UNIVERSITÉ DE GENÈVE

PRESS RELEASE

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The Concentration of Copper is Linked to the Thickness of the Earth's Crust

Study reveals the physicochemical recipe for the formation of copper deposits in subduction zones.

Chuquicamata, Chile: home to the largest copper mine in the world. 4.3 km long, 3 km wide, and 900 m deep. Photo: Massimo Chiaradia

Having examined, compared, and combined more than 40,000 items of data on 23 volcanic chains, Massimo Chiaradia, a researcher from the geological and environmental science Department of the University of Geneva (UNIGE) was able to establish a certain number of correlations that are necessary for the presence of concentrated copper in volcanic magma. This was the first study of its kind to take place on the planetary scale. It provided the parameters for the presence of porphyry copper in the Earth's crust, a kind of deposit that is mostly made up of natural copper: in order for this sort of deposit to develop, there needs to be a subduction zone, calco-alkaline magma, and the Earth's crust must rather be thick, or continental. These results appear in the latest issue of the *Nature Geoscience* review.

Petrology is the branch of Earth sciences that examines the physicochemical nature of rocks, as well as their formation over time. Massimo Chiaradia, who is a researcher in the geological and environmental science Department of the UNIGE, recently looked into the formation of porphyry copper deposits in relation to the magmatic process. His objective? To find out, on the largest possible scale, the reasons for which porphyry copper deposits can be found in subduction zones, those parts of the Earth where an oceanic plate moves under another tectonic plate, which can be either oceanic or continental. To achieve this, he relied on the GEOROC database (www:http://georoc.mpch-mainz.gwdg.de/geo- roc/), a freely accessible, web-based collection of petrographical data maintained by the University of Mainz (Germany), and he concentrated on the 23 volcanic chains he found there. Volcanic chains are segments stretching over hundreds of kilometers, in which magma is expressed in the form of volcanoes, and which are always linked to subduction zones.

Three Types of Magma Differ According to Volcanic Areas

Magma typologies depend on their geographical context. Therefore, the composition of magma changes depending on whether volcanoes are located in subduction zones, along mid-oceanic ridges, or in hot spots like Hawaii. Chiaradia noticed that magma in subduction zones belongs to the so-called calco-alkaline and tholeitic families - the latter is related to tholeite, a basalt that is mostly made up of silica, which is very common in seabeds. This then led to the observation that calco-alkaline rock formations, or those normally associated with porphyry copper, are more frequently found along chains that formed on thick parts of the crust.

Once it leaves the mantle, magma rises up and passes through the Earth's crust; along the way, it disturbs and absorbs elements that

will later crystalize and modify its composition. This physico-chemical process modifies the magma, and is what gives it its calco-alkaline composition.

An Apparent Contraction

Massimo Chiaradia noticed another correlation, which links the copper content of magma ejected in subduction zones with the thickness of the Earth's crust. The thinner the crust is, the higher the concentration of copper in the magma, which is also tholeitic. His research suggested that the presence of porphyry copper is associated with a thick crust.

The analysis of magma's path and evolution allowed him to resolve this apparent contradiction: where the Earth's crust is thin, the magma actually drags almost all the copper it incorporated in the mantle, where it was formed, to the surface. However, even though this leads to a large amount of copper, it is not concentrated enough to be mined, since it is so spread out.

Des gisements embryonnaires

Conversely, in subduction zones where the crust is thick, much of the copper has been lost by the time the magma reaches the surface. The residual copper has remained lodged under the crust, in the concentrated form of sulphides. Over time, these deposits will increase, until they form enriched pockets deep in the crust, which are only the beginnings of deposits. After a few million years, a new surge of magma will pick up this proto-concentration and transfer it closer to the surface of the Earth, where it will form copper deposits that can be mined.

Residual copper has become lodged in the crust in a concentrated form, as **sulphides**

The result of this research will help target the segments of volcanic chains that might be rich in large-scale new copper deposits.

UNIVERSITÉ DE GENÈVE
Service de communication
24 rue du Général-Dufour
CH-1211 Genève 4

Tél. 022 379 77 17

media@unige.ch
www.unige.ch

contact

Massimo Chiaradia
+41 (0)22 379 66 34 ou +41(0)79 735 32 89
massimo.chiaradia@unige.ch