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Case study of geotechnical estimation by GREATEM and a helicopter-borne magnetic survey over a tunnel construction site

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1. Introduction

Helicopter-borne geophysical explorations, such as a grounded electrical source airborne transient electromagnetic (GREATEM) method and a helicopter-borne magnetic survey (HMS), have recently become more common in surveys in geological investigation and monitoring of active volcano. These methods enable the rapidly and broadly measuring the characteristic values of the underground, and these methods allow the gathering of three-dimensional geological information. In this study, we used GREATEM and HMS to delineate the geological structures of long tunnel construction site planned in the northern side of Hokkaido pref., Japan and report the feasibility and effectiveness of these surveys to provide geotechnical information for tunnel construction.

2. Outline and Method

In this study, we conducted our surveys on a planned mountainous tunnel with a total length of 2.7 km long and maximum overburden is 380 m. Geological features of tunnel site is the Cretaceous sedimentary rocks extending north to south and is penetrated by serpentinite. The serpentinite is mostly distributed in the central part of the tunnel route, and sedimentary rocks are distributed in the eastern and western sides, respectively. Excavating through the serpentinite zone would raise various geotechnical issues, such as squeezing; therefore, it is very important that the distribution of serpentinite be detected. We describe the results of GREATEM and HMS, and compare them with those of geological ground surveys, two-dimensional electric resistivity prospecting (2DERP), controlled source magneto-telluric method (CSMT), magnetic survey at ground surface, borings, electrical logging (EL) and measured electrical resistivity (ER) of bore core samples performed in the same area by tunnel constructor.

3. Results

As the results of GREATEM, relatively high ER zones were mainly seen from the surface layer to a depth of 100 m and relatively low ER zones were distributed on tunnel elevation line. These tendencies are similar to results of 2DERP, CSMT and EL. As the results of ER by bore core samples, serpentinites, the massive type showed the highest resistivity value, followed by foliated and clayey types and sedimentary rocks in this order. Although relatively low ER zones were seen in the deeper section, high and low ER mixed layer zones and steep gradient part of ER zones, as the ER contrast zones, are present in the deeper section along the tunnel elevation line. These are estimated that low ER zones consist of a clayey layer or/and weak foliated serpentinite and sedimentary rocks. The massive serpentinites are probably distributed in relatively high ER zones. The geological conditions change at depths where correspond to existence of ER contrast zones were found in the GREATEM survey. When excavating a tunnel in these zones, one must pay attention to faults, fracture zones, unsymmetrical pressure zones due to geological condition changes, flowing groundwater, and similar factors.

As the result of HMS, magnetization map based on magnetic intensity (MI), applied upward continuing to 900 m above sea level, were delineated shown as low magnetization bodies (MB) on both sides of the tunnel site and high MB on its central part. The highly MB zones are almost identical to the distribution of serpentinites revealed in the geological map and the other geological investigation results. However, the MI distribution is not homogeneous in the direction of the geological structure underground. Therefore, it is only difficult to estimate the geological properties of underground based on MI.

The resistivity structure of deep sections determined by combination of GREATEM and HMS surveys are effective for the acquisition of basic data to predict potential geotechnical issues when excavating a tunnel. We will verify these results by comparison with clarified geological conditions after tunnel was excavated.

Keywords: GREATEM, HMS, Helicopter, Tunnel, Geological investigation