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## RECENT ARTICLES PUBLISHED IN *EXPLORE*

The following abstract is for an article that appeared in issue 187 (June 2020) of the *Explore* newsletter.

### "Exploring for Laterally Transported Copper in Gravels Using Radon Detectors"

Peter A. Winterburn[1], Thomas Bissig[1,2], Alexandra E. Brown[1]

Copper is readily leached from acid-generating sulfide ore during weathering and oxidation. Copper-bearing solutions can be transported laterally for up to 6–8 km until the solutions are neutralized (or reduced) enough to precipitate secondary Cu minerals. This lateral dispersion process can generate Cu anomalies within or below gravel units and can potentially form economically exploitable exotic Cu deposits. Detecting oxidized copper mineral species under gravel cover by traditional geochemical or geophysical means is challenging. However, because U is also mobile in oxidized meteoric fluids, it can be transported and precipitated under similar conditions as Cu. Radon gas, derived from the decay of U, may, therefore, be used as a proxy to explore for elevated U in gravels, and, by inference, for Cu. To test this hypothesis, a total of 128 Rn testing devices (the Accustar AT-100) were deployed for approximately 10 days in the soils above and adjacent to the Picarón exotic Cu prospect and the Huinquintipa exotic Cu deposit (both in Chile). An additional 12 devices were deployed in a control survey over barren ground. The Rn testing devices record alpha decay from Rn as fission tracks on cellulose film.

At both test sites, Rn detectors placed above or near known exotic mineralization yielded between 3,300 and 8,000 Bq/$m^3$. Devices placed away from mineralization or where exotic Cu is mined out, yielded 333 to 2,250 Bq/$m^3$, the lowest value coming from a device placed above low-grade primary mineralization upstream from Picarón. Limited analyses from exotic Cu mantos at Huinquintipa ($n = 6$) yielded 5–21 ppm U, roughly one order of magnitude above crustal abundance of U. At Picarón, no appropriate material was available to reliably determine the U content of gravels with elevated Cu. Selective leach geochemistry on soils taken ~35 m above the Picarón mineralization did not detect elevated Cu or U concentrations. The spatial correlation between anomalous Rn emissions and exotic Cu mineralization suggests that Rn testing devices are a potential low-cost exploration tool for detecting exotic Cu deposits where traditional soil sampling fails.

The following abstract is for an article that appeared in issue 188 (September 2020) of the *Explore* newsletter.

### "Cesium Deposits"

David Trueman[3,1], Bruce Downing[4], Tom Richards[5]

Cesium (Cs) is a little-known element, the bulk of which is used in servicing oil wells in the form of cesium formate, but it also has a myriad of uses in high-tech specialty applications. Cesium has been extracted primarily from the minerals pollucite and lepidolite, which can occur in the "giant" pegmatites at Tanco (Bernic Lake, Manitoba, Canada), Bikita (Zimbabwe), or from rare-metal granites such as the Yichun deposit (China). These sources are now problematic: the production at Tanco was stopped by a fall of loose rock; Bikita was halted due to exhaustion of its ores and stockpiles; and low Cs grades make the Yichun Granite an expensive source. Several small cesium deposits have been identified in Australia, Namibia, the USA, and Canada but none have reached systematic production. The Sinclair deposit (Dundas Shire, Western Australia) was mined out in 2019 and its ores were directly shipped to China.

Another type of cesium deposit is found in the form of epithermal geyserites, which have been identified in Tibet, India, Wyoming (USA), and Argentina. These are of lower Cs grades and of widely varying mineral assemblages, but may contain an equal or larger Cs content than the large pegmatite sources. In turn, their diverse mineralogy lends to more easily processible, and less costly, metallurgy.

The source of Cs-bearing pegmatites is probably from the fractionation of S-type granites. The source of Cs-bearing geyserites is probably similar to that at Yellowstone (Wyoming, USA) in which large volumes of rhyolite over the Yellowstone mantle plume are being leached by epithermal fluids.

Exploration techniques for cesium in rocks include the use of mineral chemistry, lithogeochemistry, soil geochemistry, geobotanical methods, and geophysical methods. Now that cesium is on the U.S. government's critical elements list, there is a burgeoning exploration for Cs-bearing pegmatites. At present, Albemarle Corporation in China and China's Sinomine Resource Group control the cesium industry.

The following abstract is for an article that appeared in issue 188 (September 2020) of the *Explore* newsletter.

### "The Taron Cesium–Thallium Epithermal Geyserite Deposit, Salta Province, Argentina"

David Trueman[6], Bruce Downing[7], Taylor Ledoux[8], Tom Richards[9]

The Taron cesium–thallium deposit in Salta Province (Argentina) is a newly recognized type of deposit that is enriched in cesium and with highly anomalous concentrations of thallium and manganese. The deposit occurs within the Ochaqui Basin, an informal name assigned to the graben-like structure composed of Miocene sedimentary and volcanic rocks. Rock types include mudstones and arkosic-, lithic- and volcanic wackes. These are intercalated with various conglomeratic facies, including one that contains pebble- to boulder-sized clasts of an orbicular granodiorite derived from the Precambrian basement. All are in unconformity and extensive areas are loosely cemented by cryptocrystalline silica, manganates, arsenates, and oxides, which are collectively termed geyserites.

The geyserite assemblages are superimposed on, and without regard to, the stratigraphy. Cesium is predominantly hosted in pharmacosiderite, an arsenate mineral which can contain up to 12 wt% Cs. Analyses by X-ray diffraction and scanning electron microscopy indicate that thallium is hosted within the manganate mineral hollandite, which can contain up to 3.4 wt% Tl. Fundamental parameter X-ray fluorescence and point sample lithogeochemistry of individual mineral samples extracted from drill core show a positive correlation between Tl and Mn, suggesting that these elements are all present in hollandite's extensive solid solution.

A fractionating S-type granite that is compositionally equivalent to Macusani glass (a Pliocene peraluminous obsidian from southeast Peru) would be expected to crystallize minerals accommodating Li, Rb, and Cs in that sequence as magmas pass through the solidus, subsolidus, and hydrothermal stages. At Taron (Argentina), a reversal of this process is seen such that the extremely highly fractionated elements of Tl, Mn, and Cs are now in abundance. To explain this observation, the authors took appropriate and comparable element data from Taron and normalized it to averaged Macusani glass. Two processes appear to have been operative at Taron: (1) the remelting of an S-type granite, or a partial anatexis, thereby reversing an expected fraction in the freezing of the same, followed by epithermal circulation of fluids pregnant with Cs and Tl to a place of geysering or hot spring circulation where the epithermal minerals formed; (2) microbial concentration of Cs in pharmacosiderite.

1 Mineral Deposit Research Unit, Department of Earth, Ocean and Atmospheric Sciences, the University of British Columbia, 2020-2207 Main Mall, Vancouver, BC, V6T 1Z4 Canada

2 Bissig Geoscience Consulting, 306-1750 Maple Street, Vancouver, BC, V6J 3S6, Canada

3 3560 Bunting Avenue, Richmond, BC, Canada V7E 5W1

4 20200 Grade Crescent, Langley, BC, Canada V3A 4J6

5 1747 2nd Avenue NW, Calgary, AB, Canada T2N 0G2

6 3560 Bunting Avenue, Richmond, BC, Canada V7E 5W1

7 20200 Grade Crescent, Langley, BC, Canada V3A 4J6

8 Mineral Deposits Research Unit, University of British Columbia, Vancouver, BC

9 1747 2nd Avenue NW, Calgary, AB, Canada T2N 0G2