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Magnetotellurics in Cascadia and beyond: resistivity studies of volcanoes, faults, and subduction tectonics

Significant advances in magnetotellurics (MT) in the past two decades have shown the method to be extremely powerful at imaging the Earth's interior. Previous computational limitations required most studies to simplify models and data to 1D or 2D, and important data about the 3D structure of the Earth had to be discarded. The arrival of parallelized 3D inversion codes along with datasets from surveys specifically designed for 3D modeling has allowed use of the full MT impedance tensor in inversions, allowing the Earth's true electrical properties to be expressed in the models. Simultaneously with these advances, instrumentation has improved dramatically while becoming significantly cheaper, making MT accessible to a growing user base. Work is underway to streamline data archiving and sharing by adopting a new standard HDF5-based data format and Python libraries to easily work with the data.

MT's sensitivity to conductive materials makes it excelllent for studies where subsurface fluids play a role, such as magmatic systems, lubricated faults, and geothermal fluids. It is also a powerful tool for exposing geologic structure, especially in settings where contrasting rock types or certain conductive minerals reveal the tectonic history of a location. I present results from several recent MT studies that I have been involved with and highlight the ways MT reveals new information that would otherwise be hidden. These include a study of fluid distribution on the Cascadia thrust fault, determining the magma composition and melt fraction at a volcano in the Cascades, how batholith growth in Washington has influenced the locations of Mount St. Helens and other volcanoes, and evidence of sulfide-rich Proterozoic ocean chemistry at an ancient subduction zone in the Midwest. There are complementary seismic and other studies at some of these areas, enabling more robust geologic characterization through joint interpretations. An additional benefit that has come from these projects is the recent realization that MT impedances have uses beyond geologic studies, and can be used to model anomalously strong electric fields that can arise during a geomagnetic disturbance, such as from a solar flare or electromagnetic pulse attack, which can devastate the electric power transmission grid. MT is now being used to identify areas of greater vulnerability so that they can be proactively reinforced. MT has evolved to become a very powerful and versatile tool in geophysics.

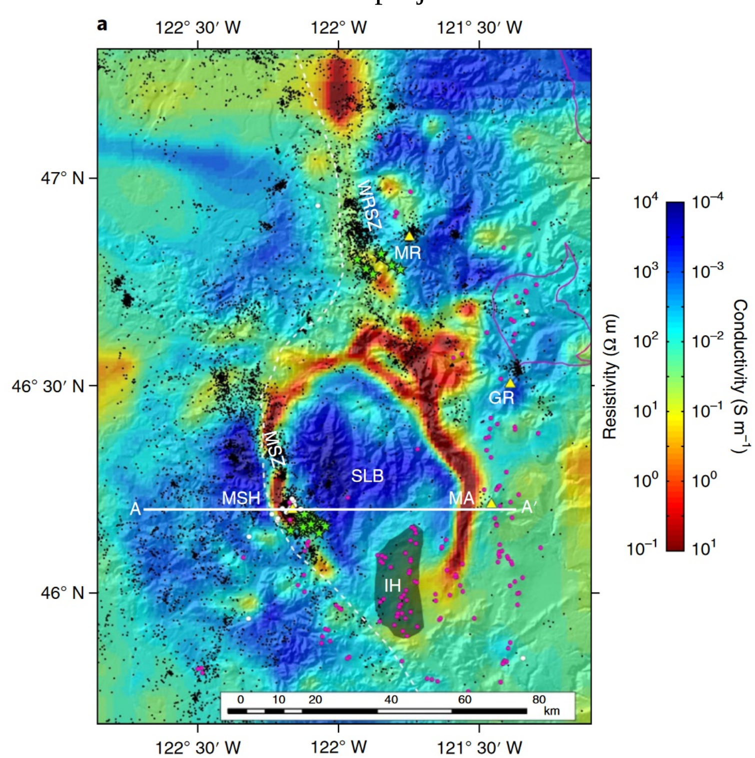

Figure: Map view of southern Washington resistivity at 7 km depth, showing resistive (blue) Spirit Lake Batholith (SLB) ringed by conductive (red) metasediments compressed during batholith growth. Mount St. Helens (MSH), Mount Adams (MA), and Indian Heaven volcanic field (IH) lie along this conductive rim.