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The Inception Horizon Hypothesis applied to karst development in the Burren: linking subsurface to surface

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The Inception Horizon Hypothesis (IHH) was developed to explain the spatial distribution of subsurface karst features. In large cave systems, passages are commonly developed within quite narrow elevation 'levels' that correlate with stratigraphic horizons (bedding planes) between lithologically distinct limestone beds. These horizons guide the first phases of speleogenesis and, combined with structural surfaces such as faults and joints, provide a framework for speleogenesis in a karst area. Despite the established link between speleogenesis and surface karst landforms, the IHH has not been extended thus far to explain the development of surface karst geomorphology. Using the example of the world-renowned limestone karst area of the Burren in Co. Clare, Western Ireland, we here show that an 'inception framework' concept can be used to explain the evolution of both subsurface and surface karst features.

Over 60 km of cave passages have been previously mapped in the Burren. Speleogenesis is guided by both stratigraphic and structural surfaces. Some limestone units contain numerous paleokarstic surfaces, as well as thin non-carbonate horizons ('clay wayboards'), along which cave passages are preferentially developed. Additionally, a suite of sub-vertical, north-north-east orientated veins, associated with the Variscan orogenic stress field, are vertically persistent through the entire limestone sequence. These calcite or silica-rich veins guide cave passage formation for several kilometres over a vertical range of > 100 m in some cases.

We conducted a new mapping of the surface karst in the Burren, with a focus on the distribution and morphology of enclosed depressions (dolines and uvalas). High-resolution remote sensing datasets, consisting of optical aerial imagery and associated digital surface models, were acquired for the Burren's entire 250 km^2 area in 2017. We have used these data, complimented by fieldwork, to record over 2500 karst depressions, representing a 25-fold increase on the existing database (109 dolines were recorded previously). We also performed a morphometric analysis to elucidate the primary controls on depression distribution and form. Our new data demonstrate that evolution of the surface karst geomorphology in the Burren, like the subsurface karst, is also primarily controlled by an inception framework comprising key stratigraphic horizons and structural surfaces (vein-associated lineaments).