

Groundwater recharge & discharge relations inferred from isotopes and hydrochemistry in Samail Catchment, Oman

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Abstract

Groundwater recharge and discharge relation along the flow path in the regional catchment of Samail, Oman has been investigated using different isotopes and conventional hydrochemistry. The subsurface geology is complex and variable ranging from karstified carbonate rocks at the elevated areas of North Oman Mountains (NOM) to fractured ophiolitic sequence overlain by porous medium of Quaternary alluvium gravel at the top of the geologic section. The alluvium is thickening from elevated area downstream to exceed 300 m at the lower reaches of the catchment. The boundary between the carbonates and the ophiolites is controlled by a major thrust along which several springs are originating. Groundwater generally flows south-north with a hydraulic gradient decreasing to the south.

Groundwater samples (total 74) from deep and shallow wells as well as springs were analyzed for the isotopes C¹⁴, ²H, O¹⁸ and ⁸⁷Sr/⁸⁶Sr and major cations and anions. Carbon-14 dating (18.9 ka to modern), wells hydrograph analyses, ⁸⁷Sr/⁸⁶Sr data (0.70810 – 0.70895) and ²H, O¹⁸ suggest two main sources of recharge: 1- direct infiltration through stream bed into alluvium and 2- recharge from carbonates lineaments and fissures into the alluvium and ophiolites. The recharge of the alluvium takes place across the entire catchment. The wells hydrograph analyses and ⁸⁷Sr/⁸⁶Sr data (0.70810 – 0.70895) show that the alluvium and Ophiolite are partly interconnected and recharged by the same water source with a delayed recharge response of 2-3 months. Groundwater in the southern part of the catchment is isotopically depleted water indicating a high altitude recharge source, whereas deviation from meteoric water line in the lower catchment indicates the effect of evaporation.

Spring discharge from the NOM down the gradient indicates local, intermediate and regional flow systems of a groundwater residence time ranging between a few years to a maximum of ca 10K years at the terminal end of flow. The Ca:Mg ratio varies in the different rock types indicating the influence of geology on the hydrochemistry.

Petrographic and geochemical characteristics of the Oman ophiolite lower crust

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Layered cumulates making up the lower crustal section of the Oman ophiolite are largely considered as the result of the fractional crystallization of normal mid-ocean ridge basaltic (N-MORB) melts at low pressure. A glance to former studies reveals however that layered cumulates have been explored only in some massifs and that no global petrological study of this unit has been performed at the ophiolite scale. Moreover, in the mantle section, melt migration structures are filled with cumulates from two contrasted parental melts: one with a N-MORB tholeiitic affinity and one with a depleted andesitic affinity, this latter being the most widespread [1].

In order to better constrain the origin of layered cumulates in the Oman ophiolite, we have conducted a petrographic and geochemical study (electron microprobe and LA-ICP-MS) on about 700 samples from the lower crustal section of seven major massifs. We discovered that abundant (~15%) primitive cumulates (XMg>80%) are characterized by the early crystallization of orthopyroxene implying parental melts significantly richer in SiO₂ than N-MORB. Moreover, at the same differentiation degree, plagioclases of the layered cumulates are richer in anorthite and clinopyroxenes (cpx) are more depleted in Al₂O₃, TiO₂ and Rare Earth Elements (REE) than N-MORB cumulates. These characteristics are reminiscent of boninitic-andesitic melts although layered cumulates do not present the extreme depletion in High Field Strength Elements (HFSE) and the REE patterns typical of supra-subduction zone boninites. The simplest way to account for these observations is to invoke mixing between N-MORB melts extracted from an asthenospheric source and silica enriched melts produced by hydrated re-melting of a depleted lithospheric source, both melts migrating in mantle channels before feeding magma chambers.

We used TiO₂ in cpx to semi-quantitatively determine the contribution of both magmatic end-members to parental melts in selected stratigraphic cumulative sections distributed along the ophiolite. This quantification in a key massif displaying a diapiric structure [2] reveals that the relative contribution of both sources evolved during the upwelling of the asthenospheric diapir within the lithosphere, an observation in agreement with melt migration structures distribution in the mantle section of this massif.

[1] Python & Ceuleneer (2003) *Geochem. Geophys. Geosyst.* **4**. [2] Ceuleneer, Nicolas & Boudier (1988) *Tectonophysics* **151**, 1-26.