

Geophysical applications across the US Critical Zone Observatories (CZO) and future CZOs for the pan-Canadian EON-ROSE research initiative

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The Critical Zone (CZ; as first defined by the National Research Council 2001) is the Earth's living skin, extending from the top of the tree canopy to the base of the deepest weathering and aquifers. Collaborations between geoscientists, ecologists, social scientists and others is critical for designing research approaches to address issues critical for humanity, such as: erosion and landscape evolution, water supply and quality, and nutrient cycles (Martin and Johnson 2017). This paper will describe the applications of some geophysical approaches to CZ studies across the US CZOs and other ecosystems (Fig. 1) and then outline plans for establishing CZOs for the new pan-Canadian EONROSE research initiative. (Fig. 2).

In 2008 Robinson et al outlined a vision for the use of electrical and magnetic geophysical methods to advance watershed scale hydrological research. Such methods are useful for examining the difficult to access deeper portions of the CZO; while the upper surface water, soil and vegetation are more readily accessible. Even the question of "How deep is deep" within the CZ is non-trivial, in part due to the variation between CZs and even within individual CZOs (e.g. Riebe et al 2017). Leopold et al (2013) used electrical resistivity tomography (ERT) across the Boulder Creek CZO to demonstrate that the Betasso lower montane basin and the Gordon Gulch montane basin with rolling hills are more variable than the Green Lakes valley (a glacially eroded alpine basin) due to the complex Quaternary geomorphic history in the non-glaciated montane landscapes.

Parsekian et al (2014) summarized a variety of geophysical techniques (e.g. seismic nuclear magnetic resonance (NMR), electromagnetics (EM), ground-penetrating radar (GPR), and seismic methods) used to map the structures that define the architecture of Critical Zones. Such geophysical applications permit synoptic research across multiple different scales to address fundamental CZ questions such as: "How does CZ structure affect exchange of fluids between subsurface and surface reservoirs?" Where is water stored within the CZ? How thick is the regolith and how do chemical weathering, climate and biologically mediation processes impact this thickness?

Each of these methods are useful for imaging weathering processes and the regolith, but are more powerful when combined. For example, ERT and seismic refraction were used to define water flowpaths and gradients in porosity in the deep subsurface at the Southern Sierra CZO (Holbrook et al 2014). McClymont et al (2011) used GPR, ERT combined with seismic to examine hydrologic flow paths in a moraine. Here low resistivity regions were identified as either fractured bedrock or unconsolidated sediments, while high resistivity regions were inferred to be unsaturated with varying levels of weathering.

In Canada there are currently no formally established Critical Zone Observatories, however there are components of Critical Zone studies currently in progress at several Canadian University research stations (i.e. Kluane Lake Research Station, Yukon Territories; or Kananaskis Research Station, Alberta; Martin and Johnson 2017). The plan for EON-ROSE is to augment these established research stations and then to establish new Critical Zone Observatories in regions such as at the interface between the Mackenzie River delta with the Beaufort Sea; in order to provide longitudinal monitoring of all the main ecosystems and watersheds across Canada (e.g. Fig. 2).

References

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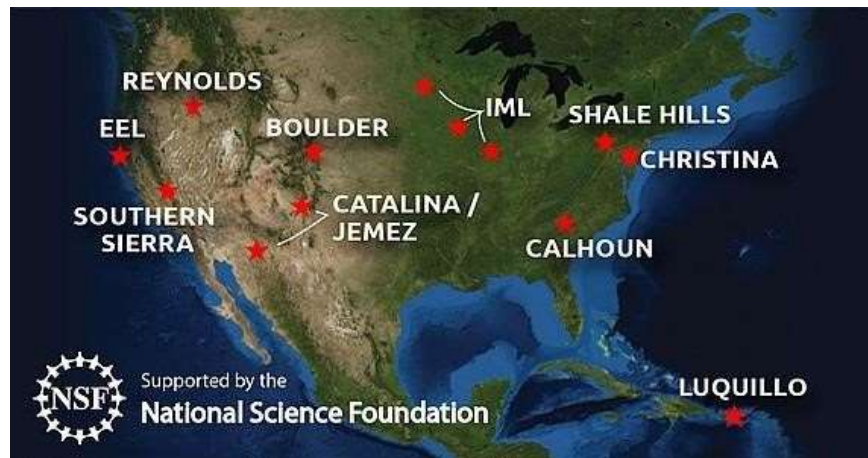


Figure 1. Critical Zone Observatories across the United States (from criticalzone.org).



Figure 2. Planned Critical Zone Observatories for Canada as a component of the planned pan-Canadian EON-ROSE research initiative.