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Characterization and classification of the erosional shapes of submarine canyon systems

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Canyons and gullies are an integral part of slope morphology on most continental margins. The submarine systems extend out for up to a thousand kilometres from the continental margin, forming branched networks whose origin is not well understood. The gradual accumulation of world-wide bathymetric and seismic data on continental margins provides a basis for the classification of slope morphology and consequent erosional and depositional processes which contribute to the formation of the shapes of the submarine systems network. Discussion and development of models for analysis of erosional shapes of submarine networks along continental margins has been confusing and controversial. Since canyon systems may cross both shelf and slope, so that limiting discussion to parts of the system can be problematic. Turbidity currents are generally credited with the excavation of submarine canyons and with transporting sediment down the canyon to the base of the continental slopes to the marine basin. However, studies indicate that turbidity currents are not necessarily the initial cause of the valley formation and, similar to subaerial river valleys, submarine systems are formed by various processes. The valleys of the sea floor appear to have had several origins, producing distinctive types; submarine features may include numerous tributaries entering from both sides, and relief comparable to major land canyons. This study aims to establish to what extent the same origin can be applied to the hundreds of canyons found around various coasts of the world along convergent, divergent and transform continental margins. In the detailed manner, we use examples of available evidence for subaerial erosion and bathymetric data that correspond to different slope curvatures and display unique canyon branching-system morphology. The methodology for quantative classification of canyon systems is based on the bathymetric data and involves 2-D depiction of tributary-like channel networks and the establishment of their spacing, paths of the tributaries and channel patterns. Additionally, we examine main channel and tributary cross-sections with emphasis on the position of the river channel thalwegs, along with the 3-D analysis of shapes of various morphological elements and bedforms. These are performed so that differences in canyon morphology can be related statistically to the properties of downslope progression of slope profile, slope shape and curvature, as well as the competence of the transport mechanism with increasing distance from sediment source. This is in analogy to both subaerial fluvial systems and erosional processes at the shelf break. Quantitative methodologies based on computational geometry used in this study have the potential to construct deductive spatial models of sequences of topological structures, spatial relationships of “non-connected” objects, and integration of objects and space, which might open ways of re-thinking traditional parameter-based approaches for classification of the erosional shapes and processes of submarine canyon systems.