Discovering Chinese Mineral Drugs

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The Chinese have been innovative for millennia, providing the world with paper, the printing press, gunpowder and the compass. China also has developed, largely by trial and error, a traditional system of medicine that has been used by billions of patients. Despite the enormous population that has been, and still is, served by this system the rest of the world has been very hesitant to accept that it has much to offer. Slowly, acupuncture is growing in acceptability. So, too, are the use of certain Chinese herbs, such as ginseng. Nevertheless, it seems logical to expect that much more can be gained from the open-minded, yet scientific, evaluation of Chinese medicines. This article is a tentative step in this direction. Its brief descriptions of the more commonly used stone drugs are designed to encourage their further evaluation and to raise the possibility that they may have potential far beyond their use in traditional Chinese medicine.

The majority of Chinese stone drugs are naturally occurring minerals, such as pyrite (Pyritum) or cinnabar (Cinnabaris). However, some are manufactured by the processing of minerals. Included in this second group are mirabilite (Mirabilitum Depura-tum) and calomel (Calomelas). In addition, a few stone drugs consist of animal fossils. These are often referred to by the Chinese as dragon's teeth (Dens Draconis), or dragon's bones (Os Draconis).

Some traditional Chinese stone drug treatments involve potentially toxic minerals such as minium (Minium), which has a high lead content; cinnabar (Cinnabaris) and calomel (Calomelas) that contain mercury; and realgar (Realgar) which is rich in arsenic. However, because overdoses of these substances easily can produce serious adverse side effects, their medical use is not promoted here. Indeed, it is recommended strongly that readers avoid all attempts at self-diagnosis and treatment. Chinese stone drugs, like Western drugs, should be taken only on the advice of a well-trained and certified physician.

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Origins of stone drugs

Most stone drugs or, as they are often called, mineral drugs, are composed of inorganic compounds, although amber (Succinum), fossilized tree resin, is an exception to this general rule. So, too, is cow-bezoar (Calculus Bovis), produced from stones found in the gallbladder of the domestic cow. Typically mineral drugs, however, are formed by a variety of geological and geomorphological processes that result in aggregates of several minerals. This is not invariably true, since single crystals of white quartz are also used in traditional Chinese medicine (Yang, 1990).

Minerals that are of value as drugs are formed under a wide variety of geological conditions in many types of igneous, metamorphic and sedimentary environments. They are created also in hydrothermal replacement deposits and in veins (Chesterman and Lowe, 1978; Deer et al, 1992). To illustrate, many minerals are formed when igneous rocks slowly crystallize from molten magma. Some of these are rich in trace elements that are essential to humans, such as selenium, nickel, vanadium and cobalt. Magnetite (Magnetium), from such sources, for example, is often enriched with vanadium. Pegmatites, igneous rocks with extremely large grains, frequently contain well-formed minerals that include various rarer elements such as beryllium, lithium, rubidium, zirconium and cesium, some of which are known to impact on human well-being (Kirschmann and Dunne, 1984). To illustrate, mica (Muscovitum), derived from pegmatites and used as a stone drug, is usually enriched with lithium and zirconium.

Many useful mineral drugs also are produced in hydrothermal veins, that is in joints

and fractures that are filled with minerals precipitated from hot water. Most such hydrothermal deposits are associated with igneous intrusions, large bodies of underground magma. They usually include sulphides of numerous metals such as those of iron (pyrite), lead (galena), zinc (sphalerite), mercury (cinnabar) and copper (covellite, chalcocite and chalcopyrite). Specific elements are more common in minerals precipitated at particular temperatures. To illustrate, quartz which is deposited from moderate temperature solutions tends to be enriched with tungsten and tin, while cinnabar which is formed at lower temperatures may contain lead, silver and silicon.

Some stone drugs such as pumice (Pumez), a form of volcanic glass containing abundant feldspars and quartz, are produced during volcanic eruptions. White rocksalt (Sal-ammoniac) also is found in volcanic environments.

Several significant Chinese stone drugs are formed by regional metamorphism, associated with high temperatures and pressures, which transforms deeply buried rocks of every type. Such metamorphism leads to the recry stallization of minerals and enlargement of crystals. Both chlorite-schist (Lapis Chloriti) and actinolite (Actinolitum) are metamorphic rocks produced in this manner that are used in traditional Chinese medicine as drugs.

Contact metamorphism occurs on a smaller scale and results in the alteration of rocks that are near the margins of igneous intrusions. Recrystallization and the formation of new minerals also can occur in such environments. Stone drugs that are associated with contact metamorphism include ophical-cite (Ophicalcitum), magnetite (Magnetium) and actinolite (Actinolitum).

Many stone drugs are formed also in sedimentary environments. Pyrolusite (Pyrolusitum) and hematite (Ochra Haematitum), for example, are colloidal sedimentary minerals that are widely used in Chinese medicine. Coral calcite (Corallium), created by coral polyps by abstracting calcium from sea water, is an example of a biochemical sedimentary mineral that is used as a drug. Gypsum (Gypsum Fibrosum) and halite (Halitum), chemical sedimentary minerals, precipitated by supersaturated solutions, such as those formed in desiccating salt lakes also are used medicinally. In addition, some fossils are utilized as stone drugs. These include fossilized mammal bones, known to the Chinese as dragon's bones (Os Draconic), in which all soft tissues have been transformed, being replaced by either calcium carbonate, or clay minerals (Zhang, 1988; Yang, 1990).

History of Chinese stone drugs

Knowledge of the medicinal value of minerals and other stone drugs has developed gradually in China, over a period of at least 2,000 years. Fortunately, because China has a far more comprehensive collection of ancient literature than does the West, it is possible to trace this growth of awareness in the written record.

Although there is overwhelming evidence that the Chinese mined minerals during the Shang (1766 - 1122 BC) and Zhou (1122 -256 BC) dynasties, the first record of their medicinal use can be found in the *Shan Hai Jing.* This comprehensive geography of China was written on silk scrolls, during the period 475 BC to 8 AD. Included within it are descriptions of 51 herbs, 66 medicines derived from animal sources and 2 stone drugs. In each case, the volume provides details of the sources of the medication, the types of illness that it should be used for and the beneficial effects that the physician might expect from its application.

Our knowledge of the early use of stone drugs by the Chinese increased markedly in 1973 as the result of the excavation of the tomb, in Mawangdui, Changsha, of the wife of a provincial ruler. Her burial place contained a very well preserved mummy, and numerous artifacts which included a variety of books dating from the West Han Dynasty (206 BC - 24 AD). Several of these volumes made reference to traditional Chinese medicine. Together they included 52 prescriptions, each of which was a combination of herbs, and/or animal or stone drugs, called formulae in this article. In total, the books from the West Han Dynasty tomb provided information on 242 types of medication, 20 of which were stone drugs. Recently this medical information has been abstracted and republished in a book logically entitled *Fifty-two Prescriptions* (Mawangdui Group,

1977).

Despite the extensive nature of the information obtained from the West Han Dynasty tomb, there is evidence that other stone drugs were in use during the Qin (221 - 207 BC) and Han (206 BC - 220 AD) dynasties. This is provided by *Shen Nong's Herbal Classic,* a book which listed 365 medicines, 46 of which were derived from minerals. This volume also provided details of the source, properties and effects of each stone drug and described details of the chemical reactions that could be expected to occur if such drugs were heated (Shen, 1986).

The development and use of Chinese stone drugs was related closely to the practice of alchemy. To illustrate, Ge Hong's (281 -341 AD), book *Bao Pu Zi's Inner Treatise* dealt primarily with chemistry and related alchemy, but also included some insights into the use of minerals in medicine. Ge Hong, for example, described the medicinal value of gypsum (Gypsum Fibrosum), alum (Alumen) and magnetite (Magnetitum).

Growing evidence of the continuing Chinese interest in stone drugs was again provided when Tao Hong Jing (452 - 536 AD) revised *Shen Nong's Herbal Classic* to produce a new volume which he called *Records of Famous Physicians.* This improved edition included details of a further 365 medicines which had not been mentioned in Shen Nong's original publication. Thirty-two of those were stone drugs. Tao Hon Jing also emphasized the necessity of breaking and grinding minerals before their use. Relatively soon afterwards, Lei Xiao published his pharmaceutical review entitled *Lei's Treatise on the Preparation of Traditional Medication.* This book described the methods used to prepare various mineral medicines, such as cinnabar (Cinnabaris), mica (Muscovitum), in great detail.

During the Tang Dynasty (618 - 907 AD), Su Jing and co-authors compiled the first officially sanctioned Chinese pharmacopeia. Published in 659 AD and known as *The Newly-Compiled Materia Medica,* this book recorded 844 types of traditional medications, 83 of which were stone drugs. Several other relevant books were published during the Tang dynasty; one of these entitled *Stone Medicines* was the first to focus entirely on the value and use of mineral drugs. This was written by Mei Biao and appeared in 818 AD. It listed 62 types of inorganic chemical substances currently used in medicine. This book also tried to throw light on terminology by classifying and standardizing the names to be applied to stone drugs. During the Tang Dynasty, Sun Simiao also explored the use of geological substances in the treatment of illness. In about 682 AD he authored both *Essential Prescriptions Worth a Thousand Gold* [of Great Value] and *A Supplement to the Essential Prescriptions Worth a Thousand Gold* [of Great Value]. Similarly, in 752 AD Wang Tao compiled *The Medicinal Secrets of an Official;* while Chen Zangqi produced a *Supplement to the Materia Medica.* In addition, Li Xun was responsible for writing an *Overseas Materia Medica,* which described medicines being imported into China. A review of all these medical publications shows that 104 types of stone drugs were being used by Chinese physicians during the Tang Dynasty.

Chinese knowledge about the value of stone drugs continued to increase during the Song-Jin-Yuan period (960 - 1368 AD). To illustrate, the *Kaibao Herbal Book,* which appeared in 973 AD, described nine types of new stone drugs that apparently were not used during the Tang Dynasty. The *Jia You Materia Medica,* which was produced in 1056 AD, added eight more, while the *Illustrated Materia Medica* added a further three and the *Rihuazi Materia Medica* eight more. These books not only increased the number of stone medicines that were known to physicians, but also provided detailed descriptions of their properties, functions and most effective use. Two further publications of note during the Song-Jin-Yuan period were the *Amplified Materia Medica* of 1116 AD which added 472 types of drugs which had not been mentioned before in the medical literature, 69 of these were mineral preparations. Similarly, the *Classified Materia Medica,* compiled by Tang Shenwei in 1 108 AD. made reference to 1455 medicines, 215 of which involved the use of stone drugs (Shen, 1986).

During this period, there appears to have been very widespread use of mineral medicines to treat a variety of illnesses, including drugs that could produce adverse side effects. To illustrate, white arsenolite

(Arsenicum Triosidum) which contains high levels of arsenic was being prescribed for malaria, dysentery, hemorrhoids and scrofula; while cinnabar (Cinnabaris) was used to treat pinworm. There must have been a major demand for stone drugs during the Song-Jin-Yuan period because the Chinese had to import minerals for medicinal use from several other countries. Such imports included borax (Borax), sulphur (Sulfur), cinnabar (Cinnabaris) and fossilized bones (Os Draconis).

In 1590, during the Ming Dynasty (1368 - 1644 AD), the great medical scientist Li Shizhen produced the *Compendium of Materia Medica* which listed 1892 medicinal substances, 19 per cent, that is 355, of which were stone drugs. This publication provided a detailed description of each mineral's name, source, method of collection, shape, colour and lustre. In addition, Li Shizhen gave information on the processing, chemical characteristics, taste, toxicity, application and dose of each stone drug.

This may have been the peak of stone drug use in China for, unfortunately, during the Ming Dynasty, alchemists actively began promoting a mineral pill, called the longevity gold pellet, which was supposed to retard aging and increase lifespan. Of course it did not work. Worse, it contained numerous toxic heavy metals including mercury and lead and those taking it, including some members of the Imperial Family, often died violently. As a consequence, the popularity of all stone drugs declined rapidly in China. Despite this setback, research continued into mineral medicines during the Qing dynasty (1644 - 1911 AD), although only 38 new drugs were discovered, none of them of great significance (Shen, 1986).

During the twentieth century, epidemiological research generally has emphasized the adverse effects of heavy metals on human health. As a consequence, many inorganic medications have tended to be viewed with suspicion. To illustrate, while the pharmacognosy compiled by Nanjing Pharmacy College (1977) listed 794 medicinal substances, only 58 of these were minerals. Similarly, the *Chinese Dictionary of Materia Medica* produced by the Jiangsu New Medical College (1977) included 5767 traditional Chinese medicines of which only 82 were stone drugs. This decline in the status of mineral drugs has been paralleled by a fall in their importance in internal Chinese trade, where they now account for only some 4 per cent of total shipments of traditional Chinese medicines.

Recently, however, a resurgence of stone drugs use seems to be occurring in China. There are many reasons for this. Medical geographers, for example, have identified numerous endemic illnesses that appear to involve mineral imbalances and may be prevented or cured through the use of mineral drugs (Tan, 1989). In addition, chemical analysis now can ensure greater stone drug purity, so reducing the chance of accidental adverse side-effects. In addition, scientific evidence of their value is growing. To illustrate, experiments continue to be conducted with animals and in clinics to scientifically test the efficacy of numerous mineral medicines that have been used traditionally by Chinese physicians.

The processing of stone drugs

It is apparent from the literature that has been described previously that Chinese physicians traditionally have modified stone drugs to decrease their adverse side effects. It is very important to understand how such drugs have been processed, since their properties and hence their use can be altered by these techniques. To illustrate, raw untreated fossil bones *(Os Draconic)* are used as a tranquillizer, while calcined fossils, that is those which have been heated strongly, appear valuable in reducing fevers and promoting the healing of wounds.

Four major stone drug processing methods currently are used, namely powder refining, recrystallization, calcining and tempering (Zhang, 1988). Each will be described now in some detail.

1. Powder refining

The aim of this process is to produce the stone drug in a very finely powdered form. This goal is achieved by mixing an insoluble stone drug with water and grinding it. The resulting powder then is placed in a pot which contains clean water. The higher settling velocity of large particles encourages them to fall to the bottom of the vessel, while finer particles remain in suspension.

The coarse particles may or may not be reground and added to the suspension. This process is repeated several times by transferring the water from vessel to vessel. On each subsequent occasion the suspension is left longer in the pot to allow smaller particles to settle out. Then they may be reground. Eventually only very small grains remain in the liquid. These are left to settle out as a fine powder which is used for medicinal purposes. In addition to producing a very finely powdered stone drug, this process also increases purity since the density of heavy metals encourages their early sedimentation and these are discarded.

The value of powder refining has been known for centuries. In 1590, for example, Li Shizhen in his *Compendium of Materia Medica* wrote that cinnabar should be used in treatment only after it has been refined three times in water. He pointed out that the residues resulting from the powder refining of this mineral should not be reused, since they consisted of impure stones and iron filings.

2. Re crystallization

Recrystallization is used to improve the purity of soluble stone drugs, such as mirabilite. In this process the drug is crushed and dissolved in water. More material is then added to the liquid until it becomes saturated. At this point the temperature of the solution is altered either by cooling the solution with ice, moving it to a room of lower temperature, or heating it to accelerate evaporation. In each case, the objective is to induce supersaturation and recrystallization of the required drug. Once this has occurred the remaining solution, often containing impurities, is discarded and the recrystallized material is collected for medicinal purposes.

3. Calcining

Hydrates are minerals, such as gypsum ($CaS0_4$ $2H_20$) and alum ($KA1$ $(S0_4)_2$ $12H_20$) that include water molecules in their crystal structure. When such substances are used in traditional Chinese medicine, their potency often is increased by a process known as calcining. Its objective is to alter the chemical composition of the mineral by removing the crystal water.

This can be achieved in two distinct ways. Either the substance is heated strongly to drive off the water, or it is left exposed to the atmosphere. In the latter case, eventually the mineral will weather and become dehydrated. The time taken for this to occur depends upon both temperature and humidity.

4. Tempering

Many stone drugs are subjected to a process termed tempering before their use. This makes minerals easier to grind and generally alters their chemical composition, so increasing their potency. Tempering involves heating the mineral over a smokeless fire until it is red hot and then plunging it into either cold water or into vinegar. Traditional Chinese medicine recognizes three types of reactions which occur when different stone drugs are subjected to tempering. These are termed decomposition, salt formation and compound reactions.

(i) Decomposition

Minerals which are composed largely of carbonates of calcium and/or magnesium and/or zinc frequently are subjected to tempering. These include ophicalcite ($CaCo_3$ and $MgC0_3$), calamine ($ZnC0_3$), stalactites and fossils (which are composed mainly of calcium carbonate). The tempering of such minerals alters their chemical composition, typically by driving off carbon dioxide and increasing the percentage of metal oxide that they contain. To illustrate, the amount of zinc oxide in tempered calamine usually is between 13 and 26 per cent greater than in the unprocessed mineral. These changes in chemical composition, caused by tempering, can improve the potency of stone drugs. Unprocessed ophicalcite (Ophicalcitum), for example, is used to treat both external and internal bleeding but its tempered form, with its higher content of calcium and magnesium oxides, is more effective in stimulating coagulation and reducing blood pressure. It is preferred, therefore, for the treatment of wounds and blood loss.

(ii) Salt Formation

Certain minerals, such as hematite, magnetite and limonite, react with vinegar in the tempering process to form iron acetate. In

traditional Chinese medicine this is used for the treatment of anemia because it is believed that in this form iron is absorbed more easily by the body.

(iii) Compound reactions

Some minerals, such as pyrite, undergo a variety of different chemical reactions when subjected to tempering. These may include oxidation, decomposition and salt formation. Tempered pyrite (Pyritum), for example, tends to become richer in ferrous sulphide, which is taken internally to speed the healing of bone fractures.

Stone Drugs and the prevention and treatment of disease

During the past 2000 years, the Chinese have identified some 350 mineral drugs with medicinal value. Approximately 60 of these are still commonly used. However, they are prescribed alone rarely, but are mixed with other components. In this way, these 60 mineral drugs are combined with herbs and/ or animal products to produce approximately 10,000 formulae (recipes) which have been developed, over millennia, to treat specific diseases.

This process of mixing and combining herbs and stone and animal-derived drugs makes it extremely difficult to evaluate individual components. However, if stone drugs are to be used more widely, their value must be established scientifically. For this reason, in the discussion which follows, emphasis is placed on instances which provide evidence of the efficacy of particular stone drugs. However, it is stressed again that in traditional Chinese medicine, the patient would normally receive such stone drugs as part of a formula, that is as one component of a complex mixture of medicinal substances. It is possible, therefore, that an analysis of the apparent value of individual components of such formulae may fail to uncover synergistic relationships that occur when they are mixed together.

Endemic disease

Endemic diseases, such as goitre and fluorosis, are caused mainly by dietary excesses or deficiencies of bulk and trace elements. Traditionally such diseases have been widespread in China because of geochemical imbalances in the soils and the great reliance on locally produced food, which tends to exacerbate their effects. Since stone drugs are excellent sources of many of the bulk and trace elements involved in such endemic diseases, it is not surprising that they have been of value in their prevention and treatment.

(i) Goitre

Simple endemic goitre is an enlargement of the thyroid gland, causing a swelling in the front part of the neck. It is due normally to insufficient iodine in the diet, although an excess of this trace element also may be linked to this condition (Tan et al, 1990). The administration of iodine cannot cure simple goitre, but can prevent most cases and can stop an existing goitre from enlarging. Seaweeds, which have a high iodine content, traditionally have been used in Chinese medicine to prevent and treat goitre. In addition, some goitre-related formulae include the stone drug pyrite (Pyritum). This consists predominantly of iron disulphide (FeS_2).

To evaluate the efficacy of pyrite, the Shaanxi Institute for the Prevention and Treatment of Endemic Disease (1986) selected two villages in that province which had similar goitre prevalences. One of these villages was used as a control. In the other, baskets of pyrite were hung in all water wells. Approximately 7 kilograms of pyrites were used for each cubic metre of standing water. At the end of the first year, the pyrite was renewed. After 30 months, the prevalence of goitre in the control and experimental villages were compared. It was found that in the control settlement, 81 new cases of goitre had developed amongst the 378 individuals who had been free of this disorder when the experiment began. That is 27.6 per cent of the previously healthy population had developed goitre. In contrast, in the experimental village 51 (18.8 per cent) out of 322 formerly healthy individuals now had the disorder. Furthermore, in the experimental group, improvement was noted in 55.7 per cent of those who suffered from goitre when the experiment started. This compared with a 38.9 per cent improvement rate in the control group. In addition, while 50.0 per cent of the old

goitre cases had worsened in the control group, deterioration had occurred in only 31.6 per cent of the previously existing goitre cases in the experimental village. While these results are far from totally convincing they do indicate that pyrite may have some therapeutic effect on goitre. If so, the mechanism involved is unknown and clearly requires further study.

(ii) Endemic fluorosis

Fluorosis is endemic in many regions of China, where it is caused most commonly by the ingestion of excessive amounts of fluorine from drinking water. Typically, it is associated with a mottled discolouration of the enamel of the teeth and can lead to combined osteosclerosis (the production of abnormally dense bone) and osteomalacia (impaired bone mineralization).

Borax (Borax) ($Na_2B_40_710H_2$) obtained from dry salt lakes, has been used for centuries in Chinese medicine. Animal experiments have established that boron, its main component, has value in the treatment of fluorosis (Bear et al, 1977; Elsair et al, 1979). More recently, Fan and her colleagues (1987) have conducted an experiment which suggests strongly that borax may be a very effective treatment for endemic fluorosis in humans. Thirty-one patients suffering from endemic fluorosis were given borax in tablet form. After a maximum of 6 months treatment, 5 individuals appeared completely free of any symptoms of fluorosis, 12 more showed very obvious signs of improvement and had recovered much of their mobility, while a further 13 patients displayed an abatement of symptoms. Only one fluorosis case appeared to be resistant to borax treatment. Biochemical experiments further demonstrated that boron (derived from the borax) was able to inhibit fluorine absorption by the intestinal tract, reduce its toxicity and mitigate the hyperparathyroidism normally linked to fluorine excess. Such abnormally increased activity of the parathyroid glands, found in sufferers of fluorosis, usually causes excess calcium loss from bones and abnormally high secretion of calcium and phosphorus by the kidneys.

(iii) Kaschin-Beck disease

Kaschin-Beck disease is characterized by necrosis of cartilage and dystrophy of skeletal muscles. It is endemic amongst the inhabitants of a broad belt which extends from northeast to southwest China (Tan et al, 1990; Tan, 1989). While its etiology, as yet, is unclear it has been established that it is particularly common in selenium deficient regions, especially those where white muscle disease in widespread amongst livestock (Hou and Zhu, 1982). As a consequence of this insight, the Chinese have begun a series of selenium supplementation programs.

In Bin county, on the Loess Plateau, efforts have been made to reduce the incidence of Kaschin-Beck disease in seven villages by adding selenium to fertilizers (Chen et al, 1988). The fertilizer used consisted of 12 per cent nitrogen, 20 per cent phosphorus and 0.05 per cent selenium. Approximately 150-200 kilograms per hectare of this fertilizer were applied in the autumn of 1986. This resulted in the addition of roughly 2,000 grams per hectare of sodium selenite to the soil, which was then planted with wheat. Prior to fertilization in this manner wheat crops contained some 6.6 ppb selenium. In contrast in 1987, levels has risen to 79 ppb selenium, dropping to 48.8 ppb in 1988. That is, the fertilizer had increased selenium levels in the wheat crop some 7 to 12 times. As a consequence, daily selenium dietary intake in the local area increased from 3.2-6.7 micrograms to 21.2 micrograms. Levels in children's hair rose from 82.3 ppb to 294 ppb (Chen et al, 1988).

The health benefits of this experiment were obvious. All children between 3 and 15 years old were x-rayed in the villages taking part and in a similarly affected control group of settlements. In the area receiving additional selenium, 1 1.56 per cent of the children had recovered from Kaschin-Beck disease, and a further 32.78 per cent showed improvement. In the control group, nobody had recovered completely and only 8.15 per cent of the children showed any improvement. There was no deterioration and no new cases in the experimental group; while 13.50 per cent of the controls had deteriorated and 1.52 per cent of them had developed Kaschin-Beck disease.

Similar experiments have been conducted by research workers at the Institute for Prevention and Cure of Endemic Disease of Chengde Prefecture, Hebei Province (Guo et al, 1988). Some 150 Kaschin-Beck disease patients, aged between 3 and 13 years old, have been treated daily with one of three selenium compounds; either selenium-enriched yeast, organic selenium oxalic acid, or inorganic sodium selenite. After six months their recovery rates were found to be 66.67 per cent, 58.02 per cent and 40.84 per cent respectively.

A further successful experiment with selenite-supplemented salt was conducted in Linyou county, Shaanxi province from September 1980 through July 1981. Forty-six children suffering from Kaschin-Beck disease repeatedly were given salt containing sodium selenite. Eighty-nine further children were used as controls. X-ray monitoring showed that some 79.17 per cent of the experimental group improved, while only 17.14 per cent of the controls did so. No additional cases developed in those children eating selenium fortified salt, while two new cases of Kaschin-Beck disease were discovered amongst controls.

Kaschin-Beck disease is widespread in the selenium deficient regions of China, yet does not occur in Finland or New Zealand, despite the fact that selenium intake in these countries also is depressed. It would appear, therefore, that this disease involves at least one other trigger mechanism. The Chinese are very aware of this possibility and are searching actively for additional interacting factors. Numerous suggestions have been made, these include deficiencies of vitamin E, methionine, molybdenum and zinc and excesses of protein, copper, cadmium, manganese, iron, strontium and barium (Yang, 1987; Li, 1988; Li et al, 1988).

It is also possible that sulphur and/or calcium deficiencies may play a role in the etiology of Kaschin-Beck disease. Li (1981), for example, observed that in many regions where this disease was endemic, soils and drinking water were very deficient in both of these elements. He decided, therefore, to test the effects of adding gypsum (Gypsum Fibrosum) ($CaS0_42H_20$) to the water supply. Two comparable villages were selected for this study, Kaschin-Beck disease being common in both. In one settlement, gypsum was placed in linen bags and added to each home's water tank. One kilogram of gypsum was used for each cubic metre of water. No changes were made to the water in the control group village.

In the experimental village, after five years, 54 (40.3 per cent) of the 134 individu-als who had originally suffered from Kaschin-Beck disease were considered cured clinically. In contrast, only 7 (9.3 per cent) out of the 72 cases of the disorder in the control village were cured. This difference was statistically significant (p 0.01). In addition, only one new case of Kaschin-Beck disease occurred in the experimental village, while 9 additional cases were diagnosed in the control settlement (p 0.01). The evidence from these experiments suggests, therefore, that the stone drug gypsum (Gypsum Fibrosum) may have a valuable role in the prevention and treatment of Kaschin-Beck disease.

As shown by Wang (1972) this may be true also of mirabilite (Natrii Sulphas) (Na_2S0_4 $10H_2O$). This research worker treated 117 patients with Kaschin-Beck disease by giving them 2 grams of this stone drug orally twice a day. One month later, 87.1 per cent showed some remission of joint pain, improved joint function and a greater ability to undertake manual work. These results are suggestive of a valuable role for mirabilite in the treatment of Kaschin-Beck disease.

Malignant neoplasms (cancer)

Cancer is a major health problem in China, causing some 700,000 deaths each year. Indeed in Shanghai, which has the highest accumulated mortality of cancer in China, between 20 and 25 per cent of the city's population can be expected to eventually die from this cause. Naturally, therefore, there is considerable Chinese research into ways of reducing cancer mortality. This has stimulated interest in traditional treatments for malignant neoplasms.

Jiangshi, concretions precipitated from groundwater, are one such widely used stone drug. The name describes their appearance and is translated as "ginger-like stone." They occur naturally, mainly in northern and northwestern China, where they are found in the

extensive loess deposits that mantle the plateau and hill regions. Many jiangshi, therefore, come from Shaanxi, Gansu, Hebei and Shangdong provinces. Although their chemical composition varies somewhat from region to region, they are dominated typically by calcium and silicon. According to Wang and colleagues (1983), jiangshi also contain a very wide variety of other elements. Details of the relative abundance of these can be seen in Tables 1 and 2. As shown by these two illustrations, jiangshi include numerous bulk and trace elements, such as calcium, iron, magnesium, potassium, sodium, manganese, zinc, cobalt, iodine, chromium, copper, selenium and boron, that might be expected to have an impact on human health.

Table 1. Major Constituents of Three Varieties of Jiangshi Origin and Composition (percentage by weight)

Element	Zhangxian Gansu	Shexian Hebei	Xingtai Hebei
Calcium	29.22	27.04	23.21
Silicon	8.31	10.07	13.22
Aluminium	2.04	2.28	2.99
Iron	0.99	1.11	1.44
Magnesium	0.42	0.73	0.59
Potassium	0.65	0.62	0.91
Sodium	0.42	0.54	0.60
Barium	0.18	0.17	0.15
Titanium	0.12	0.15	0.19
Manganese	0.022	0.021	0.025
Phosphorus	0.017	0.009	0.027
Strontium	0.019	0.020	0.024
Fluorine	0.06	0.07	0.06
Sulphur	0.008	0.008	0.008

Source: Wang et al (1983)

It is uncertain how long jiangshi have been used for the treatment of illness in China but the most interesting record of their medicinal application appeared in the *Collection of Medical Remedies for the Care of Health*, produced by the famous Chinese physician Liu Wansu, in Hebei Province, during the Jin Dynasty (1186 AD). This publication discusses the benefits of jiangshi, in the treatment of Qiye. In traditional Chinese medicine, the term Qiye is used to describe certain specific symptoms. It is applied, for example, when one is hungry and wishes to eat, but cannot, because food will not pass normally down the esophagus. To quote directly, "the food is trapped between the pharynx and the diaphragm and could be thrown up before entering the stomach." Generally it is believed that Qiye describes the symptoms typically experienced by patients with esophageal and, perhaps, gastric carcinoma. For this reason, since the 1970s, a series of experiments have been conducted in China, using jiangshi, in an effort to reduce the incidence of esophageal cancer.

Xingtai county, in Hebei province has one of the world's highest esophageal cancer mortality rates. To illustrate, during the period 1974 to 1976, annual male mortality from esophageal cancer was established at 1 11.69 per 100,000 (Gao et al, 1984). Even within Xingtai county, the incidence of esophageal cancer varied, with exceptionally high rates occurring in the west. It was in this western area that, in 1974, Gao, formerly the Director of the Xingtai Regional Institute of Medical Science, and his colleagues, began an experiment designed to explore the possibility of reducing esopha-

Table 2. The Minor Constituents of Three Varieties of Jiangshi

	Origin and Composition (parts per million)		
	Zhangxian	**Shexian**	**Xingtai**
Element	**Gansu**	**Hebei**	**Hebei**
Zinc	60	60	60
Cobalt	17	16	15
Nickel	16.69	16.75	14.85
Iodine	15	15	12
Vanadium	8.78	8.05	13.17
Chromium	3.42	6.84	10.26
Copper	3	1	1.1
Tin	1	2	2
Selenium	0.01	0.04	0.02
Molybdenum	0.2	0.35	0.95
Boron	1.15	8.07	1.04
Bromine	51	1	45
Tungsten (Wolfram)	0.18	0.71	0.73
Lead	0.9	1	1.1
Scandium	2.09	2.22	2.28
Beryllium	0.72	0.72	0.72
Silver	4.6	4.5	3.8
Tellurium	0.008	0.003	0.008
Arsenic	2	2	2
Uranium	0.55	1	0.7
Thorium	0.85	0.5	1.1

Source: Wang et al(1983)

geal cancer incidence, by modifying drinking water quality. The method used was to line wells with jiangshi, so that they were in direct contact with the water. One to two tons of jiangshi were used for every 5 cubic metres of standing water. Each year, these were removed and replaced by fresh concretions. As can be seen from Table 3, the results were extremely promising. The research area, in which water quality was being modified by jiangshi, in the five years prior to the experiment, experienced an average annual mortality rate from esophageal cancer of 275.28 per 100,000. During the first ten years of the investigation, the annual mortality rate, amongst those drinking jiangshi treated water, fell to 54.28 per 100,000, a more than 5-fold decrease. Although mortality rates also dropped from 156.86 to 1 12.84 per 100,000, in a control group drinking untreated water, this decline was far less impressive.

As can be seen from Table 4, the difference in cancer incidence between the two groups seemed to stem from a reduction of severe proliferation of esophageal epithelial cells, in individuals drinking jiangshi-treated water for prolonged periods. To illustrate, while 24.1 percent of a 220 member sample of the control group were found to be suffering from either esophageal cancer, or severe epithelial cell proliferation, only 9.9 percent of the 181 member sample of the experimental group had similar problems. The difference is significant statistically ($p < 0.01$).

A second method of altering water quality was used also by Gao and colleagues (1984). This involved dropping large quantities of jiangshi down drinking water towers, in Shahe, Lingjin and Xingtai counties, and in the suburbs of Xingtai city, Hebei province. One ton of jiangshi was added for each ten tons of water held by the towers. As can be seen in Table 5, during the five years prior to the addition of jiangshi to drinking water towers in these areas, the annual age ad-

Table 3. Changes in Esophageal Cancer Mortality in Parts of Western Xingtai, Before and After Changes in Well Water Quality Compared with Those of a Control Group

	Five years prior to experiment			Ten years after start of experiment			
	Cumulative Population	**Number of Deaths**	**Mortality per 100,000**	**Cumulative Population**	**Number of Deaths**	**Mortality per 100,000**	**Probability (P)**
Jiangshi experimental group (well water treated with jiangshi) 4,360	4,360	**12**	275.28	9,212	**5**	54.28	p<0.01
Control group (water untreated)	8,925	14	156.86	18,654	21	112.84	p>0.05

Source: Gao et al, 1984

Table 4. A Cytological Comparison of Population Samples from Hebei Province Drinking Treated and Untreated Water

Group	**Number of Cases with Severe Epithelial Cell Proliferation**				**Sample Positive Rate (percent)**	**Probability (P)**
	Esophageal Cases	**Size**	**Stage I**	**Stage II**	**Cancer**	
Jiangshi experimental group (well water with jiangshi)	**181**	**15**	**2**	**1**	**9.9**	p<0.01
Control group (water untreated)	220	**38**	**10**	**5**	**24.1**	p<0.01

Source: Gao et al, 1984

Table 5. A Comparison of Esophageal Cancer Mortality in Regions Where Drinking Water Towers Were Either Treated, or Not Treated, With Jiangshi

Group	Time Period	Cumulative Population	Number of Deaths	Mortality per 100,000	Age Adjusted Mortality per 100,000
Jiangshi experimental group (well water with jiangshi)	5 year period prior to addition of jiangshi	198,165	252	127.16	91.37
	3 year period after addition of jiangshi	120,554	109	90.41	68.37
Control group (untreated water)	Corresponding 5 year period	185,434	213	114.38	86.90 90.15
	Corresponding 3 year period	116,078	142	122.33	

Sourec: Gao et al, 1984

justed mortality from esophageal cancer had been 91.37 per 100,000. In the three years after such treatment, it dropped to 68.37 per 100,000. Clearly, there had been a substantial decline in mortality from this cancer. In contrast, during the same time period, the annual age adjusted death rate from esophageal cancer, in the control group, rose from 86.90 to 90.15 per 100,000. While tower water, treated in this manner, therefore appeared to be associated with a decline in esophageal cancer mortality, this was not as dramatic as in the previously described well water experiment. This may have been because the ratio of jiangshi to water was lower in the water tower experiment.

In a paper presented at the *International Symposium on Environmental Life Elements and Health*, held in Beijing in 1988, Zhu and An provided further evidence of the efficacy of jiangshi in reducing esophageal cancer mortality. They described how, in 1974, the existing wells of five villages, located in Xingtai, Hebei, with a combined population of 1048, had been treated with jiangshi, or replaced by new wells, which had been built with large quantities of these concretions. Prior to the resulting change in water quantity, each village had suffered at least one annual death from esophageal cancer. Since 1975, not a single case had been recorded in any of them.

In addition to the experiments of Gao and his colleagues in Hebei, there were at least two other brief mentions, in the Chinese literature, of attempts to reduce esophageal cancer mortality by using jiangshi. These experiments have taken place in Weinan county, Shaanxi province and Zhangxian county, Gansu province and both are claimed to have been successful. However, further details are, as yet, unavailable (Feng, 1984).

During their fieldwork, members of the Xingtai Regional Institute of Medical Science discovered that esophageal cancer virtually was unknown in the village of Xin Zhuang, in Shahe county. Nevertheless, this settlement was surrounded by areas with mortality rates of between 120 to 150 per 100,000. Cytological examinations proved that severe esophageal cell proliferation was limited to recent immigrants from nearby settlements and was unknown in long time residents. Indeed, folklore recorded only a single case of esophageal cancer mortality in permanent occupants of the Xin Zhuang. It was discovered that the village water well, serving this health island, had been drilled into a thick layer of jiangshi, which naturally modified the quality of local drinking

water (Gao et al, 1984).

While the evidence presented here does not prove that the addition of jiangshi to drinking water can prevent esophageal cancer, it is highly suggestive. Why this may occur, however, is unclear and several hypotheses have appeared in the literature. Zhao and colleagues (1985) have shown, for example, that jiangshi can reduce the concentrations of various metallic ions in solution. Those affected most included chromium, iron, gallium, bismuth and lead. Molybdenum and copper ions were also influenced to a lesser degree. It is possible, therefore, that the addition of jiangshi to drinking water reduces the impact of naturally occurring metallic carcinogens.

It is also known that, when added to water supply, jiangshi release high levels of mono-silicic acid (Wang et al, 1983). Liu and coworkers (1983) have argued that the drinking water in Shexian county, Hebei, an area which has age adjusted esophageal cancer mortality rates for males of 148.43 per 100,000 and 84.40 per 100,000 for females, is deficient in mono-silicic acid. In contrast, they suggest that drinking water in Changli county, Hebei, which has a male age adjusted esophageal cancer mortality rate of 7.79 and a female rate of 1.83 per 100,000, contains high levels of this acid. They argue, therefore, that it is jiangshi's ability to increase the mono-silicic acid levels of drinking water that results in reduced esophageal cancer mortality.

One of the current authors (Foster, 1986, 1989, 1990; Norie and Foster, 1989) has argued that, on a global scale, esophageal cancer tends to be more common in soft water areas. He has suggested that this may be because such waters are often deficient in both calcium and selenium. A lack of calcium appears to promote decoupling, the first phase in the process which can lead eventually to cancer of the esophagus (Garland et al, 1988), while selenium deficiency has been shown to enhance the deleterious effects of many carcinogens (Ip and Sinha. 1981; Passwater, 1980). It is possible, therefore, that the addition of calcium rich concretions, containing many trace elements, including selenium (Tables 1 and 2) increases the availability of these two elements and hence gives additional protection against esophageal cancer. Similarly, Zhu and An (1988) have suggested also that selenium deficiency is the main cause of esophageal cancer and that this problem can be remedied by adding jiangshi to the water supply.

Purple rock salt (Sal Purpureum) is another Chinese stone drug that has been used widely in the treatment of cancer, especially for that of the esophagus and nasopharynx. This material accumulates on the walls of lava caves in Qinhai and Tibet and is imported also into China from India. Chemical analysis indicates that it consists mainly of sodium chlorate but also includes iron, magnesium, sulphur and a variety of other elements.

Experiments conducted by a research group of Military Hospital No. 366 (1974) have shown that in mice a 10 per cent solution of purple rock salt can reduce significantly the growth rate of induced sarcomas. Rodents injected with a solution of this stone drug for ten days had tumours which, on average, weighed 1.03 grams, while those of a similar untreated control group weighed 3.24 grams.

Peng and her colleagues (1974) also have reported on the results obtained by the clinical application of purple rock salt to 635 esophageal cancer patients, during the period 1970 to 1973. Doses of between 1 and 3 grams were given three times daily for 15 days. After a three to five day respite, the next course of treatment was undertaken. Many patients received 10 to 20 courses. In two cases all symptoms disappeared and cytological examination could find no remaining evidence of cancer. Two years later these former patients were back at work and considered "cured". In six further cases the symptoms largely disappeared. X-ray analysis showed that their tumours had decreased in size by at least 50 per cent, an improvement that lasted for between one to six months. In 452 patients symptoms did not get any worse and x-rays indicated that their tumours had remained stable, or declined a little in size. This condition continued for one to six months after cessation of treatment. In 175 patients the use of purple rock salt proved ineffective. Clearly, the experimental evidence suggests purple rock salt may be valuable in the treatment of some

cancers, although the mechanism involved, as yet, is unclear.

Several other stone drugs traditionally have been prescribed for cancer by the Chinese. These include niter (Nitrum) which has been used to treat cancer of the liver, and arsenolite (Arsenicum Trioxidum) which is a treatment for cervical, breast and skin cancers. Unfortunately, such drugs may have toxic side effects and will not be discussed in detail.

Infectious disease

Some mineral drugs appear to have bacteriostatic properties. These include alum (Alumen), borax (Borax) and calomel (Calomelas). The latter is a coarse crystal of mercury chloride which again will not be discussed further because of possible adverse side effects associated with its use. Alum can also be very dangerous if used in large doses.

Alum, aluminum potassium sulphate ($KA1(S0_4)_2 12H_20$) is formed by the metamorphism of alkaline feldspar and is usually calcined before use. According to an entry in the *Chinese Materia Medica,* published in 1977 by the Jiangsu New Medical College, alum has been shown, in the laboratory, to have inhibiting effects on a wide variety of bacteria. These include Staphylococcus aureus, Bacillus proteus, Bacillus coli, Bacillus dysenteriae, Bacillus diphtheriae and Streptococcus viridans. It also appeared effective in inhibiting Candida albicans.

During the period 1970 to 1973 the Burns Department of Wuhan Medical College (1973) used a 0.75 per cent solution of calcined alum to treat 154 cases. These badly burned patients suffered far less infection from Staphylococcus aureus. Bacillus coli and Pseudomonas aeruginosa than had been previously the case in this institution. To illustrate, during the period 1961 to 1965, the wounds of 78 patients were tested for Pseudomonas aeruginosa. Cultures proved its presence in 35 cases. This procedure was repeated for a similar number of alum treated patients during the period 1970 to 1973. None of these had been infected by Pseudomonas aeruginosa.

Borax (Borax) also is known to be bacteriostatic. Tests carried out in the laboratory at Shandong Medical College (Zhang, 1959) established that this mineral drug can inhibit the growth of a wide variety of bacteria, including Bacillus pyocyaneus, Bacillus dysenteriae and Bacillus anthracis.

In addition, borax may have antifungal properties and has been used to treat dermatomyocosis, a superficial fungal infection of the skin, effectively. For example, Zhu and colleagues (1982) reported treating 333 cases of dermatomyocosis with a cream containing 20 per cent borax. Some 66.4 per cent of the patients were cured and a further 17.00 per cent showed improvement. An additional 240 cases were treated with a cream that included 15 per cent borax. Of these 75.4 per cent were cured and a further 17.1 per cent showed improvement. These clinical results strongly suggest that borax can inhibit the growth of certain fungi.

Mirabilite (Natrii Sulphas) also is very valuable in the treatment of common surgical infections. Zhang and colleagues (1984) described using a powder made of borneol (Borneolum) and mirabilite in the ratio of 1:10. Borneol is a crystalline organic compound obtained from the plant Dryobalanops aromatica, which is used as a pain reliever. In total, 230 patients were treated with this mixture which was wrapped in gauze and held in place with an adhesive plaster. They suffered from various infectious disorders, including acute mastitis, phlebitis, boils and abscesses. Zhang and coworkers (1984), reported that in every case the treatment proved rapidly effective.

In addition, Zhen (1956) has described the use of calamine (Calamina) to treat 39 patients who were suffering from acute conjunctivitis (inflammation of the eyelid membrane). Each was given 0.1 gram of calamine once daily, until their condition disappeared or stabilized. Zhen reported that 34 cases (87.2 per cent) were cured quickly, while the remaining 5 patients (12.8 per cent) showed improvement.

It is probable that some stone drugs also may have antiviral properties. Qiu and his colleagues (1964), for example, have shown that white rats infected with encephalitis B have a greatly increased survival rate if treated with Baihutang,a formula that has gypsum (Gypsum Fibrosum) as its major ingredient. Similarly, Yuan (1956) reported treating 50 encephalitis B patients with

Baihutang, during the period 1954 to 1956. Only three of these individuals died, the rest were cured.

Raw gypsum (Gypsum Fibrosum) has been shown to have an antipyretic effect, that is, it can be used to reduce fever. However, pure manufactured gypsum does not display this property. This suggests that the antipyretic effect is produced by one or more of the impurities normally associated with gypsum in its raw state (Guo et al, 1958). Wang and his colleagues (1981) have examined the antipyretic effects of raw gypsum in the laboratory by first injecting rabbits with typhoid vaccine to raise their temperatures and then treating them with either a decoction of raw gypsum or with Anemarrhena rhizome (Rhizoma Anemarrhenae). The latter drug is made from dried rhizomas of Anemarrhena asphodeloides Bge. (family Liliaceae) which is also an antipyretic. Some rabbits were given a combination of both drugs. It was discovered that raw gypsum alone could lower the body temperature of a treated rabbit by 0.3 degrees centrigrade; while Anemarrhena rhizome given by itself reduced temperature by an average of 0.7 degrees centigrade. When the two drugs were used together, rabbit temperatures fell by an average 1.2 degrees centigrade.

Digestive system disorders

Traditionally, several stone drugs have been used to treat disorders of the digestive system. These include red halloysite (Halloysitum Rubrum), a hydrokaoline which consists mainly of hydrated aluminum silicate but also includes ferric and manganese oxides. This clay is usually red in colour but can be grey, green, yellow, brown or white depending on its oxide content. Red halloysite was mentioned first in *Shen Nong 's Herbal Classic,* roughly 2,000 years ago, as a treatment for both chronic diarrhea and dysentery. It probably has been used continuously in China since then for these purposes. Red halloysite is utilized also by the Chinese as a water purifier because of its ability to remove impurities from potable water.

Mirabilite (Natrii Sulphas), hydrous sodium sulphate (Na_2S0_4 $10H_2O$), also was described in *Shen Nong's Herbal Classic.* It has several uses in traditional Chinese medicine, one of which is the treatment of constipation.

Conversely, Zhang (1978) described treating 49 cases of chronic diarrhea with powdered sulphur (Sulfur). Patients ranged in age from 8 months to 70 years, with 10 being less than 3 years old. The dose given varied from 0.15 to 0.5 grams, taken twice daily until the diarrhea ceased. After two days of treatment, 36 cases were cured, 7 showed improvement and 6 failed to respond. That is, 88 per cent appeared to benefit from treatment with powdered sulphur.

Fulonggan is a stone drug that is derived from cooking stoves. Many Chinese stoves are made of clay which, after prolonged use, is considered to develop medicinal properties. Heavily baked clay is collected from stoves, therefore, and used to treat diarrhea, vomiting and intestinal bleeding. However, in each case, fulonggan is not used alone, but forms one of the components of a formula that also contains herbs and animal derived components.

Chalcanthite, hydrated copper sulphate ($CuS0_4$ $5H_20$), also was mentioned as a valuable stone drug in *Shen Nong's Herbal Classic.* As a powder it has been used traditionally to induce vomiting in cases of drug intoxication. It is prescribed also as a treatment for mouth ulcers.

Calcined alum and honey, in a ratio of 1:2, are used to make pills weighing approximately 3 grams, one of which is taken four times daily for the treatment of gastroduo-denal ulcers. A course of such treatment normally lasts three months. In 1970, the efficacy of this alum and honey medication was tested on 280 gastroduodenal ulcer patients at the Wuhan Medical College Hospital. It proved very effective with 76.8 per cent of patients claiming their stomach pains had ceased. A further 21.4 per cent experienced greatly reduced pain, while only 1.8 per cent did not benefit significantly. In 40 cases, barium meals were then used to check these results. X-ray examination showed that in 32 patients the ulcer(s) had completely disappeared, and in four further cases they appeared reduced in size. Only in four patients did the alum and honey treatment seem to have had no beneficial effect.

As previously mentioned in the discussion of infectious diseases and stone drugs,

alum has known bacteriostatic properties. It has been shown in the laboratory, for example, to inhibit Bacillus dysenteriae, a cause of bacillary dysentery. Wang (1960) has described the effects of a 10 per cent alum solution, taken four times a day for ten days, on a group of 70 bacillary dysentery patients. Forty of these patients appeared cured, eight more were greatly improved, while symptoms persisted unchanged in the remaining 22 cases.

Alum also very commonly is used to treat proctoptoma (prolapse of the rectum). Shi (1981) described the effects of injections of 6 per cent alum solution on 214 such patients. One hundred and sixty five cases received one injection and the remainder two. The results were impressive, with cures being recorded for all but one patient. Even in this case improvement was noted. To further check the value of treatment of proctoptoma with alum, patients who had received this medication up to 20 years previously were surveyed. Ninety-six cases (70.1 per cent) showed no sign of proctoptoma; 18(13.1 per cent) displayed improvement, while the problem had recurred in 23 (16.8 per cent). No adverse side effects of alum treatment could be identified.

Nervous system disorders

Dragon's bones (Os Draconic) are fossil mammal bones that are used in Chinese medicine to treat various nervous problems including palpitation, insomnia and neurosis. Such bones consist largely of calcium carbonate and calcium phosphate. They are powdered and taken with water.

Gypsum (Gypsum Fibrosum), hydrated calcium sulphate, is used to treat muscle spasms. This mineral is added to water, which then is boiled. The resulting liquid is prescribed as a treatment for spasms that are accompanied by fever and indicative of infection of the nervous system.

Powdered alum (Alumen) is prescribed to control epilepsy. Long (1962), for example, has described its use in the treatment of five cases of this disorder. In this clinical experiment the twice daily dose varied between 3 and 4.5 grams. If the patient had suffered from epilepsy for one to two months the course of treatment lasted 20 days; if attacks had occurred for longer than this but less than a year, the drug was taken for one month. If the patient had suffered from epilepsy for more than a year, treatment was continued for some three months. A follow-up survey, conducted after a minimum of four months and a maximum of three years after alum treatment, established that none of the epileptics had suffered repeat attacks.

Alum is not the only stone drug to be used in the treatment of epilepsy, both amber (Succinum) and borax (Borax) are used also for this purpose. To illustrate, in a paper published in 1975, researchers from Tangshan hospital, Hebei province reported on the value of powdered borax in the control of this disorder in 65 patients. The dose prescribed depended upon the frequency and type of seizure involved. Children were given one half the borax prescribed for adults. When the latter suffered from grand mal, or very frequent petit mal attacks, they were provided with 1 gram of powdered borax, three times a day. Those adult patients who suffered less frequent petit mal attacks received 0.7 grams, on three occasions daily. If only rare epileptic attacks occurred, 0.3 grams of powdered borax was given three times each day. In addition, some patients also took herbal formulae, designed to tranquillize and to relieve muscle spasms. If improvement was noted, the treatment with borax continued for a further six months.

The Tangshan hospital researchers reported that, after one year, 12 patients appeared cured, that is they had had no seizures for at least six months. A further 19 cases showed a significant decline in the frequency with which they suffered epileptic attacks, while 22 more showed some improvement. That is 81.5 per cent of patients appeared to have benefited from borax treatment. Only 12 cases did not gain any relief from the use of this stone drug. Despite the fact that almost all patients had taken borax continuously for one year, no adverse side effects had been recorded.

Urinary system disorders

Several stone drugs are utilized by the Chinese in the treatment of urinary disorders, although the scientific basis for their use has not been firmly established yet. To illustrate, mirabilite (Natrii sulphas) is boiled commonly in water and the resulting liquid

drunk as a diuretic. Mirabilite also is used in the treatment of uremia (the retention in the blood of substances normally eliminated in the urine). Amber (Succinum), fossilized pine resin, was first mentioned in Lei Xiao's pharmaceutical review, *Lei's Treatise on the Preparation of Traditional Medication,* written in about the 5th century AD. Amber appears to have been used in China in powdered form for some 1,400 years to treat stones in the kidney and other parts of the urinary tract. It is used also in the treatment of urodynia (pain accompanying urination) and hematuria (the discharge of blood in the urine).

Talc (Talcum) consists mainly of magnesium silicate and often is found in metamor-phic rocks, limestones and shales. It was mentioned first as a stone drug in *Shen Nong's Herbal Classic,* written during the Qin and Han period (475 BC - 265 AD). Its major medicinal use in China is for the treatment of urinary infection.

External and Internal Blood Loss

It is obvious from *Shen Nong's Herbal Classic* that red ochre (Ochra Haematitum), an ore of hematite (Fe_20_3), has been used in Chinese medicine for at least some two millennia. This ore, however, usually contains arsenic impurities. Before being prescribed, therefore, usually it is calcined, tempered with vinegar and/or powder refined in efforts to reduce the amount of this toxic element present. Once processed, red ochre is used to treat hematemesis (vomiting blood), hemoptysis (coughing and spitting of blood from the respiratory tract) or nose bleeds. Red ochre may also speed the regeneration of red blood cells. However, it must be stressed that because of its original arsenic content, this stone drug can be dangerous despite processing. Its long-term use may be associated with chronic arsenic poisoning.

As described previously, fulonggan is a stone drug derived from clay cooking stoves. In powdered form it is used to treat external wounds, to reduce inflammation and bleeding and to encourage blood vessel constriction.

Red halloysite (Halloysitum Rubrum) also is used externally to treat wounds to prevent bleeding and is given internally in cases of hematochezia (blood in the feces) and uterine functional bleeding. Wounds also are dusted with alum (Alumen) powder, or bathed in a solution of alum, to reduce bleeding. Nose bleeds are treated with cotton balls saturated with alum solution. Sun (1959) has described the results of giving alum to 20 patients who were suffering from hemoptysis (coughing blood), caused by pulmonary tuberculosis. Two of these patients were coughing and spitting between 500 and 2,000 millilitres of blood each day; four were losing between 50 and 100 millilitres, while the remaining 14 patients lost less than this. Patients were treated with a powder that contained alum and the herb catechu (Catechu) in a ratio of 24:30. Catechu is a dried extract from the peeled branches and stems of the tree Acacia catechu (Leguminosae), which also helps to arrest bleeding. Those losing the most blood were given between 0.1 and 0.2 grams of powder, every three hours, the less serious cases received the same dose but only three or four times per day. Sun (1959) discovered that three patients stopped losing blood after one day, while 16 more cases ceased bleeding after two days or more. The treatment proved ineffective in only one case.

There is considerable evidence that ophicalcite (Ophicalcitum) may be very effective in the treatment of both external and internal bleeding. Ophicalcite first was mentioned as a valuable stone drug in the *Jia You Materia Medica,* written in 1056. Probably it has been used in China, therefore, for some 900 years. It is a mineral that in its original form contains calcite, serpentine, and small amounts of tremoline, diopside and olivine as impurities. While it is composed mainly of calcium carbonate, it includes magnesium, iron, aluminum and traces of zinc, copper, manganese, cobalt, nickel and chromium and some heavy metals, such as lead.

Ophicalcite, like alum, seems valuable in the treatment of hemoptysis (coughing blood) caused by pulmonary tuberculosis. Xie (1959), for example, describes using a sodium chloride solution which also included 12 grams of ophicalcite to treat 49 tuberculosis patients suffering from hemoptysis. Ten millilitres of this solution were given twice a day, until bleeding stopped, or until

the treatment proved ineffective. In 47 cases (96 per cent) the sodium chloride-ophicalcite solution was able to stop the hemoptysis.

Ophicalcite also appears to be very useful for the cessation of hematochezia (blood in feces) caused by gastroduodenal ulcers. Shen (1985), for example, describes treating 53 patients who had such blood in their feces. He used calcined ophicalcite which had been ground into a powder. Between 4 to 8 grams of this substance were given three times daily. Shen (1985) reported that 50 patients appeared cured, two were improved and in only one case did the treatment with calcined ophicalcite prove ineffective.

Liao (1980) has shown that mica (Muscovitum) also can be used to treat effectively hemorrhage of the upper digestive tract. The dose was two to three grams of finely ground mica, given three to four times daily. In total, 60 cases of upper digestive tract hemorrhage were treated, but 12 of these received additional medication, consisting of aluminum hydroxide powder and tablets of belladonna made from the plant Atropa belladonna (deadly nightshade). Liao (1980) reported that bleeding was effectively stopped by this treatment in 59 cases (98.3 per cent). These patients included 19 who had duodermal ulcers and three who suffered from chronic gastritis (inflammation of the stomach lining). The only failure occurred in a patient suffering from late-stage carcinoma (cancer) of the stomach.

As has been described previously fossil, mammal bones known as dragon's bones (Os Draconic) to the Chinese are used in traditional medicine for a variety of purposes. Powdered fossil bones, for example, are used externally to reduce bleeding. They are also boiled in water and drunk because of their hemostatic properties.

Bone Growth

It seems likely that pyrite (Pyritum), taken internally, can promote the healing of bone fractures. This was demonstrated in the laboratory by Lin and co-workers (1962) who compared the recovery rates of rabbits with fractured femors receiving 3 grams of pyrite daily for 45 days, with those of a control group. Not only did the rabbits receiving the stone drug heal more quickly but their new bone also was stronger. Pyrite appeared to increase the speed and quantity of callus growth (woven bone that links the ends of fractures), and encouraged its earlier maturity. Similarly, workers at the Beijing Medical College Hospital (1959) showed that such pyrite-stimulated bone growth was more difficult to fracture than bone formed by an untreated rabbit control group. Gypsum and jiangshi also are used in the treatment of fractures.

Excessive Lactation

Mirabilite (Natrii sulphas) appears very useful in stopping excessive lactation. Approximately 100 to 150 grams are applied to each breast and held there with a bandage. Lei (1957) reports on 36 cases in which mirabilite was used for this purpose. Lactation ceased in 33 women (91.7 per cent); in 28 of these cases this took two days, and in the remaining five cases the treatment lasted three days. The three failures occurred in women who discontinued treatment prematurely. It is thought that the suppression of lactation may occur because of the high osmatic pressure created by mirabilite on the breast surface.

Potential toxic side effects

Stone drugs have been used to treat a wide variety of diseases and disorders in China for hundreds, and in some cases thousands, of years. Nevertheless, it must be admitted that some of them contain highly toxic components. As a consequence, when improperly used these can have a wide variety of adverse side effects, which in the worst cases can include death. Of course, this is true also of many Western medicines, even those as commonplace as aspirin. Zhu (1986) conducted a literature search for cases of serious adverse side effects in patients treated with Chinese mineral drugs. He was able to find 430 cases, 37 of which culminated in death. Twenty-five of the fatalities had taken excessive doses internally. The remaining 12 had used stone drug(s) externally, but in most cases the quantity applied was unclear. However, again there appeared to have been a close relationship between death and either overdosing, or improper drug prescription.

In an effort to reduce accidental death or injury from the misuse of stone drugs, nu-

merous assessments have been made of their toxicity. Probably the most comprehensive study was that conducted by Yue and his colleagues (1989) who determined the acute toxicity on mice of those mineral drugs that were still in common use. These researchers discovered that half the lethal dose of most mineral drugs could result in hepatomegaly (enlargement of the liver). Some drugs such as cinnabar (Cinnabaris) and realgar (Realgar) appeared capable of causing pulmonary congestion and changing the appearance of the kidneys. Interestingly, processing affected the toxicity of some drugs. For instance, 50 per cent of the mice died after receiving only 8.25 g/kg of calcined fossil of spirifer (Cyrtiospirifer sinensis (Graban)). In contrast this degree of toxicity only occurred after a dose of 21.50 g/kg of unprocessed fossil of spirifer. Similarly, the source of some stone drugs appeared to affect their toxicity. Pumice from Xiamen, for example, was considerably more toxic than that derived from Yantai.

The Chinese Standards Association for Industrial Enterprise recognizes five classes of toxicity (Yue et al, 1989). When the oral LD_{50} (mg/kg) is less than 10, that is when a dose of less than 10 mg/kilogram of body weight kills half or more of the mice receiving it, hypertoxicity is present; high toxicity involves 50 per cent animal mortality at between 11 and 100 mg/kg, while moderate toxicity is defined as being present when the oral LD_{50} is between 101 and 1000 mg/kg. Low toxicity is present when between 1001 and 10,000 mg/kg are required to kill half of the test animals; a substance that requires more than this to reach this level of mortality is said to be microtoxic. If one accepts this classification, it can be seen from Table 6 that Baijiangdan, which consists of a mixture of several minerals but has mercury chloride as its dominant component, has high toxicity. White arsenolite, red arsenolite, sublimated sulphur and chalcan-thite display moderate toxicity. Most other mineral drugs appear to display low to micro toxicity. In the brief discussion of toxicity which follows, greatest attention is paid to those drugs that contain clearly dangerous elements such as mercury, lead and arsenic.

Mineral drugs containing mercury

Cinnabar (Cinnabaris) is a mercuric mineral that is used commonly in China as a component of medicinal formulae designed to treat diseases as diverse as angina and insomnia. However, its use in such formulae has led to hydrargyria (chronic mercury poisoning) in some patients. Reported symptoms include enteritis (inflammation of the intestine); nephrosis (degenerative kidney disease), muscular tremors, gum bleeding, insomnia, amnesia, and staggering gait. Zhang (1985) has reported one case of death from the misuse of cinnabar.

Calomel (Calomelas) is another mercuric mineral which has been associated with numerous adverse side effects. Consisting largely of mercurous chloride, this stone drug becomes more toxic on heating when oxidation occurs. Typically, in traditional Chinese medicine, it is one component of formulae designed to treat skin diseases. Its short-term use has been linked to abnormal fermentation in the digestive tract and to diarrhea. Long-term prescription is known to have been the cause of pathologic changes to the liver, heart and kidneys. Known adverse side effects include anuria (the complete suppression of urine formation by the kidney), fever and rhagades (cracking around the lips).

Mineral drugs containing lead

Minium (Minium) is a mineral which contains various lead oxides. It is used in traditional Chinese medicinal formulae designed to treat skin diseases, epilepsy and manic depression. Its prescription for epilepsy has been linked to nausea, hyperemesis (excessive vomiting) and colic (acute paroxysmal abdominal pain). After treatment for lead poisoning the eight epileptics involved recovered (Zhou, 1983). Other patients have not been so fortunate. Zhu (1986) reported on one individual who took a traditional formula that included minium. Intake of this stone drug was 1.5 grams daily and continued for 13 days. Symptoms included colic, muscular pain and fremitus (vibration). Despite emergency treatment for lead poisoning the patient died.

Mineral drugs containing arsenic

White arsenolite and red arsenolite

Table 6. Assessment of the Acute Toxicity of Commonly Used Chinese Mineral Drugs

Drug	Place of Origin	LD_{50} (g/kg) Dose killing 50% of mice receiving it	Length of experiment (days)
1. Baijiangdan (formula including mercury chloride)	Jiangxi	0.078* ig	**3**
2. White arsenolite	Jiangxi	0.144* ig	**3**
3. Red arsenolite	Jiangxi	0.242* ig	**3**
4. Sublimated sulphur	Hebei	0.266* ig	**3**
5. Chalcanthite	Handan	0.279* ig	**3**
6. Calcined alum	Handan	0.060* iv	**3**
7. Calomel	Xiangtan	2.068* ig	**3**
8. Alum	Wenzhou	2.153* ig	**3**
9. Borax	Imported	2.454* ig	**3**
10. Halite	Qinghai	2.789* ig	**3**
11. Purple rock salt	Gansu	4.435* ig	**3**
		2.216* ip	**3**
12. Table salt	Tianjin	4.437* ig	**3**
		2.660* iv	**3**
13. White Sal-Ammoniac	Gansu	3.517* ig	**3**
14. Realgar	Chengde	3.207* ig	**3**
15. Orpiment	Guizhou	3.83** iv	**3**
16. Amber	Fushun	0.960* iv	**3**
17. Pyrite	Wuling	1.920* iv	**3**
18. Calcined pyrite	Wuling	3.83** iv	**3**
19. Qiushi (product of urine and sodium chloride)	Anqing	4.437* ip	**3**
20. Mirabilite	Xian	4.648* ip	**3**
21. Mirabilite	Chuxiong	6.738* ip	**3**
22. Borax	Xian	7.395* iv	**3**
23. Qianfen (product of lead & acetic acid)	Nanjing	13.970* iv	**3**
25. Talc	Handan	> 36.000* ig	**3**
26. Chlorite-schist	Hebei	> 36.000* ig	**3**
27. Litharge (lead monoxide)	Henan	> 36.000* ig	**3**
28. Pumice	Yiyang	6.81** iv	**3**
29. Calcined fossil of spirifer	Xiamen	10.00** iv	**3**
30. Calcined pumice	Shanxi	8.25** iv	**3**
31. Fossil of spirifer	Xiamen	10.00** iv	**14**
32. Ophicalcite	Shanxi	21.50** iv	**3**
33. Calcined Hematite	Hebei	4.22** iv	**7**
34. Calcined Ophicalcite	Hebei	12.10** iv	**3**
35. Hematite	Hebei	21.50** iv	**3**
		12.90** iv	**3**

Table 6. Assessment of the Acute Toxicity of Commonly Used Chinese Mineral Drugs (cont'd.)

Drug	Place of Origin	LD_{50} (g/kg) Dose killing 50% of mice receiving it	Length of experiment (days)
36. Verdigris (basic copper carbonate)	Handan	14.70** iv	3
37. Magnetite	Handan	14.70** iv	3
38. Pumice	Yantai	27.80** iv	3
39. Calcined magnetite	Handan	> 36.00* ig	3
40. Stalactite	Guangdong	28.30** iv	3
41. Talc	Yichun	5.62** iv	7
42. Pyrolusite	Chengdu	2.78** ig	7
43. Limonite	Baoding	8.25** iv	7
44. Manufactured HgS	Guangzhou	10.00** iv	7
45. Calcined quartz	Baoding	10.00** iv	7
46. Cinnabar	Sichuan	12.10** iv	7
47. Quartz	Baoding	> 36.00** ig	7
48. Kaolin	Lueyang	12.90** iv	7
49. Selenite	Xingtai	12.90** iv	7
50. Calamine	Henan	12.90** iv	7
51. Calcined Fluorite	Handan	14.70** iv	7
52. Minium	Hunan	16.70** iv	7
53. Calcined stalactite	Handan	16.70** iv	7
54. Calcite	Hubei	16.70** iv	7
55. Vermiculite	Baoding	21.50** iv	7
56. Calcined fossil of Telphusa sp.	Handan	21.50** iv	7
57. Dragon's bones	Datong	21.50** iv	7
58. Calcined red ochre	Handan	21.50** iv	7
59. Calcite	Jiangsu	27.80** iv	7
60. Red halloysite	Xinxiang	31.60** iv	7
61. Raw Gypsum	Hubei	14.70** iv	14
62. Raw Gypsum	Hubei	16.70** iv	14
63. Calcined limonite	Handan	10.00** iv	14
64. Mica	Yunnan	21.50** iv	14
65. Dragon's teeth	Shanxi	26.10** iv	14
66. Maifanshi (weathering product of granite)	Neimeng	26.10** iv	14

*According to Sun's (1963) method.
**According to Horn's (1956) method.
ip and iv: mineral boiled in water and resulting solution used in the experiment
ig: suspension created and finer particles used in experiment
Source: Data in this table is derived from Yue et al, 1989.

(Arsenicum Trioxidum) both are used in traditional Chinese medicine in formulae designed to treat disorders as diverse as asthma, hemorrhoids and schizophrenia. Both are quite toxic and definitely should not be used by pregnant women. Even when applied externally in the treatment of hemorrhoids they can be absorbed by the mucous membrane and cause acute arsenic poisoning. Wang (1958), for example, described 11 cases of such poisoning resulting from the misuse of Ku Zhi Sang, a formula that is applied frequently to hemorrhoids. Ten of these patients died despite emergency treatment. The causes of death included liver function failure, water-electrolyte imbalance and toxic encephalitis.

Another traditional formula, Longhuwang, includes white arsenic, cinnabar (Cinna-baris), rhinoceros horn (Cornu Rhinocerotis) and cow-bezoar (Calculus Bovis) amongst its ingredients. This has been used to treat schizophrenia (Kuang, 1982). However, patients using it suffered epileptic attacks, a loss of balance, declining blood pressure and numbness in the limbs. One became disabled permanently.

Realgar (Realgar) is derived from a mineral that consists chiefly of arsenic disulphide. It is used externally as a detoxicant and antiparasitic agent for insect and snake bites, scabies and boils. Numerous examples occur in the literature (Hu, 1982; Zhao, 1983) of arsenic poisoning resulting from the use of herbal pills that also contain realgar. Zhao (1983), for example, reports on four patients who ingested between 225 to 1072.5 grams of arsenic from realgar. Symptoms included arsenical keratosis (horny growths), arsenical melanosis (dark pigmentary deposits), anorexia, anemia, and liver damage.

Other potentially dangerous stone drugs

Alum

The main constituent of alum (Alumen) is potassium aluminum sulphate. When taken in overdose this drug can cause burning of the mouth and larynx and may result in inflammation. Excessive amounts of alum may also be capable of producing tissue corrosion. Zhu (1986) reports that two or more grams of alum taken orally might be expected to cause stomach pain, vomiting, diarrhea and even death. This is because it forms a hyperosmotic solution in the intestinal tract which can cause reversed osmosis, drawing water into the tract and causing it to expand. Hyperperistalsis (excessive alimentary canal contraction) also can occur, resulting in diarrhea. Zhu (1986) describes the misuse of alum by an unlicensed physician in the treatment of manic-depressive psychosis. This individual combined 100 grams of crystallized sugar with an equal quantity of alum and added this mixture to boiling water. On cooling, this liquid was administered as one dose. The initial treatment resulted in nausea and shivering. Two additional doses of similar strength produced cyanosis (a bluish discolouration of the skin and mucous membranes due to excessive concentration of reduced hemo-globin in the blood), and a drop of temperature in the limbs. These symptoms were followed rapidly by death. Autopsy established that alum intoxication was the primary cause of death which had resulted in cerebral ischemia, anoxia (a serious deficiency of oxygen in body tissues) and respiratory and circulatory failure.

Chalcanthite

Chalcanthite (Chalcanthitum) is a drug which contains high levels of copper sulphate. Usually it is prescribed for externa] use, as for example in eye drops, when it is extremely diluted. Zhou (1965) reported a case in which an individual with eye disease mistakenly drank 30 grams of chalcanthite. Symptoms included nausea, vomiting, dizziness, lack of energy, discoloured urine, declining blood pressure and anuria (sup-pression of urine formation). Clinical examination established acidosis, acute hemolytic anemia (abnormal lack of red blood cells due to their shortened survival time), acute kidney failure, toxic hepatitis and tachycardia (extremely rapid heart rate). Five days after taking the excessive amount of chalcanthite the patient died.

Red ochre

Red ochre (Ochra Haematitum) normally is considered a safe mineral drug. It is derived from hematite, a red coloured iron ore composed chiefly of ferric oxide, and is

used to treat a variety of disorders including nausea, vomiting, asthma, headaches, vertigo and tinnitus. However, in 1960 a research group from the Tianjin Medical College reported that this drug actually contained 1 part per million of arsenic. Long-term use was found capable of causing arsenic poisoning in both rabbits and rats. After one week, a dose of 2 grams of red ochre per day proved fatal to the rats. Most of the rabbits died after receiving 5 grams of red ochre per day for 12 days.

In addition, Lu (1982) described how one epileptic decided to use red ochre to treat his own disorder. This individual took 3 grams of powdered red ochre, three times daily for 23 days. Resulting symptoms included purpura (characterized by spontaneous bruising and red patches on the skin), bloody stools, slowed blood coagulation and reduced platelet count. After treatment by a recognized physician the patient eventually recovered.

Toxicity: an overview

Clearly, some stone drugs can be dangerous, especially if overdoses are taken or if they are administered by untrained personnel. Similarly, the length of treatment should be controlled strictly. The processing of stone drugs only should be undertaken by knowledgeable individuals and standards should be maintained by careful inspection.

A preliminary review of possible therapeutic mechanisms

It is not easy for Westerners to understand the causal explanations given by practitioners of traditional Chinese medicine, since normally these involve unfamiliar concepts such as the Tao, the philosophies of Yin and Yang and of Chi. Typically they stress achieving balance, rather than disease cause and effect (Tan, 1990). Recently, Chinese scholars have been attempting more scientific evaluations of the efficacy of stone drugs, using techniques from disciplines as diverse as pharmacology and medical geography. Many of these research findings are still tentative. What follows is a brief summary that is not intended to be either comprehensive or definitive. Clearly, a great deal of further research still is required into this fascinating subject. However, several possible ways in which Chinese stone drugs may work have been identified and will be discussed briefly.

Trace and bulk element deficiencies

The geology, geomorphology and pedology of the earth's surface vary enormously from place to place. As a consequence, so too does trace and bulk element availability in water supply and in locally grown foods. Such variability can lead to dietary deficiencies of particular elements, which in turn may cause endemic diseases and may play a role in many chronic degenerative conditions (Foster, 1992). It is believed that at least 25 elements are essential for human health. The 11 macro elements, that is the bulk elements, include oxygen, carbon, hydrogen, nitrogen, calcium, magnesium, potassium and sodium. The 14 micro elements, known as trace elements because only small quantities are required for optimum health, include iron, zinc, copper, manganese, chromium, molybdenum, cobalt and selenium. Differing quantities of these 25 elements may be required by males and females and by individuals at various stages of their life cycles. In addition, the ability to absorb and utilize particular bulk and trace elements varies from person to person. For all of these reasons, deficiency diseases, linked to an inadequate intake of one or more of these essential nutrients, are common, not only in China, but elsewhere.

Many stone drugs include a wide variety of elements. As can be seen from Tables 1 and 2, jiangshi, used in the prevention and treatment of esophageal cancer, contains some 35, including the bulk elements potassium, sodium, calcium, and magnesium and trace elements such as iron, fluorine, iodine, zinc, copper, manganese, selenium, vanadium and chromium. Similarly pyrite, used, for example, in the treatment of goitre contains some 15 elements, including iron, cobalt, vanadium, sulphur and magnesium. To date, the chemical composition of at least 60 commonly used stone drugs has been established accurately (Shen, 1984). These analyses tend to confirm their complexity and may perhaps explain their frequent value in treating disorders, or diseases, that have mineral deficiencies as their root cause.

To illustrate, gypsum (Gypsum Fibrosum)

and jiangshi are used to treat bone disorders. Both contain large quantities of the bulk element calcium. While jiangshi normally is mixed with herbs to form an externally applied poultice to reduce bone pain, Li (1961) has described using gypsum during surgery to "patch" bones already damaged by osteomyelitis (inflammation and damage to the bone due to infection) or by bone tuberculosis. Fourteen patients were treated with gypsum in this way, of which 12 appeared cured. This assessment was made after observations lasting between 2 and 17 months. In these cases, x-rays showed that the bone defects had been repaired and that, in some instances, new marrow cavities had developed. In only two patients did the gypsum "bone graft" fail. In all others, this stone drug increased blood calcium levels and promoted ossification and bone healing. As has been suggested previously, it is possible that the apparent ability of jiangshi to reduce the incidence of esophageal cancer when added to water supply may be due to the high levels of calcium in this mineral and the trace amounts of selenium that it contains (Yu and Foster, 1991).

Trace and bulk element antagonism

The geochemical variations that may result in some populations being very short of certain bulk and trace elements also can result in the exposure to excesses. These in turn may be linked causally to various diseases, including fluorosis. Many antagonist relationships occur between minerals. For example, there is a strong antagonistic relationship between copper and molybdenum. Copper deficiencies have been observed in animals in regions where copper levels are not particularly low but where molybdenum is very common in soils and fodder. As a consequence, there is an inability to absorb and utilize copper, which in turn leads to retarded growth rates (Bowie and Thornton, 1985). It is possible, therefore, that some stone drugs may prove effective because they rid the body of specific mineral excesses through antagonistic relationships.

One such example has been described previously. Borax, a Chinese stone drug obtained from dry salt lakes, appears to be valuable in the treatment of fluorosis (Bear et al, 1977). This seems to be because its major component boron is antagonistic with fluorine and reduces its absorption by the intestinal tract. As a result, anyone taking it is less likely to suffer from fluorosis caused by fluorine excess.

It has been shown from animal studies that such antagonistic relationships may be very common (Bowie and Thornton, 1985). For example, increased dietary concentrations of molybdenum, sulphur, iron, cadmium, zinc and silver can exacerbate biochemical or pathological manifestations of copper deficiency syndrome in animals. Similarly, increased intake of sulphur, copper and silver can worsen selenium deficiency symptoms. It is clear that similar relationships probably also occur in man (Kirschmann and Dunne, 1984). It is not surprising, therefore, that the use of stone drugs, containing a variety of elements, may reduce symptoms that were originally due to the excess of other elements in diet and water supply.

Trace and bulk element synergism

Some minerals and vitamins, in contrast, have synergistic relationships; that is the presence of one increases the potency of another. To illustrate, iron, magnesium, manganese and phosphorus improve the body's ability to utilize calcium efficiently. Similarly, copper, iron and zinc increase the effects of cobalt, while selenium is synergistic with vitamin E (Kirschmann and Dunne, 1984). These and many other similar relationships may help to explain why some stone drugs appear to have great therapeutic effects when taken in combination with others, or as one of the many ingredients of a traditional formula which also contains vitamin rich organic components.

Stone drugs as bactericides

Some stone drugs have been tested in the laboratory and shown to be effective bactericides; that is they can inhibit quite a wide range of bacteria. As described previously, these include alum (Alumen), realgar (Realgar), calomel (Calomelas) and borax (Borax). There is, therefore, no mystery about their value in treating infectious diseases of bacterial origin. To illustrate, stone drugs containing arsenic and/or mercury such as realgar and cinnabar traditionally have

been used to treat syphilis. This disease is caused by the bacterium, Treponema pallidum.

Stone drugs as water purifiers

It has been shown experientially that, if jiangshi concretions are placed in water, they have a strong adsorptive effect on many metallic ions, such as iron, chromium, molybdenum, nickel, cobalt and gallium. They also seem to have a similar attraction for nitrosamines and mycotoxins. If one or more of these substances plays a causal role in esophageal cancer, such absorptive effects may explain why the addition of jiangshi to water supply has been shown to reduce esophageal cancer incidence (Zhao et al, 1985; Jiang, 1978).

Adsorption and cation exchange and stone drugs

Colloidal systems consist of very fine particles permanently dispersed in a medium. Such colloidal systems may be created during processes such as powder refining and the mixing of formulae. Colloidal particles have two important characteristics that may account for some of the medicinal properties of stone drugs. Firstly, they carry electro-negative surface charges that allow them to fix and retain by adsorption very small gaseous, liquid or solid particles. Secondly, since colloidal particles are usually less than one micron in size, there are hundreds of billions to each gram of finely powdered stone drug. These innumerable small particles have an enormous combined surface area on which interface actions, like the adsorption of water can occur (Pitty, 1971). It is thought that some stone drugs form colloidal systems when used medicinally and may be able to adsorb toxins and body fluids while in the digestive tract, leading to their eventual removal from the body (Li, 1987). This, for example, may explain some of the value of red halloysite (Halloysitum Rubrum) in the treatment of diarrhea.

Some toxins also may be removed from the body by a process of cation exchange. This process of base-exchange involves the mutual transfer of cations, such as those of Ca++, Mg++, K+ and Na+ between a liquid rich in one cation and a mineral rich in another (Pitty, 1971). Such exchange reactions are reversible and different ions are capable of replacing one another. The speed with which the exchanges occur seems controlled by various factors including acidity, organic matter, temperature and the abundance of different cations and their chemical activity. Generally, the rate of exchange between a solution and a mineral is fast, requiring only a few minutes. It is possible that some stone drugs are involved in cation exchange with fluids within the body, helping to reestablish the necessary balance of bulk and trace elements (Li, 1987).

The formation of complex compounds

As previously discussed many mineral drugs traditionally have been mixed with others, from herbal and animal sources, before their use. In such formulae, organic and inorganic components are in close proximity and, therefore, the possibility is increased that metal complexes may be formed. Such complexes occur when inorganic metal ions are integrated into organic molecules. Examples of organic molecules that may take part in such complexing include alkaloids, glycosides and proteins. Organic-inorganic complexes may be highly fat soluble and may penetrate cells and membranes more easily, so increasing their potential for therapeutic activity (Wu, 1986). Similar relationships have been demonstrated in Western medicine where the antirheumatic effects of aspirin can be increased by complexing it with copper. In addition, the antineoplastic properties of bleomycin, a polypeptide mixture, are increased greatly after complexing with cobalt.

Evidence that such complexing is important in Chinese medicine has been provided by Wu (1986). He noted that pneumonia and other infective fevers have been treated traditionally in China by a formula known as Ma Xing Shi Gan Tang, which is a decoction of the shrub Ephedra, apricot kernel, gypsum and licorice. The bulk and trace elements and the reactive organic molecules that this formula contains have been identified. The former include calcium, iron, manganese and copper and the latter ephedrine (an alkaloid from the shrub Ephedra) and glycyrrhizic acid (from licorice). Wu (1986) mixed these inorganic and

organic components in the laboratory in a ratio of 1:1, to form metal complex compounds. Animal tests showed these were as capable of counteracting fever as the original formula, Ma Xing Shi Gan Tang.

Speculative medicinal properties

Evidence is growing that electrical activity in the body plays an essential role in maintaining human health (Nordenstrm, 1983). It is speculated that certain stone drugs, such as magnetite (Magnetitum) may help to regulate the human magnetic field. It is thought also that the calming effect of quartz perhaps may be related to the semiconductive activity of silica, while the weak radioactivity associated with biotite may have parallels with radiotherapy (Sun, 1987). None of these postulated relationships have been tested experientially yet.

Conclusions

Chinese stone drugs are often chemically quite complex even in their unprocessed state. This complexity may be increased by calcining and/or tempering and by mixing with other drugs derived from mineral, herbal and animal sources. As a consequence, it is possible that their therapeutic value, in a particular case, may rest on any, or all, of the processes just described. In the final analysis, however, although it is valuable intellectually to understand cause and effect in traditional Chinese medicine, it is not necessary for its beneficial application.

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