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Cover Photo:

Spongework in the Capitan Reef limestone near the Big Room of Carlsbad Cavern, New Mexico. This feature is commonly called “Boneyard” because of its appearance. This is commonly interpreted as a classic example of dissolution by slow-moving phreatic water. However, a more feasible process is condensation of moisture from moving air masses above the water table. Solutional aggressiveness can be produced by absorption of gases from the cave air—e.g., carbon dioxide to form carbonic acid, and/or a mixture of hydrogen sulfide and oxygen to produce sulfuric acid. This type of spongework is common where air has moved slowly through the porous limestone that separates large rooms. Photo by Art Palmer.

SULFURIC ACID CAVES OF ITALY: AN OVERVIEW

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Introduction

The general geodynamic situation of Italy is quite complex. The land has undergone several stages of formation, compressed between the African and the Eurasian continents. The phase of extensional tectonics governed by the rollback of continental terrains (Corsica, Sardinia, Balearic Islands, Kabylies blocks, and Calabria) caused the generation of the Apennine chain, which crosses northwest to southeast and is the backbone of Italy's mainland. The structure of the Apennine chain contains many thrusts, horst and graben structures, and deep faults, as well as the widespread presence of mainly Mesozoic carbonate outcrops. This has caused the formation of deep karstic circulation systems, as evidenced by the abundance of hydrothermal springs and associated travertine deposits. Furthermore, the presence, at depth, of both hydrocarbon reservoirs and Triassic gypsum deposits is responsible for the presence of rising waters rich in H_2S.

Since the late 1980s, cave systems in the Frasassi Canyon and Monte Cucco, with their important gypsum deposits, undoubtedly showed that sulfuric acid played an important role in the creation of voids (Galdenzi, 1990), similar to what was described for the Guadalupe Mountains in New Mexico. Afterwards, many other caves throughout the country were found to be formed by the sulfuric acid speleogenesis, making Italy one of the most important countries in the world for the concerns of SAS caves.

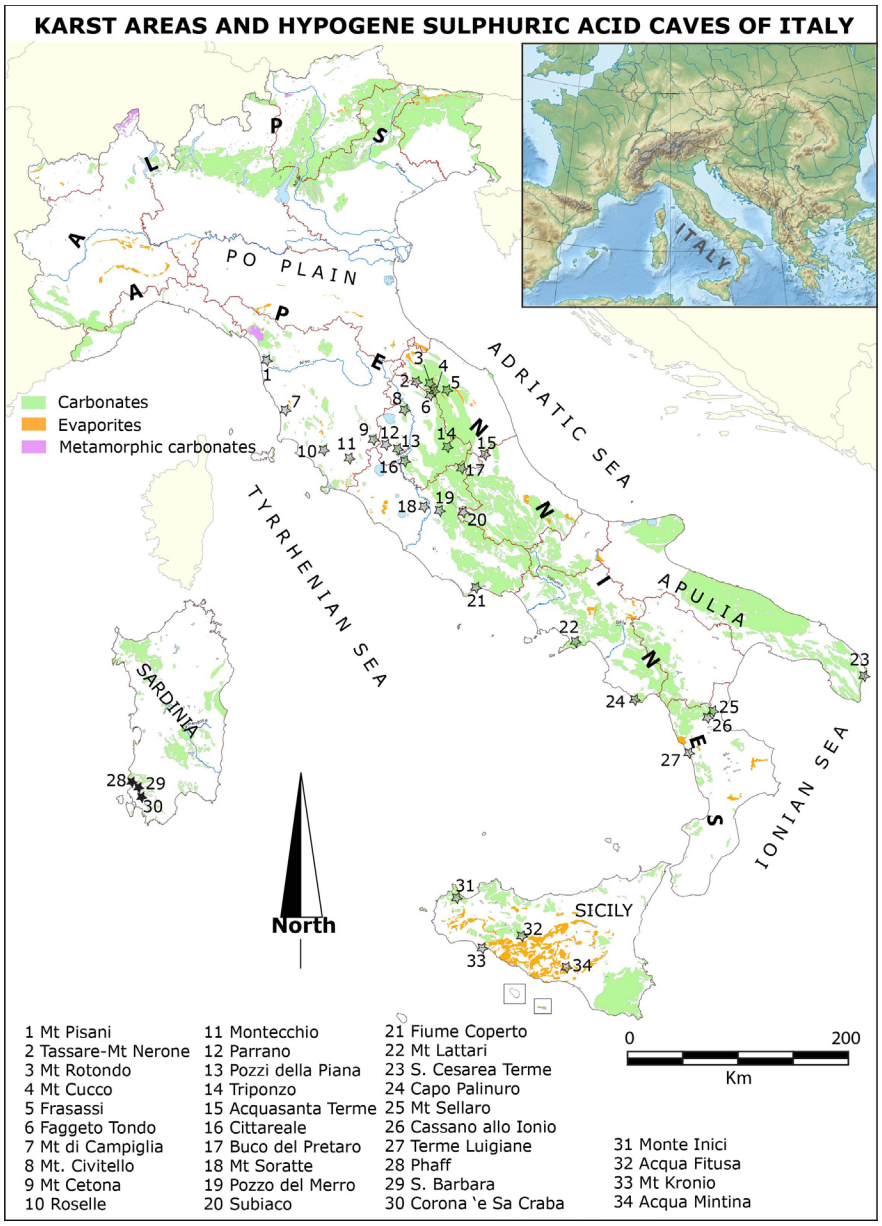

Figure 1.
Italian karst areas and the hypogene SAS karst systems (modified from Sivelli & De Waele, 2013, Speleologia 68, special issue printed for the 16th ICS Brno. GIS elaboration by M.L. Garberi).

In the past few years, detailed studies involving geomorphology, mineralogy, and geochemistry have been carried out in some of these caves. Sulfuric acid caves have been discovered from many regions along the Apennine chain (Tuscany, Umbria, Marche, Latium, Campania, and Calabria), and also from Apulia, Sicily, and Sardinia.

Here we give a review of the state-of-the-art knowledge on known hypogene SAS caves in Italy, as well as ongoing studies in selected areas.

Overview of Studies

Caves resulting from sulfuric acid have been known for almost a century (Triponzo caves, Principi, 1931). While some typical mineral deposits were studied in the 1980s (Cala Fetente caves on Capo Palinuro, Forti, 1985), the study of the mechanisms responsible for the formation of these caves and their typical morphologies started half a century later (Galdenzi and Menichetti, 1989). The first studies mainly focused on the Umbrian and Marche Apennines, around the cave systems of Frasassi-Grotta Grande del Vento (Galdenzi, 1990) and

the nearby Faggeto Tondo Cave (Forti et al., 1989). A general overview of hypogenic caves in Central Italy was brought a few years later (Galdenzi and Menichetti, 1995). This important review paper was comprised of a set of cave locations in which the presence of sulfates was a clear indication of sulfuric acid speleogenesis. These included the ones of Parrano, Pozzi della Piana, Acquasanta Terme, Cittareale, and Monte Soratte, in addition to the aforementioned caves.

A few years later, sulfuric acid caves were found in Calabria (Monte Sellaro, Cassano allo Ionio, Terme Luigiane (Galdenzi, 1997), while more and more detailed studies continued to be carried out in Umbria (Menichetti, 2011), especially the Monte Cucco System (Menichetti et al., 2007), Monte Soratte (Mecchia, 2012), Acquasanta Terme caves (Galdenzi et al., 2010), and especially in Frasassi Caves (Galdenzi et al., 1997; Galdenzi, 2001; Forti et al., 2002; Galdenzi et al., 2008; Galdenzi, 2009, 2012).

Microbiological studies started in the last two caves in 2005 (Macalady et al., 2006, 2007, 2008; Jones, 2008, 2010), bringing very interesting results. These studies also shed light on the speleogenetic role of microorganisms in Frasassi (Jones et al., 2015).

Other sulfuric acid caves have been recognized in the last few years. In Sardinia, the formation of many mine caves can be ascribed to this type of speleogenesis (De Waele et al., 2013a), while Montecchio Cave was studied in detail in Tuscany (Piccini et al., 2015). In Sicily, several caves host gypsum deposits or have typical SAS morphologies, such as Acqua Fitusa, Monte Inici, and Monte Kronio caves (Vattano et al., 2013; De Waele et al., 2014b). Typical SAS morphologies have also been described from epigenic caves in Veneto, in which the local oxidation of pyrite caused the formation of sulfuric acid (Tisato et al., 2012). Further caves are awaiting more detailed studies but are surely related to rising H_2S-rich waters (De Waele et al., 2014a).

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