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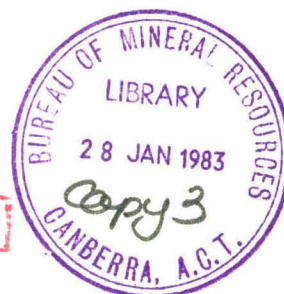
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# BUREAU OF MINERAL RESOURCES, GEOLOGY AND GEOPHYSICS

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## RECORD

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REPORT ON A VISIT TO CHINA

15-30 SEPTEMBER 1982

by

R.W.R. Rutland & D. Denham

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## SUMMARY

At the invitation of the Chinese Ministry of Geology & Mineral Resources we visited China from 15-30 September 1982.

The Ministry of Geology & Mineral Resources has responsibility for exploration, regional mapping and some industrial activities but it largely embraces geoscience research functions comparable to those of BMR through the Chinese Academy of Geological Sciences.

In Beijing we had discussions with the Bureau of Foreign Affairs of the Ministry of Geology & Mineral Resources on the possibility of establishing a formal cooperative agreement between the Chinese Ministry and BMR. It was agreed that this would be of mutual benefit. We also had discussions with members of the Chinese Academy of Geological Sciences and visited the Computer Centre of the Bureau of Marine & Petroleum Geology, and the Airborne Geophysical Team of the Bureau of Geophysical & Geochemical prospecting.

Outside Beijing we visited the Anhui Provincial Bureau of Geology whose staff led presentations on, and field trips to, the Tengcheng-Lujiang Fault near Hefei and the Tonglin Copper Mines near Tonglin.

A short visit was also made to the Zhejiang Provincial Bureau of Geology for a study tour of the geology of the West Lake region near Hangzhou.

## INTRODUCTION

Our visit to China arose from an invitation from the Chinese Ministry of Geology & Mineral Resources (CMGMR) which was issued early in 1982 following a visit to Canberra by Mr Wang Zejiu, Vice-President of the Chinese Academy of Geological Sciences.

There have been a number of previous contacts between BMR and both the Chinese Ministry of Geology & Mineral Resources and the Academia Sinica. A former Director of BMR, Dr N.H. Fisher, is very highly regarded in China for the part he played in developing these exchanges, especially at the time of the International Geological Congress in Sydney in 1976, of which he was President. There has been considerable reorganisation of the Ministry of Geology & Mineral Resources since the visit of the Australian Geological Delegation to China, 1979 (1).

In the two weeks available we were able to have in-depth discussions with the Foreign Affairs Bureau of the CMGMR. These enabled us to examine the structure and programs of the CMGMR and also to discuss possible ways and means of strengthening cooperation between BMR and CMGMR. We were also able to make contact with three of the Bureaus of the Ministry.

Through geological excursions in Anhui and Zhejiang provinces we were also able to gain some understanding of the capabilities and standards of the provincial geological surveys. Perhaps because of the short notice, these excursions were not made to the region (the Tsinling tectonic zone) which we had nominated as being of particular interest to us.

The following summarises our discussions and the highlights of our visit, including a list of personnel met (Appendix 1) and our detailed itinerary (Appendix 2).

BEIJING, 15-19 & 28-30 SEPTEMBER

Foreign Affairs Bureau of the Ministry  
of Geology & Mineral Resources

We had four main meetings with officers of this Bureau. On 16 September Mr Yang Zhi ling - Director of the Foreign Affairs Bureau of the Ministry of Geology & Mineral Resources - described the responsibilities, functions, operational structure and main programs of the Ministry of Geology & Mineral Resources.

Functions

This Ministry (which had its name changed recently from Geology to Geology & Mineral Resources) is responsible for research programs in geology, geological policy, and the framing of regulations for the development of mineral resources. It organises exchanges in technology transfer and is involved in geological mapping and exploration in China both on land and at sea. The mapping and surveys are usually of a reconnaissance nature and cover all kinds of minerals in China, including metals, non-metals, water resources, petroleum, coal, and natural gas. It is responsible for the framing of regulations which cover the procedures of geological exploration and certain requirements in the development of prospects. For example, it is responsible for the number and type of minerals processed at mines where it may be possible to extract several minerals rather than just one or two of the more abundant types.

The administration and management of the mines and the extraction of the ores are organised under other Ministries, for example:

Petroleum and Natural Gas - Ministry of Petroleum Industry

Metallic Minerals - Ministry of Metallic Minerals

Coal - Ministry of Coal

Salt, Pyrite, etc. - Ministry of Chemical Industry

In China about one million people are engaged in the earth sciences. Of this number the Ministry of Geology & Mineral Resources employs a total staff of about 400 000. Of this number, 130 000 are professional or technical and of this 130 000, 70 000 are employed directly in the Ministry itself. The remaining 60 000 work in other departments and academies responsible to the Ministry.

Geological work in China has grown spectacularly since liberation in 1949. For example in 1949 only 200 professional or technical people were employed in geological work within the Ministry, compared with the present 130 000. The growth in drilling activity has been similarly spectacular. Up to 1949 total drilling in China was about 170 km, while the total depth now drilled is about 220 000 km, with an annual drilling rate of about 7000 km for the Ministry of Geology & Mineral Resources alone.

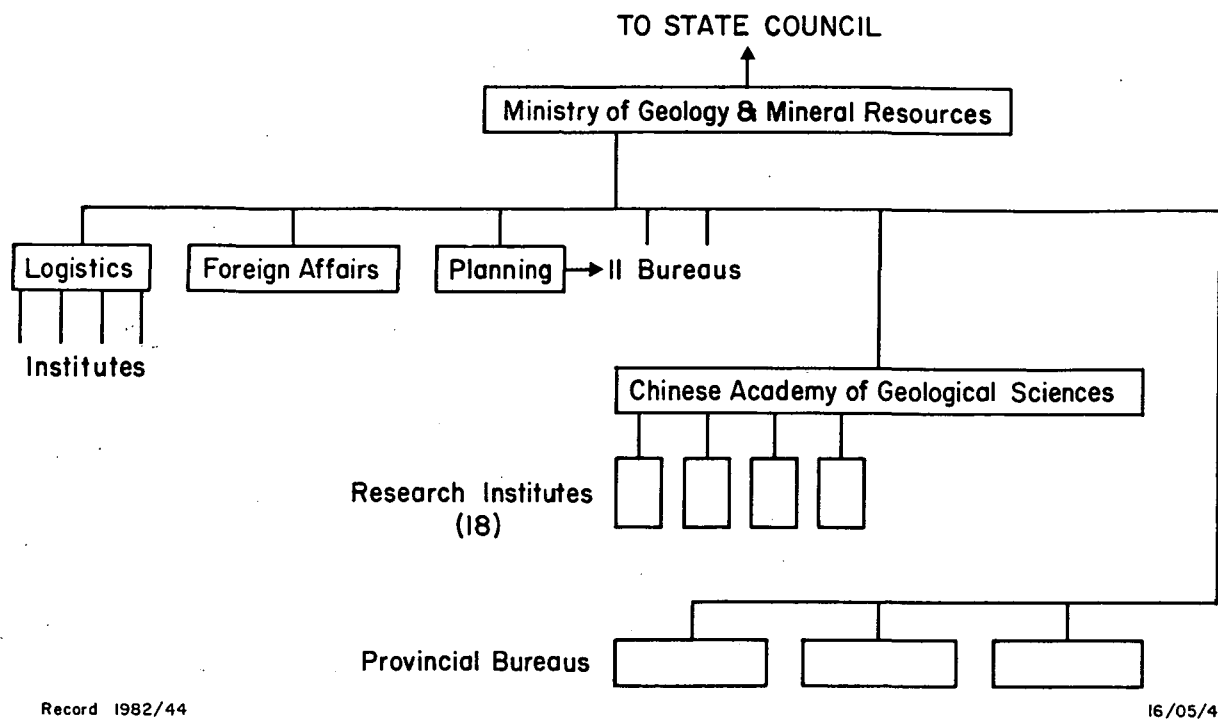
Up to 1948 China had 18 minerals with known reserves; now it has 134.

#### Structure

Within the Ministry there are eleven Bureau, as follows:-

- 1) Petroleum & Marine Geology
- 2) Geophysical & Geochemical Prospecting
- 3) Regional Geology & Mineral Resources
- 4) Hydrology & Engineering
- 5) Science & Technology
- 6) Labour & Wages
- 7) Planning
- 8) Education - including 5 geological colleges and 5 technical schools (the total teaching staff at these institutions is about 3600 and students total about 12 000 and 5000 respectively).
- 9) Drilling Engineering & Industry - including three factories for the construction of geological instruments, 12 factories for the construction of drilling rigs and parts for the rigs, and a map publishing house.
- 10) Logistics
- 11) Foreign Affairs

The structure looks roughly as shown below.



There are 18 Research Institutes in the Chinese Academy of Geological Sciences. They employ about 2000 researchers, whereas the Ministry of Geology & Mineral Resources employs about 3000.

The Institutes of the Academy concentrate on such topics as Ore Deposits, Karst Geology, Mineral Usage, and Plateau Geology. There are also Regional Institutes at places like Chengdu, Nanjing, and Xi'an.

In general the Bureaus appear to have functions more directly related to the needs of exploration and the assessment of resources while the Institutes of the Academy carry out mission-oriented research. The Marine Geology institute however comes under the Bureau of Petroleum & Marine Geology not under the Academy. There are also other geoscience research institutes outside the Ministry of Geology & Mineral Resources. These are institutes of Academia Sinica. Thus BMR's functions are largely covered by the Chinese Academy of Geological Sciences but also extend into other areas of the Ministry and into Academia Sinica.



Programs

The 1:1000 000 mapping of China has been completed and 60 percent of the 1:200 000 mapping has also been finished. Work on this mapping is proceeding, as are many research projects. The one on the search for oil in carbonate rocks was emphasised.

The Ministry operates 33 boats for geological and geophysical research. They have two vessels, the Haiyang II and the Haiyang III which are each of about 3000 tonnes and are dedicated to geophysical research.

The second meeting took place on the afternoon of 17 September when Mr Sun Renyi, Deputy Director of the Bureau of Foreign Affairs introduced the discussion. He stated that the 12th Party Congress, which had been completed in September in Beijing, had requested that the Ministry of Geology & Mineral Resources should advance the goals of mineral & petroleum development in order for them to be achieved 5 years ahead of the previously formulated 10-year plan. He said that the Government gave top priority to the geosciences and had requested the Ministry of Geology & Mineral Resources to find more minerals and petroleum products so that it could make a larger contribution to the economy of the State. This echoed the statement by Politburo member and ex-Vice President, Fang Ye, who had stated similar sentiments and also said that the State Seismological Bureau would be receiving more money in the current financial year.

Mr Sun proceeded to describe the various contacts that have been developed in recent years with overseas countries and how these have been very beneficial. He pointed out that exchanges with Australia dated from 1975 and that therefore we are 'old friends'. He mentioned that an earlier Director of the BMR, Dr N.H. Fisher, had participated in the conference to celebrate the 60th anniversary of the Geological Society of China and had visited China on three occasions. He also stated that their Ministry had sent delegations to Australia in 1975, 1978, 1979, 1980, and 1982.

As a result of these fruitful visits he expressed the hope to increase and promote exchanges between the two countries in the geosciences. He mentioned that both China and Australia were large countries where the development of mineral deposits will make important contributions to the futures of each country. As there may be many common problems in the development of ore deposits he thought it necessary to increase co-operation and exchanges in the earth sciences. He therefore stated that he would like to discuss and explore the possibility of further exchanges with BMR.

The BMR's role, structure and activities were then described in detail.

Mr Sun then returned to the possibility to establishing formal exchange arrangements. He stated that in 1979 an agreement was signed between the West Germans (BGR and their Ministry of Economics) and the Chinese (their Ministry of Geology (and Mineral Resources)). This agreement was signed after an exchange of visiting delegations as well as exchanges of scientific personnel. The topics covered by these exchanges have included the search for rare-earth elements in Yunan, a visit to Germany on automatic mapping techniques, and a visit of German experts to study wolfram. Mr Sun also stated they had agreements with France and the US and he inquired whether there was interest in exploring the possibility of setting up similar exchanges with Australia.

It was stated that at this stage there was interest but that discussions would have to be held with the Minister of National Development & Energy and the Department of Foreign Affairs in Australia about the mechanisms for a formal agreement and about funding.

At present there are several science agreements between Australia and China. These include the main umbrella agreement between the Australian Department of Science & Technology and the Chinese State Commission of Science & Technology and the longstanding agreement between the Australian Academy of Science and the Academia Sinica. Mr Sun argued that since these agreements did not specifically include the earth sciences it would be desirable, in order to strengthen the co-operation in the earth sciences, to explore the possibility of establishing a specific agreement within the framework of the present Science & Technology Agreement between BMR and his Ministry.

At this point the discussions were adjourned until the next day.

The third meeting with the Foreign Affairs Bureau took place on the afternoon of 18 September. Mr Sun Renyi opened the discussion by saying that he wanted to develop co-operation in the geological sciences on a mutual benefit and reciprocity basis in the following areas -

- 1) Mineral and energy resources
- 2) Hydrogeology and engineering geology
- 3) Marine geology
- 4) Regional geology, including palaeontology and stratigraphy
- 5) Geotectonics
- 6) Geophysics (including remote sensing) and geochemistry
- 7) Application of computers in the geosciences
- 8) Laboratory tests and experimental methods and techniques

These proposals were designed to cover the fundamental areas and were not necessarily an exclusive list. The details of specific proposals could be discussed at a later time.

Mr Sun suggested that co-operation could take the following forms.

- 1) Both sides could have an exchange of scientists and experts for visits to each country.
- 2) An exchange of scientific and technical information, including specimens and standards.
- 3) Collaboration on research subjects of mutual interest including the development of instruments, techniques and equipment.
- 4) Joint organisation of symposia, conferences, workshops and the like.
- 5) The reciprocal training of scientific personnel especially of senior research staff.
- 6) Other forms of co-operation, as mutually agreed by both sides.

Mr Sun proposed that a suitable working arrangement would be for both sides to propose appropriate topics each year. This would be followed by an exchange of ideas on these projects and if these projects were considered suitable by both sides then joint co-operative projects could be developed.

He suggested that there should be irregular meetings between the two sides as required by the development of the co-operation. These meetings could alternate between Canberra and Beijing and should consider both new proposals and any revisions to existing projects.

A three-year term was suggested as a reasonable length of time of a co-operative project.

Mr Sun proposed that the costs should be borne equally by both sides but that the costs of particular projects could be discussed on an individual basis. He proposed that travel to the country be borne by the visiting party and that travel and accommodation within the country would be borne by the host country. Thus China would pay for travel to Australia and then Australia would pay for the travel and allowances (not the salary) while the Chinese are in Australia.

If a scientist brought his family with him then the extra costs would not be covered by the project.

Mr Sun suggested that if both sides agreed to these proposals then a protocol could be signed either between Ministers or Permanent Heads. The Chinese officials likely to be involved at this level are:

Zhu Xun - Vice-Minister, Ministry of Geology & Mineral Resources, and  
Sun Da guang - Minister, Ministry of Geology & Mineral Resources.

In the Australian reply to the Chinese proposal, it was stated that the exchanges between Chinese and Australian scientists that have taken place so far have been on an individual basis. This current proposal is potentially for a more comprehensive exchange arrangement which it was believed would be welcomed by scientists in Australia. However, it would require the approval of the Australian Government. It would, therefore, be necessary to take the Chinese proposal to Australia for consideration. Funding of the agreement might present problems but the matter would be raised with the Minister of National Development & Energy to see what can be done.

There was then a discussion about the agencies to be included in the agreement. The Chinese clearly wanted an agreement between the Bureau of Mineral Resources, Geology & Geophysics and the Ministry of Geology & Mineral Resources. However, from the Australian side, it was suggested that although BMR might well be the operating authority it would be highly desirable to include universities, companies and other

institutions in Australia so that geoscientists from these organisations could participate.

On a similar vein we would not want such an agreement to preclude other co-operative arrangements involving the Academia Sinica and/or other organisations in China such as the State Seismological Bureau.

The Science Agreement signed on 23 April 1982 between the Australian Department of Science & Technology was a broad agreement without specific provisions. It should be recognized in this context, that the Chinese Commission of Science & Technology has a supra-ministerial status and is headed by a Vice-Premier. The Chinese therefore saw a need for a more specific agreement, under the umbrella of the general agreement between their Ministry and BMR. Furthermore, they did not wish to involve their C of S & T in the specific geoscience negotiations because it would complicate the practical arrangements of getting effective scientific exchanges started in the geosciences.

The Chinese side therefore suggested that an agreement between their Ministry of Geology & Mineral Resources and our Ministry of National Development & Energy might be most appropriate. The meeting closed with both sides undertaking to go back to their Governments with these proposals.

The fourth meeting took place over lunch on 29 September. Mr Yang, the Director of the Bureau of Foreign Affairs, reaffirmed the substance of the discussions at the earlier meetings. In addition he identified three specific areas of interest to the Chinese which he hoped could be included in any agreement. These were: 1) A Chinese need for training in the more specialised geological techniques and research methods; 2) studies of the structure of metamorphic rocks; and 3) petroleum exploration using geophysics and geochemistry, particularly in carbonate rocks.

During all these four meetings we were accompanied by Li Cheng da - Deputy Division Chief of the Foreign Affairs Bureau and Zheng Chuneai - interpreter.

### Chinese Academy of Geological Sciences

Mr Yang's first presentation on 16 September was followed by a talk by Professor Li Chun yu, President of the Chinese Academy of Geological Sciences. Professor Li was accompanied by Mr Zhang Zheng kun from the same Institute. Professor Li talked about the proof copies of the new Tectonic Map of Asia which was being prepared in the Academy. It will be a 6-sheet map at 1:8M covering the whole of Asia (10-90°N, 40-180°E) and dealing with the continent as a series of 10 Tectonic Plates.

During the following morning (17 September 1982) we visited the Chinese Academy of Geological Sciences and met Professor Huang Qi gong (Honourable President), Li Ting dong (President), Wang Zhe jiu (Vice President), Zheng Zhe (Petrologist and Deputy Director of the Mineral Deposit Institute), and Guo You ling (Chief of the Science and Technology Division under the Academy). Huang and Zheng are the President and Secretary of the Chinese Geological Society respectively.

The Chinese Academy of Geological Sciences is a special research organisation under the Ministry of Geology & Mineral Resources whose main task is to meet the requirements of the Ministry particularly in basic research programs. The total staff is about 5000 of which 2700 are professional or technical. There are 18 institutes within the Academy and 7 of these are in Beijing. The Institutes within Beijing are:

(1) Geology, (2) Mineral Deposits, (3) Rock & Mineral Analysis, (4) Geomechanics, (5) Geological Information, (6) National Geological Library, and (7) National Geological Museum. Of the Institutes outside Beijing, The Principal Institutes of Geology and Mineral Resources are at Shenyang, Tianjin, Nanjing, Yichang (Hubei Province), Chengdu, and Xi'an; the Institute of the Comprehensive Uses of Mineral Resources is at Omei (near Chengdu); the Research Institute of Plateau Geology is at

Chengdu; the No. 562 Comprehensive Research Brigade is at Ying Chou (Hubei Province) - it concentrates on geomechanics research; the Institute of Hydrogeology and Engineering Geology is at Zheng Ting; and the Institute of Karst Geology is at Guilin.

Since 1978 the Academy has established a post-graduate department for M.Sc. and Ph.D students. It also contains the secretariat and editorial board of the Geological Society of China. Two regular journals are produced: the 'Geological review' which is published every two months, and the 'Bulletin of the Geological Society of China' which is produced every three months. The Academy also publishes its own Bulletins at irregular intervals.

The Geological Society of China has about 40 000 members. In 1982 it celebrated its 60th anniversary and held a special symposium in Beijing on Mesozoic and Cenozoic geology to celebrate this event.

The following research projects were emphasised as being important in the Academy.

- 1) Work on the integration of the stratigraphy of China which took place from 1972-1979 is now in the process of being finalised, a conference on Chinese stratigraphy has just been held and the review to be published will contain about 3M words.
- 2) The Cambrian/Precambrian boundary is being studied in several institutes and is considered very important.
- 3) The compilation of geological maps for the whole of China, including tectonic maps, and the tectonic map of Asia. The Wuhan Geological College is collaborating with the Institutes to produce palaeogeographic maps of China.
- 4) Tibet. The program of work in Tibet is not very clear but it seems that from 1951 to 1976 the Academia Sinica organised a comprehensive research project on Tibet. However, from 1980 onwards, the Ministry of Geology & Mineral Resources has taken a leading role in the earth science studies. It has organised the Sino/French investigation of three years' duration (1980-1982) and is now co-ordinating the work of several institutes in that region. Since 1956 three



of the provincial Bureau of the G & MR Ministry have worked in Tibet and these Bureau participated in the Academy Sinica program. However, it seems that the Ministry of G & MR is not dominant as far as earth science programs are concerned.

The structure and functions of BMR were then described in detail.

After these discussions we visited the following facilities at the Institute of Mineral Deposits.

- 1) A JEOL superprobe 733 electron probe, coupled with a PDP 11, for studying silicates.
- 2) A Scanning JEOL JSM-35 electron microscope which was bought in 1975.
- 3) An AME 50 Mossbauer spectrometer, made in the USA, for a study of the valency of ions and the structure of molecules.
- 4) A MAT 260 mass spectrometer for Rb/Sr and U/Pb dating.
- 5) A Transmission Electron Microscope System (an EDAX 9100) for the study of crystal structure and chemical composition.
- 6) A device developed by Wang Yu xian for the Hf dielectrical separation of minerals.
- 7) An infrared spectrophotometer for the study of the water content of minerals.
- 8) A micromass (only 3 months old) mass spectrometer for K/Ar dating.
- 9) A C<sub>12</sub>/C<sub>13</sub> mass spectrometer for carbonate studies.
- 10) A MAT 261 mass spectrometer for examining Pb/Zn and Nd/Sm ratios, which had just been delivered and was not yet fully operative.

We then visited the Institute of Rocks & Minerals Analysis and inspected the following facilities which are mainly of a service nature.

- 1) A Jarrell-Ash Division Atom Comp Series 1100 direct reading spectrometer which can analyse 33 elements simultaneously.
- 2) An ICP spectrometer for rare-earth analysis.
- 3) A Russian spectrograph, which is no longer used because they now have.
- 4) A new Rigaku XRF facility which will analyse 24 samples simultaneously.

The Academy is therefore comparatively well off in its range of geochemical equipment (it has available).

#### Computer Centre - Bureau of Marine & Petroleum Geology

On the morning of 18 September we visited the Computer Centre of the Bureau of Marine & Petroleum Geology.

We were hosted by:

Huang Shu de - Director

Miss Hou Chung chu - an expert in airborne magnetic interpretation

Wu Kuan lian - an expert in seismic prospecting and geochemical work and

Zhang Yung chi - a hardware specialist.

The main computing facility comprises three computers, which cost about \$10 million: two Cyber 170-720 computers which were acquired in 1980, and an M160 which was purchased from Japan in 1979. The computer centre processes most of the geophysical data acquired by the Ministry, including gravity, land and marine seismics and magnetics as well as a data management facility. They plan to establish a petroleum data base. The volume of data processed is very large, because the centre operates 60 reflection recording crews for eight months of the year and has a substantial geophysical marine program.

The main computer centre is a very large facility, and is housed in a fully air-conditioned room about 35 m x 35 m. Apart from the two 170-720 Cyber computers it contains: 24 CDC 679-2 tape transports, 4 x 200 Mbyte discs and two CDC array processors. The external core memory is 2 x 256 k x 60 bits and the core memory is 98 k x 60 bits. The CEC maintenance contract is scaled down somewhat with only one expert remaining and they now have 30 Chinese hardware specialists to operate and maintain the system.

In addition to the above they have 2 x 405, 800 card/minute card readers, 4 Gould 5105 plotters, 6 x 844-41 disc storage units which provide 4 x 200 Mbytes and 2 x 80 Mbytes of memory. The line printers are two 580-120, 1200 lines/minute devices.

The major drawback with the facility was the lack of VDUs throughout the building. It appears that to access the computer it is necessary to go to the centre, and in the centre only 2 VDUs were available.

After discussing the computing facilities we were shown a seismic record section obtained and processed by the Bureau of Marine & Petroleum Geology. They bought a software processing package from CGG in 1979 and apparently their field recording facilities were acquired from the same source. The 60 recording crews are normally in the field for 8 months per year. They record 48 or 60 channels of seismic data on the SN 338B CGG systems. They would have preferred an American system but this was not possible because of the American's refusal to export computer systems to China at that time. The record section we saw was obtained from 30-fold CDP recording. However, they usually only use a 12 CDP technique for normal operations. Because seismic recording is very difficult logistically in China, they only cover between 200 and 250 km per month. Vibroseis is impossible in the paddy fields so they use explosives and normally have four rigs attached to each field crew.

After discussion of the seismic processing we were given a description of some of the aeromagnetic interpretation by Miss Hou Chung chu. She showed a comprehensive approach to aeromagnetic maps and for the 1:2 000 000 Sheet Area in northeast China she presented the following maps: 1) pseudogravity (derived from the magnetics - the method was not explained), 2), 3) & 4) upward continuation 10 km, 20 km and 40 km (all reduced to the pole), 5), 6) 7) & 8) horizontal derivative maps, the derivatives being taken in 4 directions after upward continuing to 10, 20 or 40 km. These latter maps were made from the 5 km sq mean values and are used for crustal interpretation.

Mr Wu Kuan lian then gave a presentation on the processing of geochemical data. The geochemical work is carried out to try and identify mineral zones. Usually groups of samples are collected every 4 km in various geological provinces by the provincial brigades. The data are processed on 1:200 000 scale maps and are stored on a computer so that presentations can be made in several ways. They use the Japanese M160 computer for this work and have written all the software themselves. This project started in 1979 and they now have a total data base of about 3 million samples (5 elements per location). In the future they plan to expand their system to analyse 40 elements per location.

Airborne Geophysical Team - Bureau  
of Geophysical & Geochemical Prospecting

The Airborne Geophysical Team was visited on 18 September. It is part of the Bureau of Geophysical & Geochemical Prospecting. We met the following personnel:

Cho Sung nien - Deputy Chief Engineer  
Chou Yung tsing - Chief of the Production Division  
Zhou Ji xiang - Senior Engineer for airborne geophysics.

Airborne geophysics commenced in 1953 with a 'rotation core' magnetometer having a 100 nT accuracy. In the mid 1950s this was replaced with a fluxgate magnetometer with 3-25 nT accuracy and a radiometric detector was added to the system. In the late 1960s a proton-precession

magnetometer was introduced with a 1 nT accuracy and from the mid 1970s an optical pump magnetometer with a 0.1 nT accuracy was installed. They now have an EM spectrometer detecting in three frequency bands and a 4-channel radiometric system.

the main aim of the radiometric and airborne EM work is to look for mineral deposits. To date they have found 20 000 anomalies.. These are usually caused by 3-5 percent magnetite or some other magnetic mineral. Further studies showed that within the 20 000 anomalies, 200 turned out to be significant mineral deposits and 80 of these are in the large to intermediate size.

The follow-up ground work is usually done by the Provincial Bureau who have to date, found 17 different kinds of deposits from this work.

So far they have flown 7.5 million line-km over an area of about 8 million km<sup>2</sup>. Of this million 8 km<sup>2</sup>, 1.2 million km<sup>2</sup> was flown offshore and 5.0 million km<sup>2</sup> both onshore and offshore for petroleum search.

The magnetic data are processed to reveal depth to basement and regional features. They are also used for tectonic studies and petroleum potential studies. The maps are compiled at 1:1 M and are widely used by provincial geologists. They claimed to have their own processing centre but we did not have time to investigate this. The flight line spacing varies from 500 m through 1, 2, and 5 km to 10 km and they try to fly at 100-500 m over the flat land and 1000 m over the mountains. Navigation is by radio, doppler and photo-interpretation. They hire their aircraft from CAAC and operate 5-10 aircraft per year.

#### Miscellaneous visits - Beijing

In addition to the visits described above we visited the National Geological Museum (16/9), the Institute of Geology of the State Seismological Bureau (29/9), and the cultural sites at the Forbidden City (29/9), the Temple of Heaven (16/9), and the Great Wall and the Ming Tombs (19/9).

The Geological Museum is 60 years old and has a Mr Liu as its head. The building was constructed in 1959. It has a staff of about 50 and occupies a total of about 6000 m<sup>2</sup> on 4 floors. The first floor is devoted to mineral resources, the second to the history of the earth, the third to palaeontology and mineral & rock deposits, and the fourth to arts and crafts made from stone - such as jade.

At the State Seismological Bureau, a talk on the Tectonic Development of Australia was given by Professor Rutland.

#### ANHUI PROVINCE, 20-25 SEPTEMBER

We were hosted by the Anhui State Geological Bureau for five days and studied two areas - the Tengcheng-Lujiang Fault near Hefei and the Tonglin Copper Mines at Tonglin.

#### Tengcheng-Lujiang Fault Hefei

At the Anhui Provincial Capital in Hefei - the headquarters of the Provincial Geological Bureau - we met

Chang Yin fo - Deputy Director, Chief Engineer and geologist.

Tang Chien san - Secretary of the Administrative Office.

Zhang Qin gui - Engineer, Geology & Mineral Resources Division,  
and

Yuang Hung liang - Engineer from the Regional Geological Survey Team.

The Director, Mr Xing Hao was not in the Province at the time of our visit.

In the afternoon we discussed our itinerary and heard a presentation by Yuang Hung liang on the significance of the Tengcheng-Lujiang Fault, and its manifestation in Anhui Province. Some geologists considered that this fault or fault zone extended from Manchuria to the South China Sea. However, it is best exposed in Anhui Province where it may have either 700 or 100 km of left lateral displacement, so we were told, depending on which rocks were considered to be correlated across the fault.

Apparently it had a very complicated evolution, with mainly left-lateral strike-slip motion until the Quaternary when it changed to right-lateral. The evidence for the right-lateral motion was not presented. We were told that work by the State Seismological Bureau indicated that the Moho dips from a depth of 31 km to 36 km, from west to east, in Shandong Province.

The fault is thought to have formed in the early Jurassic, and was most active in Late Jurassic and Cretaceous times. It was inactive in the early Tertiary but was active in the Neogene and remains active now - though we did not see much evidence of this. There was considerable discussion on the stress systems that may have caused the faulting, but the discussions were generally inconclusive. A WNW-SE maximum principal stress associated with conjugate strike slip faults was proposed.

On 21 September a field visit to Tengcheng County was organised to examine the Tengcheng-Lujiang Fault at the Beizhuang Nanyan Commune. The town of Tengcheng is 110 km from Hefei and it took about three hours to travel there. At Tengcheng we were entertained by Mr Sun An pin, who is in charge of the County (700,000 people, 1,800 km<sup>2</sup>). He explained the general basis for the County's economy.

The fault outcrop we examined extended for about 80 m. From east to west the moderately dipping (40°) Cretaceous sediments steepen towards the fault. Vertical shears become increasingly frequent until pervasive shearing affects both the Cretaceous sediments and the granitic basement. On the west of the zone the basement comprises migmatized monzogneiss. The field trip was led by Mr Yuang.

On returning to Hefei we gave talks on Australian geology and mineral deposits and Australian earthquakes - to members of the Provincial Geological Bureau.

On our third day at Hefei (22 September) we visited a second outcrop of the Tengcheng-Lujiang Fault. This was about 20 km from Hefei near the Shibeng Reservoir in Shannwangji, Feidong County.

Again, the field trip was led by Yuang. We met Mr Yang Zhi chuan, county head of Feitong County (population 700 000) and Mr Wang Yun min, the head of Shibagong (District 200 000). The first section of outcrop covered about 100 m from Cretaceous in the west through a cataclastic section to the migmatite. We then walked along some of the geology near the fault. In the afternoon we visited the natural history museum which showed Chinese history from 1 m.y. to about 2000 years ago. We also saw the fossil record of Palaeoloxodon and other genera now extinct from the district due to changes in climate and perhaps the activities of man. In the evening we attended a local opera.

#### Tonglin Copper Mines, Tonglin

We drove from Hefei to Tonglin on 23 September, crossing the Yangste at Wu hu, where we had lunch.

At Tonglin we were hosted by Geological Team No. 321. Team 321 comprises about 1000 people of which about 70 are professional or technical geologists and 20 are professional or technical geophysicists. The team leader was Mr Zhang Lu tang; he was assisted by Mr Huang Zhu chen and Mr Zhu Fa yu (both field geologists).

In the morning of 24 September Mr Huang gave a presentation on the geology of the Tonglin copper mine and the surrounding district.

The Tonglin copper mining region has been used for over 1500 years for copper extraction. The mining region extends over about 1000 km and it is situated on the eastern part of the Yangste pene-platform.

The District produces between 25 000 and 30 000 tonnes of copper per year. This is extracted from 3 million tonnes of ore. Before 1949, it produced about 30 percent of China's copper but now it produces only about 20 percent.



Some 3000 people work in the mining industry in the region; roughly 1000 in mining, 1000 in mineral dressing, and 1000 in refining. The mine employs 10 geologists on exploration and 3-5 geologists on mapping the mining developments.

### Stratigraphy

From Palaeozoic to Triassic the Tonglin area subsided and contains about 6 km of shallow-marine sediments. Carbonates are well developed in the sequence.

The Silurian marine clastic sediments form the base of the sequence. Lower Devonian rocks are absent but Upper Devonians sediments are present.

The Carboniferous to mid Triassic strata are mainly carbonates. The Lower Carboniferous is composed of marine to continental clastics and in the Upper Permian some coals are found.

The whole sequence was folded during the mid Triassic Indo-Sinian orogeny. This movement produced the NE-SW structural trends evident on the geological map of the area.

The remainder of the succession contains Upper Triassic to Tertiary continental clastics.

From the mid Jurassic to Early Cretaceous there were several intrusions and extrusions of continental volcanics. The copper mineralization is related to this Yenshan stage.

### Structures

There are three main structural trends in the region. The first is an almost E-W trend which (we were told) corresponds to basement structures and is revealed on the geophysical maps of the gravity and magnetics. However we were not able to inspect these maps.

The NE-NNE trends are the most evident. They were probably formed in the mid Triassic when the main Tonglin zone (a graben) was uplifted.

The final structural features discussed were a series of N-S faults which control the stratigraphy and lithology of the Lower Permian.

### Mineralization

The mineralization is associated with the magmatic activity of the Yenshan stage which formed diorite, quartz diorite, and granodiorite from 170 to 110 m.y. ago. The mineralization forms four main types:

- 1) Contact metasomatic - between Triassic marble and granodiorite.
- 2) Stratabound deposits in the shale/marble sequence, with the marble normally above the shale.
- 3) Breccia pipes containing diorite and marble fragments, and
- 4) a fissure type in which skarn veinlets bear the copper ore - this is only of minor importance.
- 5) Composite types - mainly between 1 & 2.

### Tong Guan san copper mine

This was one of the first mines to be developed in the region and is considered typical of the composite skarn type. The main orebody is about 1200 m long with a general thickness of 20-40 m - although it reaches 120 m at its widest point. It extends to a depth of 700 m. The grade of the ore is 0.9-1.1%.

### Shi Zhi san copper mine

This is a typical stratabound skarn type. Mining is now underground and the footwall is again Carboniferous shale and sandstone. The grade is about 1-1.3%.

Feng Huang san copper mines

Several mines have been developed around the Phoenix Hill granodiorite. The orebodies range in length from 300 to 1000 m. The thicknesses of the ore range from 10-80 m and extend to at least 600 m deep. The grade is 1.2-1.3% and Se, Te, Au, Ag, and Co are extracted. Gold values are about 0.5 g/t.

We were then shown the geochemical analyses that have been obtained.

Field visit

In the afternoon of 23 September we visited the Tong guan san copper mine. Open-cut mining has now stopped and the mine is being developed for underground mining; we examined all the outcrops from the footwall to the hanging wall. We also looked at the geology of the anticline which forms the main structural trend in the vicinity of the mine.

On Saturday 25 September we left Tonglin by train for Shanghai.

## ZHEJIANG PROVINCE, 26-28 SEPTEMBER

West Lake geology, Hangzhou

After the Sunday (26 September) in Shanghai we spent two days in Hangzhou where we were hosted by the Zhejiang Provincial Bureau of Geology.

We met Chao Min de - Deputy Director and Deputy Chief Engineer  
 Liang Na chian - geophysicist (specialist in aeromagnetic surveys) and  
 Tong Ji hai - a hydrologist who gave the presentation on the West Lake geology.

The Zhejiang Provincial Bureau employs about 7000 people of whom some 2000 are professional and technical staff. These figures include geologists, geochemists and geophysicists.

The Bureau is divided into four specialised teams responsible for (1) Regional Geological Surveys, including mapping (600 people in this group), (2) Hydrogeological surveys, (3) Geophysical and Geochemical Prospecting within the Province, and (4) Geodesy and Geomorphology. In addition there are five separate teams responsible for metallic and non-metallic mineral exploration, each in a separate part of the Province.

To back up these groups the Bureau has three drilling exploration teams with equipment consisting of 20 rigs that can drill to 1000 m, 20 rigs capable of drilling to 600 m, and 10 rigs capable of drilling to 500 m. These rigs are mainly employed in the search for metallic and non-metallic resources and each year they obtain about 100 km of core.

The aeromagnetic mapping of the Province has been completed at 1:50 000 scale. Usually the lines were flown 500 m apart at 120 m height with an accuracy of about 1 nT. Maps will be produced at 1:500 000 and 1:200 000 scales and a deep structure map will also be prepared. The flying took about five years to complete.

The geological mapping has been completed at 1:200 000 scale and they are now producing maps at 1:50 000 scale. We were shown an example of a special 1:20 000 map that had been produced for the West Lake area of Hangzhou and this was used in our geological tour of the region.

#### DISCUSSION AND RECOMMENDATIONS

Our visits to various sections of the Ministry of Geology & Mineral Resources provided a valuable insight into the workings of the Chinese Ministry which is probably the nearest Chinese equivalent to BMR in Australia. However, there are significant differences between the two organisations. In particular, the CMGMR has as its major responsibility the exploration for minerals and petroleum. It therefore has interests, not only in BMR's research activities but also in the work of private exploration companies in Australia.

A second difference is that of size. As stated earlier, the total staff of the Ministry is about 400 000. Thus it has the human resources to carry out mapping programs and reconnaissance surveys which would be impossible for BMR. However, BMR carries out a broader scientific program and undertakes several several projects which are carried out by other institutions in China. Thus the work of the State Seismological Bureau and some of the earth-science work of the Academia Sinica are matched by activities in BMR.

The Chinese seem to be lacking high-technical expertise in certain areas and are keen to become involved with a high-level training program of the sort that would give their leading geoscientists access to the most advanced research and exploration concepts and techniques now being employed in Australia. Australia is particularly attractive to them because these concepts and techniques are being applied in Australia to a continent with broadly similar geological evolution to that of much of China.

Australia cannot benefit significantly from reciprocal training programs in China. However, comparative studies with China could be of considerable benefit in understanding various aspects of Australian geology. Thus, comparative studies of sedimentary basins prospective for hydrocarbons could well lead to the definition of new petroleum 'plays' in Australia. Similarly, the study of Chinese metallogenic provinces could assist in the development of concepts relating to Australian provinces. In this connection it should be noted that the Chinese have a very long history of mining practice and they have a very detailed basic geological knowledge of many of their mineral fields. Their basic geological mapping is much more detailed than is available in Australia and much might be learned by comparative study.

It appears, therefore, that Australian geoscience can benefit from the opportunity for comparative study of various geological phenomena in China. Comparative mineralogy, petrology, and tectonic setting of kimberlite occurrences in the two countries, for example, could be very rewarding.

A mutually beneficial program would therefore be one in which Australian geoscientists joined with the Chinese on various projects to study phenomena in China of interest to Australia. These projects would then allow the Chinese participants to visit Australia to participate in the advanced laboratory research conducted on the material collected. The Chinese would then also have opportunities for comparative studies in Australia.

BMR could appropriately act as the coordinating agency in Australia for such a program but the program would be most effective (and less demanding on BMR) if it also involved geoscientists from private industry, universities, and CSIRO.

It is recommended that a formal agreement between the Chinese Ministry of Geology & Mineral Resources and the Department of National Development & Energy should be approved in principle.

The mechanisms for relating such an agreement to the general science agreement between the two countries need to be explored, and BMR is prepared to initiate discussions with the Department of Science & Technology.

When a satisfactory procedure has been determined, it would be useful to draft a form of agreement and to invite a delegation from China to discuss the proposals. The invitation should probably be addressed to the Minister of Geology & Mineral Resources, Minister Sun Duguang. It would be appropriate if the delegation also included Vice-Minister Zha Xun who has responsibility for the geoscientific activities of the Ministry, and Mr Yang Zhi ling, Director of the Foreign Affairs Bureau, who has led the discussions for the Chinese so far.

## APPENDIX 1: PERSONNEL MET IN CHINA

### Beijing

Zhu Xun

Vice Minister, Ministry of Geology  
& Mineral Resources.

### Foreign Affairs Bureau

Yang Zhi ling

Director of the Foreign Affairs  
Bureau, Ministry of Geology &  
Mineral Resources.

Sun Ren yi

Deputy Director of the Foreign  
Affairs Bureau.

Li Cheng da

Deputy Division Chief of the Foreign  
Affairs Bureau (ex IP Geophysicist).

Zheng Chan neai

Interpreter, Foreign Affairs Bureau

### Chinese Academy of Geological Sciences

Professor Li Chun yu

Tectonic geologist.

Zhang Zheng kun

Tectonic geologist.

Professor Huang Qi ging

Honorary President of the Chinese  
Academy of Geological Sciences and  
President of the Chinese Geological  
Society.

Professor Li Ting dong

President - CAGS

Professor Wang Zhe jiu

Vice-President - CAGS

Zheng Zhe

Petrologist and Deputy Director  
of the Mineral Deposits Institute and  
Secretary of the Chinese Geological  
Society

Guo You ling

Chief of the Science & Technology  
Division under the Academy.

Wang Yu xian

Geochemist in Institute of Mineral  
Deposits who developed an HF dielectrical  
separator.

Liu

Curator of the Geological Museum.

(ii)

Computer Centre - Bureau of Marine & Petroleum Geology

Huang Shu de	Director
Hou Chung chu (Miss)	Interpreter in airborne magnetics.
Wu Kuan lian	An expert in seismic interpretation.
Zhang Yung chi	A hardware specialist.

Airborne Geophysical Team - Bureau of Geophysical & Chemical Prospecting

Cho Sung nien	Deputy Chief Engineer.
Chou Yung tsing	Chief of the Production Division.
Zhou Ji xiang	Senior Engineer for airborne geophysics.

Anhui Province - Hefei

Chang Yin fo	Deputy Director - Chief Engineer and Geologist.
Tang Chien san	Secretary of the Administration Office.
Zhang Qin gin	Engineer, Geology & Mineral Resources Division.
Yuang Hung liang	Engineer from the Regional Geological Survey Team.

Anhui Province - Tonglin

Zhang Lu tang	Team Leader.
Huang Zhu chen	Field geologist.
Zhu Fa yu	Field geologist.

Zhejiang Province - Hangzhou

Chao Min de	Deputy Director and Deputy Chief Engineer.
Liang Na chian	Geophysicist (aeromagnetic specialist).
Tong Ji hai	Hydrologist.



# APPENDIX 2: ITINERARY

Day (all in September)	Morning	Afternoon	Evening
Wednesday 15		Arrival in Beijing of R.W.R. Rutland (17.30)	Discussion on itinerary.
Thursday 16	Briefing on Ministry of Geology & Mineral Resources, presentation on Geology of China	Visit to National Geological Museum and Temple of Heaven.	Discussion with Ma Xing-yuan on visit to State Seismo- logical Bureau.
Friday	Visit to the Chinese Academy of Geological Science including the Institutes of Mineral Deposits and Rocks & Minerals Analysis.	Discussions with Bureau of Foreign Affairs.	Dinner hosted by Vice- Minister Zhu.
Saturday 18	Visit to Computer Centre (Bureau of Marine & Petroleum Geology) and the Airborne Geophysical Team (Bureau of Geophysical & Geochemical Prospecting).	Discussion with Bureau of Foreign Affairs	Visit to Theatre.
Sunday 19	Visit to Great Wall	Visit to Ming Tombs.	Left Beijing by train to Hefei (18.30).
Monday 20	Travel on train	Arrive in Hefei (13.00). Discussion on itinerary in Anhui Province.	Visit to Theatre.
Tuesday 21	Field work near Tongshen.	Field work near Tongshen (Tengcheng-Lujiang Fault)	Talks to the Provincial Bureau of Geology.
Wednesday	Field work near Faitong (Tengcheng-Lujiang Fault)	Visit to National History Museum	

\* Denham was already in Beijing

(ii)

Day	Morning	Afternoon	Evening
Thursday 23	Travel by car from Hefei to Wu hu	Travel by car from Wu hu to Tonglin.	
Friday 24	Briefing on Tonglin Copper Mines	Visit to Tonglin Copper Mines.	
Saturday	Travel by train from Tonglin (06.10) to Shanghai.	Arrival at Shanghai (17.00)	Visit to acrobatic Display.
Sunday 26	Visit to Trade Fair in Shanghai.	Visit to Botanical Gardens.	Travel by train (18.04) to Hangchou (21.00).
Monday 27	Briefing on West Lake geology, Hangchou.	Field visit to West Lake.	
Tuesday 28	Field visit to West Lake geology.	Sightseeing in Hangchou.	Travel by plane from Hangchou (19.00) to Beijing (21.00).
Wednesday 29	Visit to Institute of Geology, State Seismological Bureau for talk on Australian Geology.	Lunch with Foreign Affairs Bureau and visit to Forbidden City.	
Thursday 30	Left Beijing by air for Hong Kong (7.55).	en route to Canberra	