Geologic Barriers Introduction

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GEOLOGIC CONTROLS ON COLUMBIA RIVER BASALT AQUIFER SYSTEM IN THE GWMAThe thick sequence of layered flood-basalt flows of the Columbia River basalt 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 Columbia River basalt aquifer systems (e.g. resource assessments, contaminant transport/fate, aquifer storage/recovery, regulatory assessment).One of the most extraordinary features of the Columbia River basalt is the physical dimensions of individual basalt flow layers. A conceptual understanding of the nature of Columbia River basalt flows plays a critical role in accurately interpreting some of the unique hydrogeologic aspects of the basalt. During the peak period of basalt 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. Columbia River 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 they formed as lateral extensive, uninterrupted sheets. This differs markedly from more typical compound basalt flows which display numerous, interfingering, discontinuous, lenticular layers. 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.Aquifer horizons within the Columbia River basalt generally are associated with intraflow structures at the top (e.g., vesicular flow-top, flow-top breccias) and bottom (e.g., flow-foot breccias, pillow lava/hyaloclastite complexes) of sheet flows. 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 Columbia River basalt aquifer system. The dominant groundwater flow pathway within this aquifer system is horizontal to sub-horizontal along individual, laterally extensive, interflow zones. Given the physical properties of the Columbia River 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. This Photograph shows basic geologic relationships in a fault zone. Folds also can control the basalt aquifer system, usually forming barriers to ground water flow, and subdividing the aquifer system into ground water sub basins. Ground water systems on either sides of these folds typically do not display significant hydrologic connection.Feeder dikes, from which Columbia River basalt lave flows erupted millions of years ago, form long, nearly vertical subsurface features which probably form boundaries to groundwater flow.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 ot 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.