Use of Total Organic Carbon (TOC) as tracer of diffuse infiltration in a dolomitic karstic system: The Nerja Cave (Andalusia, southern Spain)

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[1] Recent studies in several karstic systems in France have highlighted that Total Organic Carbon (TOC) was a relevant parameter in order to characterise the behaviour of aquifers, to differentiate the water types that participate in karstic flow (fast infiltration, unsaturated zone, saturated zone) and to evaluate their vulnerability. This study on TOC dynamics at the experimental site of the Nerja Cave has been performed to test the potential of this tracer in a particular climatic (Mediterranean climate), lithologic (dolomitic marbles) and hydrodynamic (diffuse flow behaviour) context. TOC evolution, compared to those of classical tracers used in hydrogeology, permits the understanding of the hydrodynamical behaviour of the unsaturated zone of this dolomitic aquifer, whose response to precipitation is slower than that commonly obtained in karstic aquifers of calcareous nature. *INDEX TERMS:* 1010 Geochemistry: Chemical evolution; 1025 Geochemistry: Composition of the mantle; 1832 Hydrology: Groundwater transport; 1875 Hydrology: Unsaturated zone. **Citation:** Batiot, C., C. Liñán, B. Andreo, C. Emblanch, F. Carrasco, and B. Blavoux, Use of Total Organic Carbon (TOC) as tracer of diffuse infiltration in a dolomitic karstic system: The Nerja Cave (Andalusia, southern Spain), *Geophys. Res. Lett.*, *30*(0), XXXX, doi:10.1029/2003GL018546, 2003.

1. Introduction

[2] In the case of aquifers made of organic matter free carbonates, all the TOC results from organic matter decomposition by bacterial activity in the soil, so it is an interesting tracer of fast infiltration [*Albéric and Lepiller*, 1998; *Emblanch et al.*, 1998]. In calcareous karstic systems, where the magnesium distribution is homogeneous, Mg^{2+} is a good indicator of the water residence time because of its low dissolution kinetics. Recent research on the experimental site of Vaucluse (south-eastern France) highlighted the complementary nature of these two tracers and their relevance in the study of water transit in the aquifer [*Emblanch et al.*, 1998; *Batiot et al.*, 2003]. Indeed, during flood events, the arrival of recent water at the spring is evidenced by an increase of TOC values and a decrease of magnesium. On the other hand, during low flow conditions, the discharge of long residence time water is characterised by an increase in magnesium and a depletion in TOC. Then, the use of these two parameters permits the characterisation of the different water types that participate in karstic flow. Moreover, *Batiot et al.* [2003] showed that TOC is the most relevant tracer of the fast infiltration compared to others classical tracers such as Ca^{2+}, NO_3^-, Mg^{2+} or ^{18}O.

[3] The aim of this work is to know the potential and the sensitivity of TOC as a tracer of the infiltration in the pilot site of Nerja Cave where water infiltrates slowly in the epikarst under climatic (Mediterranean climate), lithological (dolomitic marbles) and hydrodynamic conditions (diffuse flow behaviour) different to those of the south-eastern France aquifers. Since 1991, extensive research about environmental parameters, physical and chemical characteristics of the water have been carried out, both inside and outside the cave [*Carrasco et al.*, 1995, 1999; *Liñán et al.*, 1999; *Andreo et al.*, 2002]. Therefore, the cave is an interesting site to study the behaviour of TOC with respect to other commonly used tracers (i.e. major ions or isotopes).

2. Site and Methods

[4] The Nerja Cave, located in Andalusia (southern Spain), in the province of Málaga, about 5 km east of the coastal town of Nerja, is one of the most visited natural sites in Andalusia, South Spain [*Carrasco et al.*, 1999]. The cave extends almost horizontally between limits of 123 and 191 m a.s.l. and occupies a volume of about 300,000 m^3. The climate outside the cave is typically Mediterranean, with a wet season from October to February and a long dry season specially marked during summer. The mean annual values are 490 mm for rainfall and 17.3°C for temperature.

[5] From the geological viewpoint the Nerja Cave is situated in southern border of Sierra Almijara, within the Alpujarride Complex of the Betic Cordillera, and it is developed within dolomite marbles of middle Triassic age. The marbles are permeable due to fracturing and karstification and, thus, constitute a carbonate aquifer. As a result of the Plio-Quaternary tectonic activity which affected this area, the cave is currently located in the unsaturated zone of the aquifer, above the piezometric level. The thickness of the unsaturated zone above the cave is highly variable, from 4 to 90 m. Except for gardens near the entrance, there is only low developed plant (shrubland species) or soil coverage above the cave. Rainfall and irrigation water from the gardens infiltrates through fissures and fractures of the marble to drip through the cave roof [*Liñán et al.*, 1999; *Andreo et al.*, 2002]. After several years of hydrochemical monitoring, a representative drip water point was selected within the cave, located in the Cataclysm Chamber, where

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