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In-Situ Pore Pressure at IODP Site U1324, Ursa Basin, Gulf of Mexico

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Abstract

We measured pore pressures with two pore pressure penetrometers at IODP Site U1324 in Pleistocene sediments of the Ursa Basin, Gulf of Mexico, directly offshore from the Mississippi Delta. Between the seafloor and 300 meters below the seafloor (mbsf), overpressures reach 80% of the hydrostatic effective stress ($\lambda^* = 0.8 = {(u_0 - u_h)}/{(\sigma_v - u_h)}$). In this interval, only low permeability mudstones are present. Beneath 300 mbsf, λ^* is approximately 0.2 and the sediments are composed of interbedded mudstone, siltstone, and very fine sandstone. We interpret that the lower relative pressures beneath 300 mbsf are caused by the higher permeability of these sediments. Penetrometer deployments ranged from 30 minutes to 90 minutes, which was not enough time for the measured pressure to dissipate to the in-situ pressure. To estimate the in-situ pressure, we used two inverse time extrapolation techniques: $1/\sqrt{t}$, and $1/t$. We use a theoretical soil model to show that the $1/\sqrt{t}$ extrapolation provides a desirable accuracy in much shorter amount of time than the $1/t$ extrapolation.

Introduction

Overpressures, pore pressures in excess of hydrostatic pressure, have been observed in sedimentary basins around the world [1]. Knowledge of the distribution of overpressure is critical to explore, drill, and produce hydrocarbons [2, 3]. Overpressures drive pore water flow [4], impact large-scale structural development [5], and affect the state of stress [6].

In young, cool, sedimentary basins, overpressures are generated in low permeability mudstones due to their inability to drain as they are loaded by sedimentation or deformation. Although the pressure is generated within the mudstone, it is most often measured in permeable formations adjacent to the mudstone [3]. Recently, the petroleum industry has extended geotechnical techniques to measure pore pressure within mudstones through the use of pore pressure penetrometers in the borehole to depths of many hundred of meters [7-9]. This exciting technique provides direct measurements of pore pressure in low permeability rocks and in some locations it has documented very high pore pressures immediately beneath the seafloor [7].

When the penetrometer is pushed into the formation below the bottom of the hole (BOH), a pressure disturbance is created. The time that it takes to disipate this pressure depends on the probe diameter and the hydraulic diffusivity of the sediment. In ocean drilling, the time available for downhole tool measurements is expensive and limited. In this environment, in-situ properties must be interpreted from partial dissipation records. If detailed soil properties are available, the in-situ pressure and diffusivity of the sediment can be inferred from modeling of soil behavior for different penetrometer geometries [10-14]. However, in many cases soil properties are not available, or there are insufficient resources to pursue soil modeling. In these cases, in-situ pressure is inferred from a simple extrapolation approach.

We deployed two types of pore pressure penetrometers in the Gulf of Mexico deepwater during Integrated Ocean Drilling Program (IODP) Expedition 308: the Temperature-Two-Pressure (T2P) probe and the Davis-Villinger Temperature Pressure Probe (DVTPP) (**Figure 1**). The DVTPP was deployed previously during ODP Legs 190, 201, and 204 [15-17]. The T2P is a new tool under development as a cooperative effort between Penn State University, MIT, and IODP-TAMU [18, 19]. The diameter of the DVTPP is large and as a result it takes a very long time for the induced pressure to dissipate to in-situ conditions in marine mudstones [13]. The T2P has a much narrower diameter and dissipates toward the in-situ pressure at a more rapid rate than the DVTPP [13, 18, 19].

We present the DVTPP and the T2P deployments in the Ursa Basin, deepwater Gulf of Mexico at Site U1324 during IODP Expedition 308. We use a theoretical soil model to show that an inverse square root of time ($1/\sqrt{t}$) extrapolation provides a desirable accuracy in a much shorter amount of time than an inverse time ($1/t$) extrapolation. We illustrate the results of