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Detection of groundwater from space-based IR data: application to the Lake Chad basin.

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In Lake Chad basin, the Quaternary phreatic Aquifer (named hereafter QPA) presents large piezometric anomalies referred as domes and depressions. The depth of these piezometric anomalies are ∼15 m and ∼60 m, respectively [1]. Three others aquifers have been described in the Lake Chad basin and they are separated from the QPA by a thick layer of Pliocene clay. Leblanc et al. (2003) discovered that brightness temperatures from METEOSAT infrared images of the Lake Chad basin show a correlation with the QPA piezometry. Indeed, during wet seasons, domes are associated with warm brightness temperatures, at the contrary of the depressions, which appear cold in METEOSAT images. Through this observation, these authors [2] proposed that this thermal behaviour results from an excess of evapotranspiration that can also explain the formation of the piezometric anomalies. However, data provided by temperature logs in oil wells QPA measurements lead us to propose another hypothesis.

Temperature logs obtained in oil wells [3] illustrate that in the ancient Lake Chad and in the Bornu depression, at the SW of the Lake, heat transport is made by convection in the ∼3 km deep confined aquifers. Moreover, we have estimated that the heat fluxes at the surface of the ancient Lake Chad can reach 138 mW m-2 and in the Bornu depression, ∼63 mW m-2. Others oil wells show that, at the exterior of the depression, the heat transport is conductive and the heat fluxes at the surface are ∼50 mW m-2. These new observations and our convective model permit us to propose that beneath the depressions, a cold descending convective current suck the QPA. Beneath the dome, a warm ascending current creates an overpressure in the QPA. Now, to explain the link observed with the thermal behaviour, we propose that over the domes, as the QPA is warm, heat is transported by capillarity. The piezometric depressions regions are associated with a presence of clay-rich soils at the surface, which makes difficult the exchange between the QPA and the atmosphere. However, we have discovered some giant dessication cracks that can facilitate the exchanges by increasing the vertical permeability of the clay cap horizon. These facts eventually explain the correlation between the observed brightness temperatures and the piezometric anomalies.

[1] Schneider (1966), Carte hydrogéologique au 1/500 000, B.R.G.M. [2] Leblanc et al (2003), Geophys. Res. Lett., 30 (19), 1998. [3] Nwankwo and Ekine (2010), Scientia Africana, 9 (1), 37-45.