



# Looking inside Loihi with Electrical Resistance Tomography

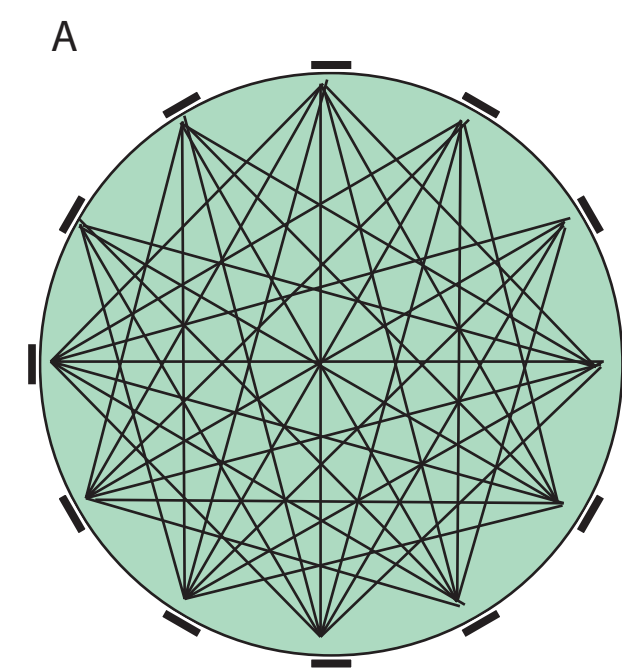
David Myer, Steven Constable, Kerry Key

contact: dmyer@ucsd.edu

web: http://www.marineemlab.ucsd.edu/

Marine EM Laboratory :: Institute of Geophysics and Planetary Physics :: Scripps Institution of Oceanography :: University of California, San Diego :: La Jolla, CA 92093-0225, USA.

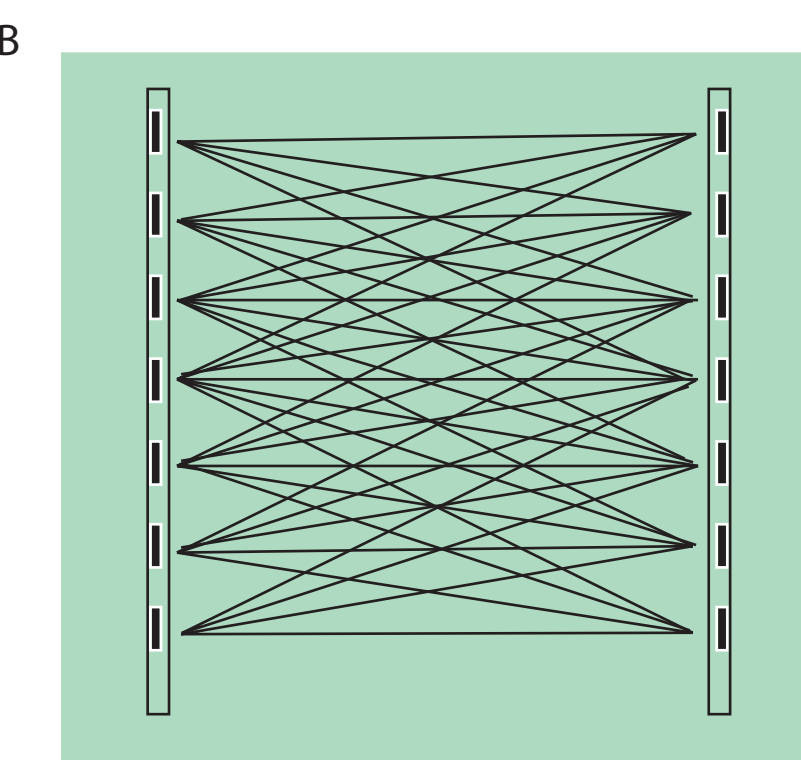
## ELECTRICAL RESISTANCE TOMOGRAPHY (ERT)



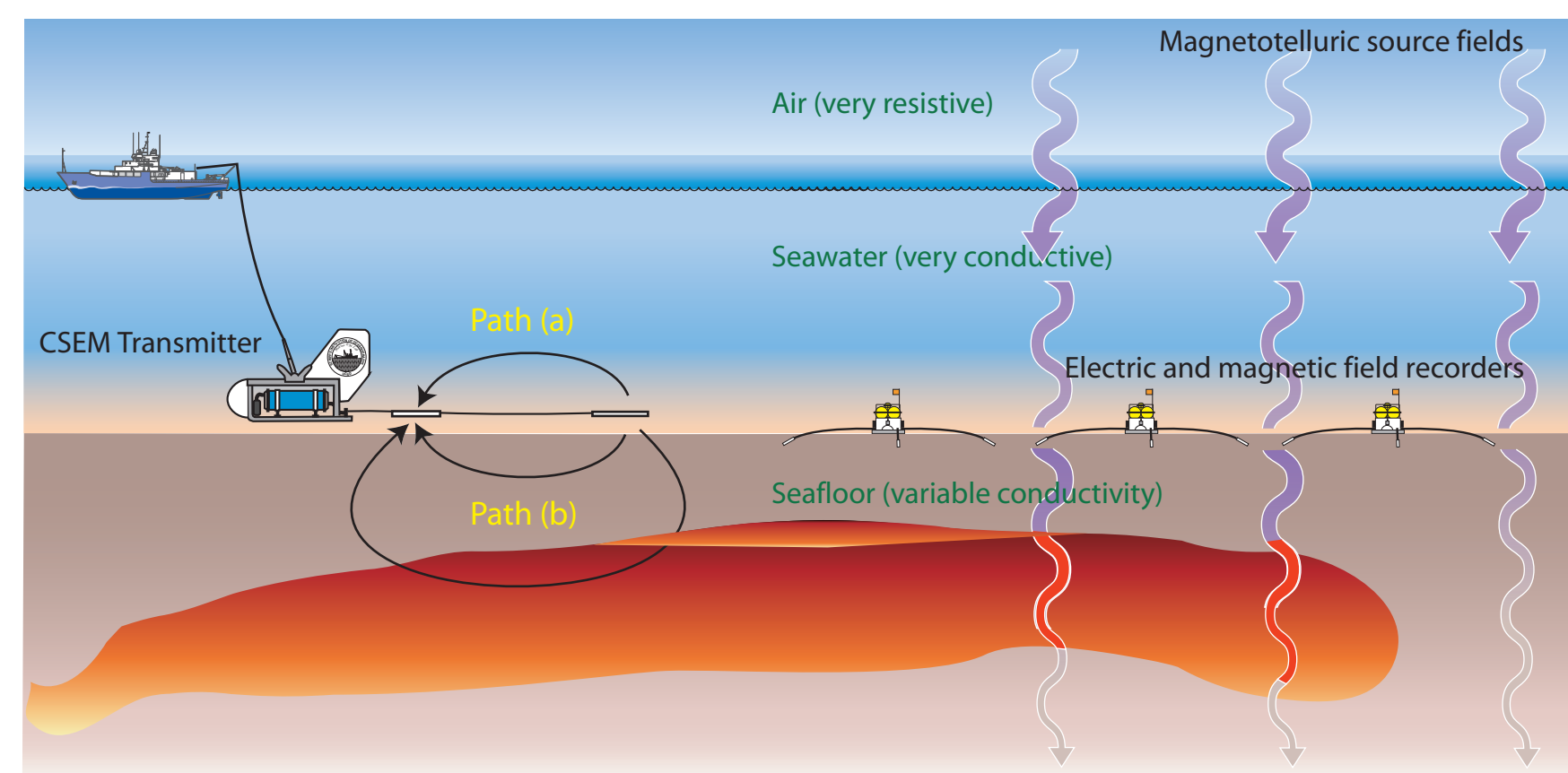
Electrical Resistance (or impedance) Tomography is used in medicine to image the human body. Typically, conducting electrodes are placed on the skin and electric potentials are measured for a variety of configurations and applied currents.

In geophysics, the basic concept behind ERT is to measure the electrical impedance between every combination of electrodes (A) surrounding a cylindrical core or (B) between two boreholes and to use the intersecting geometries of the paths of maximum current density to build an image of the electrical conductivity of the material.

We will exploit an exploration technique called Controlled Source ElectroMagnetics (CSEM) to generate the source data.



## MARINE CONTROLLED SOURCE ELECTROMAGNETICS (CSEM)



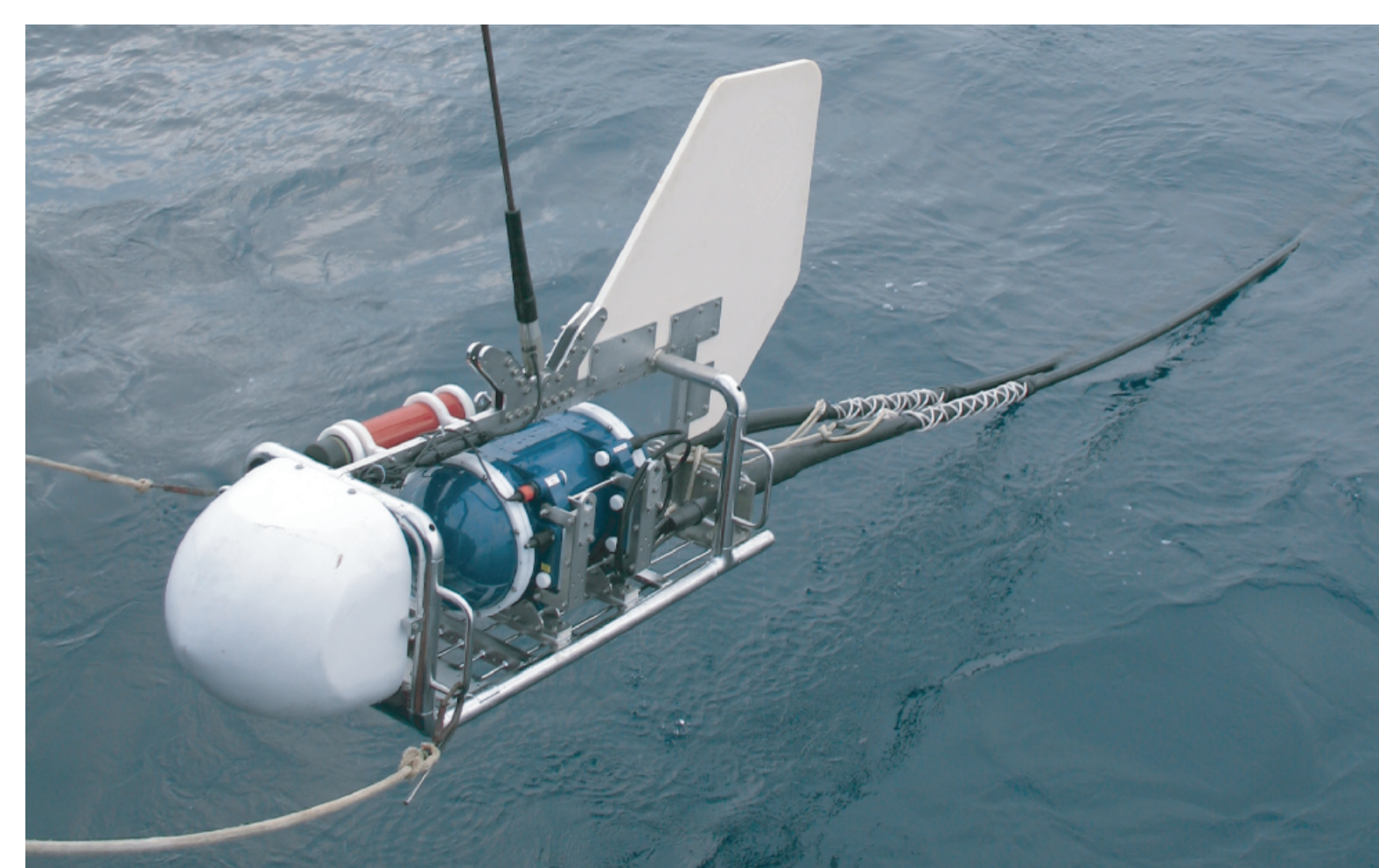
CSEM is a frequency domain technique in which a horizontal electric dipole is towed close to the seafloor. Receivers placed strategically throughout the survey area record the transmitted fields.

The fields measured at the receiver reach it through one of several diffusive paths. At the depth of Loihi, the important paths are: (a) traveling directly through the water, and (b) traveling through the seafloor.

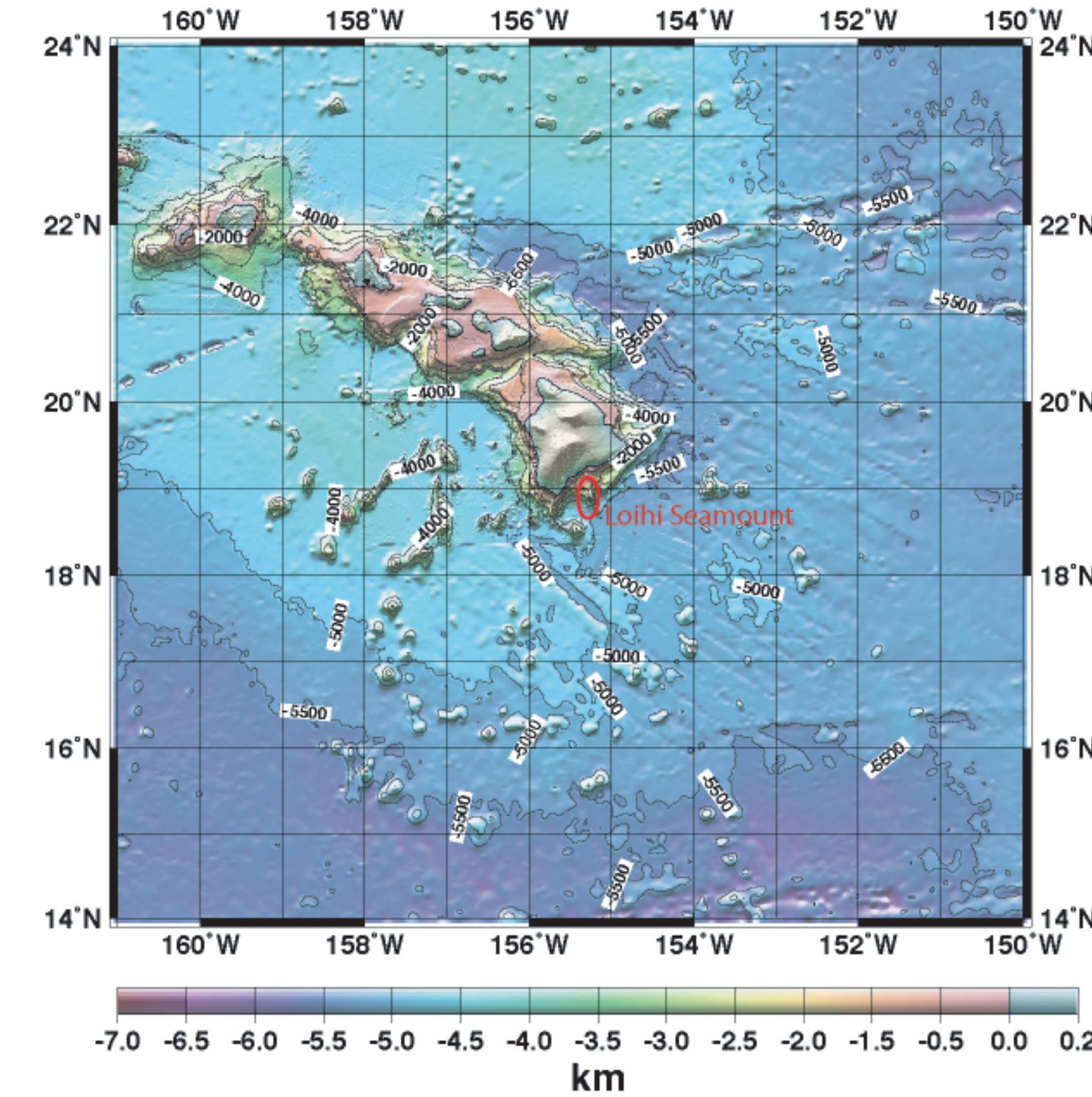
Because signal attenuation is a function of conductivity, the path that dominates the recorded signal depends on the conductivities of the media through which the signal travels.

At the closest distance between the transmitter and receiver, path (a) dominates. Higher conductivity yields greater attenuation, so at a certain distance the signal traveling through the highly conductive seawater is attenuated more than the signal that travels through the resistive seafloor and path (b) dominates the recorded signal.

The conductivities along path (a) are generally known. The conductivities along path (b) (i.e. through the seafloor) are the subject of CSEM data processing and inversion.



SUESI -- the Scripps Undersea EM Source Instrument. We will use this 500A transmitter with an approximately 100m dipole to create the source electric field.



## THE LOIHI EXPERIMENT

In July 2006, we will carry out a completely novel study of the Loihi Seamount. Using Electrical Resistance Tomography (ERT), we will map the electrical conductivity structure of the interior of this active volcano.

Electrical conductivity is a function of several factors. The most important for this study are:

- Fluid content & porosity
- Melt volume, distribution, & fraction
- Temperature

Fluid content, both magmatic and hydrothermal, in well-connected pore spaces can modify conductivity by several orders of magnitude. In contrast, we expect the bulk mineral conductivity to be relatively uniform across the survey area and therefore to contribute only small conductivity variations compared to those contributed by the fluid content.

Temperature should also have a significant effect, but not just in the obvious way related to melt fraction. Conductivity is a thermally activated process, so the circulation of warm pore fluids results in higher conductivities.

Therefore, we expect that the conductivity structure we obtain with ERT will contain useful information about the distribution of temperature as well as of melt and fluid inside the Loihi seamount.

## HYPOTHETICAL TEMPERATURE MODELS

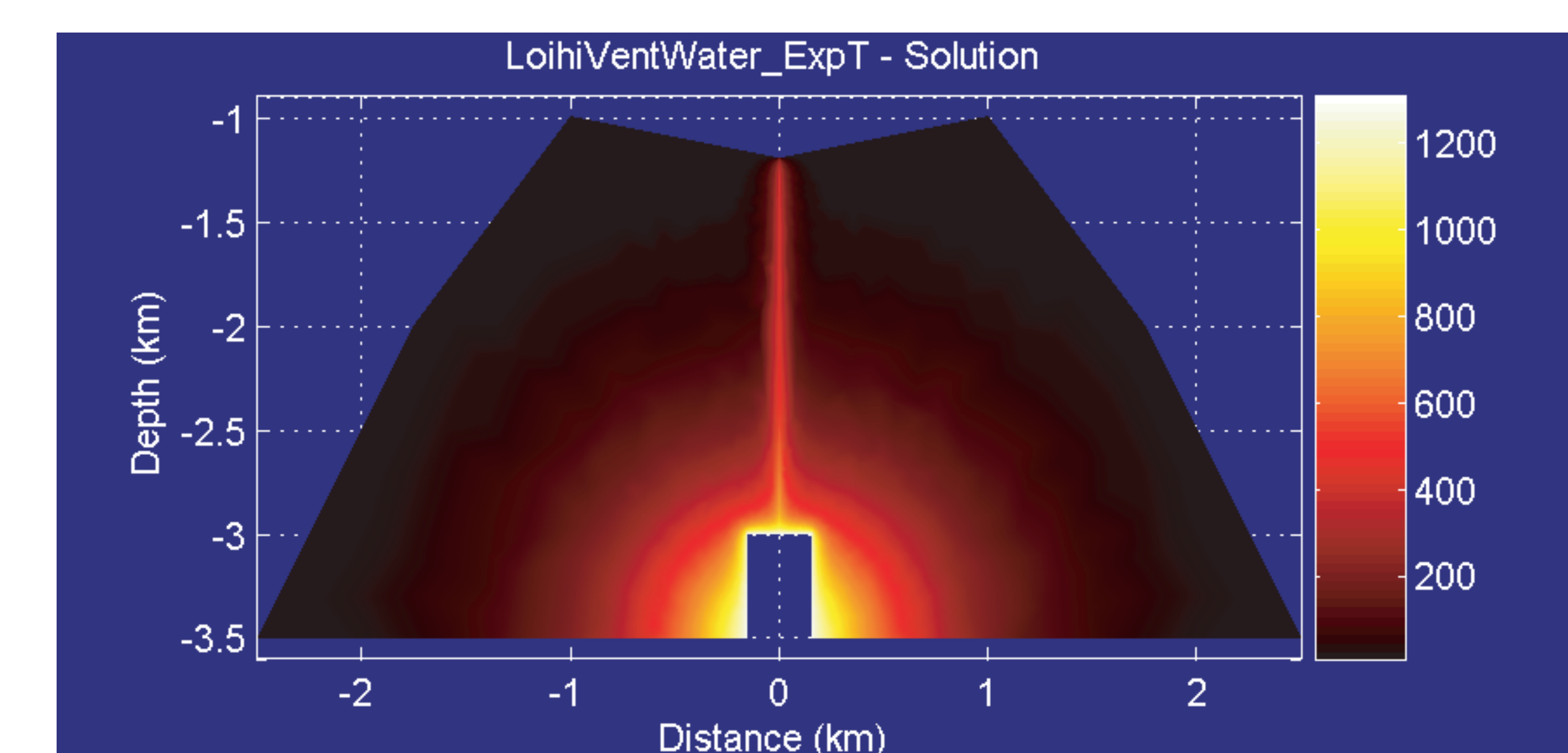
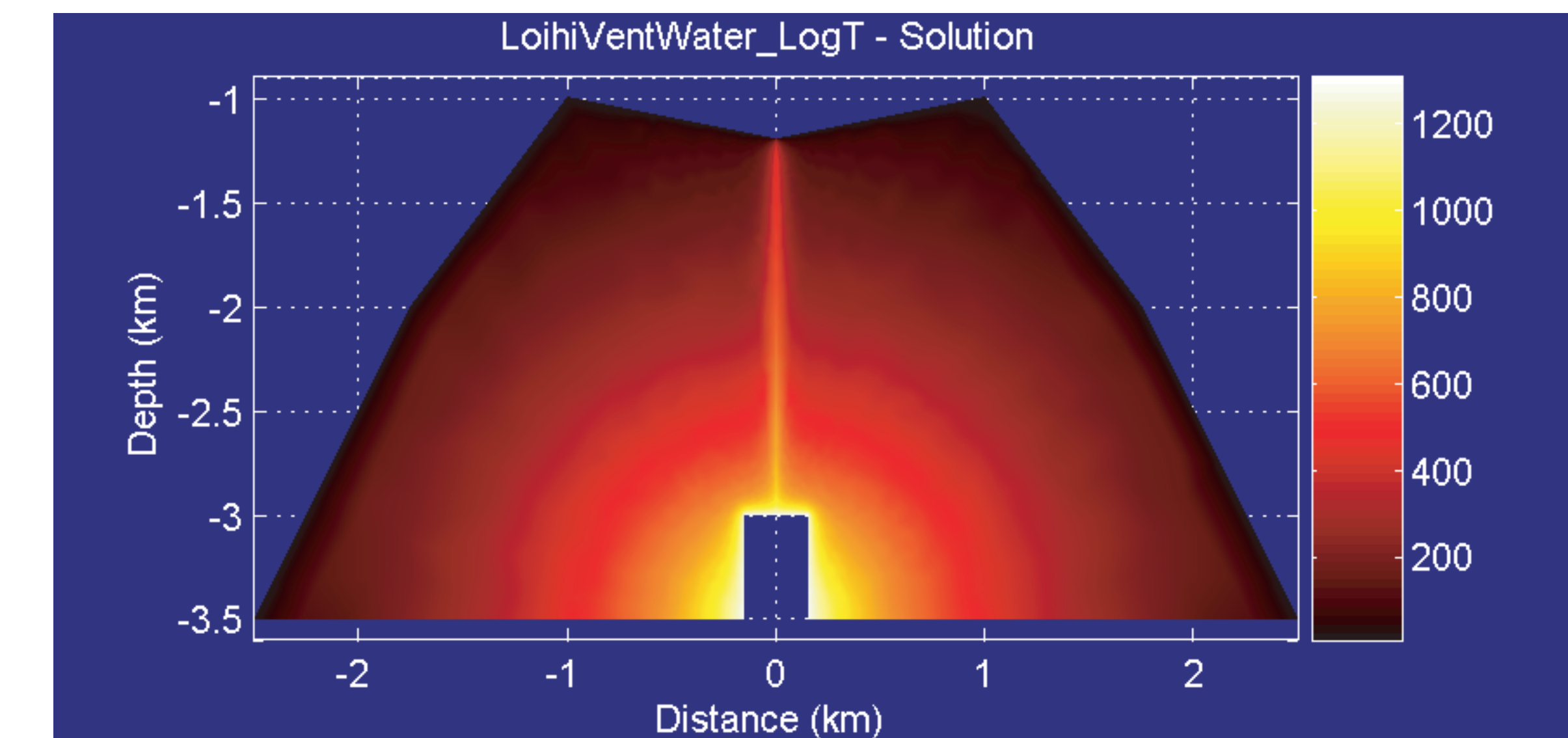
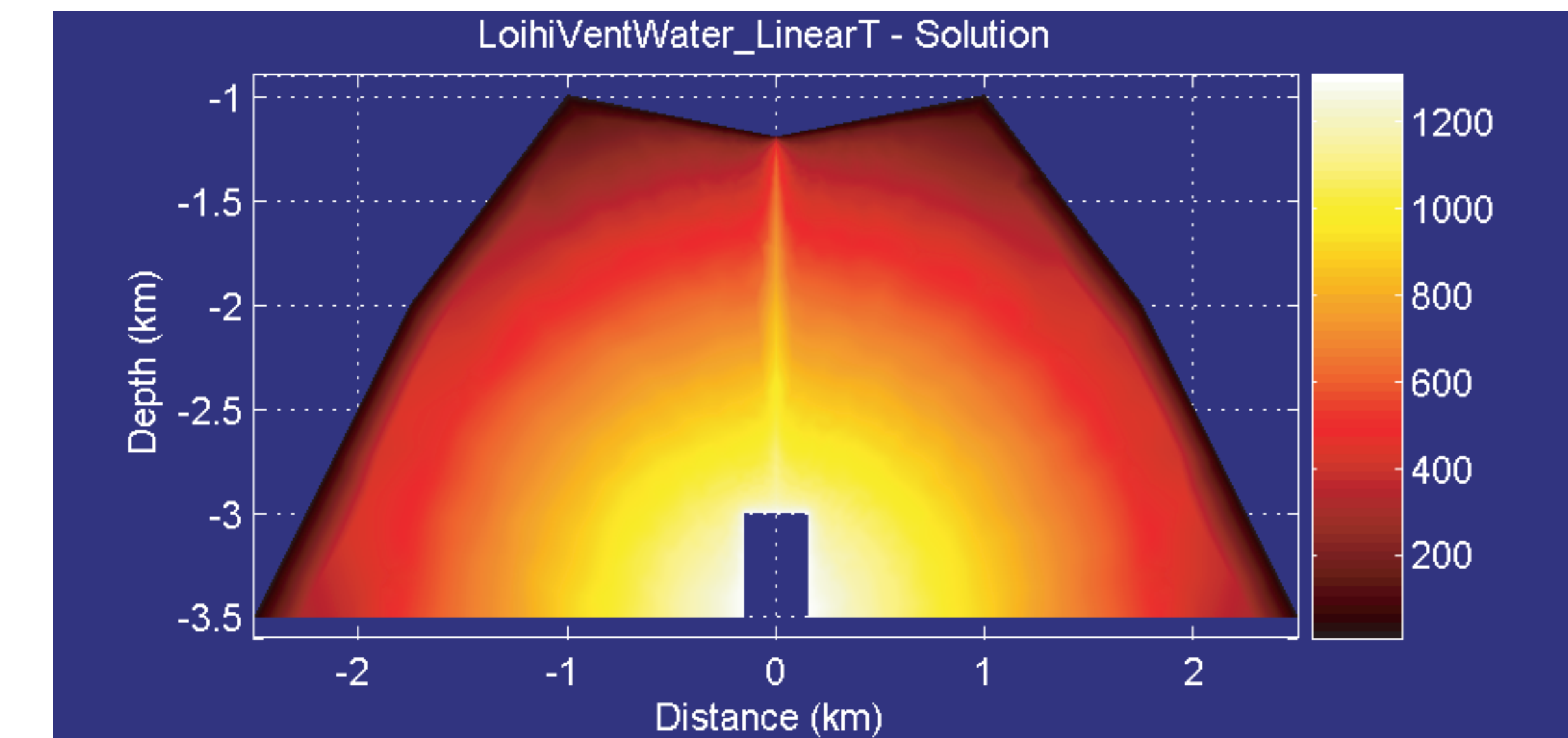
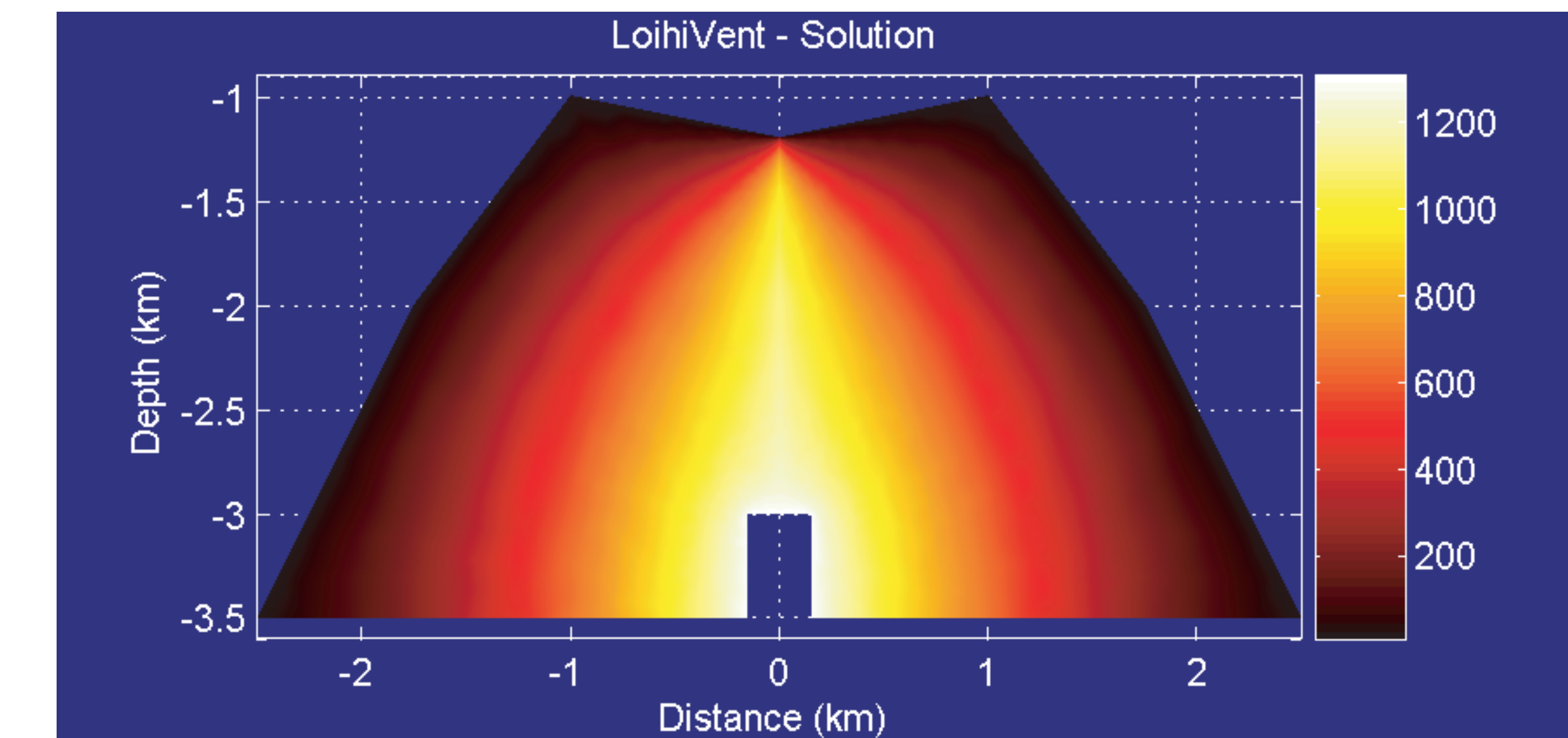
At right are several sample models of the temperature distribution within an active seamount. The models were created using finite element analysis of a static temperature distribution with limited convection. The bathymetry is idealized from an SW-NE cross-section through Pele's Pit and the East Pit on Loihi out to about 3500m depth.

In each model, a magma chamber (arbitrarily set to 300x500m) has been cut out of the base and its boundaries held at a constant 1300C (the approximate solidus temperature of basalt at this pressure). A 1m convecting conduit connects the magma chamber with the center of the pit complex and is given a temperature gradient varying linearly from 1300C at its base to 1100C at the top. The water boundary of the volcano is set to 4C and the horizontal "internal" boundary at the base of the model is weighted to zero so that temperature may evolve naturally there.

In model (a), no convection is allowed in the body of the volcano. The solution has created a much larger magma chamber that is perhaps too broad to support the weight of the volcano flanks.

In models (b) - (d), simple fluid convection is allowed in the body of the volcano to simulate the effects of water circulation. The convecting function has the form "h(Text - T)" where h is the coefficient of convective heat transfer and (Text - T) is the local gradient at each element. Model (b) is a linear gradient, model (c) is a log gradient, and model (d) is an exponential gradient.

ERT data from our study should allow us to construct a more accurate model of the temperature distribution inside Loihi.



## EXAMPLES OF ERT RESULTS

Below and at right are examples of recent ERT results. The image at right reveals the conductive magma chamber under the East Pacific Rise. The image below shows resistive hydrate deposits off the coast of Oregon. Both of these examples are vertical sections.

The Loihi experiment will be unique because the transmitter will be towed beside the receivers, making it possible to resolve a horizontal slice through the body of the volcano to receivers on the other side.

