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Stable isotope hydrology in fractured and detritic aquifers at both sides of the South Atlantic Ocean: Mar del Plata (Argentina) and the Rawsonville and Sandspruit river catchment areas (South Africa)

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ABSTRACT

The aim of this work is to characterize the isotope composition of water (^{2}H and ^{18}O) in order to establish the relationship between fractured and detritic aquifers in similar hydrological environments located at both sides of the Atlantic Ocean. The Mar del Plata zone, placed in the Argentine Buenos Aires province in South America, and the Rawsonville and Sandspruit river catchment areas, situated in the Western Cape province in South Africa were compared. Rainwater and groundwater samples from fractured and detritic aquifers were analyzed through laser spectroscopy. In both Argentina and South African study sites, stable isotopes data demonstrate an aquifers recharge source from rainfall. For the Mar del Plata region, two different groups of detritic aquifer's samples with distinct recharge processes can be identified due to the close relationship existing between the present hydrogeological environments, the aquifer's grain size sediments and the isotopes contents: one representing rapid infiltration in aquifer sediments of the creeks' palaeobeds and hills zones (sandy or silt sandy sediments) and the other with slow infiltration of evaporated water in plain zones with an aquitard behavior. In the last group, the evaporation process occurs previous infiltration or in the aquifer's non-saturated zone, because of the existence of very low topographic gradients and fine-grained sediments. The evaporation phenomenon is not evident in the Sandspruit river catchment site's detritic aquifer, because its sandy composition allows a faster infiltration rate than in the loess that compounds the Pampeano aquifer in the interfluves zones of the Argentinian study area.

1. Introduction

Mar del Plata and Cape Town cities, located to the southeast of the Buenos Aires province, Argentina Republic, South America and to the southwest of the Western Cape Province, South Africa Republic, Africa, respectively (Fig. 1), are two of the sites that were linked 200 million years ago within the Gondwana supercontinent (Suess, 1875; du Toit, 1937; Scotese and McKerrow, 1990; among others). These areas and their surroundings share some hydrological similarities and their geological setting, which determines the existence of detritic aquifers in modern sedimentary covers lying on and juxtaposed to fractured aquifers formed by quartzite rocks, as well as climatic regimes due to their latitudinal location on the Atlantic coast and a correlated effect from the sea temperature at the Southern Atlantic and Indian oceans (Fauchereau et al., 2003). Nevertheless, recent studies indicate the importance of the precipitation type on the isotope composition of precipitation, which can be the source of differences between locations (Aggarwal et al., 2016).

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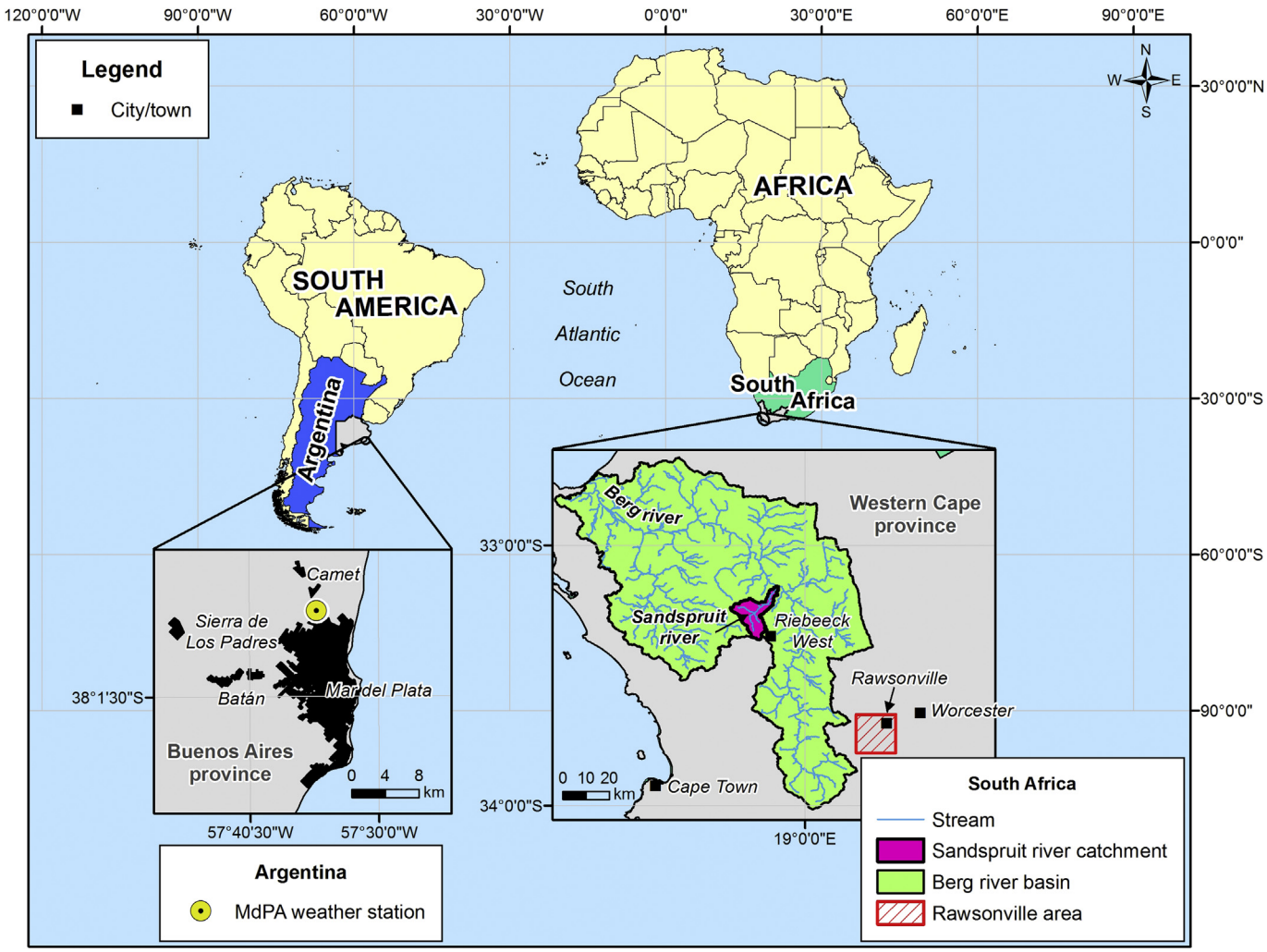

Fig. 1. Location map (MdPA weather station: "Mar del Plata Aeropuerto" weather station).

The lithological composition at both sides of the South Atlantic Ocean shows a similarity in its hydrogeological behavior, some units also showing an age correlation. Granitoids that are intruding the metamorphic rocks of the *Buenos Aires Complex* (Marchese and Di Paola, 1975a) and the *Malmesbury Group* (Hartnady et al., 1974), apart from their similar lithological behavior as impermeable basement, were emplaced in the Proterozoic Eon (Paleoproterozoic and Neoproterozoic, respectively). Regarding the *Balcarce Formation* (Ordovician-Silurian?) (Amos et al., 1972; Dalla Salda and Iñiguez Rodríguez, 1979) and the *Table Mountain Group* (TMG) (Ordovician-Devonian) (Rust, 1967; Visser, 1974), their quartzites rocks constitute the fractured aquifers of the Argentinian and South African areas, besides their depositional ages are the same (Middle Paleozoic Era, Phanerozoic Eon). Finally, the *Pampeano* and *Post-Pampeano sediments* (Frenguelli, 1950) and the *Springfontyn Formation* (Rogers, 1980) are Quaternary sedimentary sequences mostly composed by loess (Mar del Plata; Pliocene-Holocene) and sands (Cape Town zone; Pleistocene) deposits, forming the unconfined detritic aquifers of these sites, which are semiconfined and confined in parts in the Mar del Plata (*Pampeano aquifer*; Auge, 2004) and Cape Town (Rogers, 1980; Flugel, 1991) zones, respectively (Fig. 2).

The relationship between fractured and detritic aquifers is not well known in many areas, and sometimes the hard rock formations are considered just as hydrological basement. Nevertheless, being these two types of aquifers in contact, water transferences must be considered. Taking into account that the infiltration rate conditions, permeability and dispersivity in fractured and detritic aquifers are different, it can be assumed that evaporation during infiltration and mixing physical processes affect the stable isotope (deuterium, ^{2}H, and eighteen oxygen, ^{18}O) contents in rainwater and thus the groundwater isotope fingerprint during the aquifers' recharge. Most of the investigations on groundwater isotope composition indicate that, in temperate climates, it is close to the average rainfall composition because of a well-mixed system (Gat and Tzur, 1967). However, it can be expected a different isotope content comparing detritic and fractured aquifers' porosity (primary porosity versus secondary porosity). The aim of this paper is to verify that hypothesis through the stable isotopes characterization of water in both systems and to establish the relationship between fractured and detritic aquifers belonging to similar hydrogeological environments, situated on both sides of the South Atlantic Ocean. These are the Mar del Plata zone and two areas located around 90 km from Cape Town city: Rawsonville and Sandspruit river catchment (Fig. 1).

Isotopic techniques are a very useful tool for the understanding of groundwater dynamics in hydrologic systems. Physical processes and climate phenomena, responsible both for water transport in the different phases of the hydrologic cycle, produce an isotope fractionation that can be used to obtain conclusions about its