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GUTTERS AND GUTTER CASTS

The term "gutter cast" was coined by Whitaker (1973) for elongate downward-bulging, deep, narrow erosional structures on the base of sandstone beds. The overlying bed may be a small fraction of the thickness of the gutter cast to several times its thickness or, in cases, the gutter casts are isolated scour-fills surrounded by mudstone or shale. These represent the casts of small-scale erosional channels cut into consolidated mud. A wide variety of sizes and shapes have been described for these features using many different terms, including priels, furrows, rinnen, erosionrinnen, large groove casts, rills, etceteras (see Myrow, 1994). The term gutter cast is preferred and is in general use. The wide range of size, shape, lithology and internal structures of these erosional structures suggest that their origin is polygenetic. The sizes and geometries of gutter casts are likely a function of many variables including the intensity and nature of the eroding flows, length of time that erosion takes place, and the grain size and diagenetic history (e.g., degree of compaction or lithification) of the underlying eroded substrate.

Gutter casts occur in association with pot casts, which are cup-shaped and cylindrical pillars of sandstone structures that formed from the infilling of potholes, or rounded nonlinear erosional depressions. They range in shape from discs to rounded loaflike forms to tall pillars, and in size from 1 cm to 20 cm in diameter or more. The bottoms of pot casts are commonly deepest around the outside, with a central erosional high. Pot casts have geometries and markings that indicates vertically oriented vortex flow (Myrow, 1992a) similar to that which forms potholes in bedrock in glaciated regions (Alexander, 1932).

Gutter casts are generally composed of sandstone but in cases containing conglomeratic lags. Internal structures include normal grading, parallel lamination, and wave-generated stratification including small-scale hummocky cross-stratification and 2d wave ripple lamination. The cross-sectional shapes of these gutter casts range from symmetrical to strongly asymmetrical, and include u-shaped, bilobate, v-shaped, semicircular, flat-based and wide, shallow forms (see Myrow, 1992a). The plan-view shapes of gutter casts are highly variable in width, and range from straight to sinuous to highly irregular. Some gutter casts bifurcate and pinch out along strike. Sinuous gutter casts may have geometries comparable to modern meandering rivers with steep to overhanging walls on the outside of meander bends. Sole markings are common features along the sides and bases of these gutter casts, and include groove marks, prods, and flute marks, and post-depositional trace fossils. The presence of delicate groove marks on the sides of gutter casts indicates that sand-sized sediment may have aided in their erosion as an abrasive agent.

Gutter casts are described from ancient deposits with paleoenvironments that range from tidal flat to submarine fan (Whitaker, 1973). Most gutter casts are described from shallow-marine rocks, and are considered to be storm-generated features (e.g., Aigner and Futterer, 1978; Kreisa, 1981; Aigner, 1985; Myrow, 1992a,b). Currents responsible for their erosion were likely highly variable. Unoriented (Allen, 1962) to bidirectional (Bloos, 1976; Aigner, 1985) prod marks on gutter casts indicating erosion by multidirectional and bidirectional currents/waves or combined flows (Aigner, 1985; Duke, 1990). The occurrence of spiraling or ropelike pattern of grooves on the soles of gutter casts has led to the suggestion that they formed by horizontal helical flows (Whitaker, 1973; Myrow, 1992a). In many cases, gutters were likely formed by the powerful unidirectional flows that characterize the initial stages of deposition of tempestites (Myrow, 1992a). Aigner and Futterer (1978) suggested that gutters are produced by currents interacting with obstacles forming horseshoe hollows that were later developed into channels in a downstream direction. This is not readily apparent from most ancient deposits, although evidence for such and origin would likely be lost during continued erosion of the gutter. A series of laboratory experiments on fine-grained cohesive sediment are needed to constrain the nature of flows that could potentially be responsible for gutter erosion, and thus help constrain their conditions of formation within storm depositional models.

The long axes of gutter casts are generally oriented perpendicular to shoreline (e.g., Daley, 1968; Myrow, 1992a,b) although some studies indicate shore-parallel orientations (Aigner, 1985; Aigner and Futterer, 1978). Gutter cast orientation can vary within depositional sequences. McKie (1994) shows a shift from shore-parallel orientations in transgressive systems tracts that were dominated by geostrophic flow to shore-normal orientations in highstand deposits that reflect downwelling flows in friction-dominated conditions. Gutter casts have also been shown to develop at the base of highstand systems as a result of forced regression (Graham and Ethridge, 1995). They are also known from nearshore areas of sediment bypass under thick sediment-laden flows (Myrow, 1992b). In these cases, isolated gutter casts (or those connected by very thin overlying beds) are up to orders of magnitude thicker than intercalated tempestites and represent sediment that accumulated almost exclusively in the gutters during bypass to deeper shelf environments.

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Cross-references

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