V INTERNATIONAL SYMPOSIUM ON KARST

MALAGA, SPAIN 14TH - 16TH OCTOBER 2014

Annual meeting of IGCP 598 Project of UNESCO

INTRA-SYMPOSIUM FIELD TRIP 2

Nerja Cave - Mediterranean coastal karst

15TH October 2014

UNIVERSIDAD DE MÁLAGA FACULTAD DE CIENCIAS

CEHIUMA CENTRO DE HIDROGEOLOGÍA DE LA UNIVERSIDAD DE MÁLAGA

GOBIERNO DE ESPAÑA · MINISTERIO DE ECONOMÍA Y COMPETITIVIDAD · Instituto Geológico y Minero de España

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club del agua subterránea

Field trip to Nerja Cave and coastal karst.
Studies of Nerja cave and vadose and non-vadose zone

Key features

Departure: Thursday 15th October (8.30 am) from Malaga city (Hotel Malaga Palacio)
Return: Thursday 15th October (7:00 pm approx.)
Number of places: 50 (maximum), by rigorous order of inscription
Registration deadline: 1st September 2014
The trip will include lunch at the restaurant of Nerja Cave

General description

The field trip will be the 15th October 2014, during the celebration of the 5th International Symposium on Karst (ISKA). Guided by hydrogeologists from the Centre of Hydrogeology of the University of Málaga (CEHIUMA), the participants will have the opportunity to visit one of the most spectacular examples of subterranean landscape of the south of Spain: the Nerja Cave (Andalusia, Málaga), situated less than 1 km from the Mediterranean sea.

The main goals of this excursion are to present the principal characteristics of the endokarst in this part of the Mediterranean, and the considerable interest for geologic research of these forms and sediments. We shall contemplate their origin with respect to the palaeohydrology of the zone, the contemporary hydrogeologic factors that influence the surroundings and the environmental controls that are being implemented.

Panoramic view of Nerja Cave surroundings: the Natural Park of the Maro-Cerro Gordo Cliffs (left) and the Natural Park Tejeda- Almijara –Alhama (right).

The Nerja Cave, a Good of Cultural Interest, in the category of Archaeological Place and a Geosites internationally recognized, is one of the most important tourist caves in Spain, with about 500,000 visitors annually. Its popularity is influenced by its location

in a major tourist zone (Costa del Sol) and naturally by the beauty of the chambers and speleothems that can be found there.

Panoramic view of Nerja Cave

From a geological viewpoint, the cave lies within rocks belonging to the Almijara Unit (Alpujarride Complex, Betic Cordillera). The stratigraphic series of this Unit is made up of a lower metapelitic succession and of an overlying carbonate sequence, constituted of dolomitic marbles (in which the cave developed) and calcareous marbles toward the top. Endokarstic forms of certain significance are fairly rare in the Alpujarride carbonate aquifers; the Nerja Cave is a major exception. Today, the cave is situated in the unsaturated zone of the aquifer, several metres above the piezometric level, as a consequence of the tectonic lifting of the region during the Pliocene and the Quaternary.

Numerous researches have been conducted in the Nerja Cave, almost since its discovery. The cave has several microclimatic stations comprising various sensors that measure, through time intervals, temperature, relative humidity and air concentration of ^{222}Rn and CO_2, among other parameters. Furthermore, a weather station measures the environmental parameters outside the cave. This network system allows to knowing and studying the natural changes of the cave and the changes produced by the visitors.

Hydrogeological studies have been carried out within Nerja Cave since 1991 to characterise the dripwater within the cavity, both chemically and isotopically, and to determine the hydrodynamic functioning of the unsaturated zone of the aquifer in which it lies. In Nerja Cave also it have been done biological researches about the biofilms, which appear at places in the cavity where light and water coexist, about the microbiology of the air and of the water of the cave and about the fauna.

An experimental karst site is located in the immediate vicinity of the Nerja Cave, with access to 10 boreholes. Air temperature, relative humidity and CO_2 concentrations are the main variables registered, especially their variations with the depth in the boreholes. The measurements point out to average vadose air CO_2 concentrations of near 40,000 ppm, and maximum of near 60,000 ppm. In this context, the cave appears as a vadose subsystem above the groundwater level, with significantly less concentration of CO_2 due to its important natural ventilation.

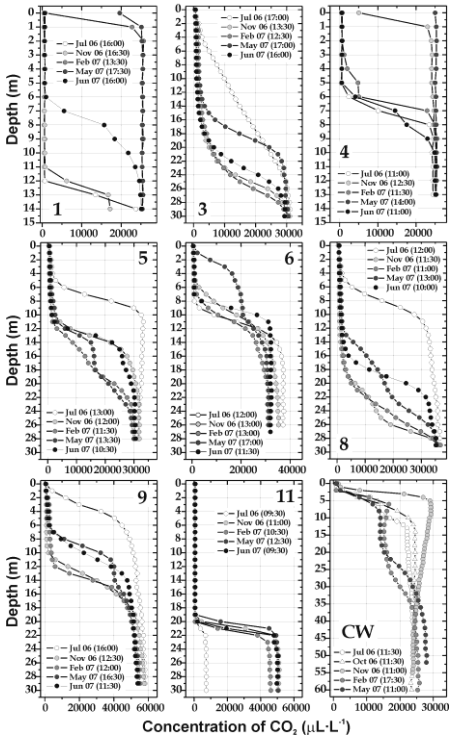
Nowadays, all these researches being carried out are part of an ambitious "Interdisciplinar Research Project" to preserve the Nerja Cave. Its main aims are to determine the pressure and factors affecting the Nerja cave, to preserve the cultural and natural heritage of the cave and to design a management system based on research, preservation and diffusion.

Provisional list of stops

✓ **Nerja Cave:** spectacular tourist cave of high interest geological and archaeological. Beautiful subterranean karstic landscape, several types of speleothems, microclimatic stations, weather station and geological and hydrogeological researches developed in the cavity from its discover are just some of the topics and features we will enjoy during the visit.

Monitoring network of Nerja Cave: weather station of the cave, on the left and microclimatic and hydrogeological station inside the cave, on the right.

✓ **Experimental karst site of Nerja Cave**: we will present the results of the monitoring of the subsurface air CO_2 concentrations in the experimental field site near the Nerja Cave. The systematic measurements of the CO_2 content of the air in the vadose environment are based on a number of boreholes, most of them having a depth of 30 m. From 2013, the experimental site has a station with a datalogger and different probes measure the temperature, humidity, CO_2 and direction and speed of the air flow in one of the borehole.



Vertical profiles of CO_2 in boreholes (left) and air control station at point 4 with data-logger and probes of temperature, humidity, CO_2, direction and speed of air (right).

✓ **View and geological-hydrogeological description of the coastal sector of Nerja:** in this stop, the major hydrogeological characteristics of Sierra Almijara aquifer will be introduced.

The coastal sectors of Nerja, Cantarriján, Cerro Gordo and Punta de la Mona constitute part of the mass of underground water of Alberquillas, which is made up of a set of outcropping marbles. The southern boundary of the aquifer is defined by fault systems that are WNW-ESE and NW-SE directional, and separate the marbles from the alpujárride schists of low permeability.

Cerro Gordo constitutes the southeastern end of the Alberquillas block. This outcrop of marbles has a sharp outline, with an enormous cliff 150 meters high that sinks some 20 meters below the surface of the Mediterranean Sea. In the rock walls, the continuous erosive action of the sea has dug a series of shallow grottos.

Overview of the coast of Nerja, with Cerro Gordo in the background.

✓ **Maro spring:** the major hydrogeological characteristics of Sierra Almijara aquifer will be introduced. It will also be explained the principal characteristics of Maro spring, the main point of discharge (300 L/s) of the aquifer where the Nerja cave is located.

✓ **Industrial Heritage:** water has always been tied to the economic development of this region, as shown by the varied infrastructures that exist for its collection and use: irrigation channels, pools and reservoirs. In addition there are two historic constructions, true gems of the local industrial patrimony: the Paper Mill (Molino de Papel), a paper factory built on the shores of the Río de la Miel in the 18th century; and the Eagle´s Aqueduct (Acueducto del Águila), constructed in the 19th century to irrigate the former sugar cane plantations and to transport water to the refinery of San Joaquín de Maro.

On the left, waters of Maro spring. On the right, Acueducto del Águila, an important element of the local industrial heritage