We have developed a new exploration model for porphyry copper deposits that formed within sedimentary wall rocks in Montana during the Sevier orogeny. Thrust-fault-related anticlinal folds provided avenues for magma ascent and structural control on hydrothermal fluid flow described in Brimhall, 2018 and 2019. We call this new porphyry copper model the **D**eep **A**pex **S**ediment-**H**osted Porphyry Copper Model or **DASH**-PCD Model.

We have addressed one key question in what has been a lingering challenge in the models which were developed nearly fifty years ago. The existing porphyry Cu paradigm (PCD's) were developed through study in and around mines where the pre-mine landscape surface was in well-mineralized areas of the **outcropping** ore deposit near the **mid-point** of the 6 to 8 km vertical cylindrically-shaped porphyry systems- NOT near their lower-grade tops where geological features may be distinctly different as are their distal edges. Within highly-structurally controlled anticlinal domes in sedimentary wall rocks the porphyry to epithermal transition may not occur as it does in Chilean PCDs intruded into volcanic or plutonic rocks.

Today however, the upper reaches of these magmatic systems are precisely where exploration, by necessity, must now focus as the outcropping deposits have largely been long-discovered and today are much more difficult to find- as proven by the comparatively few grass-roots greenfield deposits discovered in the past decade.

Through a seven-year mapping program on our Clementine Prospect in Montana, we have illuminated one feature which has been largely overlooked in the past that if recognized and systematically mapped on a district scale serves as a critical indicator of the **vertical position** of a porphyry Cu prospect within the **DASH** PCD paradigm.

Although orbicular alteration with actinolite was carefully described by Atkinson and Einaudi at the Carr Fork area of the Bingham district (Atkinson and Einaudi, 1978), Utah as a steeply-dipping distal alteration feature observed in diamond drill core, we have discerned its significance and formative processes which are particularly useful when the orbicular zones **dip outward** indicating **necking** or narrowing of a deep magmatic-hydrothermal system, but *not* closure as we have mapped a through-going, later vein system. Necking of the orb zones upwards is indicative of the **upper** reaches of a deep early high-temperature hydrothermal system occurring within anti-clinal domes in the hanging wall of the frontal Sevier-age thrust in southwest Montana. Our field work has shown that orb zones demark the outer edge of strong advective hydrothermal fluid flow. The orbs form at a 3-dimensional boundary between advection and diffusion. Hence orbicular alteration forms a district-scale halo around these large PCD systems centered on the vein system and porphyry plugs providing a bulls-eye target for follow-up pilot drilling.

Influence of Sedimentary Wall Rocks

Unlike the **plutonic** wall rocks of the Butte deposit or the Chilean porphyries that intrude **volcanic** wall rocks, porphyries in Montana are just as likely to intrude sedimentary wall rocks formed over a protracted **passive Atlantic-style tectonic margin** with **global unconformities** demarking multiple marine regressions that created widespread paleo-karst. Paleo-karsts presents multiple opportunities to discover new porphyry Cu deposits presenting both large tonnage resources but also higher-grade Leadville-Gilman Colorado style Cu-Ag-Pb-Zn replacement ore bodies.

Hypogene high grade zones could help offset the costs of developing deep, environmentally-sound underground mines without having to strip massive volumes of barren leached cappings as in open pit mines to exploit the supergene enrichment blanket.

In order to explore the genetic relationship of the orbicular actinolite alteration to the DASH PCDs Brimhall developed an entirely new chemical thermodynamic **phase diagram.** It definitively proves that orbs are part of the porphyry copper evolution (Brimhall and Ehrig, 2022)

Our Logo

Using our mapping of the advective-diffusive boundary manifest in orbicular alteration in conjunction with conventional mapping, we seek to discover new deep porphyry copper deposits amenable to modern underground mining with a minimal environmental footprint deserving of a social license for mining. Our logo reflects the certainty that copper (shown as the pick in the pick and shovel) remains as the fundamental element for all electrical applications from the mundane to the most aspirational sustainable green technology addressing climate change with wind turbine, solar panels, and electrical vehicles. However we have replaced the traditional shovel in the pick and shovel with a blue (Gallium Nitride) LED. This symbolizes that mining, implementing best practices, is no longer an arduous trade. Instead mining is becoming a modern, high-tech industry using ergonomic design, tunnel boring machines, mechanical miners, and robotics with human safety, environmental quality, and community involvement as uncompromising principles. Copper, rare earth elements, and rare metals are the essential raw materials for all forms of electrical power transmission, high field strength magnets, and semi-conductor applications. Gallium, arsenic, antimony, tellurium, selenium, and germanium are essential for making high purity semiconductors used in computer chips and light emitting diodes (LEDs) which are essential to computing and sustainable energy production and green technology. The vertical red line in our logo represents late vein systems. The head frame represents the ultimate deep underground mine centered on the orb system outline in green dots. Our **Clementine logo** honors mining as the unique resource base on which all civilizations in human history have been classified from the Stone Age to the Copper, Bronze, Iron, and present Information Age. Replacement of the shovel reflects the Herculean progress made. The LED represents the illumination necessary for innovations remaining to attain global sustainable energy production in a world dominated by the humans.

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