# The Rock Diet

Geochemists are helping people across the world find ways to deal with too much or too little of vital minerals, write Fiona Fordyce and Chris Johnson.

You may think there is little connection between rocks and our diet, indeed a serving of rocks may sound very unappetising! But rocks are a vital source of the essential elements and minerals we need to keep us healthy, such as calcium for healthy teeth and bones.

Weathering breaks down rocks to form the soils on which we grow crops and raise farm animals, which we then eat. But different types of rock contain varying amounts of elements and minerals, so these end up unevenly distributed. Most westerners no longer grow food in their back yard, and links between local geology and people's health tend to be fuzzy. However, such links are particularly important in developing countries subsistence farmers who depend on their immediate surroundings for food, and have little access to goods from outside their own area.

People suffer serious illness if their local soil provides either too little or too much of particular minerals or elements. Geochemists can show how these substances are distributed, and help discover how minerals are taken up into crops and then animals and people, as well as investigating what could be helping or hindering these processes. Together, geochemists and medical specialists are helping identify and manage health problems like mineral deficiencies associated with the rocks in our diets.

Over the last few years, the British Geological Survey, together with partners in China, Sri Lanka, Morocco and the UK*, have investigated the health effects of two essential elements, selenium and iodine.

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*Woman suffering iodine deficiency related goitre.*

## Selenium

Selenium is an interesting element because the range between deficiency (less than 40µg a day) and toxicity (more than 400µg a day) in human diets is very narrow (a µg or microgram is a millionth of a gram). In the human body, selenium acts as an anti-oxidant, preventing tissue damage. Selenium deficiency is linked to a host of diseases including cancer, muscular sclerosis, muscular dystrophy and to impaired immune and reproductive systems. Selenium also forms enzymes in the thyroid gland, which controls growth and development. On the other hand, too much selenium can cause hair and nail loss and disorders of the nervous system.

People living in Enshi District in central China show classic symptoms of the effect of selenium on health. The different villages in this remote mountainous region don't have much interaction with each other, and the geology around their villages is very variable. Some of the people live on soils derived from coal and which have very high selenium contents. These people suffer from too much selenium, while about 20 km away, people living over selenium-poor sandstone rocks have Keshan Disease.

Keshan Disease, named after an outbreak in the Chinese district of Keshan in 1935, damages the heart muscles and eventually causes death. It's linked to selenium deficiency. Between1959 and 1970 (the worst reported period for the disease) more than 8,000 cases and 1,400–3,000 resultant deaths were reported annually in China. Chinese scientists noticed that the disease occurred in a belt stretching from the northeast to the southwest of China, affecting remote populations living in areas where there was little selenium in the soils and crops. They proved the link between Keshan Disease and selenium when they found that mineral supplement tablets containing selenium significantly reduced incidences of the disease. However, handing out mineral tablets is not a long-term solution. It is much more beneficial and sustainable to try and improve the levels of selenium in food. Although researchers had established broad links between the environment and the disease, they still had some unanswered questions. Why did the disease hit some villages in the low selenium belt harder than others? What was the best way to improve selenium uptake into crops and foodstuffs?

*Sampling soil for iodine analysis from the iodine deficient area of Xinjiang Province, China*

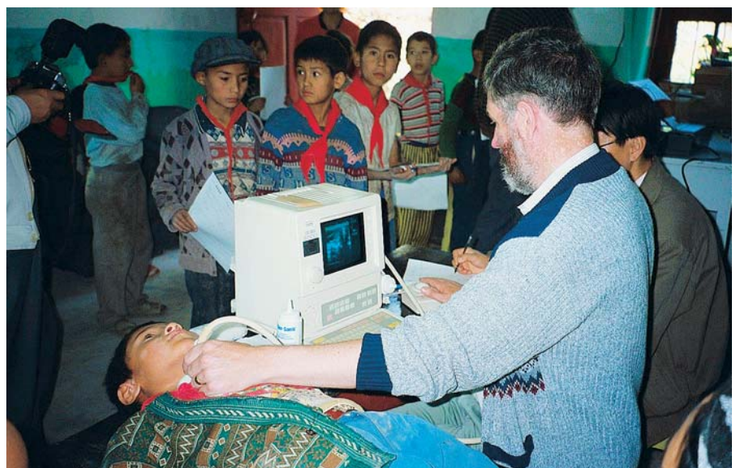
## The secret in the soil

Our team decided to look at areas with no/low, moderate and high incidences of Keshan Disease in the Zhanjiakou District of northern China. From each area we collected samples of soil, staple food crops, drinking water and human hair and analysed them for their selenium content. As expected, both the environment and the population were indeed selenium deficient, but the story had an interesting twist. We thought we'd find the lowest selenium levels in the villages with greatest disease problems, and this was true for levels in hair, drinking water and crop samples. But the soil results were surprisingly different. The highest selenium contents occurred in the area with most cases of the disease, the very opposite to what we were expecting. When we examined the soil geochemistry more closely, we noticed that although they had generally low levels of selenium, the most enriched soils were dark-brown-black and very high in organic matter. This organic matter was stopping crops taking up the element, so people eating them weren't getting enough selenium. Because the earth already had a high organic content, adding selenium fertiliser to the soil probably wasn't going to help. Instead we suggested the Chinese spray the fertiliser directly onto their plants, a method that has successfully combated selenium deficiency in Europe.

In villages with too much selenium, people are advised not to grow crops directly over areas of coal, and not to use coal and coal ash to condition their fields.

## Rock and bread roll

The links between the immediate environment and health may be less clear-cut in western countries, but our



*Ultrasound measurements of thyroid gland size in school children from the iodine deficient area of Xinjiang Province, China*

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*Sampling cabbage crops for iodine analysis from the iodine deficient area of Xinjiang Province, China.*

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*The work reported here is supported by the UK Department for International Development, Knowledge and Research Programme, Projects R6227 and R7411.*

food is still grown out there 'somewhere' and there can still be problems. Much of Finland's granite-type rocks contain very little selenium. The Finnish government was so concerned about the lack of selenium in the nation's food that it set up a national programme of selenium crop spraying. Between 1980 and 1990 this programme managed to raise the dietary intake of selenium from 45µg a day to 110-120µg a day.

People in the UK are also becoming increasingly concerned about the falling levels of selenium in our diet. Here bread is one of our main sources of selenium, but our intakes are going down because Britain no longer imports much wheat grown on the selenium-rich soils of the North America prairies. Today, most of our wheat comes from Europe where the environment is often selenium deficient. As a result, selenium intake dropped from an average of 43µg a day in 1991 to 29-39µg a day in 1995[1].

**Iodine**

Iodine is another element essential to human health. The recommended intake for adults is 100µg a day. Iodine is needed for growth hormones formed in the thyroid gland, and most cases of deficiency cause goitre, a condition where the thyroid becomes enlarged as it attempts to compensate for the lack of iodine. Goitre affects about 190 million people worldwide. Iodine deficiency in pregnant mothers can also lead to cretinism and impaired brain function in children. According to the World Health Organisation, iodine deficiency is the major cause of preventable mental retardation in the world today, with 1.6 billion people at risk, 50 million children affected and 100,000 sufferers born every year. Many of the worst affected populations live in developing countries, but about 50-100 million people are at risk in Europe.

In Britain, goitre occurred historically in the Peak District and was known as Derbyshire Neck. People used to think that this was because Derbyshire is a long way from the sea where iodine is abundant (seafood and seaweed are good sources of the element). Inland areas are often presumed to be low in iodine. However, recent research suggests the chemistry of the limestone environment seems to indirectly prevent iodine from entering into the human food chain.

There are many other myths about how iodine is distributed, for example the myth that "young' glacial soils are low in iodine'. In fact, it's the composition of the glacial soil rather than its age that matters. Iodine will reach stable levels in the soil in tens rather than thousands of years. Similarly, the idea that 'heavy rains wash iodine out of tropical soils' is a very simplistic view of a far more complex problem.

In China and Morocco we are now examining how iodine moves through the environment or becomes locked up in soils. We want to improve iodine uptake from soils into crops and then into human food because although medical remedies such as using iodised salt have proved successful in many parts of the world, populations who do not like or cannot afford iodised salt need alternative ways to get this element.

Rocks are the ultimate raw material for our food. The chemical and physical conditions associated with farmland geology affect whether we get enough of the elements and minerals that are essential for our health and well-being – so a 'rock diet' isn't as far fetched as it sounds!

[1] *MAFF 1997 Food Surveillance Information Sheet: Dietary Intake of Selenium.*