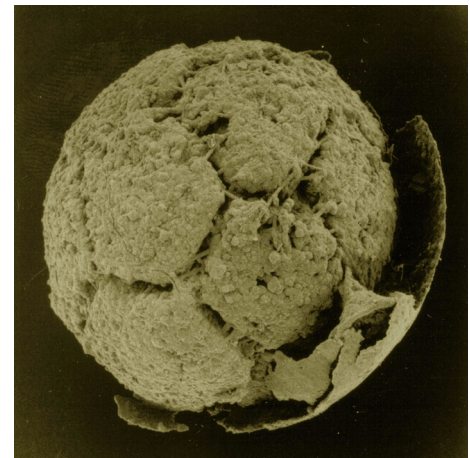


A Golden Age of Paleontology in China? A SWOT Analysis

Shuhai Xiao, Qun Yang, and Zhe-Xi Luo

In the past decade, many new Chinese fossil discoveries and the rapid progress of paleontology in China made the headlines in science news and attracted the attention of the worldwide scientific community. Reports on seemingly endless new important finds by Chinese paleontologists appeared frequently in such top journals as *Science* and *Nature*. Chinese paleontologists have become more visible and have been playing an increasingly influential role in the international community of paleontologists. China successfully hosted the Second International Paleontological Congress (2006, Beijing), one of the largest international research conferences in the recent history of paleontology. In 2009, Chinese paleontologists held a grand celebration in Nanjing for the 80th anniversary of the Paleontological Society of China, a professional society with a membership of 1500 strong. In various international meetings, workshops and organizations, there are more and more Chinese participants. More paleontologists from western countries now collaborate with their Chinese colleagues on Chinese material, or are studying at field sites in China. Many international students, postdoctoral associates and young paleontologists are now developing their research in China. Given its rapid and enormous economic growth in the past three decades, China is now expected to play a much larger role than ever before, in many scientific fields. Chinese paleontology has become a highlight of China's success in science. It has had a much greater worldwide impact than many other branches of science in China. All these appear to have ushered in a golden age of paleontology in China.

The growth of paleontology in China undoubtedly has a positive impact on the global paleontological community. All paleontologists, especially those who work in China or collaborate with Chinese colleagues, will have a stake in the sustainable growth of paleontology in China. In this commentary, we would like to provide a strategic analysis of the paleontological science in China, and would like to share our thoughts with our colleagues and funding agencies in China.



An SEM image of a fossil embryo from the Ediacaran Doushantuo Formation in South China.

In our analysis, we adopt the SWOT techniques to identify the **Strengths**, **Weaknesses**, **Opportunities**, and **Threats** for the future development of the paleontological science in China.

STRENGTHS

A strength of Chinese paleontology is in the professional quality of many Chinese paleontologists. Most Chinese paleontologists have solid skills in systematic description and biostratigraphy, and are knowledgeable in their area of expertise. China trained a large number of paleontologists in the 1950s and 1960s to meet the needs for the national geological mapping and survey of natural resources. After a hiatus during the Cultural Revolution that occurred from 1966 through 1976, training of paleontologists resumed in the late 1970s. For the majority of paleontology students and professionals, the training is classical. Their studies have centered on systematic paleontology and detailed biostratigraphy. The vast majority of the 1500 active members of Paleontological Society of China are engaged in systematic description and biostratigraphic work. Traditionally, each paleontologist is specialized in one taxonomic group, typically from a restricted geographic area or stratigraphic range. This fine division of labor makes it possible for paleontologists to individually focus on their area of study.

A small but steadily increasing number of Chinese paleontologists have developed an outstanding international reputation through their extraordinary publications both in high-profile journals, and in large volumes of monographs and synthetic books. A majority of professional Chinese paleontologists have become more prolific and have published more in international journals in the last decade than in many previous decades. Research productivity has improved, perhaps by competition and by high pressure to publish, because various academic evaluation systems, both by institutions and by funding agencies, routinely use bibliometric data to evaluate researchers.

An encouraging trend toward more publications in international and widely circulated journals has been facilitated by the fact that the younger generations of Chinese paleontologists are more proficient in English and better at communicating with international scientists. A growing number of Chinese paleontologists with international academic training are now working in China, and this has gradually changed the research culture in some major Chinese research institutions and universities. Lastly, the publications in international

journals and high impact journals have been multiplying, thanks to the rapid integration of Chinese paleontologists into the international community, through open and extensive collaboration with their foreign partners.

WEAKNESSES

Among the weaknesses that may have limited the development of paleontology in China, we would like to point out the near absence of Chinese paleontologists in analytical paleobiology and a relatively weak integration with other disciplines of geosciences and biology. Analytical paleobiology has been a major driving force in paleontology since the 1970s. The journal *Paleobiology* is almost entirely devoted to this subdiscipline. A large number of paleontologists in North America are engaged in the Paleobiology Database project. Analytical paleobiology can identify patterns from the fossil record, and thereby inferring evolutionary processes underlining these patterns. Although Chinese paleontologists have contributed significantly to systematic paleontology, much of the Chinese paleontological data have not been incorporated in the Paleobiology Database, and have not been fully capitalized for rigorous paleobiological analysis. It is encouraging, however, that efforts are being made to establish a Geobiodiversity Database at NIGPAS (Nanjing Institute of Geology and Paleontology) and to coordinate its integration with the Paleobiology Database. Also, we are delighted that a workshop on quantitative paleobiology will be held at NIGPAS in June 2010.

Interdisciplinary integration has not been a great strength in Chinese paleontology. This may have to do with the way the research institutions have been set up and divided in the 1950s and how students are trained. College students in China typically choose their major during freshman year. After a major has been chosen, their education is largely focused on in-major courses. The weakness in interdisciplinary integration has unfortunately limited the presence of Chinese paleontologists in such fast-growing fields as geobiology and geomicrobiology. Fortunately, the National Natural Science Foundation of China and a number of Chinese paleontologists have recognized the need to integrate. Several large research projects are in force to nurture the interdisciplinary dialog between paleontologists and other scientists.

NIGPAS, a research institute that traditionally focuses on systematic paleontology, is now placing significant investment in geobiology, geomicrobiology, molecular paleobiology, and biogeochemistry. As another example, a small number of vertebrate paleontologists in China are now developing approaches to integrate the research of fossils with laboratory functional studies of modern organisms—an integrative research area that has yet to establish a visible presence in China.

For major research institutions in China, it is a tradition, enforced by administrative structure, to develop a fine division of labor among researchers, either by taxonomic groups or by stratigraphic topics. To a degree, this narrow specialization can constrain the views of researchers, particularly when interactions among specialized researchers are limited. But this has changed in recent years. Retirements of many taxonomical or stratigraphic specialists in recent years have left some taxonomic groups or stratigraphic units unrepresented by experts. In the Nanjing Institute of Geology and Paleontology (NIGPAS), for example, many fossil groups (e.g., ostracods, gastropods, cephalopods, crustaceans, bryozoans, sponges, and charophytes) are no longer covered by specialists. These gaps provide an opportunity for some versatile researchers who start to work on multiple taxonomic groups, stratigraphic ranges, or geographic areas.

The culture of the Chinese research community tends to place a premium on teamwork, which is also constrained by the way large research grants are distributed to large and conglomerate team headed by senior scientists. The culture to emphasize on curiosity driven studies and to pursue individual scholarship in paleontology is not as common in China as in western countries. Although large research projects need to be structured to answer complex scientific questions, in China the younger paleontologists engaged in such large research projects tend to have a smaller degree of freedom for individual creativity than their counterparts in the western countries.

OPPORTUNITIES

Chinese paleontologists are blessed with extraordinary fossil sites and unprecedented funding opportunities. Discoveries in the field are always a driving force for paleontology. Paleontological resources in China are rich and diverse, and a good many newly discovered fossils have led to new research questions for paleontology. Many Chinese Lagerstätten, including the Weng'an,

Chengjiang, Kaili, Guanling, Jehol, and several Cenozoic sites, have attracted much international attention for the exquisite quality and the cornucopian quantity of fossils. Some of the new fossils could not be easily pigeonholed into existing groups, or have unique combination of features to broaden the paleontological vista of biodiversity in deep time. Critical paleontological finds from these sites have impacted on paleontology by filling in the blank of the unknown. But more importantly they help to provoke new questions that have broader implications beyond paleontology, and can only be addressed by integrating evolutionary biology and other subdisciplines of geosciences. More insight will be gained from in-depth work on these known Lagerstätten in the years to come. It is clear that much more exploration on the vast fossil resources is still possible. With the active work by professional paleontologists, and incidental findings from economic development in many parts of China, it will be a matter of time that even more fossil resources will become available for scientific research.

In the past ten years, Chinese paleontologists have been enjoying an enviable funding climate, after the more difficult times of the 1980s and early 1990s when paleontological research in China suffered from poor funding. This recent increase in research support comes from the growing investment by Chinese government in basic research. Chinese paleontologists have earned this improvement of research funding by their own success. Their great discoveries and important studies have made paleontology a highly visible scientific field. Several large paleontological research projects have been funded at the level of 1-20M RMB (1 USD = 6.8 RMB), although standard paleontological research grants are funded at the level of 300-500K RMB. Because Chinese research grants are taxed on relatively small overheads and costs of research, especially for fieldwork, are lower in China than in western countries, even a standard grant can go a long way. These large-scale projects have now made it possible for integrate paleontology with other disciplines of geosciences and evolutionary biology.

THREATS

The most serious threat to the sustainable development of Chinese paleontology is the decline of undergraduate education programs at Chinese universities. This is part of the overall decline of undergraduate programs in geological sciences, and also in organismal and evolutionary

biology. Unlike in the 1980s when college education was largely free and college students were assigned to a department and a major at the time of enrollment, nowadays college students in China have to pay modest tuitions but they have a greater freedom in choosing their majors. Geology in general and paleontology in particular can be perceived to be esoteric sciences with a difficult job market or with no prospect for future financial success, —a false perception that is contrary to the fact that most geology students in China are employed at graduation (thanks to a very strong industrial hiring). Thus, undergraduate students majoring in geology and paleontology, to some extent also in organismal biology, are many fewer now than in the 1980s. There are only a few universities in China (mostly Peking University, Nanjing University, China University of Geosciences, and Northwest University) where paleontology courses are being offered. The downsizing of the paleontology sections by faculty attrition at Peking University and Nanjing University, two major universities in China that collectively produced a lion's share of paleontologists who are now active in research, has made the situation even worse. As a result, qualified applicants for graduate programs in the main research institutions in paleontology have been declining. Without a wellspring of well-educated young students to replenish the talent pool for paleontology, the golden age of paleontology in China can be ephemeral.

The loss of fossil resources is another threat to the long-range development of paleontology in China. Much of China's recent success in paleontological research depends on excellent fossil resources, but fossils are not renewable natural resources. If not protected in a timely manner, or preserved adequately, fossil resources can be vulnerable. Major fossil resources must be accessible for research, but they should also be preserved for posterity as the evidence for the history of life on Earth. Spontaneous excavation of fossil resources by local citizens for economic gain is not an uncommon phenomenon in China. Although such digging is not permissible by law, the law enforce-

ment cannot completely catch up with the occasionally widespread private fossil hunting.

In some cases, the spontaneous digging of fossils for profit by local citizens or incidental discoveries for economic development have yielded more fossils than professional excavations. Many research worthy fossils discovered in this fashion have found their ways into scientific institutions and are published in scientific literature. It is undeniable that, in the case of the Mesozoic beds of Liaoning and the Triassic marine fossil sites in the Guanling area of Guizhou, the exploitation of fossils by local people greatly accelerated the pace of discovery. However, spontaneous collecting by untrained locals for profit tends to lose the critical geological context of the fossils, and sometimes even the information on their provenance. Perhaps many fossils were collected by a growing number of private collectors and have become inaccessible for scientific research. Unless China as a country can constructively resolve this dilemma, even her seemingly bountiful fossil resources will become vulnerable. It is a great challenge for the government at all levels, and for the research community, to ensure the long-term preservation of irreplaceable fossil resources, without impeding access by professional research paleontologists.

SUMMARY

Paleontology in China has had wonderful accomplishments in scientific research and broader societal impact in recent years. The success from the last decade will likely continue. To keep the paleontological science in the spot light, both for China and for the world, would require all paleontologists, major paleontological institutions, and funding agencies in China to build on the strength, to capitalize on the opportunities, to improve on the areas of weakness, and to rise to the challenges of the many threats. We are optimistic and hopeful that the success of the paleontological science in China will be even greater than in the recent past.