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Volcano-tectonic architecture of a Caldera Complex, Karthala volcano, Grande Comore: new field observations

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Karthala volcano on the oceanic island of Grande Comore, West-Indian Ocean, is one of worlds' largest active alkaline basalt shield volcanoes, with 5 eruptions since 1991. In the last century the volcanic activity mainly concentrated within the 3.5 x 2.8 km large area of the summit caldera complex. Limited study has so far been carried out to unravel the structure and geometry of the summit caldera complex, the collapse chronology and the recent changes caused by the 2005 - 2007 eruption phases. Two exploratory missions to the Karthala summit in July 2011 led to an updated overview of the volcano-tectonic structures, evidence of the local orientation of the principle stresses and a preliminary stratigraphy of the 400 m deep rock sequence exposed in the caldera walls.

Three overlapping caldera's build the main structure of the complex, with vertically-subsided blocks forming intermediate terraces along the caldera structures. Within these blocks, several graben-like structures with N-S and N135°E orientations are evidencing a secondary influence of extension during or after the overall vertical collapse. One of the southwestern caldera blocks shows a 'tilted block' morphology, with a caldera-inward rotation. 'Choungou Changouméni', a nested pit crater in the Northern caldera, was 30 m deep in 1965 and has now been almost completely filled with pyroclastic deposits and lava flows. Caldera walls in the whole complex consist of massif meter-thick alkali-basalt flows with decimetric intercalations of weathered pyroclastic layers, and are topped by scoria and tuff cones. The caldera floor itself is covered by volcanic ash, lapilli, and massif scoriaceous surfaces of ancient flows.

At the intersection of the 3 main caldera structures two deep explosion craters are located, together named 'Choungou Chahalé'. These were the centres of recent phreatic activity. Their vertical walls show a sequence of thick alkali basalt flows and hold numerous cross-cutting dykes which fed small-scale eruptive cones, vertical degassing fissures and former caldera levels. Fissures with active fumaroles inside the two explosive craters and in the area between Choungou Chahalé and Changouméni are indicating a focus area in the hydrothermal activity. It is this hydrothermal system that is suggested to have controlled the phreatic nature of recent eruptions (1991, 2005 and 2007). Several pyroclastic beds and cones affected by block and bomb impacts inside the caldera complex and around the summit area testify the high explosive nature of these recent eruptions, in contrast with the effusive Hawaiian-style character generally associated with Karthala.

The orientation of caldera-bounding structures, eruption and fumarolic fissures, dykes as well as the orientation of intra-caldera extensional faults indicate one minor (E-W) and two major volcano-tectonic directions (N-S and N135°S). The latter are concurring with previously identified regional stress orientations and rift zone's orientations on Karthala flanks. Upcoming field work will be dedicated to the exhaustive structural and stratigraphic mapping of Karthala caldera as it provides exceptional exposure to document the internal architecture of an alkali basalt shield volcano and a complex caldera subsidence chronology.