Importance of Sea-Level Controlled Depositional Architecture to the Understanding of Permafrost and Gas Hydrates on High Latitude Shelves

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Modern arctic continental shelves are characterized by the development of permafrost to sub-bottom depths of several hundreds of meters. Thermal modeling suggests that this thickness must have developed over several glacial-interglacial cycles. Shelves exposed at low sea level stands were subject to sub-zero average annual temperatures that allowed freezing temperatures to penetrate below the surface. During transgression and highstand conditions, bottom waters may have been slightly above the freezing point so that some melting of the permafrost would have ensued. Similarly, the depth of the gas hydrate stability zone, which is close to the seabed under present day conditions, would have been subject to large fluctuations through time, potentially leading to periods of de-gassing modulated by sea level fluctuations. Better understanding of the links between sea level and the distribution of permafrost and/or gas hydrate stability requires that the depositional history related to sea level fluctuations be better understood. A conceptual model for the construction of shelf depositional architecture, permafrost and gas hydrates is developed. The sawtooth character of Pleistocene glacial and sea level cycles involves progressive sea level fall punctuated by extended lowstand conditions and followed by rapid sea level rise. This would lead to a progradational stacking pattern with one or two mid-shelf lowstands per cycle. During these lowstands, permafrost would aggrade on the topset portion of the clinoform and degrade on the foreset portion. Thermal conditions at the topset/foreset hinge line would be most variable, potentially leading to destabilization of gases bound in hydrate form. In this model, gas release structures are inherently associated with lowstand hinge points, representing nearshore conditions.