Application of GPR Method Due to Active Faults Determination in Urban Area, Case Study: North Shahre Ray Fault, South of Tehran, Iran

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Abstract—The main objective of this paper is to show GPR (Ground Penetrating Radar) applicable method for active and seismonogenic fault exploration in urban area. The case study has done on north Shahre Ray fault in South of Tehran (Iran). The north shahre Ray fault on base of exist data is reported as main earthquake sources in Tehran and Ray city. GPR method has applied in three points of active north Ray fault with 100 and 200 MHz frequency antennas in Azim abad village and around. The two points had selected on soil and one on the asphalt where three point locations were on fault along approximately. Field observation of GPR method testing on fault consists of three simple and compound profiles. The compound profile interpretation results shows that fault plan and Tectonic anomaly sharply. The case study conclusions suggest that GPR method is useful and quick tool in compare with other methods for active fault exploration in urban area with average deep fault.

Keywords-GPR method, North Ray fault, active fault identification.

I. INTRODUCTION

The active fault locality determination is important and necessary in urban areas. The GPR method is one of active fault exploration surface methods in urban areas that it is without digging. The other applicable methods for fault exploration contains Geolectric, Geoseismic, trench, borehole, well logging, remote sensing and study on Groundwater surface anomaly. Comparing to other methods, GPR is inexpensive, fast without problems for citizen and sharp in urban area, however it is completive other methods. It is one of the Geophysical methods that developed in1930 [7] and is based on an electromagnetic exploration tool that to be useful in tectonic (fault, fold, joint system...) and undersurface lithology [15], [9].In hydrogeology, GPR is used for groundwater level movement monitoring [6]. In magnetoelectroncic, it is usable for study of the complexity of weathered zone. In general, this method is useful for pipes, cables location distinguishing, monitoring of the water well field [17], determination of caves and other deep karsts phenomena in carbonates rock [4], [5] and [12], soil and cements consolidation in civil structure and pipeline seepage determination from surface to a certain deep [16].In addition the GPR method is applied for ice and snow measurement [3].

In this research, GPR technique has applied with 100 and 200 MHz antenna on three sites of active and seismonogenic north Ray fault at Azim abad village around (Fig 1).

Two sites has selected on the soil and one site on the asphalt. Then field operation has done with 100 and 200 MHz antenna on 100 m long line vertically to fault direct and take out different profiles. In office the profile analyzed And compound profiles of three sites are prepared.

Figure 1- Index map of Iran and Shahre-Ray situation. Topographic map above Shows site of field work (profile1, 2 and 3), (Iran map after IIEES 2000)

The results shows active north Ray fault and anomaly zone sharply.

The GPR has defects and virtues due to active fault determination in urban area, to compare other exploration methods that are as follows:

Defects
1-The GPR method is inexpensive.
2- It is accurate in urban areas.
3- It is quick method.
4-It doesn’t make problems for other activity in urban area.
Virtues
1- The GPR method is not popular in Iran and other countries that exists active faults in their cities and method instruction may be appear difficult at the beginning.
2- It is useful provided the fault location is identified distance from 10 to 20m. Therefore application of this method needs to have knowledge of fault situation approximately.
3-Its penetration depth is average and is not useful for deeper site.

II. BACKGROUND OF NORTH SHAHRE RAY FAULT

The north Shahre Ray fault is located on south of Tehran City and north of Shahre Ray City (Fig 1). The length of fault is 16.5 km and direction is W-E and dip of fault is towards north. This fault has an escarpment between hanging wall and footwall about 2 meters (Fig 2). The north Ray fault is thrust and Shahre Ray depression formed by fault mechanism [1]. This fault influenced on groundwater and water table of aquifer is different in two sides of the fault [8], [10] and [14]. This reason presents the north Ray fault activity on Tehran plain groundwater that shows it is active fault. The north Ray fault topography shows an escarpment between hanging (A) and footwall (B) (Fig 2). The escarpment continues along fault and distinguished in site 1 towards west (Fig 2). The local depression was formed by two branch of the north Ray fault in west of Azim-abad village. First time, the north Ray fault introduced by Berberian [2] and then covered by Ray city urban area development.

The Seismicity and related Seismicity of North Ray fault quoted from Berberian are shown in table 1. The available information about the north Ray fault earthquakes (table 1) indicate that this fault is active and has not strong shaking for a long time (about 1100 years). Therefore it may generate strong earthquake and shaking in future. Similarly study and find position about the north Ray fault is important and useful for future urban area development plane. So that, north Ray fault located in Shahre Ray and south of Tehran.

Table 1- The north Ray fault earthquakes characterizes

<table>
<thead>
<tr>
<th>No</th>
<th>Magnitude</th>
<th>Intensity</th>
<th>Date</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Ms = 7.6</td>
<td>I = X</td>
<td>300 B.C</td>
</tr>
<tr>
<td>2</td>
<td>Ms = 7.1</td>
<td>I = VIII</td>
<td>855 A.C</td>
</tr>
<tr>
<td>3</td>
<td>Ms = 5.3</td>
<td>I = VII</td>
<td>864 A.C</td>
</tr>
<tr>
<td>4</td>
<td>----------</td>
<td>---------</td>
<td>1786</td>
</tr>
<tr>
<td>5</td>
<td>----------</td>
<td>---------</td>
<td>1966</td>
</tr>
<tr>
<td>6</td>
<td>----------</td>
<td>I = IV</td>
<td>1966</td>
</tr>
<tr>
<td>7</td>
<td>----------</td>
<td>I = IV</td>
<td>1966</td>
</tr>
<tr>
<td>8</td>
<td>----------</td>
<td>I = III</td>
<td>1970</td>
</tr>
<tr>
<td>9</td>
<td>----------</td>
<td>I = IV</td>
<td>1970</td>
</tr>
<tr>
<td>10</td>
<td>Ms = 4.3</td>
<td>----------</td>
<td>1977</td>
</tr>
<tr>
<td>11</td>
<td>Ms = 5.2</td>
<td>----------</td>
<td>1980</td>
</tr>
<tr>
<td>12</td>
<td>Ms = 5.4</td>
<td>I = I or II</td>
<td>1982</td>
</tr>
</tbody>
</table>

III. THE GPR METHOD

The surface Ground Penetrating Radar (GPR) method is comparable to the – reflection seismic method [13]. The source array is an antenna generating a very high-frequency electromagnetic pulse. The range of frequency varies from a few tens of MHz to GHz frequency. The electromagnetic waves, which penetrate in the ground formation, are recorded by receiving antenna [7]. In north Ray fault we use an antenna that contains source and receiver.

Table 1- The north Ray fault earthquakes characterizes

Figure 2- North Ray fault topography and situation of site 1 in west of Azim abad (A= hanging wall, B= footwall)


Figure 4 presents the GPR method antenna. It shows antenna that is contains source and receiver (Fig 4-A) and shows antenna with source and receiver separately (Fig 4-B). Also GPR antenna (200, 100, 35 MHz frequency) with different deep penetration was applied for fault distinguishes. Firstly line of fieldwork is determined in GPR method. Length of line renege from 10 to 20 m which is divided into small segment of one meter long, then antenna is pulled...
along the line and electromagnetic wave send into ground formation in predetermined points. The antenna then receives the reflected wave from the ground formation (Figure 4-C). Reflective intensity waves are recorded by Monitoring and different intensity shows anomaly in Underground (Fig 4).

**Figure 4- GPR method antenna types (after Miyata et. al. 2000). A= antenna with Source and receiver. B=antenna with separated source and receiver. C= types of antenna with penetrating deep.**

**A. GPR survey lines in North Ray fault**

Along north Ray fault three lines determined around Azim- abad Village in northeast of Shahre Ray city.(Fig 1) Site 1(line1) is west of village and site2 is in the north of village and site3 is in the east of village. Direction of line is north to south and perpendicular with the north Ray fault direction. The length of line is 20m that had 20 segments with one-meter long and center point of line is located on fault approximately. GPR antenna 100 and 200 MHz frequency used in the north Ray fault at three lines.100 and 200 MHz frequency antennas were pulled along line and radar wave penetrated into ground formation and reflected wave recorded by antenna and presented by monitor. The deep of penetration the100 MHz frequency antenna is 20m and 200MHz antenna frequency is10m maximum.

IV. **FIELD OBSERVATION**

Field observation of GPR testing in north Ray fault consists of few profiles. These profiles interoperate after filtration.

**A. Simple Profiles 1-3**

The Profile site of 1 it has been obtained from 100 and 200 MHz frequency antennas with penetration deep from 6 to 20m. It appears that tectonic anomaly (flexure) in this profile is not narrow and has a width about 5m as well as that layers bended and formed a flexure. The fault direction is west to east and fault dip is 70 degree toward north.

The Profile of sites 3 has been taken from 100 MHz frequency antennas with penetration deep about 7.5 to 11.3 m. This profile shows anomaly and the fault is near the south of line. The tectonic anomaly is differing layer in both side of fault. The fault direction is west to east and fault dip is 60 degree towards north. The Profile of sites 1, 2 are on soil surface and profile of site 3 is on asphalt surface.

**B. Compound profiles**

The compound or combination profiles prepared from few profiles that have been take from different antenna. The compound profiles are useful for general views and final interpretation.

The compound profiles of sit1 prepared from information take from 100 and 200 MHz frequency simple profiles. These profiles show tectonic anomaly and fault that is near the middle of line 1. The tectonic anomaly is flexure and fault location is the south of anomaly. The fault dip is 70 degree towards north. The fault is reverse and north wall uplifted. (Fig 5)

The compound profile of site 2 was on the basis of information were obtained from 100 and 200 MHz frequency antenna. This profile shows tectonic anomaly and fault in middle of anomaly. The tectonic anomaly is flexure and the fault dip is 70 degree towards north. The fault is reverse and north wall uplifted (Fig 6).

The compound profile of site3 prepared on the basis of information was obtained from 100 MHz frequency antennas. This profile shows fault without anomaly. Fault dip is 60 degree towards north (Fig 7).

**Figure 5- Compound profile of site 1 shows North Ray fault and bended zone anomaly part is fault zone. Depth of Profile is 20m.**
V. DISCUSSION

The GPR technique is a very useful method to exploration fault location in urban areas. The buildings and streets or others cover most Faults in urban area with thin or thick cover. When the faults covered by thin layers, the GPR method can be use to distinguishing the situation of hidden faults as a non-destructive technique.

The active faults covered by urban facilities such as buildings, roads etc, so in many of the Iranian city. In many plans we need to learn position of fault in urban areas accurately. The experience in north Shahre Ray fault shows

That the GPR technique is a fast, inexpensive and Economical method for fault identification in Iranian and Other country where contains fault. For example in Tehran city many active Faults such as Niavaran, Mahmodieh, Shian, kosar, Sorkhe-Hesar, north Tehran, north and south Shahre Ray and South Mehrabad are Located in urban area of the Capital of Iran. We can use GPR method for faults exploration in Tehran and other cites of Iran and another country that is like to Iran. This method is applicable and inexpensive technique for fault identification in urban area.

VI. CONCLUSION

The significance of the GPR method application in the north Shahre Ray fault is as follows:

1-The fault characterizes (situation and dip) obtained from the GPR method are the same as those are available from predevelopment of Shahre Ray city.

2-In sites 1 and 2 the tectonic anomaly was observed by the GPR method accurately around natural fault plane.

3-In site 3 the fault was distinguished clearly from top layer the asphalt.

Based on the north Shahre Ray fault, we suggests the GPR Method as an applicable technique for urban environment faults exploration of Iran and semi country. Bay the same token this method application is easy and economical.

REFERENCES