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Update on the Hypogenic caves of Sicily

Philippe Audra[1], Jean-Yves Bigot[2], Jo De Waele[3], Ermanno Galli[4], Giuliana Madonia[5], Jean-Claude Nobécourt[6], Giovanna Scopelliti[5] & Marco Vattano[5]

[1] University of Nice Sophia-Antipolis, CNRS, IRD, Observatoire de la Cote d'Azur, Geoazur UMR 7329 & Polytech Nice – Sophia, 930 route des Colles, 06903 Sophia-Antipolis, Nice, France (audra@unice.fr)
[2] Association française de karstologie (AFK), 21 rue des Hospices, 34090 Montpellier, France (catherine.arnoux@club-internet.fr)
[3] Istituto Italiano di Speleologia, University of Bologna, Via Zamboni 67, 40127 Bologna, Italy (jo.dewaele@unibo.it)
[4] Dipartimento di Scienze della Terra, University of Modena and Reggio Emilia, Largo S. Eufemia 19, 41121 Modena, Italy, (gallier@unimore.it)
[5] Dipartimento di Scienze della Terra e del Mare, University of Palermo, Via Archirafi 22, 90123 Palermo, Italy (giuliana.madonia@unipa.it; marco.vattano@unipa.it)
[6] Crespe, Le Hameau de l'Ara, 259 Bd Reine Jeanne, 06140 Vence, France (jcnobecourt@free.fr)

Introduction

After the preliminary study on the hypogenic caves in Sicily, new explorations allowed to discover new areas characterized by ascending fluid movements and rich in caves. In those areas speleogenetic, geomorphological and mineralogical studies started to define the hypogenic processes and to link this to the geomorphological evolution of the different areas. Nowadays in Sicily the Monte Inici karst system, the Acqua Fitusa cave, the Monte Kronio system and the Personaggi cave, are still under investigation (Fig. 1).

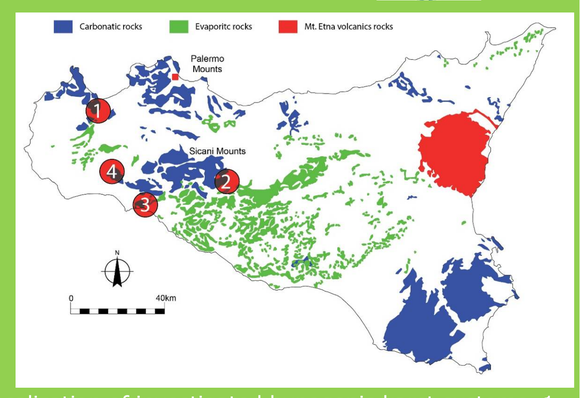


Fig. 1 Localization of investigated hypogenic karst systems. 1. Monte Inici karst system; 2. Acqua Fitusa cave; 3. Monte Kronio karst system; 4. Personaggi cave

Monte Inici karst system is located in northwestern Sicily (Fig. 1), along the southeastern side of Mt. Inici. It is composed of two caves, Grotta dell'Eremita and Abisso dei Cocci, formed in Lower Jurassic limestones and dolomitic limestones (Inici Fm.), and Middle-Upper Jurassic reddish-gray limestones with ammonites (Buccheri Fm.). The caves are 3D phreatic systems, reaching respectively a total length of over 2 km, and a depth of about 300 m (Fig. 2). The air temperature, measured in December 2011, is 15.5-18.0 °C in Abisso dei Cocci and 17.6-21.0°C in Grotta dell'Eremita. Thermal waters forming Gorga 1 (T = 48.2 °C), Gorga 2 (T = 49.5 °C), and Terme Segestane (T = 43.8 °C) hot springs (Favara et al., 1998) emerge eastward and at lower altitude in respect to the cave systems.

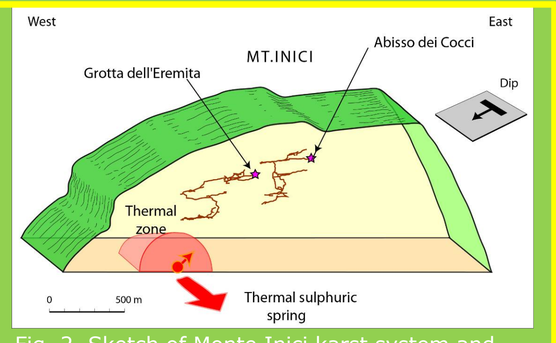


Fig. 2. Sketch of Monte Inici karst system and localization of the thermal zone.

Fig. 3. Lower gallery with megascallops and cupolas.

Fig. 4. Upper gallery with several cupolas on the wall.

Fig. 5. Upper gallery with megascallops

Grotta dell'Eremita and Abisso dei Cocci caves are characterized by large subhorizontal galleries and chambers connected by deep shafts (Figs 3 to 5). Some galleries are inclined and follow the dip of bedding planes, whereas the shafts correspond to vertical fissures or fault planes. Passages display sub-circular cross-sections, or vadose entrenchments. Different morphologies, such as mega-scallops and big cupolas, linked to condensation-corrosion processes are present along the walls and ceilings of several passages (Figs 3 to 5) (Vattano et al, 2013). Different types of chemical deposits were observed: gypsum crusts, phosphates connected to guano presence and aragonite needles occur along the lower parts of the walls of several passages. Both caves lack alluvial sediments.

Acqua Fitusa cave is located in Central Sicily (Fig. 1), along the north-eastern scarp of a N-S anticline, westward vergent, forming the Mt. La Montagnola. The cave formed in the Upper Cretaceous Rudist breccias member of the Crisanti Fm., composed of conglomerates and reworked calcarenites with rudist fragments and benthic foraminifers. The cave consists at least of three stories of subhorizontal conduits, displaying a total length of 700 m, and a vertical range of 25 m. Nowaday it is inactive with a thermal spring occurring 300 m north and at a lower altitude than the cave. The H2S-rich waters are indicated as chlorine-sulphate alkaline, and have a temperature of about 25°C.

Despite the small size, Acqua Fitusa cave is very interesting for the abundance and variety of forms and deposits related to rising waters and air flow. A ~ 7 m deep inactive thermo-sulphuric discharge slot intersects the floor of some passages for several meters (Fig. 6). Different morphologies of small and large sizes, generated by condensation-corrosion processes, can be observed along the ceiling and walls: ceiling cupolas and large wall convection niches occur in the largest rooms of the cave (Fig. 7); deep wall convection niches, in places forming notches, incise cave walls at different heights (Figs. 6); condensation-corrosion channels similar to ceiling-half tubes carve the roof of some passages; replacements pockets due to corrosion-substitution processes are widespread (Vattano et al, 2013; Vattano et al, 2013).

Fig. 6. A. Passage with discharge slot at the floor and different levels of wall convection niches.

B. Genetic mechanism of cave passages due to H_2S degassing in the cave atmosphere.

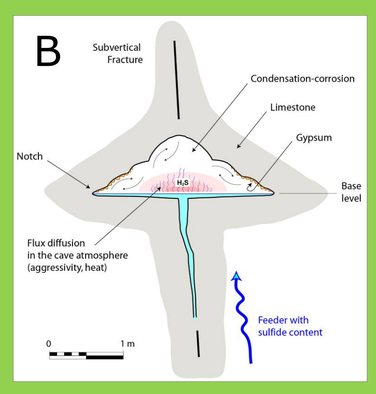
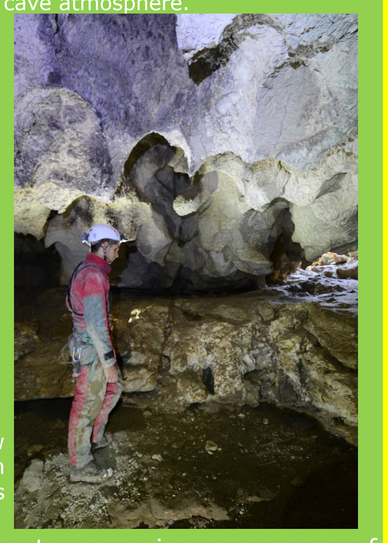


Fig. 7. A gypsum level just below several condensation-corrosion cupolas



The origin of the cave is due to corrosion processes of carbonate rock with replacement of gypsum by H_2S-rich thermal water (Fig. 7). In particular, the enlargement of voids and formation of the main morphologies are due to H_2S degassing in the cave atmosphere, oxidation of sulphides and thermal convection that produce strong condensation-corrosion processes above the watertable, according to the origin of sulphuric acid caves (Vattano et al, 2012) (Fig. 6B).

Monte Kronio karst system opens in the southern scarp of Mt. Kronio, north-east of Sciacca town (southern Sicily) (Fig. 1). Mt. Kronio consists of an imbricate fan system linked to ENE-striking, closely spaced imbricate thrust sheets, involving Triassic to Miocene platform and pelagic platform carbonate deposits. The karst system is made up of a series of cavities characterised by rising of hot air and vapour flow at temperature of about 38 °C, connected to the presence of thermal waters indicated as chloride-sulphate alkaline type and with a temperature ranging between 32 and 55 °C (Grassa et al. 2006 and references therein). The caves were visited by man since the end of the Mesolithic for residential use, place of worship, necropolis, and from the Ist century BC for thermal purposes. The first attempts to explore the caves date back to the end of the XVIIth century; since the 40s several exploration campaigns conducted by the Commission Grotte "E. Boegan" of Trieste identified and surveyed the cave system nowadays known. The explorations, carried out with great difficulty, due to the critical environmental conditions with temperatures of about 38 °C and humidity of 100%, have allowed the discovery of an extended maze cave system about 200 m deep (Perotti 1994).

Fig. 8. 3D sketch of the Monte Kronio karst system (www.boegan.it)

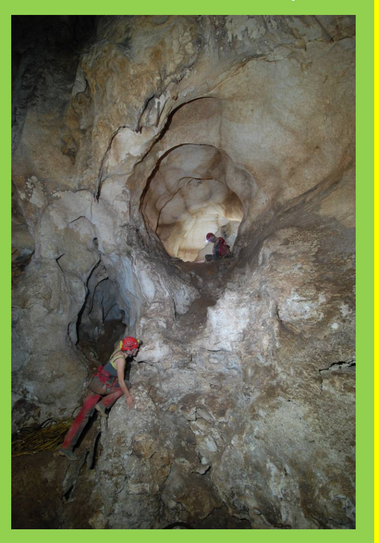


Fig. 9. Passages with forms due to condensation-corrosion.

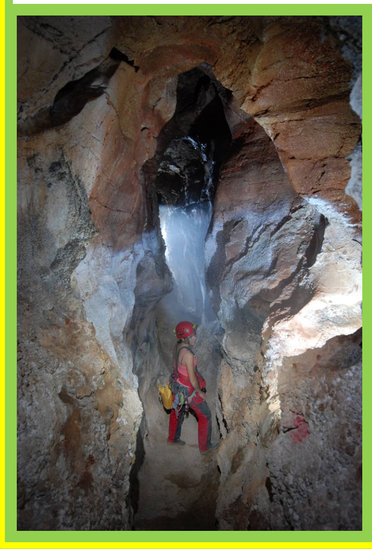


Fig. 10. Cucchiara cave passage with a condensation cloud.

The system is composed of more cavities (Fig. 8), located at different altitude, characterised by subhorizontal passages connected by deep shafts or steep passages (Fig. 9), but there is not always a passable connection between the several branches of the caves. Some galleries breach the southern scarp of Mt. Kronio through small openings some of which emit hot air (Fig. 10), other ones aspire cold air from outside.
Walls and ceiling of the caves are weathered and important gypsum deposits, in form of powders or crusts, were observed (Vattano et al, 2013).

The **Grotta dei Personaggi** cave is located in western Sicily, near Monte Magaggiaro, on the south side of the Montevago village (Fig. 1, AG). In the area there are some thermal springs, characterized by alkaline earth sulphate-chloride water with an average temperature of 40 °C and pH 7. The Grotta dei Personaggi is known since the early 1900s and is famous for the archaeological findings inside, but it was never surveyed and studied in detail. The cavity developed in platform limestones (Inici fm., Lower Jurassic) and in scarp to basin limestones (Buccheri fm., Lower-Upper Jurassic). It is a sub-horizontal cave that, until now, shows a length of roughly 1,7 km, a rise of 15 m and a depth 32 m (Fig. 14). The pattern of the cave is mazy and is influenced by the geological structure; there are no true shafts, but fractures that narrow at depth; the rising branches are characterized by cupolas interpenetrating upwards (Vattano et al, 2015). Among the subterranean morphologies drip holes, condensation-corrosion channels, condensation cupolas, feeders, pillars and partitions are recognized (Figs 11, 13, 15). In the cavity there is also a bat colony and different mineral deposits rich in phosphates, iron, manganese and silica which are both still undergoing study (Fig. 12). The analysis of large and mid-scale morphologies and the presence of hot springs in the area do suggest that the genesis of this cave is linked to hypogenic processes (Vattano et al, 2015).

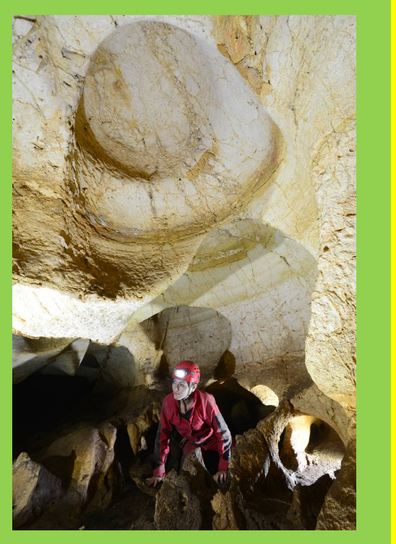


Fig. 11. Passage with condensation corrosion forms as cupolas and bridges

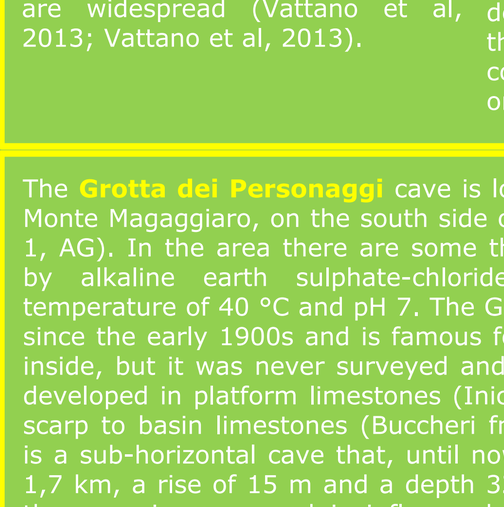


Fig. 12. Different SEM images from crusts and mineral samples of the Grotta dei Personaggi cave.

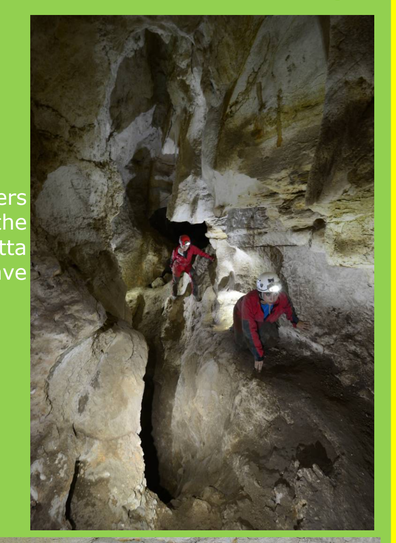


Fig. 13. Feeders with cupolas on the roof in the Grotta dei Personaggi cave

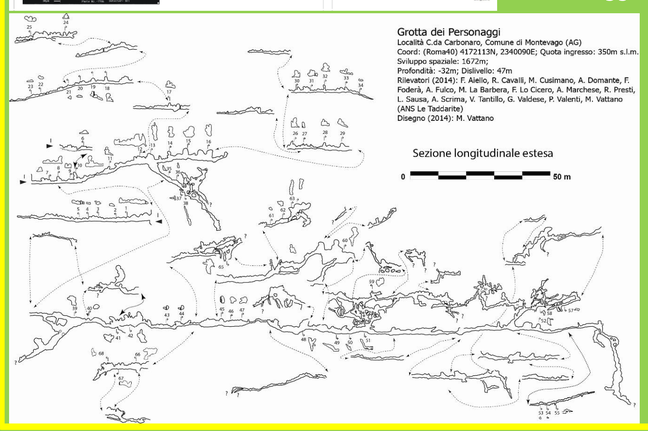


Fig. 14. Section of the Grotta dei Personaggi cave.

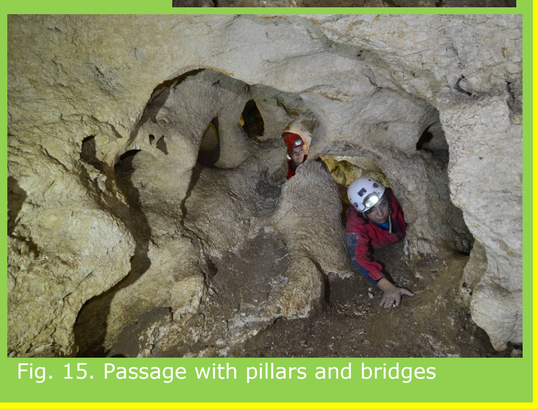


Fig. 15. Passage with pillars and bridges

References

FAVARA R, GRASSA F, INGUAGGIATO S & VALENZA M, 2006. *Hydrogeochemistry and stable isotopes of thermal springs: earthquake-related chemical changes along Belice Fault (Western Sicily)*. Pure and Applied Geophysics, 163, 781-807.
GRASSA F, CAPASSO G, FAVARA R, INGUAGGIATO S, 2006. Chemical and isotopic composition of waters and dissolved gases in some thermal springs of Sicily and adjacent volcanic islands, Italy. Pure and Applied Geophysics, 163, 781-807.
PEROTTI G., 1994. Kronio. - Le stufe di San Calogero e il loro flusso vaporoso. Bollettino dell'Accademia Gioenia Scienze Naturali, 27 (348), 435-475.
VATTANO M., AUDRA P., BIGOT J., DE WAELE J., MADONIA G., & NOBÉCOURT J., 2012. *Acqua Fitusa Cave: an example of inactive water-table sulphuric acid cave in Central Sicily*. Rend. Online Soc. Geol. It., Vol. 21, pp. 637-639.
VATTANO M, AUDRA P, BENVENUTO F, BIGOT JY, DE WAELE J, GALLI E, MADONIA G & NOBÉCORUT JC, 2013. *Hypogenic Caves of Sicily (Southern Italy)*. In: FILIPPI M, BOSAK P (Eds.), Proceedings of the 16th International Congress of Speleology, Brno 19-27 July 2013, 3, 144-149.
VATTANO M, SCOPELLITI G, FULCO A, PRESTI P, SAUSA L, VALENTI P, DI MAGGIO C, LO VALVO M & MADONIA G, 2015. *La Grotta dei Personaggi di Montevago (AG), una nuova segnalazione di cavità ipogenica in Sicilia.* In: De Nitto L, Maurano F & Parise M (Eds), Atti del XXII Congresso Nazionale di Speleologia, Pertosa-Auletta (SA), 30/05-02/06/2015. Memorie della Soc. Speleologia Italiana, II, vol. XXIX, 295-300.