Basin Analysis and Reservoir Characterization for Geothermal Deep Direct-Use Thermal Energy Storage (DDU-TES) in Portland, Oregon

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Location

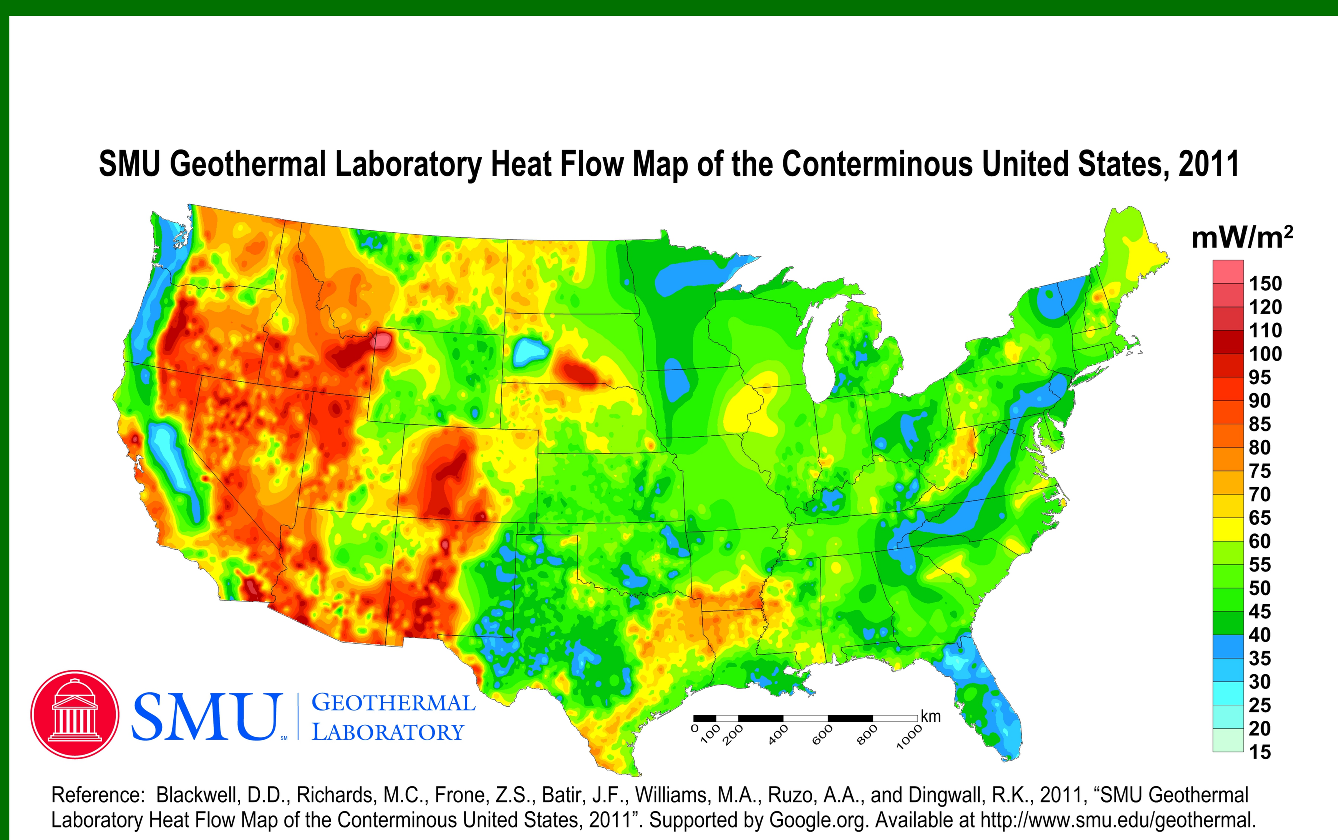

Figure 1. Heat map of the Conterminous U.S. illustrating the absence of conventional geothermal resources in and around Portland, Oregon

DDU-TES technology aims to utilize the inherent permeability in deep brackish/saline aquifers to store heat for later use in areas that lack conventional geothermal resources (Figure 1) (energy.gov). Brackish/saline conditions correspond to low advective velocities, indicating that stored heat will not be swept away. We are targeting deep aquifers with sufficient permeability to allow efficient storage and extraction of heat (Figure 2).

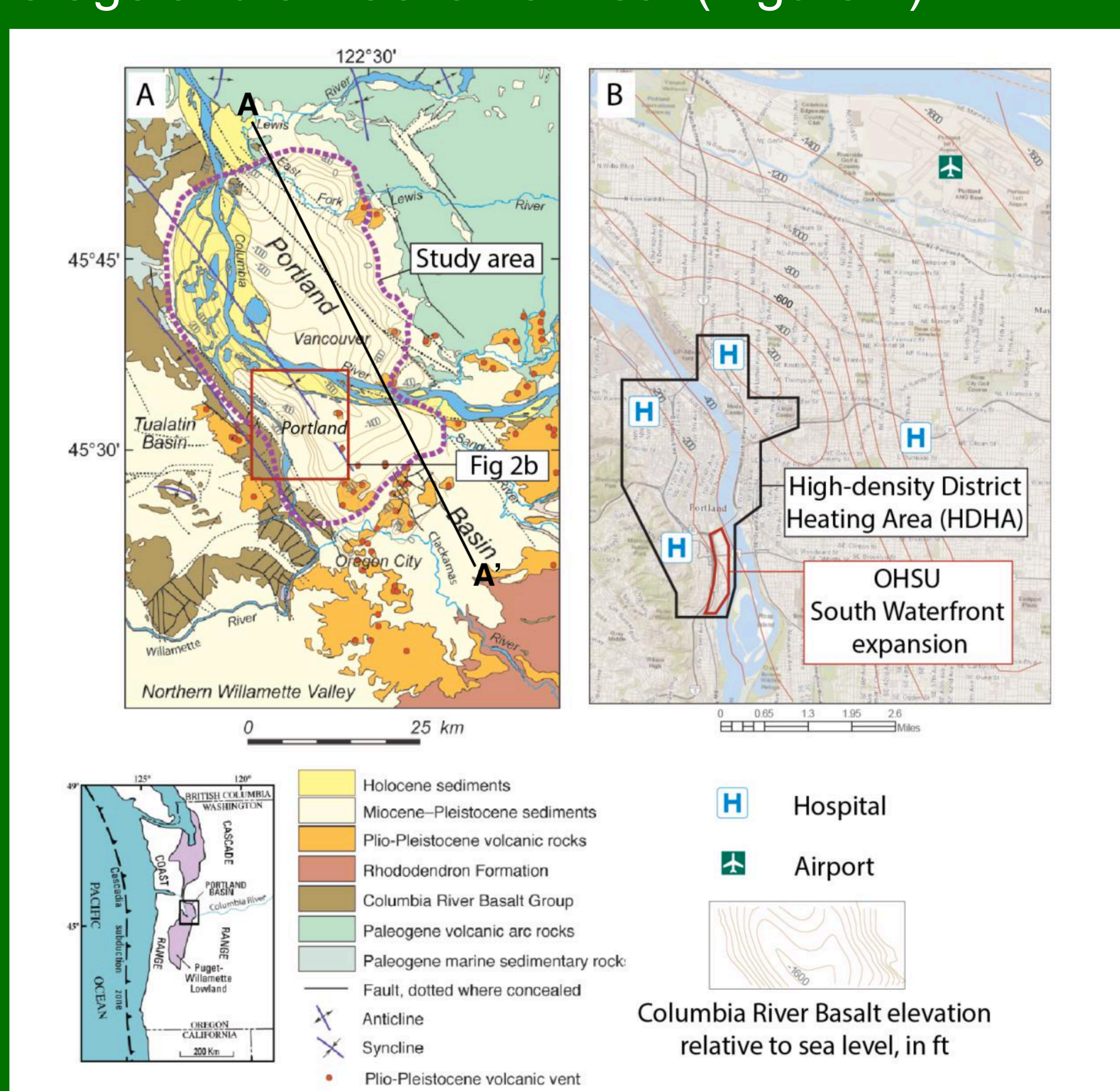

Figure 2. Location maps of study area, where contours correspond with the top of the Columbia River Basalt Group (CRBG), the base of which is the target reservoir for circulation of geothermal working fluid. (A) Study area extent showing the Portland Basin and A-A' cross section line. Geology is modified from Evarts et al. (2009). (B) Focus area inset map showing features for economic analysis, including high-density areas for district heating. The South Waterfront expansion area is where Oregon Health & Science University (OHSU) plans to build 6 new large energy-efficient hospital buildings over the next two decades. The lower small inset map shows regional context of A.

Scientific Question/Approach

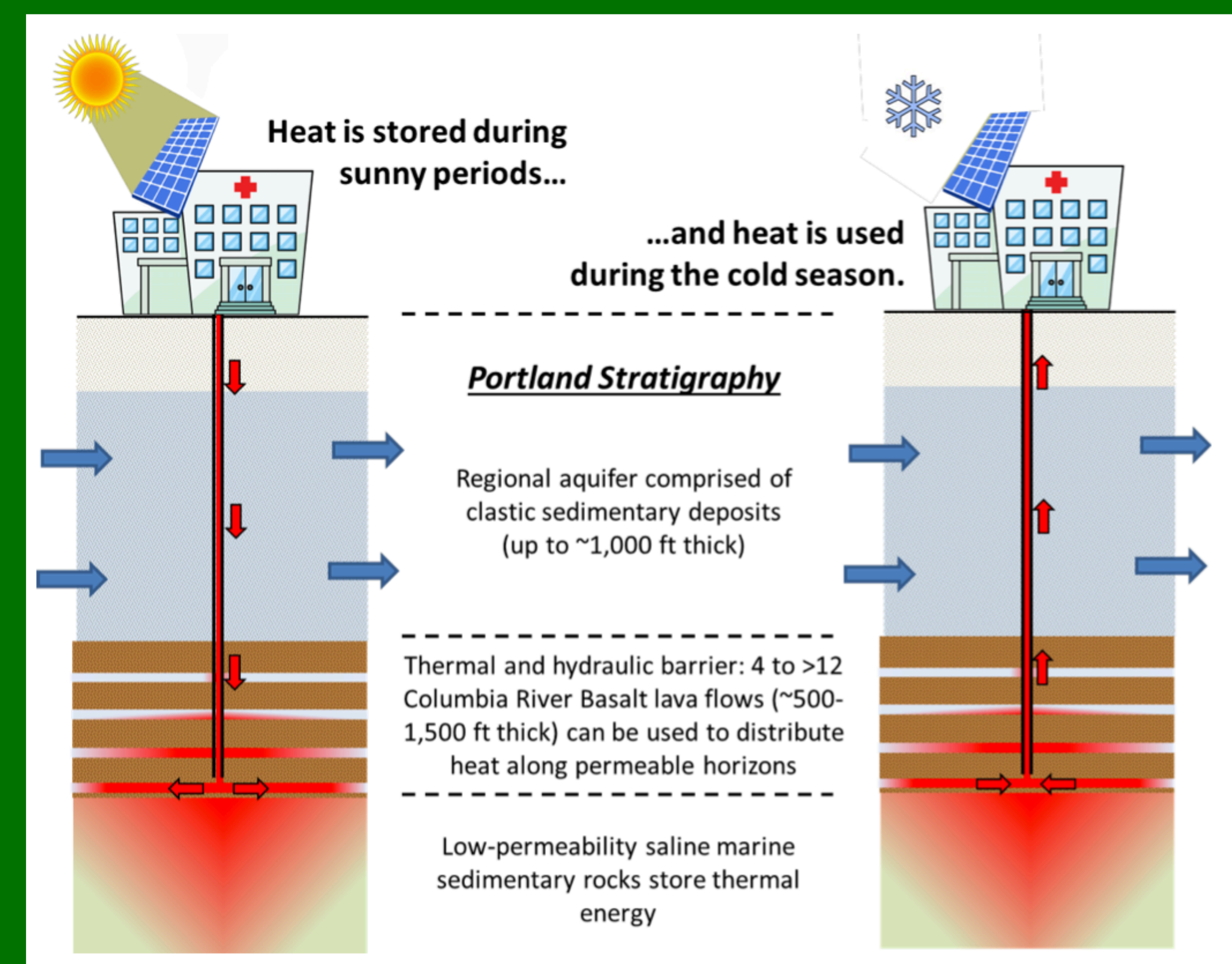

Figure 3. DDU-TES schematic showing the general stratigraphy of the Portland Basin. [Note: Well configuration in this diagram is schematic only. Single- and multi- well configurations will be examined during the analysis].

Deep Direct-Use with Thermal Energy Storage (DDU-TES) heats "stagnant" permeable zones to temperatures suitable for direct-use (Figure 3). For an efficient DDU-TES system, it is critical that there is sufficient hydraulic and thermal separation between the thermal energy storage zone and the overlying aquifer to prevent high heat loss due to advection by groundwater (Figure 4). This feasibility study will constrain the geometry, relevant structures, and reservoir properties of the Portland Basin for a 3D model as well as groundwater and heat flow simulations. We will evaluate studies of fluid injection depths, rates, and volumes from recent work in Oklahoma, California, Ohio, and elsewhere during our feasibility study (e.g. Gobel, 2015; McGarr, 2014; McGarr et al., 2015) and the geochemical interaction between the geothermal fluid and the DDU-TES system.

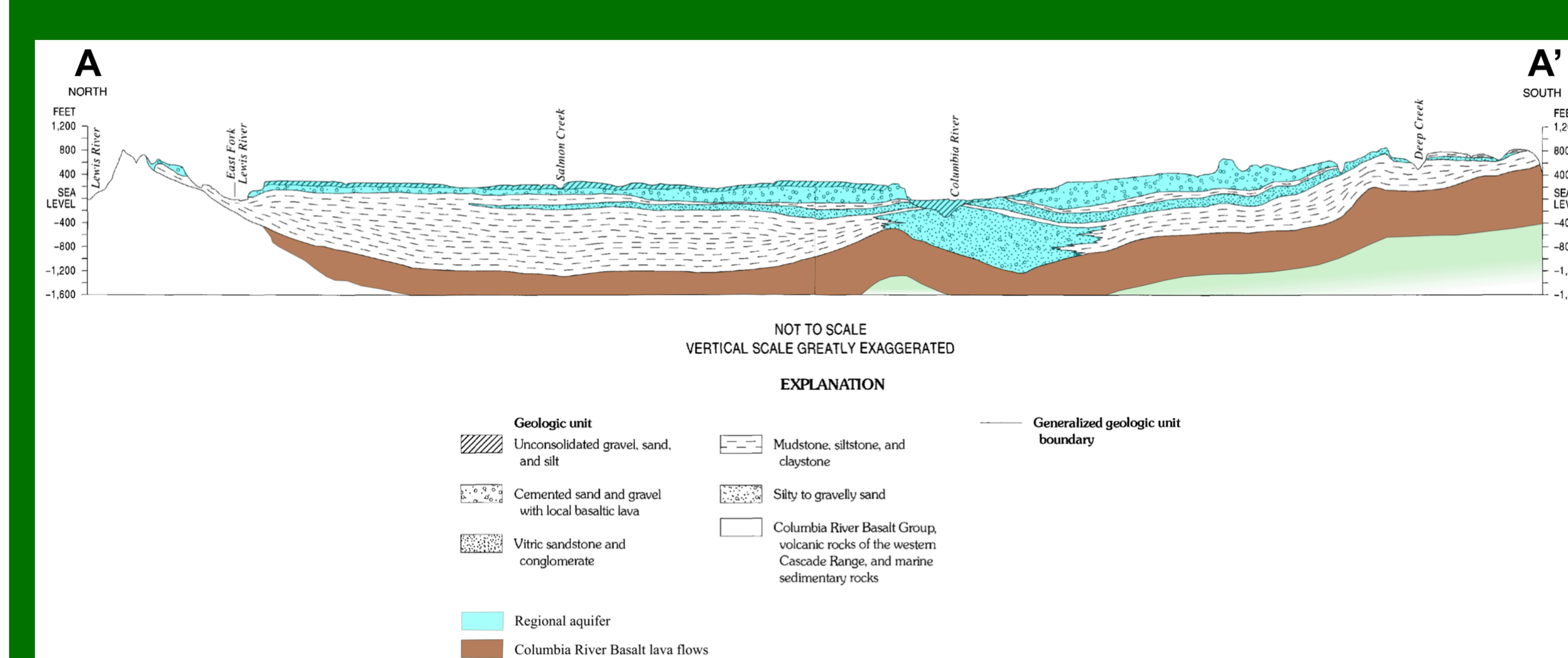

Figure 4. CRBG lava flows occur throughout the Portland Basin and provide an effective thermal and hydraulic barrier. This cross-section of the Portland Basin is for illustrative purposes and is modified from Gannett and Caldwell, 1998 & Swanson and others, 1993, Plate 2

Impact

This study can be viewed as a proof of concept and recipe for success for the Portland Basin and other saline and brackish aquifer systems across the U.S. In principle, the necessary conditions are cold winters, summer sunlight, and a deep brackish or saline aquifer (not connected to the ocean), indicating low groundwater flow conditions. These conditions are plentiful in the eastern U.S., including the major sedimentary basins of the midwest.

DDU-TES infrastructure could be constructed under new buildings, seamlessly integrating with and supplying heat to older facilities through district heating infrastructure. Further, new construction allows cascading of heat to be a design consideration for new buildings. Having an independent local source of building heat may also prevent loss of critical hospital functions during natural disasters that include volcanic eruptions and earthquakes. For this last reason, the tectonic and seismic analysis will evaluate the vulnerability of DDU to interruption of service during natural disasters. An analysis of the Portland Basin may also provide insight into the tectonic evolution of the region, including both the timing and forcing mechanisms behind its formation.

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Acknowledgments

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