MRS dynamic monitoring study of landslide in Hefeng East Mountain, Anhui (China)

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SUMMARY

We have proposed MRS monitoring method of landslide. We first analysed the distribution of resolution in array coil measuring mode, and then obtain that in this mode we can achieve fast 2D detection of groundwater in a wide range under the condition of higher resolution. By a way of MRS monitoring in wet season and dry season, we realized 2D MRS imaging of landslide in Anhui Hefeng East Mountain. We accurately determined the scope of shallow landslide 3-7 m. And comprehensive analysis the rapidity, accuracy and effectiveness of the method, making it become a main way in landslide exploration and monitoring.

Key words: MRS, landslide, dynamic monitoring, 2D MRS imaging.

INTRODUCTION

Water can cause serious geological disasters, threatening the livelihood security. For example, the underground water can soft the base material strength of the structure surface and induce landslide. Every year, there are huge economic losses due to water geological disasters in China. The ground magnetic resonance sounding (SNMR) is a new geophysical method developed in recent years. This method can directly detect the hydrogen nuclei abundance of the underground medium, it can not only be for and evaluation of groundwater resources in water scarce areas, but also play a unique role in the detecting and warning of geological disasters caused by groundwater such as landslide.

Anhui Hefeng East Mountain is located in the transition zone of warm temperate and the subtropics. Due to the warm air, every summer, high temperature, high humidity, precipitation often accompanied by the occurrence of strong precipitation weather disasters such as massive accumulation landslide.

In order to implement dynamic monitoring of the landslide and determine the range of landslide zone, this paper puts forward magnetic resonance method for landslide dynamic monitoring. Using 2D MRS imaging method, we implement real-time monitoring of landslide both in the wet season and dry season. With the help of drilling displacement in the landslide zone, pore water, rainfall record and combined with ground geological investigation, we can determine the effective and real-time performance of the magnetic resonance sounding monitoring on landslide.

METHOD AND RESULTS

2D MRS imaging is mainly on imaging of water content of each position of the underground space. The MRS signal can be described as the linear matrix:

$$e_0 = Kw \tag{1}$$

Where e_0 is the initial amplitude; K is the kernel function; w is the distribution of water content.

In order to acquire the water content distribution image of 2D groundwater model by using the existing MRS signal data, we use the Occam inversion method to minimize the difference between the forward signal Kw and the observed initial amplitude e_0^{obs}, the difference is described as two order norm:

$$\Phi_d = \left\| D_\varepsilon \left(e_0^{obs} - Kw \right) \right\|_2^2 \tag{2}$$

Where D_ε is weight value, it can be acquired by using the calculated uncertainty of the observed data and noise.

The direct optimization of the above expression is not stable. In order to obtain the imaging results of high resolution and stability, the objective function inversion need to introduce the smoothing constraints:

$$\Phi_m = \left\| Cw \right\|_2^2 \tag{3}$$

Where C is the smoothness matrix. So the final optimization problem can be described as:

$$\Phi = \Phi_d + \lambda \Phi_m \rightarrow \min \tag{4}$$

Where λ is the regularization parameter.

MRS signal perform as the relaxation characteristics in time domain, the envelope of the signal amplitude decay with time. The multi-exponential relaxation signal can be expressed as:

$$V(q,t)=\int K\left(r,T_2^*,q,t\right)w\left(r,T_2^*\right)dT_2^*dr \tag{5}$$

For the inversion of 2D in groundwater:

$$V(q,t)=\int K\left(m,q,t,T_2^*\right)w(m)\,d^2m=\int K(m,q)e^{-t/T_2^*(m)}w(m)\,d^2m \tag{6}$$

Where $w(m)$ and $T_2^*(m)$ are the water content and the relaxation time of the m part, they are the variable that need to be calculated. To the end, we will calculate the Jacobian Matrix of water content and relaxation time:

$$\Delta V=\begin{bmatrix}K_w & K_{T_2^*}\end{bmatrix}\begin{bmatrix}\square w\\ \square T_2^*\end{bmatrix} \tag{7}$$

Where □ stands for the difference; K_w and $K_{T_2^*}$ are the Jacobian matrix of the kernel function of water content and relaxation time.

$$K_w(n,l;m)=\frac{\partial V(n,l)}{\partial w(m)}=K(n,m)e^{-t(l)/T_2^*(m)} \tag{8}$$

$$K_{T_2^*}(n,l;m)=\frac{\partial V(n,l)}{\partial T_2^*(m)}=\frac{t(l)}{T_2^*(m)^2}K(n,m)e^{-t(l)/T_2^*(m)}w(m) \tag{9}$$

Figures and Tables

The MRS instrument is a four-channel broadband detection system, which has a transmitting coil of 75m*25m wire frame and four double turns receiving coil of 25m*25m wire frame. The receiving coils are laid side to side and synchronization acquisition, as shown in Fig 1.

The distribution of the array coil measuring model resolution using Fig 1 is shown in Fig 2, (a) -(c) represent the results of the different noise level. We can see that the shallow surface zone has the minimum resolution radius, with the increase of depth resolution radius are increased. Using array coil model, we can achieve fast 2D detection of groundwater in a wide range under the condition of high resolution.

The 2D MRS landslide monitoring inversion results on Anhui Hefeng East Mountain in wet season and dry season are shown in Fig 3 and Fig 4.

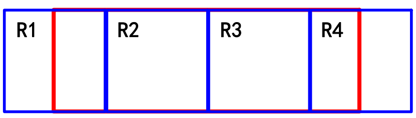

Figure 1. Coil laying mode.

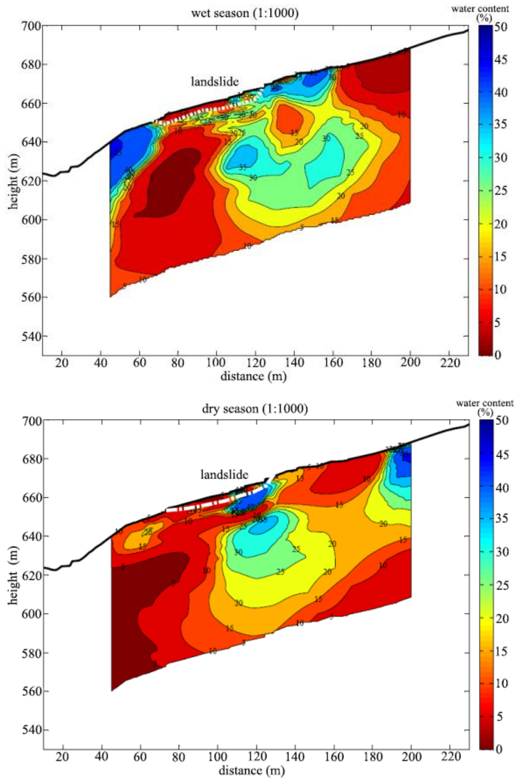

Figure 3. The MRS water content distribution map in wet season and dry season.

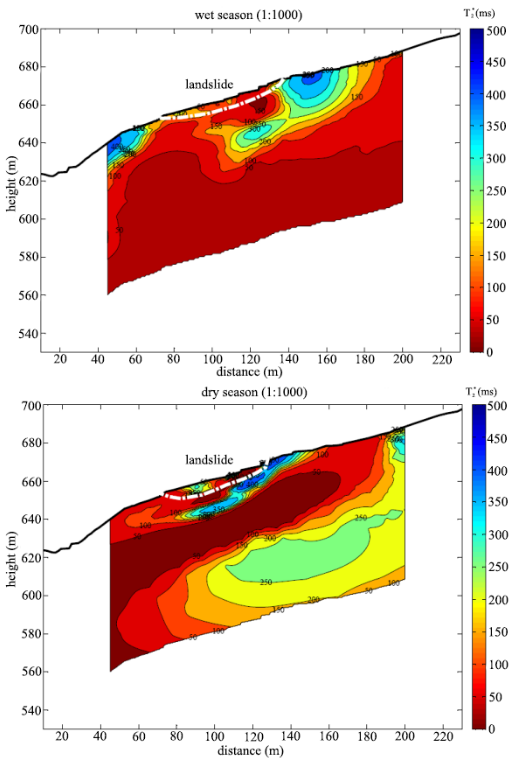

Figure 4. The MRS relaxation time distribution map in wet season and dry season.

CONCLUSIONS

In this paper we have given a way to monitor landslide, and also analysed the distribution of resolution in the array coil measurement mode. We applied our method in Hefeng East

Mountain, Anhui. We can see that (1) points 50-80 were interpreted as aquifer of bedrock fissure water; (2) points 75-125 were inferred to sliding range; (3) points 100-180 were considered as bedrock fissure belt.

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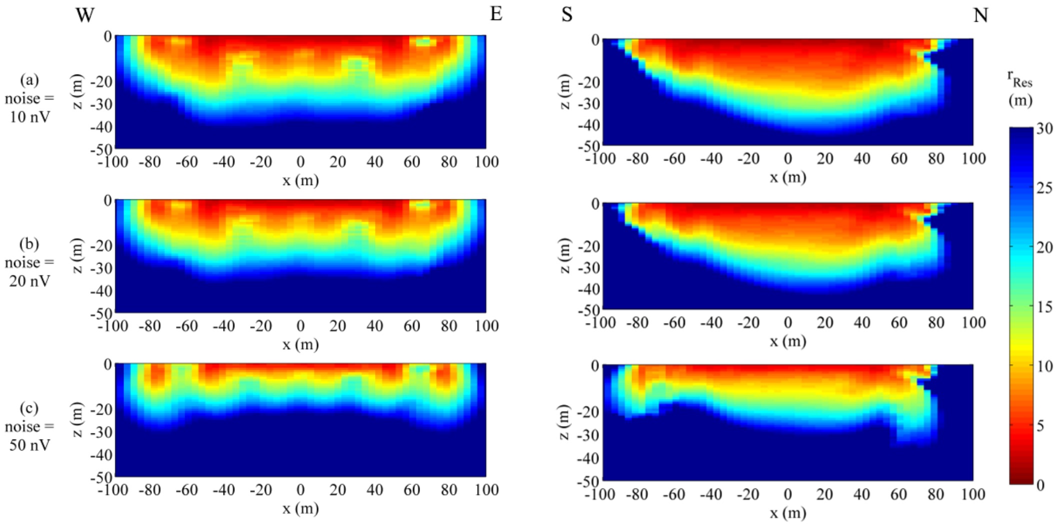

Figure 2. East-west and north-south direction resolution radius in array coil measurement mode