Aquifer Assessment Introduction

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Columbia River Basalt Geology and HydrogeologyColumbia Basin Ground Water Management Area Subsurface Geologic Mapping and Aquifer Assessment ProjectAbstractThe thick sequence of layered flood-basalt flows of the Columbia River Basalt Group (CRBG) are prime sources of potable groundwater throughout their extent in Washington, Oregon, and Idaho. Having a realistic and accurate understanding of how ground water enters and moves through these flood-basalt flows is of fundamental importance to anyone working with CRBG aquifer systems (e.g. resource ssessments, contaminant transport/fate, aquifer storage/recovery, regulatory assessment).One of the most extraordinary features of the CRBG is the physical dimensions of individual basalt flow layers. A conceptual understanding of the nature of CRBG flows plays a critical role in accurately interpreting some of the unique hydrogeologic aspects of the CRBG. During the peak period of CRBG eruptive activity (Grande Ronde and Wanapum Basalts) it was common for eruptive events to rapidly (~2 to ~12 weeks) emplace individual flows having volumes of 500 to >1,000 mi3 and for the lava to cover areas >10,000 mi2 creating the largest known lava flows on the Earth. This combination of huge volume and rapid emplacement typically produced simple sheet flows 50 to >300 feet thick and not compound flows commonly associated with basaltic volcanism (e.g. Hawaii, Snake River Plain).CRBG basalt flows are typically very widespread, covering an average area of 10,000 mi2. This, coupled with the physical geologic characteristics of CRBG flows indicates these flows formed as lateral extensive, uninterrupted sheets. This differs markedly from more typical compound basalt flows which display numerous, interfingering, discontinuous lobes. The net hydrologic result of this is that the aquifers within the sheet flows typical of the CRBG occur as a series of layered, tabular, confined features whereas those in compound flows (not normally found in the CRBG) would form an interconnected, semi-confined to unconfined system.Aquifer horizons within the CRBG are generally associated with intraflow structures at the top (e.g., vesicular flow-top, flow-top breccias) and bottom (e.g., flowfoot breccias, pillow lava/hyaloclastite complexes) of sheet flows; collectively these intraflow structures can comprise between 10 to >30% of the total flow thickness. Flow-top breccias and pillow lava/hyaloclastite complexes often have excellent reservoir properties and can be exceptional aquifers, but these intraflow structures are not always present. However estimates of their potential locations, extent, and thicknesses can often be made with an understanding of the local (and regional) paleoenvironmental conditions during flow emplacement. The interiors of thick sheet flows (in their undisturbed state) are for all practical purposes essentially impermeable and act as aquitards, typically creating a series of “stacked” confined aquifers within the CRBG.The dominant groundwater flow pathway within CRBG sheet flows is horizontal to sub-horizontal along individual, lateral extensive, interflow zones. Given the physical properties of CRBG basalt, outcrop observations, and interpretations of well hydraulics vertical groundwater movement through undisturbed basalt flow interiors is small to essentially non-existent. However, vertical groundwater movement between layered CRBG aquifers is possible, but occurs predominantly under specific geologic conditions where basalt flow interiors are disturbed or truncated. Specifically, vertical to sub-vertical groundwater movement through basalt flow interiors occurs naturally where:

- Sheet flows pinchout (flow margins),
- Erosional windows thin and/or cut through one or more flow interiors, connecting separate interflow zones,
- Geologically recent faults and associated tectonic fractures provide open fractures across multiple, impermeable, layered, flow interiors.Additionally, uncased (pumped and unpumped) wells completed across multiple aquifer layers act as manmade vertical groundwater flow pathways. Flow margins, erosional channels, and faults are features that can create potential vertical pathways for ground water movement in the CRBG aquifer system. Flow margins create very limited (single flow) vertical connections. Erosional channels (during and post-CRBG time) can breach multiple flows creating the potential for a more extensive vertical connection. The greatest potential vertical pathways within the CRBG are created by faults. Shatter breccia produced along the fault creates a permeable pathway. The extent, thickness, and physical character of shatter breccias is related to the style (i.e., reverse, normal, or strikeslip) and intensity of deformation. Fault breccias often display some degree of secondary alternation or mineralization which reduce (or eliminates) the vertical permeability of these features. These conditions also allow faults to act as horizontal barriers to ground water movement. Where faults are incompletely altered or mineralized, they may also act as vertical conduits. However, the occurrence of vertical faults and tectonic fractures may be minor by comparison to the areal extent of these flood-basalt flows. Poorly constructed water wells may overshadow these natural vertical features allowing even greater hydraulic intercommunication between aquifers. The current Columbia Basin GWMA subsurface geologic mapping and aquifer assessment project has mapped the distribution of the major geologic units comprising the CRBG aquifer system, and the features within it that potentially effect the lateral distribution of individual aquifers. In addition, this work, which includes an evaluation of water level trends and ground water geochemistry provides GWMA scientists with important clues into the nature of: (1) aquifer continuity and extent, (2) aquifer interconnection, or the lack of that interconnection, (3) ground water recharge and the potential age of ground water within the CRBG aquifer system, and (4) ground water discharge, or the lack of that, especially from deeper portions of the system. The results of this project also give GWMA stakeholders insights into how to better manage the aquifer system, including ways to evaluate recharge project feasibility. The photos in this article when clicked on will open in a larger format.View the presentation here!