The Fourth Slope – Mathematical correlation of shape and process on continental margins

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Clinoforms are the building blocks of sedimentary geology and their typical s-shaped geometry can be recognized in cm-scale ripples up to the kilometre-scale slopes connecting the shallow continental shelves to the deep abyssal ocean floor. To what extent there is a systematic relationship between the shape of clinoforms and the processes responsible for their formation, is addressed in this study based on curve-fitting of over 150 continental margin slopes. Previously three mathematical functions have been found to closely match many submarine slopes. The present study broadens the range of mathematical functions to improve the potential for prediction of along-strike variations between form and processes. Four mathetmatical functions are found to closely match most slopes: Linear, Gaussian, exponential and quadratic (positive and negative/inverse). The study reveals that the fourth slope, the quadratic, is by far the most common. While exponential and quadratic slopes are similar, there is a crucial difference in the way in which the declivity of the slope changes. Continental slopes are created through a complex interaction of destructive and constructive processes, although by and large they are sites of deposition hosting large amounts of the ocean sediment despite covering only 4% of the surface area. It is suggested that the even reduction of the angle in quadratic slopes represents systematic decay of sediment with distance, previously attributed to exponential slopes. Exponential slopes, meanwhile, are suggested to result from slope readjustment, with upper slope sediment bypass and lower slope aggradation. There is a clear link between abrupt shelf-edges and long slope-aprons, which supports connection to erosional processes. This in turn means that the quintessential sigmoidal (s-shaped, Gaussian function) slope, with a smooth rollover, represents a fundamental depositional slope profile. The even, fairly uncommon, linear slopes, are typically the longest and lowest angle slopes, and likely form in response to high sediment input. The ability to understand the governing processes, sediment type, rate, and transport mechanisms, influence of antecedent geology, and ensuing slope stability, has wide-stretched economic and environmental implications relating to marine life, resources, climate change and sea-floor infrastructure.