Electromagnetic study of fluid distribution at the Aleutian-Alaska subduction zone

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SUMMARY

The Aleutian-Alaska subduction zone (AASZ) is recognized for producing some of the most powerful earthquakes of the past century. The AASZ demonstrates notable along-strike variations in rupture history, plate coupling, and seismicity. However, the mechanisms driving this lateral variability remain largely elusive. Central to this understanding is the role of fluids within subduction processes, which are thought to profoundly influence these variations and seismic hazards. To further investigate it, we propose employing geophysical electromagnetic (EM) methods. These EM methods include magnetotelluric (MT) and controlled-source electromagnetic (CSEM) techniques, which are known for their capability in imaging and providing direct constraints on subsurface fluids in the crust and mantle. By analyzing the inverted electrical resistivity structure, we can quantify the porosity of the upper plate and the subducted sediments. In the Electromagnetic Alaskan GeoPRISMS Experiment (EMAGE), we collected data from a total of 159 broadband MT stations and 130 CSEM stations spanning Shumagin Gap and Semidi segments of the AASZ, mainly along three trench-crossing profiles which were co-located with active source seismic profiles from the 2011 ALEUT experiment. Our inversion results of the Shumagin profile challenge the prevailing hypothesis that high fluid pressure may lead to less stable faults or weakly coupled plate interfaces, as we observed a fluid-starved plate interface that is weakly coupled. It suggests that the presence of fluids alone may not account for the weakly coupled plate interface observed at the Shumagin Gap. By integrating EM data with geological and seismic information for all the profiles, our study aims to provide unique insights and significant contributions toward comprehensive understanding of complex behaviors in subduction zones and enhancing seismic hazard assessments in the AASZ.

Keywords: Subduction zone, Marine EM, Fluids