Application of GPR at exposure field

Ayumu Makuuchi[1]; Takeharu Takahashi[2]; Yuki Hama[2]; Erumu Nishiyama[2]; Koichi Matsuo[1]

[1] NMCC; [2] Tech. Dev. & Energy Sec,
Resources Dev. Dept.,
NITTETSU MINING

http://www.nmconsults.co.jp/

GPR is a geophysical profiling method with Non-destruction, convenience and high-accuracy. This method is recently used widely for civil engineering, disaster prevention, and environment, such as, detection of buried objects or vacant space, maintaining concrete, archaeology, groundwater, mines, geological structure, etc.

Radio wave suffers attenuation due to the conductivity of medium. The biggest weakness of GPR is short of investigation depth, about a few meters, because of the high-conductivity soil covering around surface or groundwater. On the other hand, at exposure field, high-resistivity rock is outcropped at surface, therefore GPR can survey up to unimaginable depth from usual GPR survey, because radio wave does not attenuate.

In this paper, we present some case studies of GPR survey at open pit limestone mines which are a kind of typical exposure field. Limestone is only a self-sufficient resource and over 250 mines are under operation in Japan. Almost all of these are open pit mine. Since open pit limestone mine has outcropped limestone which is high-resistivity, over a few hundred ohm-meter, it can be assumed the one of the most appropriate fields for GPR.

1. Geological boundary survey

It is possible to distinguish geology, such as, soil, limestone, slate, etc., by GPR, because they have the different physical properties (specific permittivity, resistivity). On a survey for obtaining the distribution of soil thickness (soil-limestone boundary) at a new development area, we can estimate its boundary up to about 15m under surface by reflection waves from canine-tooth-like limestone underlying soil by using 80,40,20MHz antennas. On other case, an experiment to distinguish geology by attenuation of radio wave strength is conducted. At limestone, reflection waves can be seen until the deeper part of GPR profiles, because limestone has high-resistivity, so radio wave does not attenuate. On the contrary, other rocks, such as clay or slate, have low-resistivity compared with limestone, so the radio wave attenuates immediately. By using attenuation of radio wave, to estimate the boundary between limestone and the other rocks or limestone contaminated by clay is getting possible.

2. Crack survey

It is possible to detect open cracks filled by clay, etc. by GPR as continuous reflection plans, because its specific permittivity is different from surrounded rock. At one mine, we carried out GPR survey for obtaining the distribution of clack which continued from holes on the cliff of hillside under about 30m from the excavation floor. We set survey lines on excavation floor and surveyed with 200,80,40MHz antenna, a few strong continuous reflection plans were obtained. One of these reflection plans had 20 degrees dip to the cliff, and the extension of this reflection plan corresponded to the depth of holes. We carried out drilling to confirm actual structure, then encountered clay zone at the corresponding depth of this reflection plan. At other mine, an experiment by GPR to obtain the distribution of cracks which parallel the rock slope are carried out to predict rock slope stability.

3. Vacant space survey

Vacant space survey is the one of the most appropriate survey for GPR. Strong and clear reflection wave with distinctive reflection pattern is generated at the boundary between limestone and vacant space. At one mine, we carried out GPR survey with 200MHz antenna for obtaining the distribution of vacant spaces which made by the past excavation. The two-dimensional distribution of the ceiling of vacant spaces up to 10m under surface was obtained. At other mine, the clear reflection waves from a tunnel under about 35m from surface were obtained by 40MHz antenna.