Copper-bottomed deposits

March 15 2017

Chuquicamata, in Chile, is amongst the largest copper deposits in the world. Credit: © M. Chiaradia, UNIGE

The world's most valuable copper deposits, known as porphyry deposits, originate from cooling magma. But how can we predict the size of these deposits? What factors govern the amount of copper present? Researchers at the University of Geneva (UNIGE), Switzerland, have studied over 100,000 combinations to establish the depth and number of years required for magma to produce a given amount of copper. The same scientists have also devised a model that can detect the quantity of copper held in a deposit by means of a simple factor analysis. The research, which is published in the journal *Scientific Reports*, will make it possible to estimate the potential for mining the metal before beginning any drilling. It is a model that will undoubtedly be of great benefit to mining companies.

Porphyry copper deposits account for 75% of natural copper worldwide. They are formed by magma chambers situated between 10 and 15 km beneath the Earth's surface. At this depth, the magma heats to around 900°C but when it comes into contact with the surrounding rock, it cools and crystallises. The water in the magma can then no longer be in solution: it forms bubbles that escape to the surface, carrying with them a substantial part of the copper originally contained in the magma. At a depth of around 2-3 km, the bubbles cool down in the porosities of the rocks, and precipitate the copper they contain as sulphide, creating deposits that may include from 1 to >200 million tons of copper. This explains why Massimo Chiaradia and Luca Caricchi, researchers in the earth sciences department in the faculty of science at UNIGE, were so keen to discover what dictates the amount of copper in a deposit and whether it was possible to anticipate its size.

More magma means more copper

The volume of magma determines the amount of copper, but under what conditions does the volume of the initial magma form? Chiaradia explains: "We used models that incorporate the depth and timescale at which the magma accumulates, the duration of the build-up that forms the deposit, the water content of the magma and the quantity of copper in the water. We then varied these parameters from a minimum to a maximum based on actual measurements." By modifying the parameters, the scientists obtained 100,000 simulations that they compared with the actual data available to them, which helped define the ideal conditions for the formation of a huge deposit. As Caricchi adds: "The optimum conditions for creating a magmatic system that results in the formation of a deposit of 30 to 240 million tons of copper is a depth of over 20 km and a continuous injection time of molten magma of over 2 million years."

In search of the ideal deposit

Magma contains water, copper and various other chemical components, including Strontium (Sr) and Yttrium (Y). We know that when the Sr divided by Y ratio is between 50 and 150 in the magma, there is a high probability of finding copper in the deposit. The researchers at UNIGE integrated this ratio into their new model and merged it with the estimated formation time for deposits. Other minerals are associated with copper in these deposits, which allows scientists to date them thanks to the natural decay of uranium into lead and rhenium into osmium. This enabled the scientists to establish the age, i.e. the birth, but also the length, i.e. the number of years, for forming a copper deposit, which can range from tens of thousands of years to two million years. "These two items of data—the Sr / Y ratio and the duration of the formation—meant we could design a table of probabilities for determining the amount of copper in the deposit under analysis", continues Chiaradia. Mining companies will be able to use this model to assess the size of a copper deposit at the initial research stage, before starting any significant drilling work. "Our model," says Caricchi, "which we have compared to real data, has an excellent match rate, and it can save an enormous amount of time and money during mining explorations."

Provided by University of Geneva