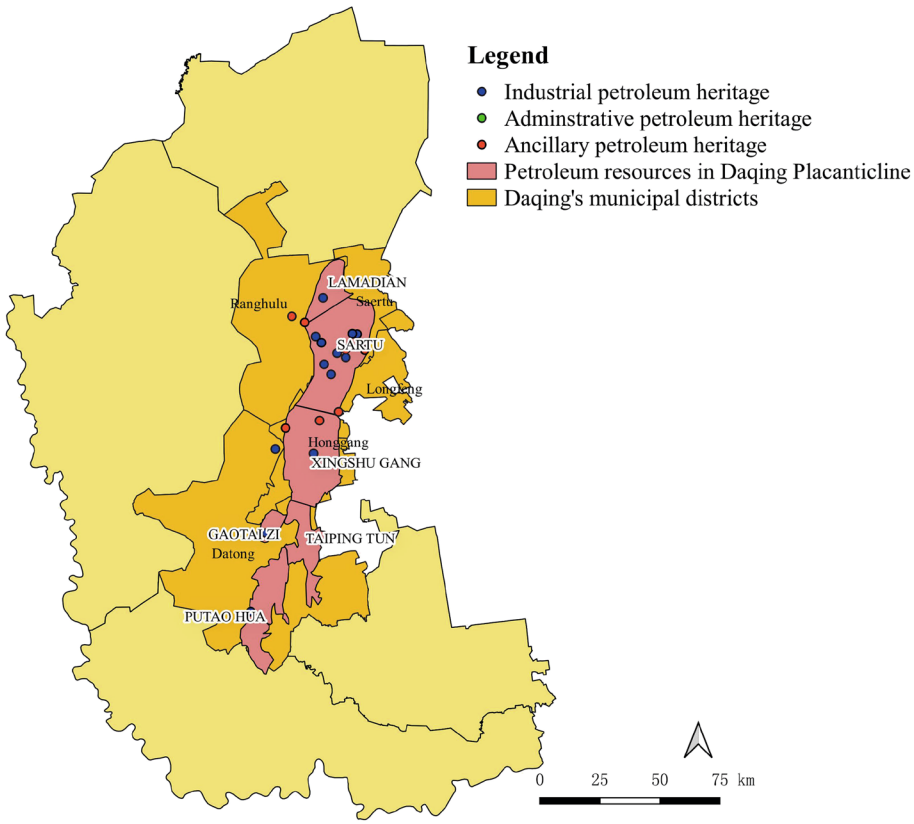


**Fig. 8** Spatial distribution of Daqing's petroleum industrial heritage (Source: the author)

distribution of petroleum resources, oilfield development strategies, and the evolution of urban areas in Daqing.

Petroleum resources in Daqing are mainly found in the Daqing Placanticline (Fig. 8). Daqing Placanticline is approximately 120 kms from north to south and 30 kms from east to west and covers an area of 2,800 square kilometres, which includes seven oilfields: Saertu, Xingshugang, Lamadian, Gaotaizi, Putaohua, Taipingtun, and Aobaota (Compilation Committee of *Daqing Oil Field Annals* 2009). As shown in Fig. 8, the Daqing Placanticline runs through Saertu District, Ranghulu District, Honggang District, Datong District, and Zhaoyuan County, creating a large and widely distributed oil production area and a scattered layout of industrial production sites and settlements, which directly determines the scattered spatial distribution characteristics of the area's petroleum industrial heritage.

The development strategy of the Daqing Placanticline was directly related to its underground oil reserves. In 1959, oil was first discovered and explored in the Gaotaizi oilfield and Putaohua oilfield in the southern Daqing Placanticline. Owing to the relatively large quantity of oil reserves, the Putaohua oilfield became the first oilfield for preliminary exploration. In 1960, after the underground oil layer in the north of the Daqing Placanticline was confirmed to be thicker than that in the south, the planning and development focus of the Daqing Oil Field shifted from the Putaohua oilfield (1959) in the south to the Saertu (exploited in 1960), Xingshugang (exploited in 1966), and Lamadian (exploited in 1972) oilfields in the north (Compilation Committee of *Daqing Oilfield Annals* 2009).

Moreover, compared to other oilfields, the Saertu oilfield boasted favourable underground and aboveground conditions owing to its thicker oil layer, larger dimensions, higher output, and location along the Binzhou Railway connecting Harbin and Qiqihar (Qiu and Gong 1999). Therefore, it became the first oilfield exploited in the initial stage of the construction plan (1963 – 1966) and became the earliest developed, largest, and most productive comprehensive oil field in Daqing (Compilation Committee of *Daqing Oil Field Annals* 2009).

The urban area of Daqing has undergone four major evolution stages. In this research, with the current urban area map of Daqing (yellow area) as the base map, we performed an overlay analysis of the urban areas of four evolution stages (orange area) and the corresponding oilfield exploitation areas (purple area) (Fig. 9).

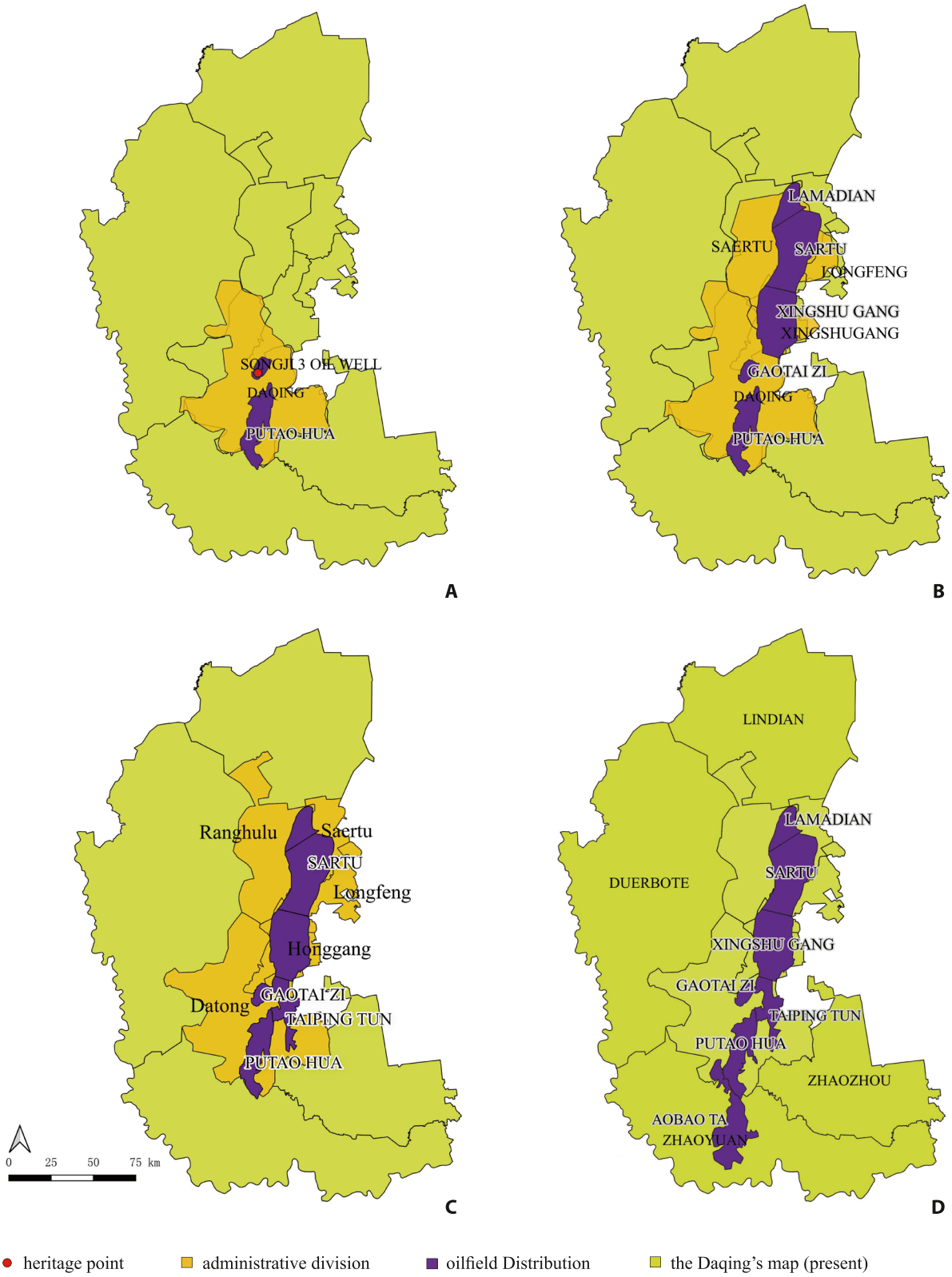


**Fig. 9** Daqing's urban area evolution map. **A** Daqing District in the 1960s. **B** Anda Special Zone in the 1970s. **C** Daqing City in the 1980s. **D** Daqing City in the 1990s (Source: General Compilation Committee of *China Oil and Gas Field Development History* 2011; Chinese National Human Geography Committee 2016; redrawn by the author)

The first stage (1959 – 1964) involved the establishment of the Daqing District, which belonged to Anda City at that time. The Putaohua and Gaotaizi oilfields of the Daqing Placanticline, as well as the Songji No. 3 Well (red dot), which is a discovery well, were all located in this spatial region (Fig. 9-A). Additionally, the first construction and exploitation of oilfields at that time occurred in this spatial region.

The second stage (1964 – 1979) involved the establishment of the Anda Special District, mainly including Daqing District, Saertu District, Xingshugang District, and Longfeng Subdistrict Office at that time (Zhao 2011; the yellow area in Fig. 9-B). During this period, the construction and exploitation of the Daqing Oil Field occurred in the Saertu (exploited in 1960), Xingshugang (exploited in 1966) and Lamadian (exploited in 1978) oilfields in the northern Daqing Placanticline (the purple area in Fig. 9-B). The figure indicates the expansion of the regional scope of the Anda Special District.

The third stage (1980 – 1991) involved the establishment of Daqing city and its five municipal districts (Datong, Saertu, Ranghulu, Honggang, and Longfeng) (Daqing Local Chronicle Office 1988) covering the Saertu, Xingshugang, Lamadian, Putaohua (exploited in 1979), Gaotaizi (exploited in 1983) and Taipingtun (exploited in 1980) oilfields in the Daqing Placanticline (see the yellow area in Fig. 9-C). As it was exploited in 1995, the Aobaota oilfield was not included in the administrative districts of Daqing during this period.

The fourth stage (1992 – present) involved the addition of four counties (Zhaozhou, Zhaoyuan, Lindian, and Lamadian) based on its five municipal districts (Fig. 9-D) (Compilation Committee of *Chinese National Human Geography* 2016), thus forming the complete urban area of Daqing. The Aobaota oilfield is located in Zhaoyuan County.

In terms of the four evolution stages of the urban area of Daqing, the urban development of Daqing has always been conducted around oilfield construction operations, which has affected the distribution of all the petroleum industrial heritage sites in the city's municipal districts.

This analysis revealed that the petroleum industrial heritage in Daqing is mainly distributed across the Saertu, Xingshugang, Lamadian, Putaohua, and Gaotaizi oilfields in the Daqing Placanticline, rather than the Taipingtun and Aobaota oilfields, which are also located in the Daqing Placanticline, excluding the oilfields in the Daqing Placanticline periphery. This may be because of the earlier construction of the first five oilfields and their higher historical and social value. However, we propose that petroleum industrial heritage, as the marker and witness of the history of an oilfield, should involve all important spatiotemporal developments and evolutions of the oilfield. Therefore, future research on the protection of petroleum industrial heritage should include the entire area of the Daqing Oil Field.

#### *4.2.3 Overall spatial distribution characteristics of the 'one belt, one axis' of Daqing's petroleum industrial heritage*

In terms of the overall spatial distribution of characteristics of the petroleum industrial heritage in Daqing, another notable characteristic is the spatial form of 'one belt, one axis' (Fig. 10). 'One belt' refers to the long strip-shaped area (orange area) that runs from the north to the south of the city and includes the Saertu, Ranghulu, Honggang, Datong, and Longfeng districts. The analysis revealed that this belt-shaped spatial area captures the main spatial distribution of oil resources in the Daqing Placanticline.

'One axis' refers to the one railway line, the Binzhou Railway (see the black line in Fig. 10). The Binzhou Railway is a part of the Chinese Eastern Railway (1903), connecting the city with Manzhouli to the west and Harbin to the north. It was the only external transportation line in Daqing before 1959. As the main transportation line in existence during the early stage of the construction of the Daqing Oil Field, the railway line is surrounded by different types of industrial sites, including oil depots, oil refineries, and chemical plants. Therefore, a certain amount of petroleum industry heritage is located around the railway. Heritage types mainly include petroleum industry production heritage and ancillary heritage, such as three oil depots (East Oil Depot, West Oil Depot and South No. 3 Oil Depot) (see big dots in Fig. 10).

To further explore the 'one belt, one axis' idea, which describes the spatial pattern of the petroleum industrial heritage in Daqing, we performed a correlation analysis of the heritage sites and urban development mode (i.e., the evolution of urban spatial form).

Daqing has experienced three stages of urban development: the mining area construction stage (1959 – 1979), town construction stage (1980 – 1989) and urban construction stage (1990 – present). During the mining area construction stage (1959 – 1979), Daqing always adhered to the principles of 'all for oilfield production', the 'integration of workers and peasants, integration of urban and rural areas, good for production, and convenient for livelihood' (*gongnong jiehe*, *chengxiang jiehe*, *youli shengchan*, *fangbian shenghuo*)(Compilation Committee of *Chinese National Human Geography* 2016), forming a special rural development mode for the mining area, which became the model of industrial city development in China at that time.

At the mining area construction stage, the main characteristics of the rural development model of the mining

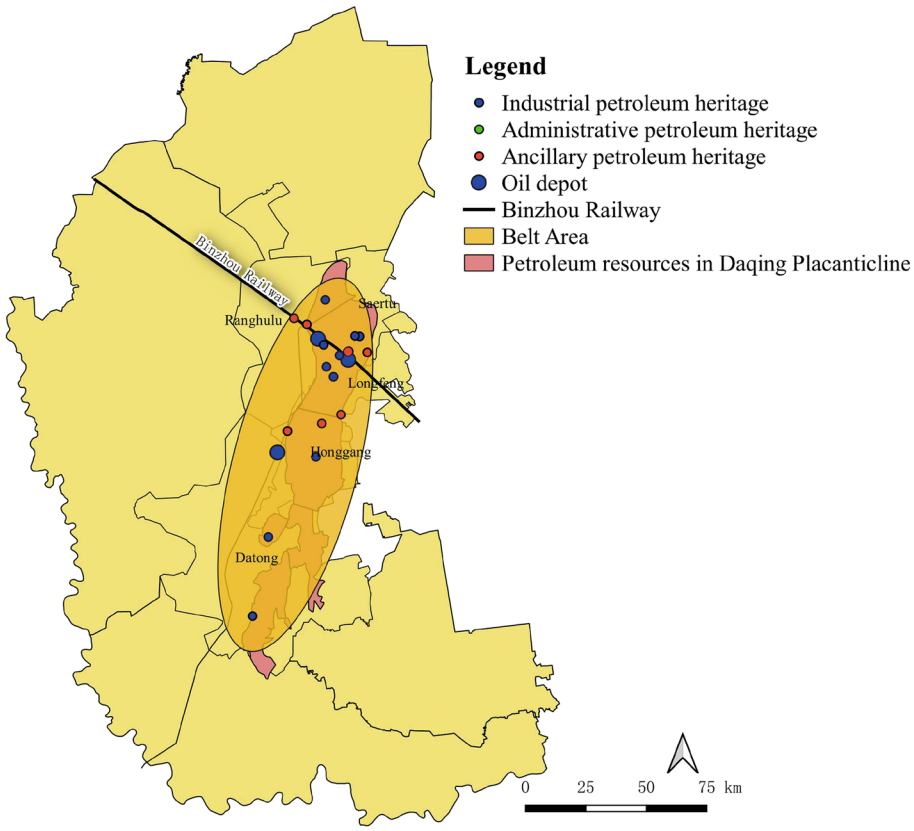


**Fig. 10** 'One belt, one axis' spatial distribution of Daqing's petroleum industrial heritage (Source: the author)

area were as follows: the urban road network was developed based on the oilfield construction road network, and the oilfield production sites and settlements were distributed in the form of scattered points on the strip space of the Daqing Placanticline, forming a decentralised layout of 'urban–rural integration'.

According to each type of oilfield production sites, different locations and scales were selected for settlements, and these settlements can generally be divided into three types (Daqing Local Chronicle Office 1988; Hou 2021). The first type of settlement is a workers' town centred on the location of the enterprise management department with a general population of 30,000 to 50,000 people. Such settlements include Saertu, Ranghulu, and Longfeng. The second type of settlement is a central village with a population of approximately 500 households, and these are centred on the location of oil production plants, mines, and other institutions, which have a fixed but dispersed workplace. Several settlements are arranged around the central village, and farmland is reclaimed between the settlements, forming a spatial layout pattern of 'integration of industry and agriculture'. For example, Red Satellite Village (1966) is a central village with four settlements arranged around it (Fig. 11). The third type of settlement is motorised infrastructure, drilling teams, and pumping stations, which are distributed around the central village. This type of settlement is both an industrial production base unit and an agricultural base, with a residential population of approximately 200 households (Fig. 11).

These three types of settlements form a three-level village and town layout system of the 'workers' town–central village–settlement point', presenting a decentralised spatial layout with many points, long lines, and wide areas, thus forming the rural mining area's spatial pattern. The development mode of the mining area in the construction stage of the Daqing mining area can be considered to directly determine the spatial pattern of Daqing city and determine the belt-shaped and scattered spatial layout characteristics of the petroleum industrial heritage.

The rest of this paper uses the urban area map of Daqing in the 1990s as the base map and presents a comparative analysis of the urban spatial form (roads and residential zones) of Daqing in the 1960s, 1980s, and 1990s.

The analysis chart reveals that Daqing had no urban road transportation network in the early 1960s, with the Binzhou Railway being the only external transportation

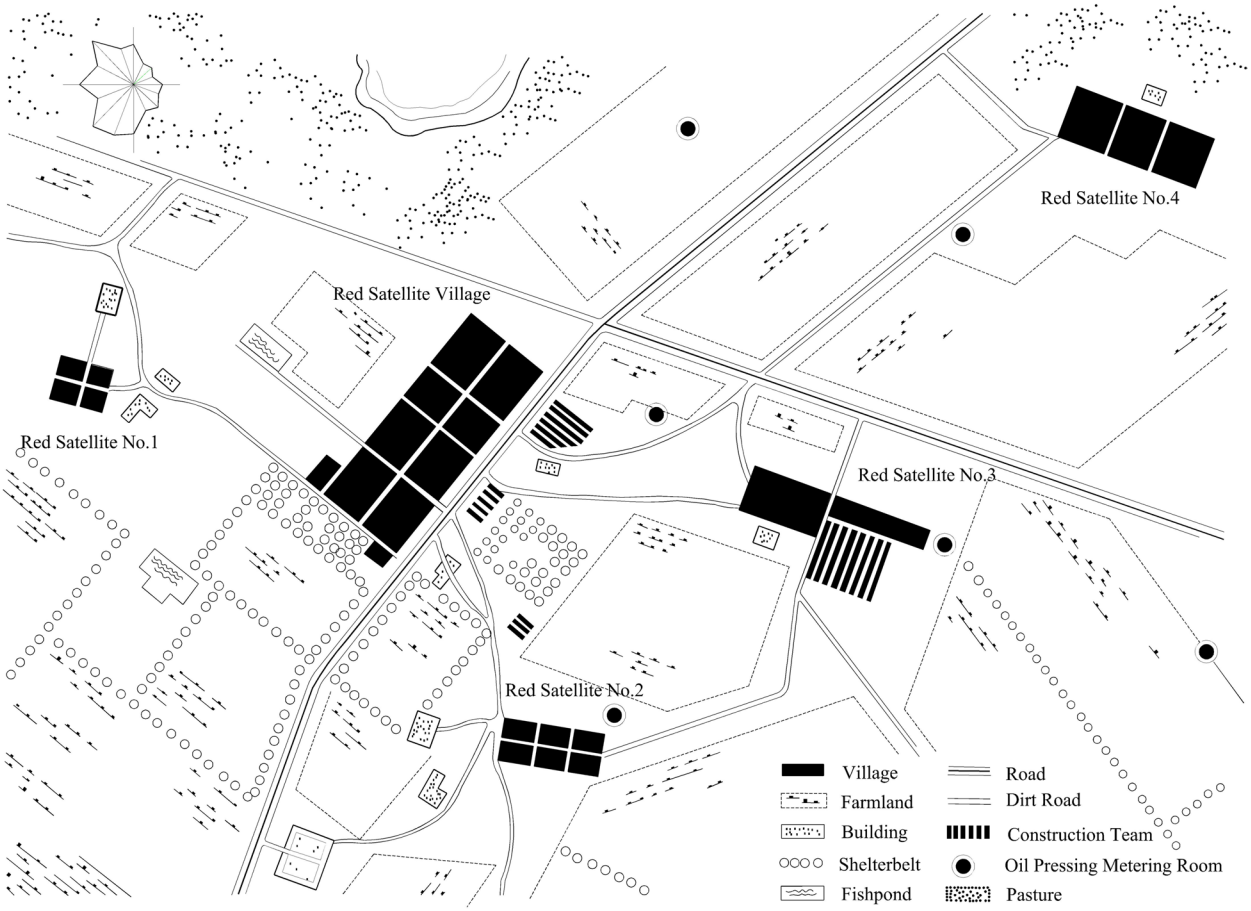


**Fig. 11** The cluster of Red Satellite villages, 1964 (Source: Hou 2020, redrawn by the author)

line (Daqing Local Chronicle Office 2017) and the Saertu Railway Station being the only external railway station. A certain number of oil production sites and settlements were constructed in the area surrounding the Binzhou Railway, which was the most important transportation line during the early construction of the Daqing Oil Field, thus gradually forming two main production and living areas centred on the Saertu Railway Station and Ranghulu Railway Station. Moreover, with an increase in oil production sites and settlements, these two production and living areas gradually expanded in size to form two important workers' towns (Fig. 12-A).

By the end of 1963, with the Saertu, Ranghulu, and Longfeng railway stations on the Binzhou Railway as transportation centres, the spatial pattern of the Daqing petroleum industry was initially formed. Saertu Town was the oilfield management centre, Ranghulu Town was the oilfield scientific research centre, and Longfeng Town was the petrochemical centre (Party History Laboratory of Daqing Municipal Committee of CPC 2009). In this way, the spatial area around the Binzhou Railway had the largest number and most abundant types of petroleum industry sites and relics and became the area with the highest density of heritage sites forming the spatial distribution of petroleum industrial heritage and exhibiting the characteristics of a single axis.

In the 1980s, the urban road network in Daqing was formed, with a north–south longitudinal distribution in the shape of a belt. It mainly included three north–south arterial roads (Sada, the east arterial road, and the west arterial road) and several east–west branches connecting the east and west arterial roads (Daqing Local Chronicle Office 1988). All heritage sites were connected by the road network. During this period, the settlement points, which exhibited a decentralised layout, were closely combined with the production areas of the petroleum industry, with a significant increase in both area and quantity. The centre of the production and living areas gradually expanded from three to four towns, namely, Saertu

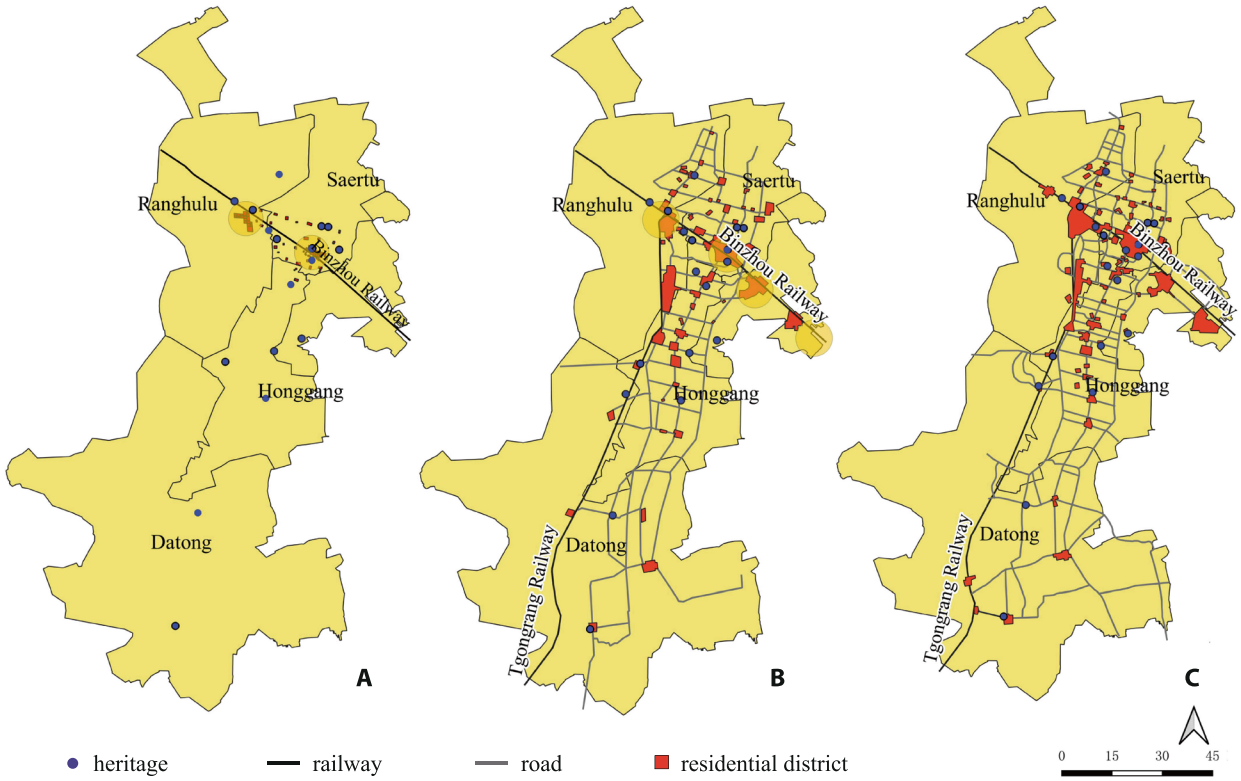


**Fig. 12** Morphology Evolution of Daqing's Urban spatial form, 1960–1990. **A** Daqing District in the 1960s. **B** Daqing City in the 1980s. **C** Daqing City in the 1990s (Source: Liu 2010; Daqing Municipal Planning Bureau 1989, 2000, 1995; redrawn by the author)

(District), Ranghulu (District), Longfeng (District), and Wolitun (District), thus forming the spatial pattern of Daqing as an industrial and mining city (Fig. 12-B).

In the early 1990s, the spatial distribution pattern of the urban road network and settlement points in Daqing remained the same as those in the 1980s, with a significant increase in density. Additionally, the cluster spatial pattern of the small town was initially formed. During this period, only one heritage site of the petroleum industry production chain (No. 16 Combination Station) was added to the heritage list. Therefore, the spatial pattern of heritage sites and types remained unchanged (Fig. 12-C).

This comparative analysis revealed that the 'one belt, one axis' spatial distribution of the petroleum industrial heritage in Daqing formed in the early stage of construction of the Daqing Oil Field (1959 – 1963) and Daqing mining area (1959 – 1966), which is highly consistent with the pattern of urban development and the evolution of the urban spatial form of Daqing.

## 5 Discussion

A comprehensive study including multiple aspects of the diverse types of petroleum industrial heritage elements can facilitate the understanding of and provide appropriate guidance for the preservation of China's petroleum industrial heritage. To explore the systematic conservation of China's petroleum industrial heritage, this study introduces a global petroleumscape approach and employs the petroleum industrial heritage of the Daqing Oil Field as a case study for interpretation.

First, the typology of the petroleum industrial heritage in Daqing was analysed based on the classification defined by the global petroleumscape notion. In terms of spatial petroleumscape layers, the tangible heritage of the petroleum industrial heritage in Daqing can be divided into three types: petroleum industry production heritage, ancillary heritage, and administrative heritage. However, four heritage types (retail heritage, infrastructure heritage, philanthropy and state welfare, and petroleum architecture products) are missing. This indicates that China's petroleum industrial heritage is currently more concerned with the remains formed during the flow of petroleum materials; in particular, there is a focus on the sites and remains directly related to oil extraction, production, storage and processing, and sites and remains formed during the flow of petroleum capital have received less attention.

For example, as a petroleum retail heritage site, gas stations are a key link between petroleum material flow

and petroleum capital flow and are also the most common type of petroleum building in people's daily lives. Hein (2018) described gas stations as an important type of building in the petroleum retail network, and Aldera (2020) performed a detailed analysis of the historical development and evolution of the exterior architectural forms of Italian gas stations. However, the conservation lists of Chinese governments at all levels do not currently involve gas stations. One reason is that domestic heritage conservation institutions and scholars have not paid enough attention to gas stations, which leads to some historic gas stations (e.g., the oldest station in Nanjing) not being on any heritage conservation lists. Another reason is that many older stations have been demolished, and the remaining historic gas stations have almost all been rebuilt (e.g., the 'No. 1 station' in Shanghai). However, as an important petroleum industrial heritage type, gas stations should be conserved in the future.

Structures such as educational buildings, medical buildings, and sports buildings are important channels for the flow of petroleum capital. Hein (2018) categorised these building types as philanthropy and state welfare, and these building types were also investigated and analysed in Carola Hein and Mohamad Sedighi's (2016) study on Iran's petroleum industrial heritage and in Maria Aldera's (2020) study on Italy's petroleum industrial heritage. During the construction of the Daqing Oil Field, oil enterprises contributed to the construction of a large number of public welfare buildings, such as the former Daqing Petroleum Institute, Daqing Medical College, and Daqing Oil Field General Hospital, but these buildings are not currently included on the conservation list. Only one public welfare building heritage site from the Dushanzi oilfield is included on the existing national petroleum industrial heritage conservation list, and other oilfields are not included. This illustrates that these heritage types have not received enough attention.

The intangible heritage of the petroleum industry in Daqing focuses on the expression of the value and significance of petroleum industry sites, which provide a collective narrative of oil industry culture. In the existing conservation list, the working and living conditions of oil workers (individuals) and their memories and living habits are excluded from the list. Moreover, as the carriers of petroleum industry culture, their music, films, cultural works, paintings, and other artistic forms,, have been ignored in official narratives.

Hein (2018) believes that petroleum culture and art can show the growing presence of petroleum in daily life and help in the further integration of petroleum into people's imagination. From the 1960s to 1970s, the Daqing Oil Field, as a model of China's industrial development, inspired several artistic works depicting the oilfield's construction and scenes involving oil workers, such as a series of posters called 'Learn from Daqing in Industry', 'I Offer Oil for the Motherland'(1964), 'Song of the Gandalei House' (1960) and other petroleum-related poems, which can be regarded as a form of intangible heritage. However, these forms of heritage elements are not included in the current conservation lists.

This comparative analysis revealed that there are many sites and remains that were formed through the flow of petroleum capital in China, but these buildings are not currently included in conservation lists. The main reason is the lack of systematic conservation consciousness regarding China's petroleum industrial heritage, which leads to the lack of some types and elements of petroleum industrial heritage being neglected. Therefore, to realise the systematic conservation of China's petroleum industrial heritage, future conservation studies should identify and fill the gaps in heritage types and elements using the global petroleumscape approach.

At the same time, we take all the heritage elements of petroleum industrial heritage in Daqing as a whole in conducting a historical analysis and study of spatiotemporal patterns, and the results revealed that there are some common characteristics.

The construction dates of Daqing's industrial heritage sites are relatively concentrated, occurring mainly during the Daqing petroleum campaign (1959 – 1963). This was directly related to the country's urgent need for petroleum industry development and the 'exploring, constructing, and producing' development strategy of the Daqing Oil Field. Additionally, it reflects that the current conservation of China's petroleum industrial heritage is most concerned with the remains of a particular time period in the history of each oilfield. For example, the industrial heritage of the Yumen Oil Field is mainly focused on the construction and production period (1939 – 1957) (Liu 2022), and the industrial heritage of the Karamay Oil Field is mainly focused on the initial development stage of the oilfield (1951 – 1965) (Jie 2022). This indicates that current petroleum industrial heritage conservation does not cover the entire process of creation, development, decline, and disappearance of oilfields, which inhibits the understanding of the historical evolution of the petroleum industry in a particular oilfield or region. Therefore, future conservation efforts regarding petroleum industrial heritage should investigate all sites and relics across the entire development cycle of an oilfield.

The petroleum industrial heritage sites in Daqing are scattered in municipal districts, exhibiting a 'one belt, one axis' spatial pattern. This is directly related to the spatial distribution of oil resources in a 'belt' pattern, the 'rural' development pattern of mining areas, and the evolution of the 'oilfield-construction-centred' urban

area. Notably, the spatial distribution of oil resources is the most important factor, and it directly determines the characteristics of the spatial distribution of petroleum industrial heritage and the development pattern of mining areas. In addition, we observed that the current conservation efforts regarding petroleum industrial heritage in Daqing, in terms of its spatial dimension, mainly focus on the Daqing placanticline oilfield area (five oilfields) and does not involve the peripheral oilfield areas. It thus cannot fully reflect the entire development history of the Daqing Oil Field. Therefore, future studies on petroleum industrial heritage conservation should continuously expand the scope of conservation areas.

The application of the global petroleumscape approach and the placement of all the elements of petroleum industrial heritage into a system for interpretation not only points to some typological and spatiotemporal characteristics of all heritage sites but also aids in the understanding of the heritage itself and the correlation between heritage and other elements and facilitates the identification of critical issues of current conservation. In summary, systematic conservation is the key to the conservation of China's petroleum industrial heritage.

## 6 Conclusion

The global petroleumscape provides an approach for achieving the systematic conservation of China's petroleum industrial heritage. Using this research approach, future research on the conservation of China's petroleum industrial heritage can be expanded in the following ways.

First, the approach can be used to clarify the scope of conservation research, heritage types, and heritage elements of China's petroleum industrial heritage, which is a key step in the conservation of petroleum industrial heritage. The current national petroleum industrial heritage conservation list covers only tangible heritage, which is dominated by petroleum industrial, ancillary, and administrative heritage, and does not cover intangible heritage, indicating that the heritage types under official protection are not sufficiently comprehensive. Based on Hein's (2018) global petroleumscape types, we can determine the typological composition of China's petroleum industrial heritage, find each heritage element that is worthy of conservation, and fill in gaps in heritage types and elements.

Second, based on the spatiotemporal pattern perspective of petroleum industrial heritage, we conduct systematic conservation research on petroleum industrial heritage in China. Through historical analysis of the overall spatiotemporal pattern of petroleum industrial heritage in Daqing, we find that petroleum industrial heritage presents some common spatiotemporal distribution characteristics that are closely related to the spatial distribution of oil resources, oilfield development strategies, and urban development patterns. Therefore, for the future conservation of petroleum industrial heritage in an oilfield or a region, a more systematic conservation strategy can be proposed based on the characteristics of the spatiotemporal pattern of the petroleum industrial heritage, combined with the oilfield development strategy and urban development strategy of the heritage site. Additionally, we can try to take the petroleum industrial heritage of all oil fields in China as a whole to conduct a more macroscopic study on the evolution of the spatiotemporal pattern of petroleum industrial heritage and study the correlation between the evolution of the spatiotemporal pattern of petroleum industrial heritage and the development pattern of China's petroleum industry, China's macroeconomic development strategy, and China's petroleum town development mode in order to explore the future overall conservation strategy of China's petroleum industrial heritage. The development of these studies will contribute to the realisation of systematic conservation of China's petroleum industrial heritage.

There are two limitations in this research. First, the systematic protection of petroleum industry heritage is a very complex process that involves not only the physical space formed during petroleum materials and funds flowing but also the social space. This paper devotes more attention to the protection of the physical space, meaning that it inevitably overlooks some heritage elements. Thus, subsequent studies should investigate the social space formed by the petroleum industry. In addition, this paper presents a typical case study and analysis for interpreting the typological characteristics and spatiotemporal pattern characteristics of petroleum industrial heritage, which inevitably has some limitations. Future studies can extend the research method of several cases to compare and contrast multiple oil series heritage sites built at different times, in different spatial areas, and at different scales of comprehensive oil fields, which can reveal the holistic characteristics of China's petroleum industrial heritage more comprehensively and accomplish the systematic protection of China's petroleum industry heritage.

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**Authors' contributions**

The author finished this paper alone. The author read and approved the final manuscript.

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**Availability of data and materials**
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## Declarations

**Competing interests**
The author declare that they have no competing interests.

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