Introduction: During Galileo’s 28th orbit (G28) around Jupiter the SSI camera has imaged a caldera-like feature (clf) on Ganymede to test for evidence of cryovolcanism (Fig. 1a). These data were evaluated in a previous study [1], but without utilizing their stereoscopic potential. Here we revisit this data set and include topography in the analysis to find new constraints on the formation of the feature.

Digital Elevation Model (DEM): The G28 images are composed of two sets which were taken with an interval of 16 min to acquire stereo coverage. From these we derived four individual DEMs with horizontal resolution of about 1 km and vertical precision of 20-40 m (Fig. 1b). Their relative elevation levels have been adjusted such that there is no elevation offset between identical geologic units.

Observations: Termed “scalloped depression” in the previous study [1], the DEM reveals that the clf stands in fact higher (up to ~200 m in its southern part) than the surrounding band. The interior is roughly planar rather than convex-shaped with relief similar to that of the band, typically 100 m at the DEM’s resolution. The only exception is the western boundary region. Along that there is a ~3 km wide and up to 400 m deep trough which is associated with an elevated surrounding terrain flank (Fig. 1c, p2).

Figure 1. (a) Image mosaic of G28 frames showing a 20x40 km clf at 24°S/42°E (arrows) surrounded by a bright band. (b) Color-coded DEM in that region derived by stereo image analysis [2]. (c) Selected DEM profiles. p2 reveals flank uplift at the western boundary of the clf. For comparison, the dotted profile demonstrates flank uplift at a rift zone boundary [9].

There are broader but curved ridges inside the clf which can be traced back to the band outside (Fig. 3).

Overall the interior is pervaded with dark material (dm), however dm can also be observed outside the clf. In many places, it appears as lobate deposit located in shallow depressions (white contour in Fig. 1a, b) and showing embayment relationships (Fig. 2). Photoclinometry suggests that at least two 0.7x1.5 km dark patches have smooth surfaces (Fig. 2; p1, p2).

Within the modelled area, dark terrain stands 100-200 m higher than the abutting bright band.

Discussion: A clf with high-standing interior has also been observed in Ganymede’s Sippar Sulcus, though at much lower DEM resolution [3]. A high-standing interior may thus be characteristic for clfs. An obvious process that could account for this and which is consistent with a fractured interior as observed here would be a diapir. A diapir with radius of 40 km would be able to push up and fracture the lithosphere [4]. This may also result in a domed interior as has been observed in photoclinometry-derived profiles in one case [5]. The diapir could also have trapped icy magma which then was released to the surface upon touching the lithosphere [4]. The elevated flank of the bounding trough (Fig. 1c, p2) is interpreted to be the result of post formational isostatic ductile ice flows in response to unloading due to drainage of the magma chamber.

The magma chamber must have been located at depths smaller than a critical depth d_c so that otherwise frictional forces would have prevented collapse. d_c is approximately given by the ratio of the width of the bounding trough (3 km) to the coefficient of friction (0.69) which is ~4 km. The vertical dimension of the magma chamber is expected to be comparable to the depth of the bounding trough i.e. ~400 m.

Conclusions: Diapirism is a viable explanation for the formation of caldera-like features on Ganymede. In the scenario described here, a compositionally and thermally buoyant diapir has flexed and subsequently disrupted the surface thereby flooding and displacing pre-existing surface features. Consistent with the observed topography, the up-rising plume could have squeezed lavas outwards forming an annular magma chamber which after drainage leads to collapse in the overlying layers.

In the given case the estimated depth to the magma chamber is < 4 km, and its vertical dimension is ~400 m.