The other side of caldera unrest: why do caldera subside?

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Calderas are known for their restless behavior: remarkable ground deformation is commonly observed during non-eruptive periods, sometime accompanied by seismicity and by significant changes in the chemistry and flow rate of discharged fluids. Uplift phases usually draw attention, as they may be due to shallow magma intrusion, and could therefore prelude to eruptive activity. However, the peculiar feature that characterizes calderas since their very formation is subsidence. Generated by a syn-eruptive collapse of the magma chamber roof, calderas commonly feature a long-term, secular subsidence, that is usually ascribed to magma cooling and contraction and/or to compaction of the soft volcanic deposits. Over a shorter time scale, subsidence may follow episodes of volcanic unrest, as a result of either magma movement or due to the discharge of volcanic gases. Despite its common occurrence and its relevance in the caldera evolution, a systematic assessment of the processes that could drive and explain caldera deflation is still missing. In this work we focus on the secular evolution of the Campi Flegrei caldera. Thanks to the presence of urban settlements along the sea shore, dating back to Roman times, this caldera is a unique site to evaluate the time scales associated with uplift and subsidence phases. Based on this formidable benchmark, we review the geological processes that may be responsible for subsidence, searching for time scales and magnitudes of displacement that are consistent with the available constraints. We believe that a comprehensive analysis that considers all the aspects of ground motion could provide a better image of the deep phenomena that fuel the caldera restless activity.