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Deep-Marine Sediment Waves Formed as Cyclic Steps and Antidunes in the Northern Gulf of Mexico

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A large deep-marine sediment-wave field on the continental slope of the northern Gulf of Mexico has been recently discovered and investigated in this study using a 3D seismic dataset covering 635 km^2, along with wireline logs. This study characterizes its geomorphology and interprets its formative mechanisms.

The ∼100 m thick sediment-wave succession was deposited during late Pliocene (∼3 Ma) constrained by the biostratigraphy data. The sediment-wave field covers a minimum of ∼200 km^2 area, likely extending towards northeast-southwest beyond the seismic coverage. Their dimensions decrease both upslope and downslope from the center of the field. Individual sediment wave exhibits up to 500 m in wavelength and up to 15 m in height. The wave crests oriented northeast-southwest are broadly aligned parallel to the regional slope-strike, indicating their sediment gravity flow origin without any bottom-current influence. The salt mobilization caused a local slope break along the paleo-continental slope and affected the hydrodynamics of the sediment gravity flows, which likely introduced two different formative mechanisms for the same series of sediment waves. Densimetric Froude numbers were calculated based on the equation of Bowen et al. (1984) and further constrained by the chart of Cartigny et al. (2013) to be ranging from 1.9 to 2.5 before the local slope break and approaching unity after the local slope break. The sediment waves before the local slope break were interpreted to be formed as highly up-slope asymmetrical (symmetry index: 0.2 to 0.3), long-wavelength, long-chain cyclic steps under ultra-supercritical sediment gravity flows, whereas the sediment waves after the local slope break were likely formed as symmetrical, or slightly asymmetrical, short-wavelength, short-chain antidunes under supercritical or critical sediment gravity flows. The presence of ultra-supercritical and supercritical sediment gravity flows can be further confirmed by a gamma-ray curve which indicates a large volume of coarse sediments (∼80% sand and ∼20% mud) input to the paleo-continental slope to generate the high-density sediment gravity flows. The abnormally high volume of sandy sediments input is also proved by the presence of contemporary, vertically stacked, high amplitude submarine channels and lobes. Since the hemipelagic and pelagic draping can also retain the undulating shape of sediment waves without active deposition of coarse grains, this study suggests adopting up-current migration rate to distinguish depositions by draping versus by supercritical sediment gravity flows. The high up-current migration rate in this study is likely associated with active and rapid build-up by fast-moving currents, whereas the low up-current migration rate is likely linked to slow build-up by hemipelagic and pelagic depositions. This interpretation can be further justified by the amplitude contrast between up- and down-current flanks where depositions by sediment gravity flows lead to a much greater amplitude contrast than hemipelagic and pelagic depositions. The large amplitude contrast is likely attributed to sediment partitioning, meaning that the thicker and coarser sediments accumulated on the stoss side and thinner and finer sediments on the lee side.