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Estimation of the maximum burial depth of siltstones from the Kazusa Group by laboratory experiments

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To evaluate maximum burial depth of sedimentary formations is important for many topics in earth science and engineering such as estimating uplift and erosion of sedimentary basins. As a one of effective methods of the evaluation, a laboratory-based method for determining the maximum effective stress have been proposed. This method is based on a conventional method to evaluate preconsolidation stress (maximum effective stress experienced) of soil. However, this method cannot be necessarily applied to sedimentary rocks in simple ways, because sedimentary rocks have experienced not only mechanical compaction but also other processes such as cementation between grains, which should affect the mechanical properties of the rock. Thus applicability of this method to sedimentary rocks should be examined for several sedimentary basins. We performed laboratory experiments to measure porosity of siltstone specimens collected from several formations of the Kazusa Group, Boso peninsula, Japan, and tried to estimate the maximum burial depth based the results. We then compared the results with differences of burial depth ($\Delta Depth$) among locations of collecting samples which were estimated from geological setting, and examined the applicability of this method for estimation of the maximum burial depth in this site.

We collected rock blocks from Umegase (UMG), Otadai (OTD), Kiwada (KWD), Ohara (OHR), and Katsuura (KTR) Formations (in the descending order of stratigraphic horizon), and prepared cylindrical specimens of approximately 40 mm in diameter and 30 mm in length from these blocks. The porosity of these specimens was measured under different confining pressure (up to 35 MPa) and constant pore pressure (1 MPa) by using an intra-vessel deformation fluid-flow apparatus at Toho University. We used water as a pore fluid, and the measurements were performed at room temperature. Porosity under each effective pressure (the difference between confining pressure and pore pressure) was estimated by measuring volume of water drained from a specimen when confining pressure was loaded. The relation between measured porosity and effective pressure could be bilinear in log?log scale. The maximum effective stress experienced ($P_{e,B}$) of the tested rocks was determined from the intersection point of the two straight lines of the compaction curve. The maximum burial depth (D_{max}) was obtained by $D_{max} = P_{e,B} / [(\rho_r - \rho_w)g]$, where ρ_r, ρ_w and g are density of rock, water and gravity acceleration, respectively.

In the case of UMG, OTD and KTR, porosities decrease as the burial depth increases. Porosities of OHR and KWD, however, were relatively high although their burial depth is relatively large. There was a linear correlation between D_{max} and $\Delta Depth$ except for OHR, but the slope of the relationship was less than one (approximately 0.27). Therefore, further investigation is necessary to examine the applicability of this methods to this site. $P_{e,B}$ of OHR was less than that of other specimens, which supports the possibility that pore pressure in this formation was approximately 5 to 12 MPa higher than hydrostatic conditions.

Keywords: porosity, maximum burial depth, maximum effective stress experienced, Kazusa Group, overpressure, laboratory rock experiment