

RESTORING THE GOOD EARTH AND BUILDING FRIENDSHIPS IN CHINA

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In China, approximately 20,000 hectares of land are being degraded each year by mining and require rehabilitation. The objective of a four year project, funded by AusAID, was to help create a permanent capability in China for rehabilitating lands covered with mining wastes or disturbed by mining activities. This involved not only a transfer of technical and organisational skills, but also the fostering of institution building skills and an appreciation of the multi-disciplinary approaches that are needed to ensure all-round success. The technical fields included range from mine planning through geotechnical engineering, geohydrology, soil science, geochemistry, agronomy, human health and epidemiology, to social fields such as community development and the vital role women can and should play in environmental and social decision making. The project was completed in August 1997, but several young Chinese counterparts are studying in Australia to increase their skills.

In China, especially in the well watered regions with dense populations, land is at a premium, either for food production or for urban or industrial uses. Mining in these regions has caused, and still is causing large areas to be covered with mine wastes, from waste rock and overburden to tailings - the pulverised ore rocks - after the valuable components such as metals have been removed by an industrial process, often involving leaching or washing with chemicals. Rehabilitation of these degraded lands is recognised as a high priority by the Chinese Government and by mining bodies, such as the China National Non-Ferrous Metals Corporation (CNNC). Australia, also a major mining country, has valuable experience to offer in reclaiming degraded land.

AusAID in co-operation with CNNC funded the setting up of the China-Australia Research Institute for Mine Waste Management (CARIM) within the Beijing General Research Institute for Mining and Metallurgy (BGRIMM), which is a part of CNNC. The Environmental Protection Section in BGRIMM became the home of CARIM. CARIM selected two copper mines as pilot project areas for tailings rehabilitation. At the Yuanqu copper mine, about 1000 km south

of Beijing in the Zhong Tiao Shan mountains, the objective was to create productive agricultural land from the modification of the tailings, and at Tong Ling, a major city 180 km south west of Nanjing, the 12 hectare tailings pond was to be made suitable for urban and park land.

Some of CARIM's many tasks revolved around the assessment of the qualities of the tailings which would limit their suitability for growing plants, be it crops as at Yuanqu or grasses and trees as at Tong Ling, and how these could be improved by adding other materials or by management. However, establishing cordial personal relationships between the Australians and the Chinese were just as important as the technical and scientific aspects of the project.

The tailings are the finely ground ore rock after the copper has been extracted by chemical means, and have the feel of a very fine beach sand but with a dark grey colour. They proved to be devoid of two of the three major plant nutrients, plant-available forms of nitrogen and phosphorus. Potassium, however, was present in adequate concentration because the ore rock contained minerals that release potassium to the water surrounding the tailings particles. Let's call this the "soil water". Like any sandy soil, tailings are unable to store much water and would have to be classed as droughty soils needing frequent watering to make plants grow. Spontaneous colonisation of the tailings by weeds was nil at Tong Ling and very sparse on the tailings deposited on the tailings dam itself at Yuanqu. It attests to the inhospitable environment for plants on these materials, especially the virtual absence of plant-available nutrients.

Also, because there was no clay fraction in the tailings to "glue" the mineral particles together as in most normal soils, they become dust-prone as soon as a wind arises. At Yuanqu, the villagers living downwind from the tailings dam had suffered badly for years by dust penetrating into every nook and cranny of their homes, creating bad feelings towards the mine. When there was a stiff breeze, visibility was limited to some 20 m!

We were fortunate in that the tailings at both locations consisted for about 30% of dolomite and lime so that "acid drainage" was never going to be a problem. "Acid drainage" consists of a mixture of water and sulphuric acid that has formed by the interaction of rainwater, oxygen and sulphide minerals in tailings or waste rock.

At both locations the only heavy metals of concern turned out to be copper and cobalt. Both these metals are essential to all animal life. For example, a cobalt atom occurs in each molecule of vitamin B12, and copper is essential to all plant life as well. Nevertheless, an excessive intake of copper and cobalt via the food chain is potentially dangerous to humans or animals. The real risks of toxicities occurring through the food chain from food grown on tailings must be evaluated right at the beginning of any rehabilitation strategy.

Fortunately, the geochemical behaviour of heavy metals in a soil environment and the uptake of them by plants has been studied for at least half a century by scientists all over the world, and we start with a good knowledge base. We could rely on previous work to predict that in the presence of lime and dolomite the copper and cobalt would remain largely inert in the tailings, their concentrations in the soil water would be infinitesimally small, and the plants would not be able to accumulate too much copper or cobalt in their tissues.

The problem for the Chinese is the difficulty of finding the information, as there are so few well-stocked scientific libraries with up-to-date books and journals, and, in many cases, because of inadequate mastery of the English language. Scientific books and subscriptions in the West are inordinately expensive by Chinese standards. A second problem is a tendency for local organisations to aim for complete self sufficiency, which creates a culture where one does not readily breach the "Great Wall" to visit another organisation which may have expertise, information or materials relevant to one's own work. This is where Australian scientists working with the Chinese can be helpful, especially if they have a habit of maintaining good personal links with colleagues, e.g. in CSIRO, the universities and international research bodies.

But back to the tailings. In many valleys between the mountains at Yuanqu there were prodigious quantities of loess deposits, which contained some 35% clay, which could be mixed with the tailings to create a better sand-clay mixture with improved waterholding capacity and capable of stopping the generation of dust. The loess also was very low in all heavy metals, including copper and cobalt, and low in nitrogen and phosphorus. Loess is a natural material originally deposited as a very fine dust over the landscape at the close of a

glaciation. There have been a number of glacial epochs in recent geological history. The soils that ultimately form from loess are highly fertile. It is no coincidence that the loess regions of China which receive good rainfall are heavily populated, and that the Ukraine, the Mid-West of the United States and the Pampas of Argentina have become the world's granaries. They are all on loess soils.

In the area around Yuanqu the Chinese themselves had already been quarrying the loess and covering some older tailings ponds with 1 to 2 m of it before re-commencing agriculture. Apparently, this method was immediately successful. However, their method involves a huge amount of earth moving. We thought that mixing the tailings with some loess could have the same beneficial effect at a fraction of the cost. All that needed to be added after that would be a heavy dose of nitrogenous and phosphatic fertiliser to establish an initial "capital" of nutrients in the "soil bank" so that the first crop would not exhaust the entire supply of nutrients in one year. Later on, by returning farm wastes to the rehabilitated tailings one can rely on cycling nutrients and only replacing what has been removed by the crop, lost in drainage water, or has become chemically unavailable.

At Yuanqu the four experimental treatments of the tailings were (a) a control without loess, (b) 15 cm of loess on top of tailings and mixed as well as we could with an ox-drawn traditional plough, (c) 30 cm of loess on tailings and mixed, and (d) 40 cm of loess cover without mixing with the underlying tailings. Superimposed on the control (a) and the loess only treatment (d) we experimented with three different green manures with the objective of using the first year of cropping to simply add organic matter, before cropping with edible crops the second year. All treatments received the same fertiliser application rate.

At Tong Ling it was not possible to obtain enough natural soil material to mix with the tailings, so all we could do was to apply fertiliser to entice the plants to grow. The experiments here involved different species of grasses, legumes and trees reputedly suitable for very sandy and high pH soils. Although the grass and legume seeds were largely imported, all species were indigenous or had been present for decades or longer.

In China even more than in Australia, life is not meant to be easy. At Yuanqu the cropping

season of 1994 started with good rains in April and early May but the summer was the driest for 30 years. The early growth was excellent, and two crops, which happen to require less water, peanuts and sorghum, gave yields as good or better than district average, but the maize was disappointing and the soybeans were a total failure. The peanuts produced quite well on the control with the fertiliser and without the loess. The soybeans grew lustily till they started flowering, but then the water gave out and the flowers never set seed. There is a picture of my counterpart, Zhou Lian Bi, standing triumphantly knee-deep in soybean plants, but little did he know how the story would end three months later. Elsewhere in the district the maize and soybeans were just as much a disappointment. Quite fortuitously, an article explaining the different physiological responses of soybeans and peanuts to drought appeared in "Nature", one of the most prestigious British scientific journals, in November 1995, which we copied for the Chinese. Now we know what to expect from soybeans.

The initial response of the Yuanqu mining company officials was to regard the whole rehabilitation scheme a failure. China has been a command economy for a long time. If you don't achieve the result you were commanded to achieve, you have failed! My counterpart, Mr Zhou Lian Bi, a young university-trained man, and I had an arduous task in convincing them that, if in the first year we could equal the average productivity of the district, even if that happened to be very low in a drought year, we were doing very well! In the end we did convince them. All in all we had plenty of good publicity, and became very friendly with the company's television producer, Mr Huo Dong Yue. Yuanqu is a company town and the company seems to have its own transmitter and airs a number of its own programs.

Through Mr Huo I was asked "Would I write an article about the rehabilitation for the Yuanqu newspaper?" "Of course, I would be only too happy." So the Yuanqu News of 5 November 1995 on page 3 has an article on rehabilitation linked to the idea of people taking responsibility for protection of their environment as part of a world-wide perspective, and to civilisation in general. A Buddha-like photo of the author, who was paid Renminbi 50 for his effort, smiled serenely at the reader.

It was a welcome opportunity to find out if the Chinese liked the definition of a civilised person as someone who, out of his own convictions and

awareness, takes responsibility for the well being of his/her world in the broadest sense of the word, although I also linked it to environment protection. Also one could test the idea that in spite of cultural differences some fundamental human values are universal. For example, in the article I said I had asked my Australian first year students once, in Socratic fashion, if they liked being physically or verbally abused. The answer was a unanimous "No.". I repeated the question, asking if anyone had any friends who liked that. "No" again. Did they think any persons in Finland or Uruguay (you name the country) enjoyed being abused. Once again "No.". Then I asked them if perhaps one could conclude that human dignity is a universal requirement for a happy life, and should we not all defend it? Should we not abandon a tribal psychology where the only moral values are absolute loyalty to your own group and obedience to your chiefs, and you can do anything you like to someone who belongs to some other group? I did that after Paul Keating and Gareth Evans were excusing human rights abuses in Asia by saying that peoples' cultures vary, and what we in Australia don't find acceptable is not necessarily seen the same way somewhere else.

The Chinese people have suffered horrendously during the civil war, but especially during the Cultural revolution. The many millions of victims know very well that abuse, torture, jailing or executions took place for no reason at all, except power politics and popular hysteria. Somehow, raising these principles had the same effect in China as they had in my Melbourne class: they strengthened the friendships.

Back to the food chain. When we harvested the produce and had it analysed it contained no more copper than did the seed used for the experiment, which presumably was grown on normal soils. There was a slight increase in cobalt in the produce compared to the seeds, but when this was modelled in a sophisticated toxicological risk assessment model RISC-Human, developed in The Netherlands, it was predicted that the produce posed no danger to people consuming it.

The following years were all relatively dry. In 1995 no rain fell after the beginning of May. Rain was needed to fill out the ears of the winter wheat during the final growth phase, but it stayed away, severely depressing the yield when the wheat was harvested on 8 June. District yields were less than half normal levels, but the best experimental plot produced almost at the

same level as the district average. Peanuts again produced well on the tailings with just fertiliser added. One of the three types of green manures, Sudax, produced a notable positive effect, and this effect lasted even in the subsequent winter wheat planted in the autumn of 1995 and harvested in June 1996.

The experiments at Tong Ling proved that deficient nutrient levels were the chief limitation to plant growth. All areas where fertiliser had been placed, around the tree planting holes, and where it washed off the experimental plots onto pathways and buffer strips, were suddenly invaded by weeds. The experiments also suggested that the tailings were quite sterile, lacking in soil micro-flora, as the legumes failed to establish themselves. Clovers and lucerne, etc., require specialised nitrogen-fixing bacteria living in symbiosis in spongy nodules on the roots to obtain their nitrogen, while the nitrogen fixers obtain their food from the plants. In the spring of 1997 we tried legumes again, this time mixing the seed with the right bacterial inoculants, and my counterpart reports that the clovers have become established very well this time.

In April 1996 two hectares were sown to a mixture of suitable grass species and clovers on that part of the tailings pond that had become dry enough. In April 1997 this looked like a beautiful green expanse flanked by the remaining 10 hectares of grey bare sand. The green area had become a nocturnal foraging area for hares, whose droppings were visible everywhere, and the home of a larch. During the sunny mornings the larch could be heard singing, high in the sky, invisible, until it descended towards its favourite clump of grass. The Tong Ling mine officials grasped the fact that there had been a very real change for the better in this environment.

Our work had shown that turning the tailings into a suitable soil for plants was amenable to a logical process of analysis and strategy, that it was feasible at acceptable cost, and in some cases might only require the addition of fertiliser. Growing peanuts on fertilised tailings at Yuanqu would even pay for itself.

No foreign co-operative project achieves its goals unless there is real friendship between the parties. We were lucky that mutual respect and friendship between the Chinese and Australians developed early. For example, the TV producer of the Yuanqu mine, Mr Huo, invited us to his home on several occasions in the evening and

we discovered that he had a young daughter with excellent musical skills and the family had a piano in their tiny apartment. Huo Ren was only 10 years old but played with a great deal of technique and enthusiasm. When we next visited Yuanqu, we brought cassettes with piano music played by famous musicians for her to hear their style. I also brought a cassette of Beethoven's piano trio "The Archduke", a favourite of mine with its dignified, tender passions and reflective qualities. When it was played on the Huo family hi-fi system, Huo Ren became totally absorbed, her little hands moving with the rhythm. Beethoven has been dead for 170 years but he still speaks clearly to a Chinese girl who had not truly met him before! There must also be something universal in the ability of people to understand and feel what music conveys.

However, no cultural exchange is a true exchange unless both parties gain. We learned from the Chinese and better understood their very difficult recent history. I discovered that the old Chinese philosophers tended to concentrate on ethics and human conduct, where our own Greek and Roman philosophers thought much about the nature of matter and atoms, the earth and the universe, and religion. The Greeks and Romans still are very much part of our cultural heritage today and their contributions to western science sowed the seeds for this rehabilitation. Confucius, who died in 479 BC, 10 years before Socrates was born, has much of value to say to us inhabitants of greedy, materialistic societies. Only an aware, civilised and free spirit would say:

"failure to cultivate moral power, failure to explore what I have learned, incapacity to stand by what I know to be right, incapacity to reform what is not good - these are my worries".

Would it not be good if more people in Australia today, where the distance between rich and poor is increasing, and the rich appear to condone or even promote the trend, had the same worries?

The glory of being alive today is the accessibility of other cultures through working and living with other peoples and seeing the world as one. I was so privileged in being part of this fascinating Project.