

## Occurrence and engineering characteristics of spherical concretions in the Mizunami Group

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Concretion is a rock mass existing in sedimentary rock, and refers to a rock mass that is hard and condensed due to the precipitation and filling of minerals in the particle pores of the sediment. Among such concretions, calcium carbonate-based concretions may have dead biological remains as their core. It is known that carbonate concretion rapidly condenses between the organic acid diffused from the core biological remains and calcium ions in the void water by a supersaturation and precipitation reaction. This rapid sedimentation reaction and the mechanism for sealing the gaps in the sediment are expected to be applied to the sealing technology for rock groundwater cracks in structures such as underground cavities and tunnels. Previous studies have shown that the concentration of calcium inside the concretion is generally constant. However, there have been no quantitative studies on the hydraulic and mechanical properties such as water permeability and hardness properties associated with the sealing of calcium carbonate.

In this study, we targeted concretions produced in the Neogene Mizunami Group in Gifu Prefecture for material evaluation. Many spherical and ellipsoidal concretions can be observed from the riverbed of the Toki River that flows through Mizunami City. For material evaluation, we observed the structure inside and around the concretion, as well as porosity measurement, hardness test, and permeability test.

The major axis, minor axis, and height were measured for each of about 100 concretion samples. At the same time, the strike and dip symbol of the long axis of the concretion was measured in order to confirm the relationship with the bedding surface of the stratum. For the purpose of observing the structure and composition inside the concretion, we observed it with an electron scanning microscope (SEM) and made and observed flakes. The porosity was calculated by measuring the dry weight and the wet weight in order to examine the permeability characteristics. In addition, a sample with a diameter of 5 cm and a thickness of about 3 cm was cored from the inside of the concretion and the host rock, and the hydraulic conductivity was measured by the variable water permeability test and the flow pump method. The hardness test was performed on the cut and polished rock surface using an echo chip (a measuring device that hits a rock surface made of super steel and calculates the hardness from its falling speed and bounce speed).

The carbonate concretions observed in Mizunami were all spherical and ellipsoidal, and the larger ones tended to be ellipsoidal. The observed ellipsoidal concretion had a major axis in the horizontal direction and a minor axis in the vertical direction with respect to the stratum surface. As a result of flake observation and observation of the void state inside the rock with an electron microscope, it was confirmed that the inside of the concretion was filled and sealed with calcium carbonate (calcite) even to the fine voids. By this filling with calcium carbonate, the porosity is lowered, and if it is low, it is lowered to 5% or less. As a result of measuring the hardness with the echo tip, it was shown that the concretion was harder than the surrounding host rock, and the density was increased by the sealing of calcium carbonate. Furthermore, as a result of the permeability test, the permeability coefficient was on the order of 10<sup>-12</sup> (m/s), which was comparable to that of granite in spite of clastic rock. From these results, the concretion has high durability against physical and chemical weathering even after being exposed to the ground surface due to the progress of sealing with calcium carbonate in the early stage after deposition and the decrease in permeability.

Keywords: concretion, sealing