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An alternative origin for the 'Silverpit crater'

Recent interpretation of three-dimensional seismic data in the southern North Sea has led to the recognition of a concentric, multi-ringed depression (the 'Silverpit crater'), the genesis of which Stewart and Allen attribute to a meteor strike[1]. Although this interpretation has understandably excited the scientific community, an independent evaluation of the well calibrated and densely spaced seismic data indicates that the structure may have a different origin. This new interpretation attributes its formation to salt withdrawal at depth, rather than to extraterrestrial impact.

Seismic lines across Silverpit demonstrate the folded nature of the sedimentary section, which affects all stratigraphic levels down to and including the top Permian (Fig. 1). Each fold has a structural relief of 1-second, two-way travel time (that is, over 2 km). The Silverpit crater lies in the core of one of the two prominent synclines lying between three antiforms. As the top Permian and basal Permian (top Rotliegend Group) seismic reflectors are not parallel to each other, the intervening Zechstein Group clearly varies in thickness across the area. Significantly, the synclinal configuration of the top Permian and younger stratigraphic horizons and the thinning of the Zechstein Group are exactly coincident, a fact that was not mentioned by Stewart and Allen.

Well observations in the Silverpit area indicate that the Zechstein Group predominantly consists of highly deformed evaporite deposits. Their burial promoted mobility on geological timescales, leading to complete withdrawal and grounding of the sedimentary overburden in some areas[2]. Conversely, influx and buoyant rise of evaporites has led to the formation of salt pillows and diapirs that fold and penetrate the overburden elsewhere[2].

Given the local structure, scale (both amplitude and wavelength) and regional considerations, the obvious conclusion is that the structural depression previously attributed to meteor impact has an unusual but more mundane origin as one of a number of depressions created by the almost complete withdrawal of support at depth. Stratigraphic onlap of seismic reflectors within the sedimentary succession demonstrates that the last phases of its growth occurred during Cenozoic deposition. Truncation beneath the base Cretaceous seismic reflector suggests that an earlier phase of evaporite mobility also occurred.

Two other aspects of the original interpretation[1] are also worthy of discussion as both were interpreted to support bolide impact. These are the development of annular fracture patterns and the apparent occurrence of a central conical peak.

The concentric array of normal faults affecting the top Cretaceous horizon is attributed here to deformation that accommodated folding[2]. Analogous ring faults occur in association with other salt withdrawal basins[3]. Other examples of extensional deformation in such settings include fracture patterns related to caldera collapse following volcanic eruption[4], ice-melt collapse pits[5], ice cauldrons on the top of ice sheets resulting from subglacial heating[6] and mining subsidence. Given the plausible alternatives, comparison with Valhalla-type multi-ring basins should not be used as vindication of meteor impact.

Evidence for the presence of the central peak is not unequivocal. Indeed, the seismic data show that all of the post-Permian stratigraphic horizons (for example, the top Cretaceous) reach their greatest depths in the core of the syncline. The difficulty in substantiating the peak's existence leaves open the possibility that it was an artefact of the seismic processing, velocity modelling or the method of interpretation itself.

In conclusion, although publication of the image of the Silverpit crater demonstrates the added value provided by the interpretation of seismic volumes, ascribing its genesis to meteor impact remains speculation. In the absence of independent supporting data, an origin through salt withdrawal is not only more plausible but also consistent with the geological history of the basin.

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Figure 1 Seismic line and corresponding geological cross-section through the Silverpit area. **a,** The line transects the centre of the Silverpit crater and demonstrates the structural relief of folding and the exact coincidence between the synclines and thinning of Upper Permian Zechstein Group evaporites at depth. The implication is that the feature is simply one of a number of unusual but similar structures that resulted from salt withdrawal at depth, rather than from meteor impact. **b,** Stratigraphic relationships imply that the structure did not result from a single episode of evaporite mobility but had a long-lived growth history that started in the Mesozoic and continued in the Cenozoic. The section is vertically enlarged by about three times for clarity.