Carbon Dioxide Sequestration in Continental Flood Basalts: Meeting Subsurface Imaging and Characterization Challenges in Eastern Washington

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Brecciated pahoehoe flow tops of stacked continental flood basalts appear to offer storage potential for tens of millions of tons of anthropogenic carbon dioxide where the basalts contain unpotable water and are at depths greater than 800 m. In laboratory experiments at reservoir conditions, basalts react with formation water and supercritical CO2 to precipitate carbonates, adding a potential mineral trapping mechanism to dissolution and hydrodynamic trapping mechanisms associated with conventional sedimentary reservoirs. The DOE's Big Sky Carbon Sequestration Partnership (BSCSP) is conducting a pilot test of the sequestration potential of the flood basalts of the Columbia River Basalt Group (CRBG) in eastern Washington. In contrast to geologic sequestration in most brine-filled sedimentary formations, successful sequestration in basalts requires significant technological advances in subsurface imaging and characterization.

An innovative 6.5 km, five line multi-component seismic swath revealed that S-wave noise swamps the P-wave signal, and that the velocity structure of fast basalts and slow interbeds in the upper 300m of section results in a critical angle of refraction beyond about 15 degrees. The resulting filtered and migrated P-P data imaged a succession of approximately 2400 m of basalt layers with no major faults, suitable for wellbore characterization and testing.

Subsurface stratigraphy of the subsequent 1253 m pilot well on the Boise White Paper Mill property at Wallula, Washington was established through XRF geochemistry, tied to wireline logs and petrographic data from rotary sidewall cores and well cuttings. Information from acoustic logs that acquire cross-dipole and multispaced monopole measurements, combined with fracture, texture and dip information from resistivity based image logs provide a robust methodology for analyzing mechanical properties, earth stresses, reservoir quality and seal integrity of the fractured basalts. These data combined with other log data allow for ranking of sequestration reservoirs and seals, as well as the determination of log signatures for basalt lithofacies observed in CRBG outcrop analogs. The lessons learned from analysis of these challenging rocks have implications for assessing local and regional potential for CO2 sequestration, as well as calibration of log and seismic data acquired for deeper natural gas exploration in the region.