INTRODUCTION

Landslide is one of geological disasters caused by natural phenomena or land use mismanaging by human activities. The impact of this disaster is very harmful; both directly as damages to public facilities, farmland, human sacrifices as well as damages the development and economic activities in the affected areas. Landslides in Indonesia generally occurs during wet season, this is caused by soil material can’t able to hold water in large quantities. One of the most dangerous landslide events in Aceh occurred in Village of Paya Ateuk, South of Aceh. This event has occurred four times in the last six years and the greatest one occurred at May 30, 2008. These event were not only affected to people economically, but also had claimed the lives of local residents. The similar disaster can be potentially occurred in the future as long as no mitigations effort conducted in the area. We have applied geophysical method of very low frequency (VLF-R) in order to study physical properties of the landslides area. Electrical resistivity of soil materials are highly influenced by water content. VLF-R method is believed suitable to distinguish variations in electrical resistivity of geological structures.

SITE DESCRIPTION AND LOCAL GEOLOGY

This research was conducted at Paya Ateuk Village, Sub district of Pasie Raja, Aceh Selatan. Geographically the area is located at latitude: 3.189820 and longitude: 97.303899. Topography of the area is surrounded by mountains range with slope 40° (Fig.1). The main cause of landslides in Paya Ateuk is highly induced by rainfall, so that the land can’t withstand water flow and landslide disaster occurred.

BASIC CONCEPT

Electromagnetic methods are based on Maxwell equations. Electromagnetic method does not require contact with the ground. VLF is an electromagnetic method that uses electromagnetic radiation from military navigation radio transmitters operating in the VLF frequency band (15-30 kHz) as the primary electromagnetic field. This method compares the magnetic field of the primary signal (Transmitter) to that of the secondary signal (induced current flow within the sub surface electrical conductor).

The radio signals are transmitted either as ground waves or as waves guided by the solid earth and the conducting ionosphere. The primary field can induce secondary eddy currents in electrically conductive, steeply dipping, elongated (2D) targets. VLF was build in two mode; mode tilt (VLF-EM) and resistivity (VLF-R). The VLF-EM instruments measure only the vertical (Hz) and the horizontal (Hy) components of the magnetic field, but the VLF-R
need minimum of two magnetic field and electrical field to be measurement. The measured parameters in VLF R are apparent resistivity ($\rho$) and phase ($\varphi$).

RESULTS

VLF-R measurement was conducted using T-VLF Instrument. The data were measured in 10 profiles covered the landslide risk area. The length of the profile measurements varied between 90-250 meters, with stations spacing by 10 meters while the profiles distance between 20-50 m (Fig.1).

We used two frequencies Hwu France (18.3 kHz) and JJI Japan (22.2 kHz) for data measurements. However the data obtained at frequency of 22.2 kHz wasn’t fairly good, it is caused by the location of the research in the mountains. However, we believe that the data have been able to provide an overview of the electrical properties of the location of the landslide. Many ways can be used to present the data VLF-R, one of them is by looking at the distribution of values of apparent resistivity profile and map. Fig. 3 shows a few examples of the distribution of apparent resistivity with frequency 18.3 kHz on profile 1 and 5.

FIGURE 1. Map of Studied landslide Area, Paya Teuk, Pasie Raja, Aceh Selatan.
Figure 3 shows the distribution of data are dominated by the apparent resistivity of conductive and resistive zones at several stations. In the Profile 1 (Fig. 3a) relative low resistivity values found at station 20-70 m, 110 and 180 meters, this indicates that the zones are relatively wide, so that the region is estimated as prone to landslides. In the phase values, Profile 5 (Fig. 3b) is dominated by conductive zones with exception at 140-170 meter along the profile. The resistive zone is mostly dry that less water contain. Overall distribution of apparent resistivity values shown in Figure. 4.

Apparent resistivity variations shown in each profile can’t be used directly to locate the potential landslide areas (Fig. 4) since the electrical resistivity ranges of geological materials are very wide. Therefore we show the data in logarithmic scale. Based on Fig. 4b, the apparent resistivity presented in logarithmic scale clearly indicates high risk landslide zones. The areas are dominated by apparent resistivity values of 2.5 to 3 Ohm.m in logarithmic scale.

CONCLUSION
Based on qualitative data interpretation of VLF-R can be concluded that the method can be used to investigate landslides areas. The apparent resistivity values are highly correlated with the landslides zone in the area; generally indicated by low resistivity values. Based on historical records, landslide hazards in Paya Ateuk are highly influenced by rainfall intensity. The high water content in the soil is characterized by high electrical conductivity of the area.

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REFERENCES

2. Bell,Rainer. Kruse,Jan-Erik. 2006. mas Glade, Bonn, Andreas Hördt, BraunschweigSubsurface investigations of landslides using geophysical methods geoelectrical applications in the Swabian Alb (Germany). Geographica Helvetica