Radon constrains the transit time of springs water at the border between tabular Middle Atlas and the Saïs Basin (Morocco)

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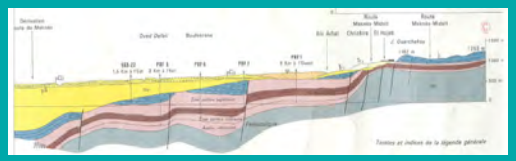
GEOLOGICAL SETTING

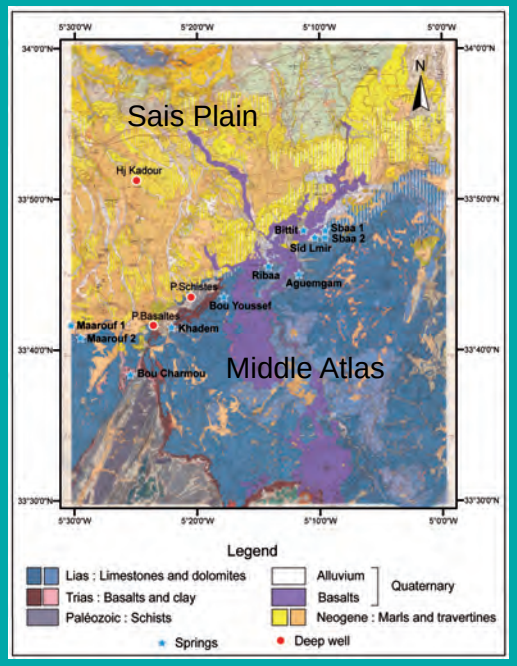
The Tabular Middle Atlas (TMA) is an important fractured karstic reservoir in northern Morocco constituted by Liassic limestones and dolomites with a nearly sub-horizontal attitude, overlying basalts, shales and evaporates of Triassic age, as well as Paleozoic anchi-metamorphic schists.

The zone is characterized by relative abundant rainfall (700 mm/y) and the absence of a surface watershed, which lead to an important groundwater reservoir hosted in the karstic (k-) aquifer.



GEOLOGICAL SECTION

TMA is bordered to the North by extensive graben-like, normal, northward, fault-systems, which burden the Karstic formations under Plio-quaternary sediments at the Sais Basin border.



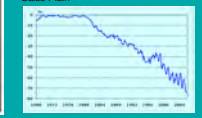
STUDY AREA

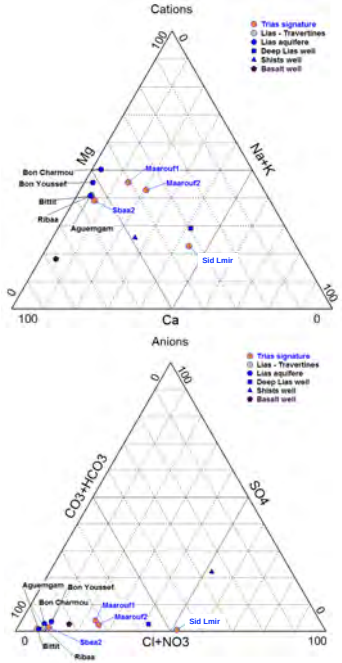
Several important springs of high water-quality occur at the northernmost outcropping Lias limestone, which is overlaid in some areas by quaternary travertines. Two of these springs in particular, Bittit and Ribaa springs, provide drinking water for the town of Meknes (0.7 Million inhabitants), for local population and agriculture.

MOTIVATIONS OF THE STUDY

These springs experienced a significant drop in water flow-rate in the last decades. Although the main origin of this water is certainly the k-aquifer, the drop in water-table raises several questions regarding the modality of water transport (influence of fractured and karstic systems in particular) and the possible participations of other groundwater reservoirs, which may deteriorate the high water-quality.

Drop in piezometric levels in wells of the Saiss Plain

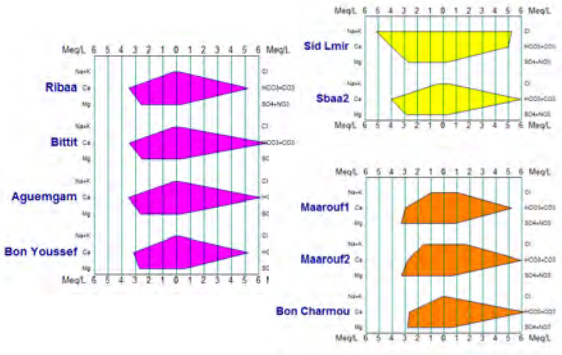




HYDROCHEMISTRY OF THE SOURCES

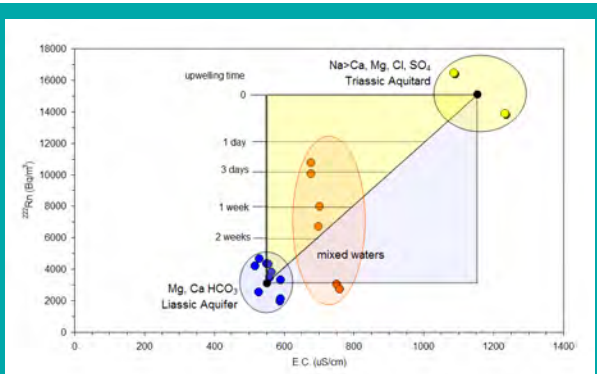
All sampled waters springs-out of Liassic carbonates or between the latter and quaternary travertines.

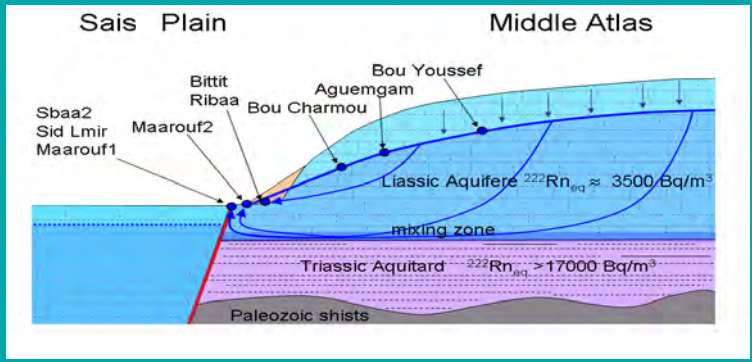
Several springs in the TMA yield Mg-Ca HCO3 rich water equilibrated with limestone and dolomite. Other springs situated at lower altitude yield more mineralised water (EC = 1200 uS/cm), richer in Na, K, Cl. These waters most probably interacted with a non-karstic aquitard, such as underlying Triassic marls, and evaporites (gypsum, halites).

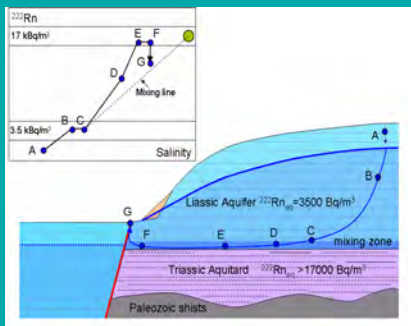


Mg-Ca-HCO3 springs yield very similar ^{222}Rn activity of 3500 Bq/m³, unrelated to spring altitude. Similar radon activity is also found in a deep well in the Lias-confined aquifer of the Sais Basin. This value is hence considered the steady state activity in Lias-aquifer.

Higher radon activities are found in water having enrichments in Na, Cl, SO_4. The highest activity (Rn MAX) of 17000 Bq/m³ is found in a Na>Ca>Mg, Cl>HCO_3 spring (Sid Lmir). We assume that this value (Rn MAX) represents the activity of water in equilibrium with the Triassic aquitard.







RADON CONSTRAINTS THE UPWELLING TIME

Water having interacted with Triassic Aquitard (based on hydrochemistry data) have Rn activity higher than the expected activity calculated from simple binary mixing (mixing line).
This suggests that groundwater mixed in the Liassic aquifer near the Triassic-aquitard.

The difference between Rn MAX and the activity found in spring of "mixed" water **constraints** the time elapsed from the moment these waters left the mixing zone (F) and reached the surface (sampling moment G).

With this simple model, this Rn difference indicates a total upwelling time in less than 2 weeks.
Remote sensed images of the area evidences that these mixed-water springs lies on important tectonic alignments, which perhaps play a role in the rapid groundwater upwelling.

Aknowledgements

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