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Welded Slump-Graded Sand Couplets: Evidence for Slide-Generated Turbidity Currents (Grès D'Annot Submarine Fans, Maritime Alps)

Most investigations that discuss the origin of turbidites state, or intimate, that turbidity currents are surges commonly initiated by catastrophic events related to submarine sliding on slopes. This concept is almost universally accepted by specialists although little "hard" observational data are available. In general theory, failure is triggered by stresses that can result from several factors (high sediment accumulation rate, slope oversteepening, earthquake, subsurface gas generation, etc) which give rise to excess pore pressure and a weakening of the sediment. Liquefaction and decrease in overall shear resistance are usually invoked as causes of sediment mobility. Increased mobility within the slab results in increased disorder of original sediment stratification and structure. Grain-to-grain structure is disrupted during acceleration, causing changes in pore pressure and allowing mixing with water that, in turn, results in further alteration of original structure. Metastable, high sensitivity, cohesionless sediments are most susceptible to mobility and, in turn, transformation from submarine sliding to turbidity current flow.

Continuing sedimentologic studies of spectacularly exposed grès d'Annot deep-sea fan deposits (lowermost Oligocene) in the French Maritime Alps provide clues to resolve the problem of slide-to-turbidite transformation. Most noteworthy are massive channelized strata in upper and mid-fan sectors characterized by a lower slump member that evolves upward to a turbidite. This merging is indicative of probable generation of sediment gravity flows from submarine sliding. A proposed scheme suggests failure on a fan valley wall by submarine sliding that could entrain the flow of sand either from adjacent reaches of valley walls and/or from farther up-axis in the fan valley. In this manner, flow of some of the sand initiated by the sliding event would come to rest at nearly the same time and position as the slump mass near the base of the fan valley wall and in the axis proper. In some cases, the slump mass may bypass the base of the valley wall and, as it accelerates, transformation may be induced with resulting flow of sediment down-axis and basinward.

The above phenomenon has a bearing on hydrocarbon exploration. Modern ocean floor surveys and regional field studies, such as those of the Annot Sandstone Formation, indicate that there is a nonrandom distribution of turbidites with respect to slumps deposited on marine margins and basins. Moreover, massive channelized submarine fan valleys may serve as ideal reservoirs for both oil and gas. Thus the model proposed here, if valid, clearly would be important in helping refine paleogeographic interpretation and in pinpointing potential hydrocarbon-bearing targets in the subsurface.

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Quantitative Determination of Geologic and Thermal Evolution of Sedimentary Basins

A 3-dimensional deterministic dynamic basin model is constructed and applied to several sedimentary basins to determine the quantitative mass and energy transport in sedimentary sequences of a basin as a function of the geologic history. Input data consist of sedimentation rate and type, paleobathymetric estimates, initial physical (density, porosity, and permeability), and thermal (thermal conductivity and specific heat) properties of sediments, and heat flow. All the available data and know-how from geology, geophysics, geochemistry, strength of materials, hydrodynamics, and geothermics are combined in an integral form using the general physical, physicochemical, and chemical concepts as mathematical expressions. The results of the model are: geologic history and quantitative stratigraphy, pressure history, thermal history, subsidence history, compaction history, porosity distribution, and organic matter maturation history.

The model results are then compared with the measured sediment thicknesses, pressures, temperatures, porosities, vitrinite reflectance values, and other geochemical maturity indicators. The model is calibrated, using a special iterative method based on sensitivity analysis. This method enables us not only to optimize the parameters of the system, but also to check the system for possible errors in the assumptions or in our understanding of the basin (conceptual model). Thus, each basin is analyzed as being a unique system.

Application of the model to several sedimentary basins has shown that high sedimentation rates increase pressures (mainly in shales) and temperatures, erosion decreases pressures (approach to hydrostatic) and temperatures, and thrusting generally decreases geothermal gradient. We have also found that generation of hydrocarbons can only be determined from heating rates using a kinetic model and not from simple generation vs. maturity trends (generation curve concept).

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Additional Abstract

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High-Resolution Studies of Amazon Fan Distributary Channels and Growth Pattern Using GLORIA, SEA BEAM, and Seismic Reflection Data

Deep-sea fans have become increasingly important targets for exploration because their facies associations can provide the necessary geologic factors for hydrocarbon generation and accumulation. We need to acquire a better understanding of channel morphology, vertical and lateral facies distributions, and growth pattern of modern deep-sea fans to successfully exploit the hydrocarbon potential of both ancient and modern fans. To this end we have developed a series of studies to investigate the structure of the Amazon Fan. Long-range side-scan sonar (GLORIA) and single-channel seismic records have revealed that the fan is composed of relatively few channel/levee systems. The channels (width 1.5 to 0.5 km or .9 to .3 mi) are intensely meandering with sinuosities up to 2.5. Cutoff meanders, channel branchings, and overflow deposits are associated with these channels. GLORIA sonographs and seismic reflection profiles show a probable growth pattern for the fan. Apparently only one major channel is active at a given time. In early 1984 we will conduct multi-narrow-beam bathymetric swath mapping (SEA BEAM) and high-resolution seismic (watergun) studies of critical channel segments in order to further resolve the bifurcation and meandering patterns of the channels. We will collect quantitative data on channel development across the fan, and on channel/levee structure, including depths, widths, and intra-channel topography (terraces, point bars). These data should provide important new insight into the origin and evolution of fan channels and associated inter-channel deposits. Detailed studies such as these should provide new information for predicting the distribution of hydrocarbon reservoir rocks in fan deposits.