



Origin and development of soil science in ancient China

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Abstract

Based on many ancient records, archaeological discoveries, and current studies, knowledge of soils including their classification, distribution, and utilization was understood 2000 years ago in China. Thus, pedology may have originated in China. A brief history of Chinese thoughts about soils is described along with the development of their farming experiences since ancient times. Even today, people still get useful information from these old records and works.

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1. Human activities in ancient China

1.1. General comments

China is one of the oldest civilized countries in the world. Human activities and the practice of agriculture date back nearly 10000 years when people began gaining an understanding and knowledge about soils. Records of these activities can be found in ancient or current Chinese references (Deng, 1957; Zhang, 1959; Wang, 1980; Lin, 1996; Gong, 1999; You, 2002) and in non-Chinese literature like those in English and Russian (Thorp, 1936; Kovda, 1960; Needham, 1986; Li and Cao, 1990; Gong and Liu, 1994; Gong et al., 1999). A brief analysis of the origin and development of soil science in ancient China is given below.

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1.2. The earliest human activity records within Chinese territory

With more and more of archaeological discoveries, increased understanding of the earliest human activities in China has been reported including the presence of *Beijing Man*, *Yuanmou Man*, *Lantian Man*, *Maba Man*, and also lately *Nanjing Man*. *Beijing Man*, discovered in the 1920s, is the most important among all these discoveries. *Beijing Man* was found at Zhoukoudian, 39°40'N and 115°58'E southwest of the Chinese capital Beijing, where a 40-m section with 13 layers dates back to 0.7–0.2 Ma BP (Wu, 1984). The time of *Yuanmou Man* is thought to be a bit earlier (Lin, 1978). It is believed that they knew how to use fire and were engaged in animal raising and fishing as some simple tools and burnt remains were found together with skull bones in buried soil horizons. Man in China about 200 000 years ago (mid-Pleistocene) influenced his environment.

1.3. Long history of agriculture

China is called one of the four oldest civilized countries in the world. Carbonized grain and paddy unearthed in Banpo village, Xi'an and Hemodu, Zhejiang have ^{14}C dates of 5600–6080 (Zhu, 1964) and 6890–7040 (Zhejiang, 1978) years BP, respectively. Farmers in the Yellow River area began to plant millet, while the people along the Yangtse River started to grow rice about 6000–7000 years ago. Rice grain unearthed at Pengtoushan, Fengxian county, Hunan Province in 1988 has dates of 9100 ± 120 and 8200 ± 120 years (Pei, 1989), which is new evidence of rice planting about 2000 years earlier than previously known. According to ^{14}C dating in the Taihu Lake region, Jiangsu province, rice and wheat pollen spores were buried in a soil horizon about 5000–6000 years ago, clearly indicating the long history of agriculture in China (Gong and Liu, 2002). Thus, people started to plant crops as early as in the Stone Age, which was followed by expansion of culture and agricultural activities nationwide.

1.4. Agricultural activities in ancient time

It is reported (Deng, 1957) in Chapter 2, Soil, of the book *The Four Chapters on Agriculture in Lushi Chunqiu*, published in 239 BC that an agricultural official Houji, during the time of Emperor Shun, taught farmers how to plant different crops about 4200 years ago. There is still something now called “teaching platform for planting” in Wugong county, Shaanxi province in memory of Houji. As agricultural activities spread, a series of irrigation systems, melioration engineering practices, and improved ways to plant followed suit nationwide. Some outstanding irrigation engineering systems were built, such as the Zhengguo Channel (246 BC) on the Loess Plateau, the Ximen Bao Channel in northeast China, and the Ling Channel (214 BC) connecting the Yangtse River and the Pearl River water systems. The Qin Channel and Han Channel built in the Spring and Autumn and the Warring States Periods (770–221 BC) are still important in present-day agriculture. Agricultural techniques like rice seeding, transplanting, and greenhouse planting were developed in the Han Dynasty (206 BC–220 AD). Later on, cultivating methods like plowing, harrowing, and hoeing together with the use of farmhouse manure and green manure were widely used to combine land use with land maintenance in both the Yellow

and the Yangtze River areas. Rotation systems were carried out, especially those with leguminous and gramineous crops. Terraced fields were built in mountainous areas like the ones up to 2660 m above sea level in the Yunnan–Guizhou plateau. In some lowlands, ridges were built for better drainage like buttress fields or mulberry ridge with fishing pools. In aridic areas, some special irrigation systems were built, like the underground Kanerjing wells, and some fields were covered with stones to capture dew and reduce erosion thereby minimizing the risk of drought.

2. Soil understood in ancient China

In ancient China, soil was considered one of the five natural factors: ‘gold’, ‘wood’, ‘water’, ‘fire’, and ‘soil’. In ancient Greece, they considered water, fire, soil, and air, and in ancient India, they revered land, water, fire, and moon. These ideas reflect regional cultures and are the seeds of current soil science.

2.1. Understanding the soil

Soil is very much like the term ‘mother’ in languages of the world. The scholar Xunshen, of the East Han Dynasty, considered soil as something of the land that provides living things with nutrition. The book *Yingjing li* noted that all food, grasses, and forests come from the soil; thus, the soil was a basic concept linked to the whole world. The writings in Guanzhi during the Spring and Autumn Period and the Warring States Period pointed out that land was the basis for administration, while the soil was the basis for people to prosper. Thus, in ancient times, soil was considered to be necessary for growing crops, and soil affected the rise or the fall of the administration.

2.2. Chinese characters used to describe soil in ancient time

According to *Great Geographical Events of China* (Chen, 1992), there were more than 27 types of the Chinese character “土” in inscriptions on bones or tortoise shells of the Shang Dynasty (16th–11th century BC). This written language was developed about 3000–4000 years ago. Life in the primitive societies revolved around two major activities, obtaining food and reproduction (You, 2002); consequently, these activities influenced the character language that was evolving. Chinese characters were described by their shapes, meanings, and even sounds. The earliest description was often by shape. In some inscriptions on bones and tortoise shells, soil was expressed as “土” meaning the male reproductive organ and the character “匕” represented the female. When a male character was added to a generic one, it conveyed male gender, for example, a generic cattle “牛” symbol with “土” character added represented a bull “牡.” In a similar manner, a generic cattle symbol with a female character added represented a cow “牝.”

Xunshen in the East Han Dynasty (25–220 AD) pointed out an interesting interpretation of the Chinese character for soil. In the Chinese character “土”(i.e., soil), the upper horizontal stroke “一” refers to the topsoil, the lower horizontal stroke “一” to subsoil, and the vertical “丨” to both aboveground and belowground parts of plants (Fig. 1). It

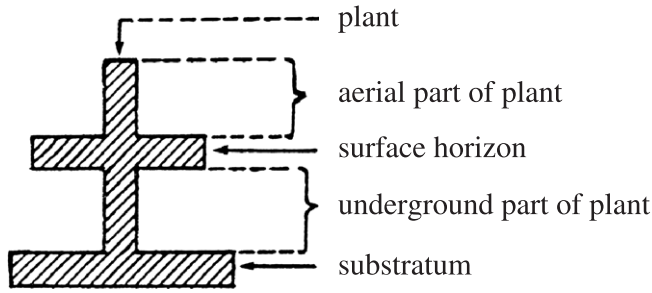


Fig. 1. Chinese character for “soil” (Wang, 1980).

illustrates that the soil nurtures and supports plant growth, reveals the close relationship between the soil and plant, and conveys the same meaning as the definition of soil in modern pedology. This may be regarded as the earliest scientific interpretation of soil.

2.3. The earliest soil exhibition

Chinese emperors in many dynasties established “the land and grains altar” in order to show their worship to the Land God and Grain God for a good harvest and security of the country (Liu, 1984). Such an altar was first established in the Zhou Dynasty (1100–771 BC). The five-colored “sacrificial altar” established in 1421 of the Ming Dynasty has been preserved at Zhongshan Park, Beijing. Its highest layer is 15.8 m² in area, paved with five types of soils in different colors: the soils in the east are blue; south red; west white; north black; and central yellow (Fig. 2). It is consistent with the general soil distribution of the country: in the east of the country, most soils are bluish in color because of gleization; in the south, the dominant soils are reddish Ferrosols; in the northwest, Aridosols and saline soils often are whitish; and in the center, the Cambosols in the Loess Plateau are

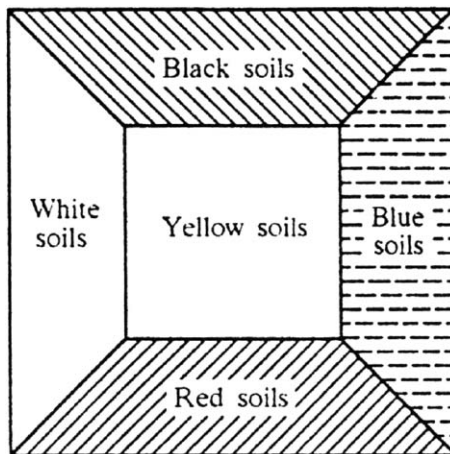


Fig. 2. Five-colored “Sacrificial Altar” in Beijing.

yellowish in color as are many of the Agrosols (Gong, 1999). There existed knowledge of the soils and their general distribution in the country.

3. Soil classification in ancient China

Some great works concerning soils like *Yugong*, *Zhou li*, and *Guan zi* came into being in ancient time to meet the needs of better land use planning and to provide more taxes for the feudalist dynasties. Soil classification was important for these tasks.

3.1. Soil classification in the book *Yugong*

Soil classification in the Xia Dynasty about 4000 years ago was recorded in the book *Yugong* that is thought to have been written in the Warring States Period about 2500 years ago. There is an old story about a man called Yu who fought against the big floods. He was away from home for more than 13 years until he found effective ways of building dikes and dredging river ways to make the flood waters flow orderly into the sea. Yu toured the whole country and learned a lot about soils and agriculture. The classification of soils at that time was recorded in the book *Yugong*.

Yu recognized and described the lands of the Nine Provinces of the Shang Kingdom. He determined the high mountains, great rivers, kinds of soils, and the commodities and characteristic products of each province. Soil classification in *Yugong* was based on some soil characteristics like soil fertility, soil color, soil texture, soil moisture, and vegetation. Soils of the Nine Provinces (Fig. 3) were classified into nine groups as pale rang, black fen, red chi-fen, mud tu ni, blue li, yellow rang, white fen, lu, and zhi according to their colors like black, white, red, yellow, and blue as well as some terms related to soil texture (Table 1). We assume that rang related in a general sense to loessial soils and their derivative alluvial silts, that fen reflected humus-rich soils, lu suggested dark hard compact soil with an implication of claypans and shajiang horizons, zhi applied to all sticky soils containing much clay, and that chi unquestionably referred to saline soils of the solonchak type. Each of these soil groups had taxation classes based on soil fertility levels.

3.2. Soil classification in *Zhou li* (Xia, 1979)

Zhou li was a book of the Spring and Autumn Period and the Warring States Period in which agricultural activities especially soil classification and land use planning of the Zhou Dynasty were recorded. Some regions within the above nine soil groups were subdivided based on relief into mountainous forest areas, low lands of rivers or lakes, hilly areas, alluvial plains, and wet highland areas. Soils of the Nine Provinces were classified mainly according to soil color and soil texture into nine soil types: xing (red color and hard consistence), red ti (red-yellow color and consistence less hard than xing), fen rang (probably clay), ke ze (similar to some wet soil or dried up wet land), lu xie (saline soil), bo lang (maybe sandy soil), zhi lu (clay loam with good fertility), jiang han (harder than xing or zhi lu), and qing biao (sand).

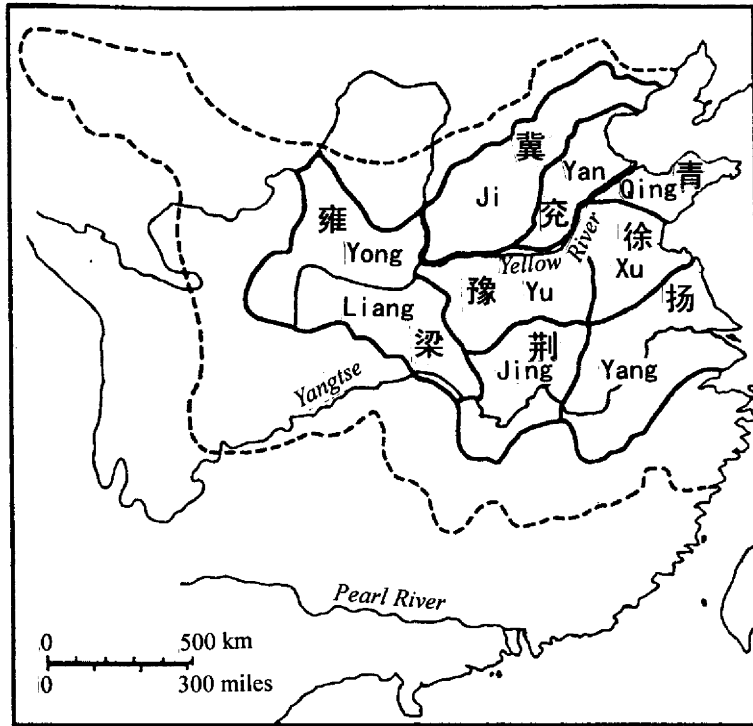


Fig. 3. Soil map of the Nine Provinces in the book *Yugong*.

3.3. Soil classification in *Guan zi* (Xia, 1981; Ding, 1993)

Guan zi is a set of papers from different fields of study collected between the Warring States Period and the Han Dynasty (about 200 BC). Based on soil properties including texture, structure, soil pore space, organic matter, soil reaction, and soil fertility together with natural conditions like relief, soil moisture, and vegetation, soils were grouped into

Table 1
Soil description of the Nine Provinces in the book *Yugong*

Province	Soil description			Approximate terms in Chinese soil taxonomy
	Dominate soil	Color	Texture	
<i>Ji</i>	pale <i>rang</i>	white	loam	Halosols, Aquic Cambosols
<i>Jing</i>	<i>tu ni</i>	grey	clay	Gleysols, Ferrosols
<i>Liang</i>	blue <i>li</i>	dark	clay	Aquic Cambosols, Gleysols
<i>Qing</i>	white <i>fen</i>	white	clay loam	Agrosols, Halosols
<i>Xu</i>	red <i>chi-fen</i>	red	clay	Udic Agrosols
<i>Yan</i>	black <i>fen</i>	black	clay loam	Vertosols, Agrosols
<i>Yang</i>	<i>tu ni</i>	grey	clay	Gleysols, Ferrosols
<i>Yong</i>	yellow <i>rang</i>	yellow	silty loam	Ustic Argrosols
<i>Yu</i>	<i>rang, fen, and lu</i>	yellow (black)	loam	Aquic Cambosols, Vertosols

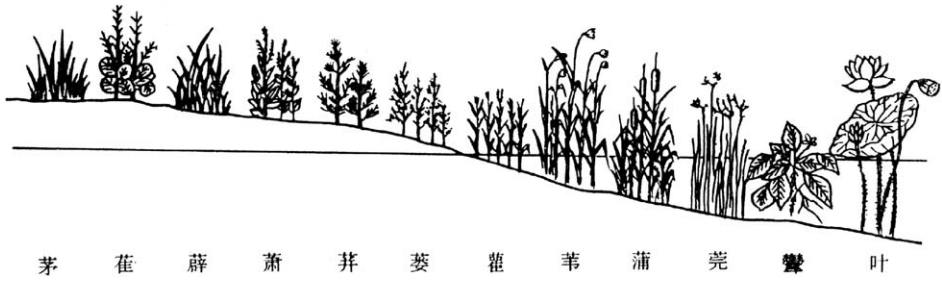


Fig. 4. Relationship among plants, soils, and landscape positions.

three classes under which there were 18 sublevels; for instance, su, wuo, wei, rang as good soils; lu, piao, sha, ge as medium soils; and you, chi, fu, jie as poor soils. Each of these 18 classes was further divided into five more; thus, there were 90 soil classification units in the section of the book called *Ninety soils of Nine provinces*. There were ideas about relationships of soil genesis, soil distribution, and the production of crops. There was information about differences of soil distribution, soil properties associated with various crops, and the relationships of plants (1–12) with landscape positions and moisture conditions (Fig. 4).

3.4. Soil classification after the Han Dynasty

Many reports on soils and their utilization have been written since the Han Dynasty (206 BC–220 AD) (Shi, 1979) like *Works of Sisheng* (Wan, 1980), *Shuowen Jiezi* (Xun,

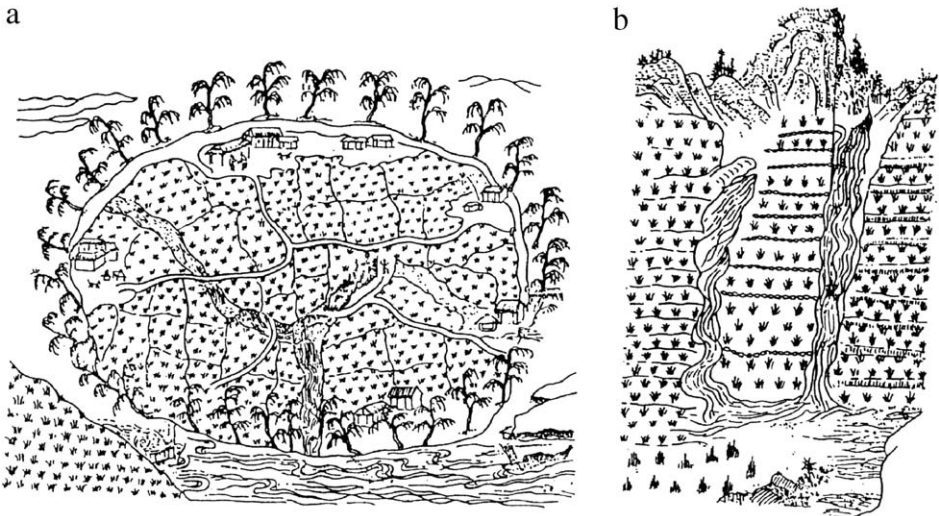


Fig. 5. (a) Ancient polder; (b) Ancient terrace.

1963), *Qi Min Yao Shu* (Miu, 1982), and the *Wei and Wangzhen's Farming Notes* (Wang, 1981) written in 1313 during the Yuan Dynasty.

In *Wangzhen's Farming Notes*, soil types were divided according to relief and soil moisture regimes as highland, mountainous, upland, lowland, wetland, and marsh and further divided according to soil color and texture: black rang, black fen, red tu, yellow tu, white tu, sandy lands and then according to fertility: fertile, infertile, and poor. Farm fields were also classified such as: furrowed fields in the dry area to retain soil moisture; garden fields for vegetables and fruits; polder in different lowlands enclosed with dikes; terrace fields in mountainous areas; coast fields along the sea coast; and flooded fields along the bank of rivers (Fig. 5a and b).

The ancient soil classifications originated with farming practices. Some terms are still popular with farmers today and were even used in the Second National Soil General Investigation (1979–1995).

4. Characteristics of land use in ancient China

There has always been a matching process between natural conditions and the use of soils. During several thousand years of agricultural practice in China, our ancestors kept improving cultivation methods, and based on their experiences of making land use fit more closely with nature, they were able to sustain agriculture and make a living. We still learn and benefit from some aspects.

4.1. Concept of harmonization of weather condition, land, and man

A famous Chinese philosopher, Mencius, said that anything can grow when properly suited to the environment while nothing can grow when unsuited. These works indicate that we must not misuse nature and should maintain a proper degree of matching between social development and nature. There should be a match of the environment and soil suitability according to the book *Shou Shi Tong Kao* (Hui and Niu, 1999), a famous classical agricultural notebook compiled in 1742 during the Qing Dynasty. It pointed out that the key problem in land use is the harmonization of soil and its environment. Hou Guang-jiong (1905–1997), one of the founders of modern Chinese soil science, considered soil fertility to be a blending of weather conditions, land, man (cultivation), and material (crop) (Hou, 1982). Together with his Natural Zero Tillage Method, these ideas continued spreading the concept of harmonization of heaven, earth, and man.

4.2. The idea of renewable soil fertility

Guanzhong in the Spring and Autumn (770–476 BC) and the Warring States Periods (476–221 BC) carried out some policies that valued good cultivation and improved agriculture production, indicating that there should be a good relationship between soil conditions and plant growth. It was written in Chapter 2, Soils, in the book *The Four Chapters on Agriculture in Lushi Chunqiu* more than 2300 years ago, that soil fertility

could change from good to poor at some times in some places suggesting that soil fertility was something dynamic. In *Chen Fu's Farming Notes* (Miu, 1981) of the Song Dynasty (960–1280 AD), the idea of renewable soil fertility was implied when it mentioned that poor soils could be kept fertile and produce stable harvests by adding farm manure.

4.3. Skillful farming in practice

A major characteristic of China is many people with little land; there are 7 Chinese mu (~ 0.47 ha) per capita of land and only 1.59 Chinese mu (~ 0.11 ha) per capita of cropland. Meticulous farming to increase crop production has been practiced in China for many thousand years. Over time, agricultural practices like selection, domestication, and breeding of leguminous crops were implemented, as were bean–grain rotations, green manure–food crop rotations, and intercropping and interplanting were introduced, and it is believed that such methods enhanced land use efficiency and helped maintain soil fertility.

5. Conclusions

In *Science and Civilization in China*, Needham (1986) wrote, “It was Chinese farmers and economists too who laid the foundations of pedology or the science of soils, for many different kinds of soils are described in the *Yugong* chapter *Shujing* which can hardly be later than the early the 5th century B.C., as also in the *Guanzi*, which may be dated in the 4th B.C. By comparison we show how the Roman agriculturalists practically gave up the attempt to classify soil types. This is why we make so bold as to say that along with oecology and plant geography, pedology too was born in China.”

China's agriculture has been very successfully feeding 22% of the world population with only 10% of the world cropland. Today, with over 1.2 billion people and a loss of about 1 million Chinese mu (66,000 ha) of cropland each year, additional pressure is causing environmental problems like desertification, soil erosion, and soil pollution (Gong, 2000).

Harmonization of weather conditions, land, and man is still thought to be important to maintain good ecological environments and sustain agriculture. The results of soil science developed in ancient China are still significant to agriculture today.

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Appendix A. Chronology of some soil-related events

Time	Common name	Important event
about 8000–2000 BC	Shun emperor	planting different crops (Houji)
about 2100–1700 BC	Xia dynasty	soil classification
about 1700–1100 BC	Shang dynasty	Chinese characters, soils of nine provinces (Yu)
about 1100–771 BC	Zhou	land and grain altars
770–476 BC	Spring and Autumn	<i>Zhou li</i> writings
475–221 BC	Warring States Periods	<i>Yugong</i> writings; Zheng guo channel
239 BC	Warring States Period	four chapters on Agriculture
221–206 BC	Qin	<i>Quanzi</i> writing; Fig. 4
206 BC–220 AD	Han dynasty	rice growing techniques
25–220 AD	East Han	<i>Yingjing li</i> writings; (Xunshen)
960–1279 AD	Song dynasty	Chen Fu's farming notes
1206–1368 AD	Yuan	Wangzhi's farming notes
1368–1664 AD	Ming dynasty	five-colored land altar
1616–1911 AD	Qing	<i>Shou Shi Tong Kao</i> agricultural notes

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