American Soil Scientists' Contributions to Chinese Pedology in the 20th Century

Zitong Gong,* Jeremy L. Darilek, Zhigang Wang, Biao Huang, and Ganlin Zhang

abstract

American and Chinese soil scientists have a long and storied history of cooperation. In this article we introduce a few key American pedologists whose influence shaped pedology in China. These pedologists can be divided into two time periods. The first wave arrived in the 1930s and were prominent until 1949 and included John L. Buck, Charles F. Shaw, Robert L. Pendleton, and James A. Thorp. The second group, namely Richard W. Arnold, Hari Eswaran, Larry P. Wilding, and Stanley W. Buol, began collaborating with Chinese soil scientists after the Reform and Opening Policy of 1978. The development of pedology and soil classification in the United States and China is also discussed and an introduction to Chinese soil taxonomy as it relates to the U.S. classification system is given.

Despite numerous cultural and political differences, Chinese and American soil scientists have been faithfully collaborating with one another for more than seven decades. In the late 19th century, modern pedology was established as a separate discipline in the West, and in the 1930s pedology was first introduced to China (Cooperative Research Group of Chinese Soil Taxonomy, 2001). From this time until the 1950s, soil classification followed the Marbut system. There were three soil orders: Zonal, Azonal, and Intrazonal. At the suborder level there were Pedocals, Pedalfers, Hydromorphic, Calcimorphic, Alpine, and Young soils. Under this were 18 soil groups, followed by subgroups and series (Thorp, 1936). Due to poor working conditions and limited material and human resources, soil survey and mapping was primarily restricted to the eastern China. American pedologists were the first foreign soil scientists to come to China, and they played an important role in the advent of modern pedology in China.

Later, due to changes in international policies, Chinese pedology became deeply influenced by the Soviet Union, and communication between Chinese and American pedologists diminished. After the Reform and Opening Policy of 1978, Chinese soil scientists strengthened communication with scientists from other countries of the world. At this time *Soil Taxonomy* and the FAO Soil Map of the World were introduced to China. After 1978, many American soil scientists came to China for academic exchange and promoted development in many disciplines of soil science, particularly soil geography and soil classification. In 1980, the Symposium on Paddy Soils was held in Nanjing and was the first soil academic conference with western soil scientists attending in 30 yr. J.A. Thorp's attendance signaled the restoration of communication between Chinese and American soil scientists. Chinese and American soil scientists began collaborating on Chinese Soil Taxonomy (CST), which draws from the strengths of the U.S. soil taxonomy system while taking into account unique soil characteristics and land use in China. Although many American soil scientists have been to China, the scope of this article is to introduce a few key pedologists whose influence shaped pedology and soil classification in China.

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Early American Contributors to Soil Science in China

The revolutionary concept of the soil profile was just coming into mainstream soil science in the United States early in the 20th century and was popularized by C.F. Marbut, who had gleaned the concept from Russian scientist Konstantin Glinka (Marbut, 1927). Due to the source of these ideas, he met with resistance for some time before they were accepted (Tandarich et al., 2002). Charles Shaw furthered these concepts by defining the terms *soil layer*, *soil profile*, and *soil horizon* (Shaw, 1927). Charles Kellogg then defined the A and B horizons for use in the national soil survey (Tandarich et al., 2002). It was during this critical period, as modern concepts in pedology were being developed, that U.S. scientists began to venture abroad.

John L. Buck

Under the direction of the Pacific Science Congress, initiated by American scientists in 1920, Buck, a young graduate from Cornell University, came to China to extensively investigate rural villages and agricultural practices in 22 provinces. He remained from 1929 to 1933 and wrote *Land Utilization of China* (Buck, 1937). The contents of this 494-page book describe primarily China's agricultural economy and

therefore have not received a lot of attention from soil scientists. The book, however, also includes extensive information concerning topography, climate, and land use, and a chapter on soils, written by Thorp, is also included (Fig. 1). Thorp said of Buck, "[He] is the one who first conceived the idea of establishing a Soil Survey for all [of] China and who was responsible for the initiation of this work which was later taken over by the Geological Survey. We have done much cooperative work with Dr. Buck and he has always shown a great willingness to share with us data collected by his organization" (Thorp, 1936). Buck was the first American scholar to investigate agriculture in China and served as the head of the Department of Agricultural Economics at Nanjing University (Thorp, 1936). He also met his wife while in China, the author Pearl S. Buck.

Charles F. Shaw

The fourth Pacific Science Congress was held in Bandung, Java in May 1929. One of the two important decisions of the Congress was to begin surveying soil and building institutions for soil science research in the Asia Pacific Region. In the same year, the Department of Agricultural Economics at Nanjing University began to investigate land utilization of China under the direction of Buck. For the soil data portion, they invited American pedologist Charles Shaw to investigate soils in the middle and lower reaches of the Yangtze River and the lower reaches of the Yellow River. Shaw, a 1906 graduate from Cornell University, had already traveled extensively and had conducted soil investigations in Australia, the Fiji Islands, New Zealand, Raratonga, and Tahiti (Cornell Alumni News, 1923). In 1930, using a donation from the Pacific State Fair, Shaw took a sabbatical from the University of California, Berkeley and went to Nanjing University. While there he performed an extensive soil investigation and wrote *The Soils of China* (Shaw, 1930), which was the first official soil survey of China.

Robert L. Pendleton

To rehabilitate the nearly bankrupt Chinese agriculture market, the National Geological Survey of China (NGSC) under the Ministry of Industry was commissioned to further survey soils in China from 1930 to 1932. The research money ($100,000), secured by Weng Wen Hao, director of the NGSC, was from the China Foundation for Education and Culture, which was set up using money from the Boxer Indemnity. Weng used this money to build the first soil research organization, the Soils Division of the NGSC, which was completed in July 1930, and he became the first director. When Shaw returned to America, he introduced Weng to Pendleton, who was the first chief soil technologist of the Soils Division (1930–1933) and on faculty at Johns Hopkins University. Before coming to China he already had field experience in India and the Philippines.

Pendleton taught his Chinese colleagues many soil survey and lab analysis techniques; led soil investigations in Suiyuan, Shanxi, Guangdong, and Heilongjiang; and improved methods for the sterilization of night soil (human manure) for use as fertilizer. His investigations in Guangdong were collected into two unpublished volumes in 1933, now housed in the Nanjing Institute of Soil Science Library: *Reconnaissance Soil Survey of Kwangtung Province* and *Improvement of Agriculture and Forestry in Kwangtung*. His notes in the former book show his intense interest in the unusual management practices he saw during this expedition, "The extensive and heavy use of lime on rice fields on older soils, and the incorporation of straw into some of the rice soils during crop growth are interesting features of local soil management practices." Pendleton was the first American pedologist to spend several years in China during the early stages of modern soil survey. He later conducted extensive soil surveys in Central America (Pendleton, 1944) and Thailand (Pendleton and Montrakun, 1960).

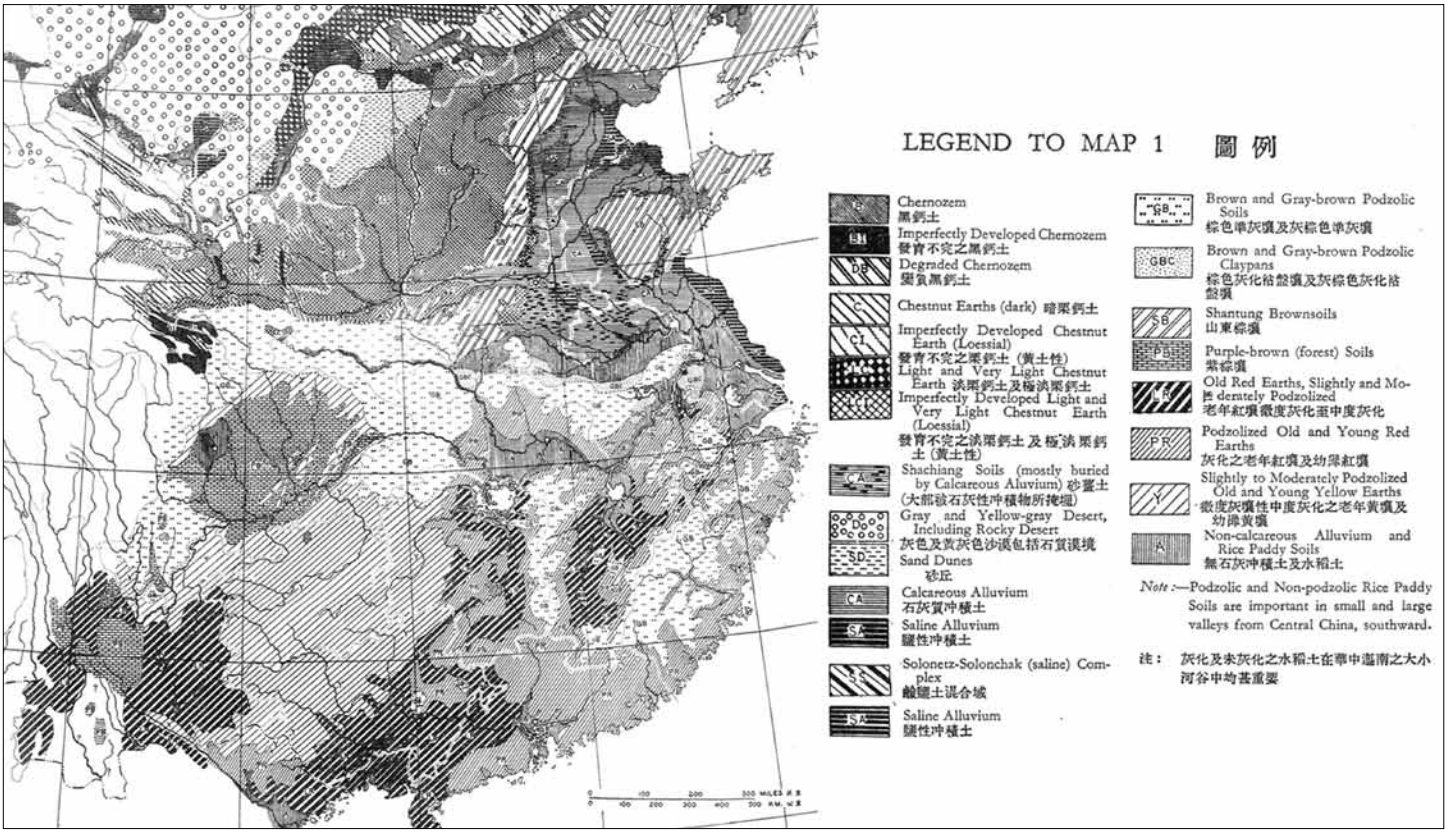

Fig. 1. James Thorp's soil map of China using C.F. Marbut's soil classification system (Buck, 1937).

James A. Thorp

After Pendleton completed his term and returned to America in the summer of 1933, Thorp came to China to replace him as the chief soil technologist of the Soils Division. It was through the recommendation of famous pedologist and head of the U.S. Bureau of Soils of the USDA, Dr. Curtis Fletcher Marbut, that Thorp came to China for 3 years with a $350/month salary (Fig. 2).

During his term, Thorp introduced numerous modern soil research methodologies, particularly soil survey techniques, new lab analysis methods, and the soil classification scheme of C. F. Marbut. In 1935, after attending the Third International Soil Congress in Oxford, Dr. Marbut took the Trans-Siberian train to China with the hope of seeing Thorp and investigating Chinese soil (Tandarich et al., 1985). Unfortunately, the pedologist contracted pneumonia during the journey and died in the early morning of August 25, 1935, in the chernozem soil region of Harbin, China, at the age of 72. To this day, Chinese soil pedologists regret that he was unable to investigate the soils of China and exchange his experience with Chinese colleagues.

Fig. 2. Pictures from Thorp's collection with the following captions: (top left) photo taken at office; (top right) rapid transit, Yangtze Delta; (bottom left) crowd around soil sample pit; (bottom right) J. Thorp and C.Y. Tschau making monolithic sample of Brownsoil 5 li [2.5 km] southwest of Tsinan.

With the cooperation of young Chinese pedologists, Thorp investigated many soils of China, though his detailed work was impaired by the Japanese invasion of northeastern China at that time. It has been said that Thorp and his colleagues took just 6 weeks to write *Geography of the Soils of China*, a culmination of almost 7 years of personal investigation (Thorp, 1936). This book introduced the main soil types of China according to Marbut's classification scheme and included a 1:7,500,000 soil map of China, and although some blanks exist in the map, the outline of the distribution of soils of China can be clearly seen. The book was translated into Chinese and Japanese and greatly informed the international pedology community of the time. It was in this historical work that paddy soils, the brown soils of Shangdong Province, and the purple soils of southwestern China were first introduced in literature form, which later enabled the Shangdong brown soils to be introduced to American pedologists.

The young Chinese pedologists who worked under Thorp quickly became more proficient, and many of them became the first generation of pedologists and academic leaders of various branches of scientific disciplines in China (Fig. 3) (Thorp, 1980). In 1927, before working with Thorp, Hou Guang Jiong, one time Director of the Soils Division of the NGSC, had been to the United States for the First World Congress of Soil Science. Later in life, he became a good friend of Dr. Richard Arnold. After working with Thorp, Li Lian Jie went on to receive his M.Sc. from the University of Tennessee and his Ph.D. from the University of Illinois. He later became the Dean of the Agrochemistry Department at China Agriculture University. Xiong Yi went on to receive his M.Sc. from the University of Missouri and his Ph.D. from the University of Wisconsin and became a Director of the Institute of Soil Science, Chinese Academy of Sciences (ISS-CAS). Li Qing Kui received his Ph.D. from the University of Illinois, became a Deputy Director of the ISS-CAS, and upon retirement, the Honorary Director. These four men all became academicians of the Chinese Academy of Sciences. Ma Rong Zhi became the Corresponding Academician of Germany and a Director of ISS-CAS. Chen En Feng went for further education to Germany and became the president of Shenyang Agriculture University. Zhu Lian Qing became the Director of the Soil Survey Department of the Agriculture Ministry of China and Song

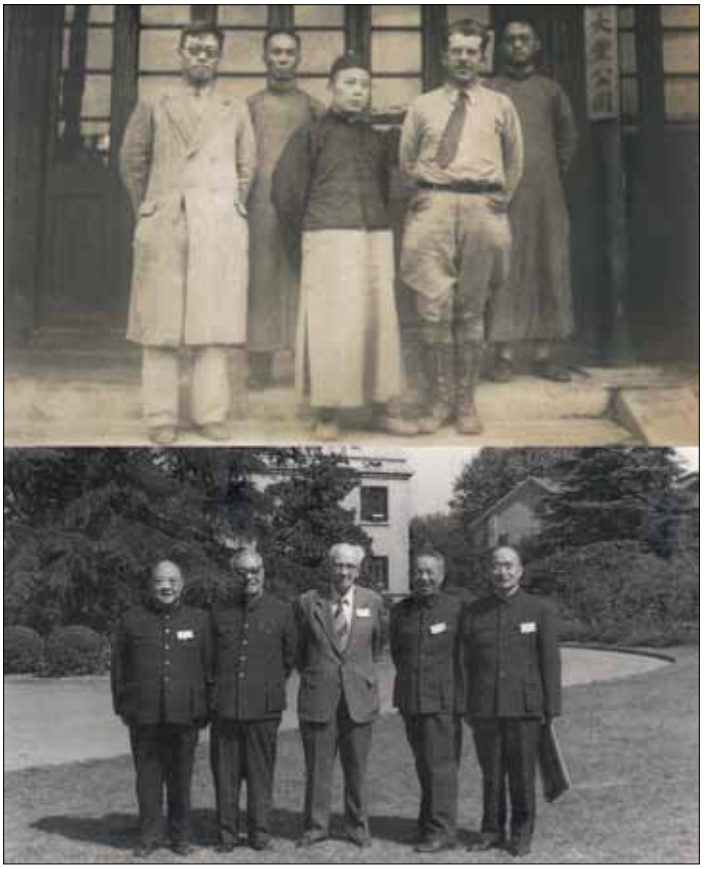

Fig. 3. (Top, from left) Thorp with his Chinese colleagues (on far left, Hou Guang Jiong; on far right, Zhu Lian Qing); (bottom) Xiong Yi, Li Lian Jie, James Thorp, Li Qing Kui, and Chen En Feng.

Da Quan, and after 1 year of research at Cornell University, became the Deputy Director of the Forestry and Soil Science Institute. In short, Thorp had a long and lasting influence on soil scientists in China.

During the Symposium on Paddy Soils in 1980, 80-year-old Thorp returned to China. During the symposium, Q.K. Li took out 12 original copies of *Geography of the Soils of China* and gave them to the participants, which surprised and thrilled Thorp. He enthusiastically talked with others using the Chinese phrases he still remembered. He recalled that in the early days there were 14 employees of the Soils Division of the NGSC, and among them only eight pedologists. Now he saw that there was an independent institute with hundreds of research fellows and modern equipment, and he expressed hope that Chinese soil science would continue developing.

Recent American Contributors to Chinese Pedology

From 1949 until 1978, Eastern and Western pedology developed simultaneously, yet independently, from one another. During this time, under the direction of Guy Smith, the U.S. Soil Conservation Service began a 20-year process of expanding and improving the U.S. soil classification system (Ahrens et al., 2002) which culminated in *Soil Taxonomy* (Soil Survey Staff, 1975).

Chinese pedology from 1954 to 1984 developed alongside the Soviet Union. In 1954, the National Soil Congress of China devised a classification system based on the geographical genesis of soils and soil forming conditions. Soil type was the basic unit, and the system had five levels: type, subtype, genus, species, and variety (Cooperative Research Group of Chinese Soil Taxonomy, 2001). After 1978, although soil classification was still based on genetic concepts, ideas and soil designations were integrated from *Soil Taxonomy* and the FAO Soil Map of the World. In 1984, work began in earnest on a Chinese soil taxonomic classification. To this end, several American soil scientists devoted time and energy in an effort to create a distinctly Chinese taxonomic soil classification system.

Richard W. Arnold

Richard Arnold is the former director of the USDA-NRCS Soil Survey Division, a retired professor of Cornell University, a chairman of the Commission V (soil genesis and classification) of the International Union of Soil Sciences (IUSS), and an honorary member of the IUSS. His contributions to building the American soil taxonomy system and promoting the development of soil taxonomies of other countries is far reaching.

His first experience in China was in 1982. He received an invitation from Rafael Pacheco at the FAO office in Rome, asking him if he would teach soil taxonomy in China. Arnold and his wife spent 6 weeks at Beijing Agricultural University, where he trained leaders of the Chinese Second National Soil Survey, as well as soil geography professors and teachers from every province. Arnold recalled

> There were about 35 participants ranging in age from about 35 to 79. [One professor] had worked with the Geological Survey in Illinois and was a trained soil scientist who had known Jim Thorp. The Chinese soil survey had been patterned after the one in the U.S., even the soil classification system. Most of the class was fifty years [old] or older and I learned from them that many were involved in the current effort of making a new soil map of China. Some were professors at provincial universities and some worked for state and national organizations that were involved in land use planning, water use, reclamation, and so forth. We had a great time discussing soils, landscapes, classification, and some general philosophy. We even learned to sing-song some of the funny words of *Soil Taxonomy*. We went to Handan, about 300 km south of Beijing to do field work. After classifying about 20 profiles we talked about map units and how they would be delineated in the U.S. In the end they showed me a soil map at a scale of about 1:20,000 and so they had just been testing me (I think).

The lectures Arnold gave introduced the concepts and methodologies of modern American diagnostic soil classification to China. The teaching materials were compiled as an instructional book, *Soil Classification*, which aided the spread of *Soil Taxonomy* in China. In addition to the lectures in 1982, Arnold returned to China on four other occasions (Fig. 4). He visited the Institute of Soil Science in Nanjing at the invitation of Zhao Qi Guo and gave lectures on soil conservation and soil survey in the United States. He attended the International Workshop on Classification and Management of Arid-Desert Soils in 1993, the International Soils Conference on the Interaction between Humans and the Environment, and the Chinese Soil Taxonomy Classification at the lower category seminar in 1997. During that time he also took part in soil investigations in north, south, and east China and in the Xinjiang Province in the far west.

Arnold gained a comprehensive understanding of the development of soil science in China and encouraged soil taxonomy research there. He also copiously contributed to the development of CST, and wrote the foreword for the English version (Cooperative Research Group of Chinese Soil Taxonomy, 2001). In it he wrote, “I believe this classification will enhance the utility and application of the vast storehouse of soil maps and supporting databases compiled by Chinese scientists in recent years. The recognition and definition of additional diagnostic features, horizons, and soils unique to China are major contributions to world pedology. Global data is vital to solve global issues and this work is most welcome by the international community.” Arnold also worked diligently to spread the work of Chinese soil scientists in western journals.

Hari Eswaran

Eswaran has been the World Leader of the World Soil Resources Office of the USDA, an academician at the Belgium Academy of Sciences, a chairman of the Commission V of the IUSS, and an honorary member of IUSS. As a leader of the World Soil Resources office of the USDA, he has participated in research on world soil resources and soil classification, particularly Oxisols, Aridisols, and Vertisols, in more than 100 countries.

Eswaran has worked extensively on soil organic carbon storage, soil degradation, and desertification around the globe, and his research has been especially useful in China. He attended the International Oxisol Seminar in 1983, the International Workshop on Classification and Management of Arid-Desert Soils in 1993, the World Reference Base Correlation Meeting on Anthrosols in 1998, the International Conference on the Sustainable Soil Management of Tropical Regions in 2003, the International Workshop on the Status and Research Needs for Soil Genesis and Classification in 2005, and several other soil and water conservation meetings in China (Fig. 5). Eswaran also had opportunities during the 14th and 17th World Congresses of Soil Science to investigate the soils of Northeast China and Yunnan Province. Because of his frequent investigations in and communications with China, he has facilitated scientific exchange between China and the rest of the world, especially among pedologists of the Asian Pacific Region. As a Malaysian-born pedologist, his Mandarin proficiency and cultural understanding has aided his understanding of Chinese soil science.

Through his efforts, the Rockefeller Foundation agreed to sponsor a soil taxonomy workshop in China in 1987. American pedologists S.W. Buol, L.P. Wilding, J. Kimble, and W. Reynold were also in attendance and gave informative lectures to 120 Chinese pedologists

Fig. 4. (Top) Richard Arnold at Beijing Agricultural University in 1982; (bottom) Richard Arnold at the Chinese Soil Taxonomy Classification at the Lower category Seminar in Nanjing in 1997.

Fig. 5. (Top) Hari Eswaran giving a lecture at the International Workshop on Classification and Management of Arid-Desert Soils in 1993; (bottom) Hari Eswaran in a soil pit in the Pearl Delta Region during the World Reference Base Correlation Meeting on Anthrosols in 1998.

Fig. 6. (Left) Stanley Buol and Larry Wilding with Gong Zi Tong at a soil classification training in 1987; (center) Stanley Buol (in light blue jacket) and John Kimble (next at Stanley's left) on a field trip to Shandong Province in 1987; (right, from left) Gong Zi Tong, Larry Wilding, and Lin Hang Sheng at the Soil Science Society of America Meeting in 1997. Lin was Wilding's interpreter in China and later became his Ph.D. student.

from every province of China. After the workshop, these participants investigated soils in Southern Jiangsu and Shandong Province. Their educational workshop greatly propelled the ongoing work of CST. At the International Society of Soil Scientists meeting in 2002, Eswaran praised CST, saying "Chinese Soil Taxonomy should be the standard for soil classification in Asia." In his book *Soil Classification* he amply introduced CST to the world and introduced other national soil classification systems to Chinese pedologists, which accelerated the quantification, standardization, and internationalization of CST. He also cooperated extensively and published some joint papers with Z.T. Gong (Eswaran and Gong, 1991, 1994).

Larry P. Wilding

Larry Wilding is a retired professor from Texas A&M University and was awarded an honorary membership in the IUSS at the 18th Word Congress of Soil Science. He has also served as the chairman of the Soil Science Society of America and as chairman at the International Soil Morphology Working Group. He has been to China to teach, dialog, and collaborate countless times. He first came to China as a keynote speaker in 1987 to give lectures on the applications of soil mapping in soil classification (Fig. 6) and at that time gave a copy of *Pedogenesis and Soil Taxonomy* to the Institute of Soil Science, compiled by him and his colleagues, as a book that represented the soil taxonomy research

of American pedologists. In 1989, at the International Conference of Soil Morphology, which he organized, he gave a copy of *Vertisols: Their Distribution, Properties, Classification and Management* (Wilding and Puentes, 1988) to Chinese pedologists. Later he wrote the preface to the Chinese version of *Opportunities in Basic Soil Science Research* (Sposito and Reginato, 1992). In that preface he said, "I hope this translated book can strengthen the scientific communication and relationship between Chinese and American soil scientists." His numerous contributions encouraged and influenced Chinese soil pedologists such as Q.G. Zhao and Z.T. Gong and promoted the development of soil science, especially the soil geography of China.

Stanley W. Buol

Stanley Buol is a William Neal Reynolds Distinguished Professor of Soil Science and Alumni Distinguished Graduate Professor at North Carolina State University. He is also an honorary associate member of the Soil Science Society of America and American Society of Agronomy. He has received the Soil Science Distinguished Service Award and the North Carolina Soil Science Society Lifetime Achievement Award. He was chairman of the International Oxisols Committee and is the lead author of *Soil Genesis and Classification*, which is now in its fifth edition (Buol et al., 2003). This textbook has been favored by soil scientists around the globe and has been translated into Spanish, French, German, and Arabic due to its breadth of information and always up-to-date coverage of soil genesis. The book *Soil Genesis, Classification and Resource Assessment*, compiled by the famous Chinese pedologist R.C. Huang, was based in large part on *Soil Genesis and Classification*, and 1300 reprints have been published in China. These books popularized the basic ideas and classification rules that have been adopted by many subsequent university textbooks.

When Buol was invited to China to give lectures on soil taxonomy (Fig. 6), he focused on the application of computers and introduced a new diagnostic horizon, the kandic horizon. He showed enthusiasm for the advance of CST, and an introduction to CST was incorporated in the fourth edition of *Soil Genesis and Classification*. In 2008, Biao Huang, a professor at ISS-CAS visited with him about the advancement of soil classification in China. At that time he gave invaluable constructive criticism of CST. For example, concerning the criteria for designation as an Allitic property, Buol said,

> I'm very delighted to see in the Allitic properties they use the Al per effective CEC as greater than 60%. That is an excellent property related to practical use of crops, liming, etc. In fact, I would almost prefer that be used as a subgroup criterion to define distrophic or very poor soil condition, if the Al is greater than 60%. I like that criteria because it fits my idea of practicality. I wish we used the 60% criteria in *Soil Taxonomy*.

Comparison of Soil Taxonomy and Chinese Soil Taxonomy

Because of the strong influence of these American pedologists, there are many similarities between U.S. soil taxonomy and CST and once an introduction has been made it is not difficult for users of one to become familiar with the other. Several important concepts from U.S. soil taxonomy influenced the development of CST. When the Genetic Soil Classification System was developed in China, classification was made based on the pedologist's knowledge of the climate, vegetation, geology, relief, etc. of the soil. With the inception of the CST, quantitative classification became a foundation. Related to this, the use of predetermined diagnostic criteria was incorporated into CST. The structure of the U.S. soil taxonomic key was also adopted in CST.

Chinese Soil Taxonomy has 14 orders that key out in the order of: Histosols, Anthrosols, Spodosols, Andosols, Ferralosols, Vertosols, Aridosols, Halosols, Gleyosols, Isohumosols, Ferrosols, Argosols, Cambosols, and Primosols. Several orders of the CST were taken directly from U.S. soil taxonomy. Namely, Histosols, Spodosols, Andosols, and Vertosols of CST directly and wholly correspond with U.S. soil taxonomy Histosols, Spodosols, Andisols, and Vertisols, respectively. It should be noted, however, that other divisions starting at the suborder level are divided differently in CST than U.S. soil taxonomy.

Roughly speaking, CST Ferralosols, Isohumosols, Argosols, Cambosols, and Primosols correspond with U.S. soil taxonomy Oxisols, Mollisols, Alfisols, Inceptisols, and Entisols, respectively, but some dissimilarity exists. For example, CST Isohumosols follow the criteria for U.S. soil taxonomy Mollisols but must also meet the criteria of an isohumic property, which cannot have an abrupt decrease in organic matter in the profile. For this reason, some soils that would key out as Mollisols in U.S. soil taxonomy are excluded from Isohumosols in CST and instead key out as Cambosols. Ferralosols and Ferrosols in CST have CEC_7 criteria values of <12 $cmol_{(+)}$ kg^{-1} clay and <24 $cmol_{(+)}$ kg^{-1} clay, respectively, while ST Oxisols and Ultisols use <16 $cmol_{(+)}$ kg^{-1} clay as the criteria.

Furthermore, ST Aridisols use aridic moisture regime as a criteria while CST Aridosols must have an aridic epipedon. Saline and sodic soils key out as Aridisols in ST, but are designated at the order level in CST as Halosols. Also, Gleyosols in CST are soils that have gleyic features in a horizon at least 10 cm thick within 50 cm of the mineral soil surface. These soils key out at the suborder level in U.S. soil taxonomy.

Most notably, CST created the order Anthrosols, which are completely based on human interaction with the soil. Anthrosols are the most novel addition to the CST, have drawn the most international attention, and have ultimately been included in the World Reference Base of soil resources (WRB) system.

Reception of Anthrosols in the international community has had mixed reviews. Eswaran said of Anthrosols

> Establishment of the soil order Anthrosols in [CST] is an important innovation. The concept of Anthrosols as an established man-made soil order in the international arena has been in existence for several decades, but Chinese pedologists gave us a clear, detailed, and quasi-quantitative meaning.

Dr. Buol on the other hand said

> I can understand the Chinese desire to have it, but in the context of genesis I would consider it a temporary soil condition that is only perpetuated as long as there are people around to make rice paddies…I would prefer to see the Anthrosol criteria used as a suborder or subgroup of the other orders, because you have calcareous soils, acid soils, [and] all different kinds [of soil] that are now Anthrosols [which] have chemical and physical properties that are related to the other soil orders.

He also conceded,

> I can understand with all the paddy soils you have in China why the Chinese want it as an order. Realize that I have only been to China twice and seen it, but I am not Chinese. I don't have a whole country full of paddy soils here and I don't have that history. Paddy soils have been recognized in Chinese taxonomy forever, so it is tradition.

At least 25% of the world's paddy soils are located in China (Gong, 1986). One unique characteristic of Chinese soil is the amount of human activity over a period of hundreds and sometimes thousands of years,

particularly as a result of cultivation in the form of fertilization, tillage, and irrigation. Furthermore, human impact has exponentially increased in the past two decades (Gong et al., 1999). Anthrosols develop under either an anthrostagnic moisture regime (submerged for part of the year) or under an upland system.

Stagnic Anthrosols are submerged paddy fields with a unique profile known as the Anthraquic horizon sequence. The Anthraquic horizon sequence begins with a plowed surface horizon, followed by a plowpan (these two in combination are called the Anthraquic epipedon), followed by a hydragric horizon caused by redox reactions of iron and manganese. Below the Anthraquic horizon sequence a horizon of Mn and/or Fe accumulation may be found.

Orthic Anthrosols do not meet the criteria of Stagnic Anthrosols and often develop in upland farming systems with irrigating siltigation (in west China where silt is deposited through heavy irrigation over long periods of time), cumulating cultivation, or vegetable cultivation (high in extractable P). These soils all have high organic carbon content and inclusions of coal cinders, charcoal, brick, tile, and other non-natural inclusions throughout the horizon.

Chinese Soil Taxonomy has now been translated into English, Russian, and Japanese and has gained international acceptance. The influence of CST can be seen in the World Reference Base of Soil Resources, the *Handbook of Soil Science* (Spaargaren, 1999), *Encyclopedia of Soil Science* (Gong and Zhang, 2005), and many textbooks. In 2005 the working group of the CST received the China National Natural Science Award for their outstanding work on this project. A soil map of China has now been created at the 1:12,000,000 scale, and soil has been classified at the subgroup level. A new project is now underway to establish families and series for the soils of China.

Conclusions

Today, communication between Chinese and American pedologists continues, and exchanges and joint research cover many fields such as geographic information systems, remote sensing, and digitized soil mapping. Chinese pedologists remain grateful for these and other contributions from American soil scientists. We believe that as this partnership continues and expands, substantial progress will be made in these fields and many others.

Acknowledgments

The authors are grateful to Dr. Arnold for his personal notes from his experiences in China and to Dr. Buol for the time he devoted to an interview with Dr. Biao Huang. Mr. William Reed, of the UDSA-NRCS, also provided valuable biographical information about C.F. Shaw.

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