



## **Coastal karst geomorphosites at risk? A case study: the floods of 6-9 December 2004 in central-east Sardinia**

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Extreme rainfall causing floods and great damage occurred in many areas of Central-East Sardinia in the period 6-9 December 2004. Major hazard occurred in villages located in mountainous regions (Ogliastra), where major floods caused two human victims, and in the coastal alluvial plains along the main rivers (e.g. Cedrino river).

Hydrogeological risk was less important in the less populated littoral of the Gulf of Orosei, a very well known coastal karst area with high landscape and natural value, nevertheless, flooding occurred in many coastal areas.

The coast of the Gulf of Orosei is prevalently characterised by the outcropping of Mesozoic carbonates overlying a Palaeozoic basement mainly constituted of granites and shales. This basement complex crops out in the internal mountainous areas where erosion has determined the complete destruction of the Mesozoic cover.

The Mesozoic marine sequence immediately follows the thin continental coastal deposits of the Genna Selole Formation of Bajocian-Bathonian age. The Mesozoic limestone succession, Middle Jurassic in age, is composed of dolostones, dolomitic limestones and pure limestones reaching a total thickness of more than 800 meters. These carbonates form a monocline dipping gently (ca. 30°) towards the East (centre of the Gulf) and is affected by important alpine N-S directed reverse fault systems.

Submarine and subaerial volcanic rocks have been put into place during Plio-Pleistocene followed by several marine and continental sediments, the most important of which are the *éboulis ordonnés*, which have formed during several interglacial periods, and the marine Tyrrhenian (isotopic stage 5e) deposits (beach deposits and fossil

dunes).

The coast of the Gulf of Orosei constitutes a good example of tectonic coast, characterised by high sea cliffs, generally related to main faults, locally interrupted by major streams forming deep canyons that end up in the Sea creating small beautiful beaches that, together with the extraordinary pocket beaches, represent major internationally well-known tourist attractions of this area. Landscape is typically fluviokarstic, with major and minor karst landforms such as dolines, karren and many caves, and almost all-year-round dry river beds and deeply cut canyons.

The entire southwestern coastal area is characterised by medium annual rainfall of 700-1000 (standard deviation 350 mm), with maximum in December (mean monthly rainfall 130-170 mm). During autumn it is not rare to have hot and moist currents coming from Africa that cause convective motions giving rise to rain storms that succeed each other in short time intervals and with the same epicentre. One of the last extreme events of this type dates back to 1951 and caused severe damage in several places of Sardinia and in particular in Ogliastra, not far South of the Gulf of Orosei.

A total of ca. 680 mm of rain fell on the territory during the extreme event of 6-9 December 2004, with a maximum reaching 510 mm of rainfall in one day at Villagrande (Ogliastra), leaving no doubt on the seriousness of the event. The impact of this extreme rainfall on the territory has been disastrous also because enhanced by many factors, mainly related to the human activities, such as deforestation, bushfires, intense sheep-breeding, badly conceived engineering and hydraulic works and so on.

During and immediately after the event all fluviokarstic canyons activated for at least one week, reaching the highest water levels since at least 50 years and reversing great quantities of sediment-loaded water onto the coast. Damage on human artefacts such as small concrete bridges, buildings and dirt roads was severe in places close to the river beds. Public opinion feared serious damage of the natural resources, such as the famous Cala Luna beach that was almost completely destroyed by the flood of the river Codula Ilune and by the coinciding sea-storm. The river, in fact, eroded the longshore bar (beach) and cancelled the small back shore lagoon. A monitoring study has been started in order to analyse the natural evolution of this littoral system and to define the resilience of this interesting geomorphosite in the framework of the National Project COFIN 2004-2006 on geological heritage. From the first observations it seems that the flood, albeit impacting negatively in the moments immediately after the disaster, in the medium-long term will probably have restored the natural equilibrium of this coastal karst geo-ecosystem.