Natural Tracer Study of Mountain Block Recharge in a Headwater Catchment: Davidson Canyon

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Study Motivation
While mountain block recharge (MBR) is an important hydrological process, the spatial distribution and flow paths of MBR are often poorly constrained (Markovich et al., 2019). This study aims to understand MBR in a headwater catchment via the instrumentation and study of the Davidson Canyon watershed in the northern Santa Rita Mountains, Arizona.

Previous Studies
Why Increased pressures in the Santa Rita and Empire mountains (development, the proposed Rosemont open pit copper mine, and climate change) are putting increased stress on the water resources.

Precipitation
Tritium values from precipitation have varied in the past decade, so modern surface and groundwater ages can’t be calculated with absolute certainty. However, the tritium data show that surface water in Davidson Canyon is older than recent precipitation, and likely is approximately a decade old (Vicenti, 2018).

Surface Water
Studies by PAG have shown that Davidson Canyon contributes up to ~35% of flows to Cienega Creek after their confluence (PAG, 2003). Tritium, major ion chemistry, and isotopes all support the idea flows are not runoff but are rather sourced from longer residence time, more chemically evolved, waters. The likely source of surface flows in Davidson Canyon is the shallow alluvial aquifer, which has not been sampled.

Proposed Study
Precipitation-driven shallow groundwater discharge

Local bedrock high-caused springs

Groundwater
Bedrock
— Barrel Canyon
— Davidson Canyon
— Cienega Creek

Santa Rita Mountain Block

Barrel Canyon

Empire Mountains

The Empire mountains are comprised primarily of Paleozoic to Mesozoic rhyolites and limestones, with complex local geology.

Cienega Creek

Cienega Creek, a tributary of Panano Wash which feeds the Tucson Basin drains the Whetstone, Santa Rita, and Empire mountains. Its perennial and intermittent reaches are spring fed and support various riparian habitats. Cienega Creek is protected by the Las Cienegas National Conservation Area and the Cienega Nature Preserve.

Study Area
Santa Rita Mountains

While local geology is extreme complex, the Santa Rita mountains are comprised primarily of Mesozoic to Cretaceous andesites.

Barrel Canyon

Barrel Canyon is a headwater tributary to Davidson Canyon and drains the northern Santa Ritas. Certain reaches are spring fed.

Davidson Canyon

Davidson Canyon follows the fault which separates the Santa Rita and Empire mountains, with up to ~3,000’ of offset east to west. It drains the eastern Santa Rita and western Empire mountains. An important tributary to Cienega Creek, Davidson Canyon is a designated Arizona Outstanding Water.

Key Definitions
Mountain Block
Topographically elevated land with minimal to no soil

Basin Fill
Unconsolidated sediment comprising lower elevation, intermountain basins

Alluvial Aquifers
Aquifers located in basin fill rather than bedrock

Mountain Front Linear feature separating the mountain block and the adjacent basin

Mountain Block Recharge
Recharge to alluvial aquifers that originated in mountain blocks

Diffuse MBR
MBR that occurs across the mountain front

Focused MBR
MBR that occurs through discrete geologic units, such as faults or streambeds

Research Questions and Plan
Research Questions
• What is the seasonality and elevation of recharge from precipitation in the Santa Rita and Empire mountains?
• What are the ages of surface and groundwater in the Davidson Canyon watershed? How do these ages change seasonally and during individual precipitation events?
• What is the composition of the shallow alluvial aquifer?
• What is the relationship between the shallow alluvial aquifer and streamflow?
• Can the evolution of water in the stream channel be visualized?
• What is the role of MBR from the Santa Rita and Empire mountains in the Davidson Canyon and Upper Cienega Creek watersheds?

Research Plan
• Continue to build a long-term data set of water quality in the Davidson Canyon watershed for the following: tritium, stable water isotopes ($\delta$O, $\delta$H), electrical conductivity, major ions, and alkalinity.
• Start sampling the shallow alluvial aquifer and analyze individual precipitation events

References


Vicenti, N., Natural tracer study to constrain transit times and flowpaths of groundwater from Davidson Canyon to Lower Cienega Creek. UA master’s thesis, 2018.