

**NUMERICAL SIMULATIONS OF SILVERPIT CRATER COLLAPSE: A COMPARISON OF TEKTON AND SALES 2.** G. S. Collins, E. P. Turtle and H. J. Melosh, Lunar and Planetary Laboratory, University of Arizona, Tucson, AZ 85721 (Email: gareth@lpl.arizona.edu or turtle@lpl.arizona.edu).

**Introduction:** SALES 2 and Tekton are two numerical tools that have been used to simulate complex crater collapse [1,2]. SALES 2 is a hydrocode capable of modeling the dynamic collapse of large impact craters. It has been successfully applied to the problem of central peak and peak-ring formation [1]. Tekton is a finite-element code designed to be applied to a wide range of tectonic problems, where displacements are relatively small and the dynamics are less important. It has been used extensively to simulate the relaxation of large craters and the formation of exterior rings in multi-ring basins [2]. Here we apply both techniques to the collapse of the Silverpit crater, to compare and contrast their capabilities.

**Silverpit crater:** The Silverpit crater is a recently discovered, 60-65 Myr old complex crater, which lies buried beneath the North Sea, about 150 km east of Britain [3]. High-resolution images of Silverpit's subsurface structure, provided by three-dimensional seismic reflection data, reveal an inner-crater morphology similar to that expected for a 5-8 km diameter terrestrial crater. The crater walls show evidence of terrace-style slumping and there is a distinct central uplift, which may have produced a central peak in the pristine crater morphology. However, Silverpit is not a typical 5-km diameter terrestrial crater, because it exhibits multiple, concentric rings outside the main cavity. External concentric rings are normally associated with much larger impact structures, for example Chicxulub on Earth, or Orientale on the Moon. Furthermore, external rings associated with large impacts on the terrestrial planets and moons are widely-spaced, predominantly inwardly-facing, asymmetric scarps. However, the seismic data show that the external rings at Silverpit represent closely-spaced, concentric fault-bound graben, with both inwardly and outwardly facing fault-scarps [3]. This type of multi-ring structure is directly analogous to the Valhalla-type multi-ring basins found on the icy satellites. Thus, the presence and style of the multiple rings at Silverpit is surprising given both the size of the crater and its planetary setting.

**The mechanics of Valhalla-type multi-ring basin formation:** Theoretical and numerical modeling of multi-ring craters [2,4] suggests that external ring formation is a consequence of the basal drag exerted on a brittle, elastic surface layer by a more mobile substrate as it flows inwards to compensate for the absence of mass in the excavated crater. This model has been further constrained for Valhalla-type multi-ring basins. The formation of closely-spaced, concentric fault-

bound graben, appears to require that the elastic upper layer be thin and that the mobile substrate be confined to a relatively thin layer [5,6,7]. This rheologic situation is easily explained in the context of the icy satellites; however, the presence of a thin highly mobile layer just below the surface is not a common occurrence on rocky bodies in the Solar System. In the case of the apparently unique Silverpit structure, it has been suggested that the mobile subsurface layer was caused by the presence of overpressured chalk layers at depth that acted as detachments and expedited bulk inward flow of a thin subsurface layer [3].

**Numerical Simulations:** We have begun to test the proposed model for the formation of the Silverpit crater using two contrasting yet complementary numerical tools: SALES 2 and Tekton. In both cases, we simulate the gravity-driven collapse of a bowl-shaped transient crater, 1-km deep and 3-km in diameter. We model the target to a radial distance of 20 km and a vertical depth of 10 km to avoid boundary effects. Our models consist of three, originally-horizontal layers, deformed using the Z-model approximation of the excavation flow. The top two layers are assigned appropriate rheologic parameters to represent the brittle upper chalk layer and the lower mobile chalk layer at Silverpit. The bottom layer occupies the remainder of the mesh. We simulate the inner-crater collapse using the acoustic fluidization model for complex crater collapse, where a fluidized region surrounding the transient crater facilitates slumping of the crater wall and uplift of the crater floor [for example 1,2]. We define the viscosity of the acoustically fluidized region to be the same as the viscosity of the mobile chalk layer.

**Results:** Results from our preliminary simulations suggest that the brittle upper layer must be ~1-km thick in order to reproduce the observed fault patterns and the central uplift. We will present the results of our models and the implications for both Silverpit and the two modeling methods.

**References:** [1] Collins, G. S., et al. (2002) *Icarus*, 157, 24-33. [2] Turtle, E.P., (1998) *Ph.D. Thesis, University of Arizona*. [3] Stewart, S. A. and Allen, P. J. (2002) *Nature* 418, 520-523. [4] Melosh, H. J. and McKinnon, W. B. (1978) *Geophys. Res. Lett.* 5, 985-988. [5] McKinnon, W. B. and Melosh, H. J. (1980) *Icarus* 44, 454-471. [6] Melosh, H. J. (1982) *JGR* 87, 1880-1890. [7] Allemand, P and Thomas, P. (1999) *JGR E* 104, 16501-16514.