*REPUBLIC OF TURKEY*
*Prime Ministry*
*Disaster And Emergency Management Presidency,*
*Earthquake Department, Ankara – TURKEY*

# REPORT ON VAN EARTHQUAKE
# (EASTERN TURKEY)
# (Ml=6.7 Mw=7.0)

**CONTRIBUTORS**

*This study was prepared by* ***Prime Ministry, Disaster and Emergency Management Presidency, Earthquake Department***

*In addition, the various stages of work;*

*Dear Prof. Dr. Ali KOÇYİĞİT and Dear Prof. Dr. Mithat Fırat ÖZER (member of AFAD Earthqauke Advisory Board)*

*Dear Colonel Onur LENK, (General Command of Mapping)*

*Dear Zahide ÇOLAKOĞLU, (Van Disaster and Emergency Management Direction)*

*Dear Prof. Dr. Mehmet ÇELEBİ, Dr. Thomas Holzer ve Dr. Katherine Sharer, (USGS)*

*Dear Prof. Dr. Jens HAVSKOV (Norway Bergen University)*

*have been involved*

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**ABBREVIATIONS**

AFAD: Disaster and Emergency Management Presidency

GIS: Geographic Information Systems

CHARTER: Using of Space Technology in the Natural Disaster

DLR: German Aerospace Center

EMSC-CSEM: European-Mediterranean Seismological Center

HGK: General Command of Mapping

MMI: Modified Mercalli Intensity Scale

MTA: General Directorate of Mineral Research and Exploration

Ml: Local Magnitude

Mw: Moment Magnitude

OIS: Organized Industrial Site

PGA: Peak Ground Acceleration

PGD: Peak Ground Displacement

PGV: Peak Ground Velocity

SED: Swiss Seismological Service

DEM: Digital Elevation Model

TDY-2007: Turkish Earthquake Resistant Code 2007

TOKİ: Housing Development Administration

TR-KYH: National Strong Motion Observation Network

TS: Local Time

USGS: US. Geological Survey

Z3: Soil Class

# 1. General Characteristic of Earthquake

A destructive earthquake occurred 20 km. North of Van City Center near Kasımoğlu Village (West of Erçek Lake) on 23 October 2011 at 13:41 local time. According to the National Seismological Observation Network, operated by Prime Ministry Disaster and Emergency Management Presidency (AFAD) magnitude of earthquake is Ml:6.7 and the depth is 19.07 km. Epicentral coordinates are determined as 38.68N-43.47E (Fig.1.1). After comprehensive calculations, moment magnitude is calculated as Mw:7.0 for this earthquake with the help of the program which is called SEISAN. It was developed by Jens HAVSKOV (Fig.1.2).

Immediately after the event, all necessary information about the earthquake was transmitted to National Crisis Management Center established at AFAD headquarters and to high level local authorities of Van. Team of AFAD Earthquake Department reached to Van with Deputy Prime Minister responsible from disaster and emergency management 4 hours after the event and contributed to crisis management at Van. Field studies also initiated immediately after the AFAD Team reached to Van and Erciş.

According to the information given by AFAD, 644 people lost their lives and 252 people were saved alive from the debris. AFAD informed that, by 09 December 2011, 17005 dwelling units were determined as collapsed and/or heavily damaged in Van City Center, Erciş and villages.

23 October 2011 Van-Merkez earthquake is unique from several aspects. Very high number of aftershocks within short period after the event, was not experienced previously. Within the first week of the earthquake, there happened ***114*** earthquakes with magnitudes between 4.0 and 4.9 and ***7*** earthquakes with magnitudes bigger then Ml:5.0. Within the first month after the event daily average aftershock number is around ***180*** earthquakes. By 09 December 2011, the number of aftershocks reached to ***6284***. Focal depths of aftershocks varies between 2.5 km and 25 km. (Fig.1.3,1.4) (Graph 1.1,1.2,1.3).

During the very intense aftershock activity of the Van-Merkez earthquake, another earthquake occurred at 10 km. South of Van, near Edremit Province on 09 November 2011 at 21.23 local time. The magnitude of this earthquake was calculated as Ml:5.6 (Mw:5.7) (Fig.1.5).

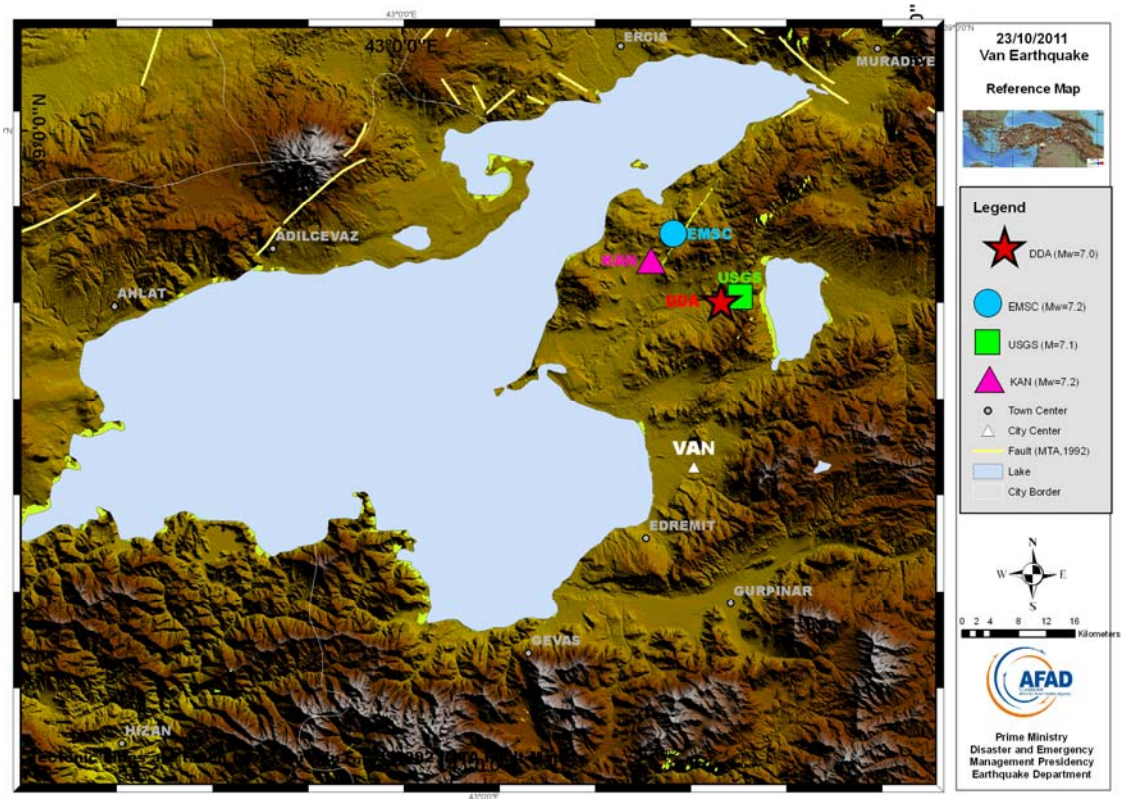



Figure 1.1: Epicenteral coordinate of Van Earthquake (according to different institutions)

Mw_Solution - Not Defteri

Dosya Düzen Biçim Görünüm Yardım

```
    date hrmn   sec       lat      long depth   no m    rms   damp erln erlt erdp
111023 1041 18.26 38.68N  43 47.0E   19.02   15 3   0.69 0.000  9.6   5.1209.1
 stn   dist    azm   ain w phas    calcphs hrmn tsec  t-obs  t-cal    res    wt di
 VMUR    34   23.4 38.8 0 P       PN5     1041 25.2   6.96   7.31  -0.35 1.00 14
 GEVA    54 215.4 37.0 0 P       PN6     1041 28.7  10.47  10.77  -0.30 1.00 12
 BASK    89 144.7 36.1 0 P       PN7     1041 34.9  16.62  16.69  -0.07 1.00 21
 DYDN    95   14.2 36.1 0 P       PN7     1041 36.6  18.38  17.74   0.64 1.00 10
 EKAR   132 297.8 35.8 0 P       PN8     1041 41.9  23.65  23.82  -0.17 1.00  8
 EATA   151 328.3 35.8 0 P       PN8     1041 43.7  25.41  27.07  -1.66 0.99* 6
 CUKT   163 174.0 35.8 0 P       PN8     1041 47.2  28.92  28.78   0.14 0.87*11
 VRTB   177 287.0 35.8 0 P       PN8     1041 50.7  32.44  31.13   1.31 0.73* 5
 DIGO   189 358.9 35.8 0 P       PN8     1041 52.5  34.19  33.30   0.89 0.61* 3
 HOMI   197 319.2 35.8 0 P       PN8     1041 55.1  36.83  34.60   2.23 0.53* 2
 BNGL   199 278.5 35.8 0 P       PN8     1041 53.3  35.07  34.77   0.30 0.51* 3
 SVAN   203 252.9 35.8 0 P       PN8     1041 51.6  33.31  35.10  -1.79 0.47* 3
 BTMN   209 244.8 35.8 0 P       PN8     1041 56.8  38.59  36.19   2.40 0.41* 2
 EAK    220   4.2 32.2 0 P       PN11    1041 56.8  38.59  38.17   0.42 0.30* 1
 ECAT   233 296.0 26.3 0 P       PN12    1041 57.7  39.46  40.01  -0.55 0.17* 0
 KOPT   290 300.9 26.3 0 P       PN12    1042  5.6  47.37  47.29   0.08 0.00* 0
 DIYA   301 254.2 26.3 0 P       PN12    1042  8.3  50.01  48.21   1.80 0.00* 0
 ELZG   387 267.9 26.3 0 P       PN12    1042 17.9  59.67  58.70   0.97 0.00* 0
 Return to continue, q to end listing

 SVAN BZ   gdist:     203.0   mom:          19.8   mw =   7.1
 BNGL BZ   gdist:     199.0   mom:          19.5   mw =   6.9
 BTMN BZ   gdist:     209.0   mom:          19.3   mw =   6.8
 ELZG BZ   gdist:     387.0   mom:          19.7   mw =   7.1
 DIYA BZ   gdist:     301.0   mom:          19.3   mw =   6.8
 KOPT BZ   gdist:     290.0   mom:          19.6   mw =   7.0
 Number of spectra available and number used in average      6      6
 2011 1023 1041 18.3 L  38.710  43.417 18.0  DDA 18 1.1 7.0WDDA
```

Figure 1.2: Moment Magnitude Solution of Van Earthquake

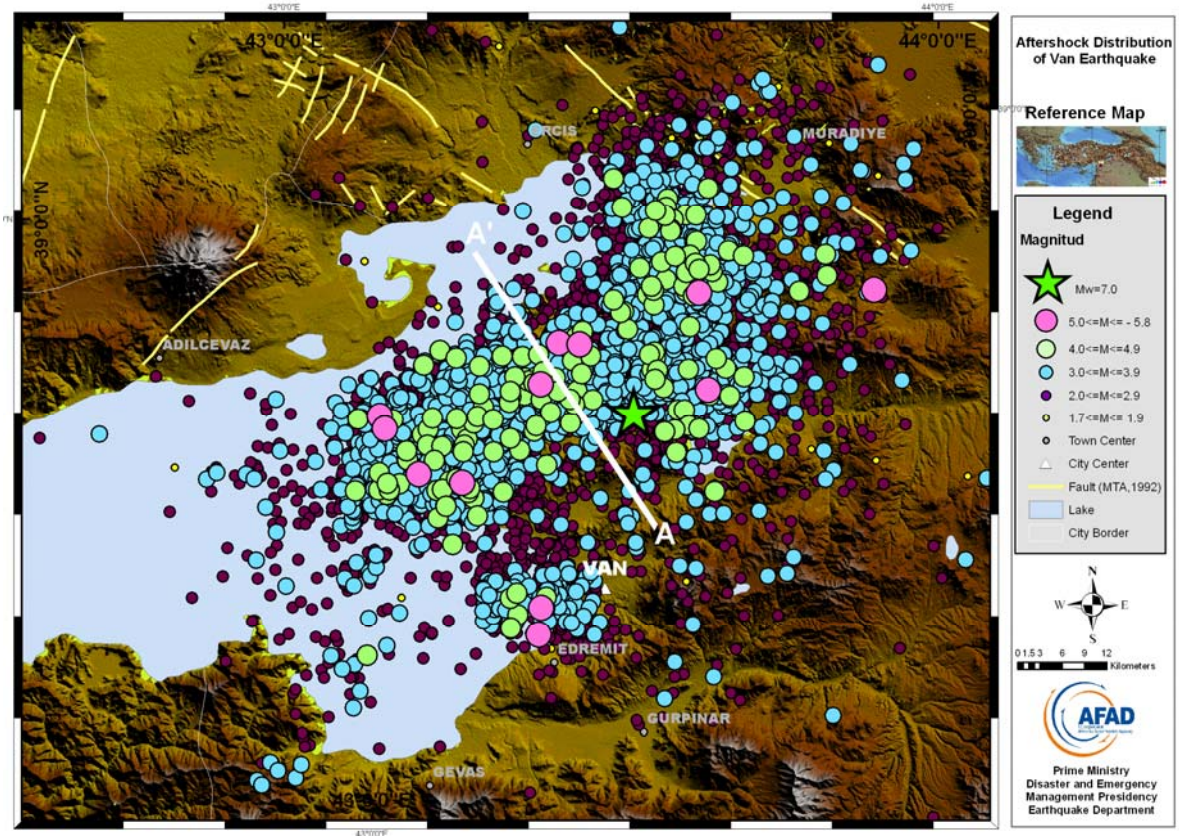



Figure 1.3: Aftershock distribution of Van Earthquake

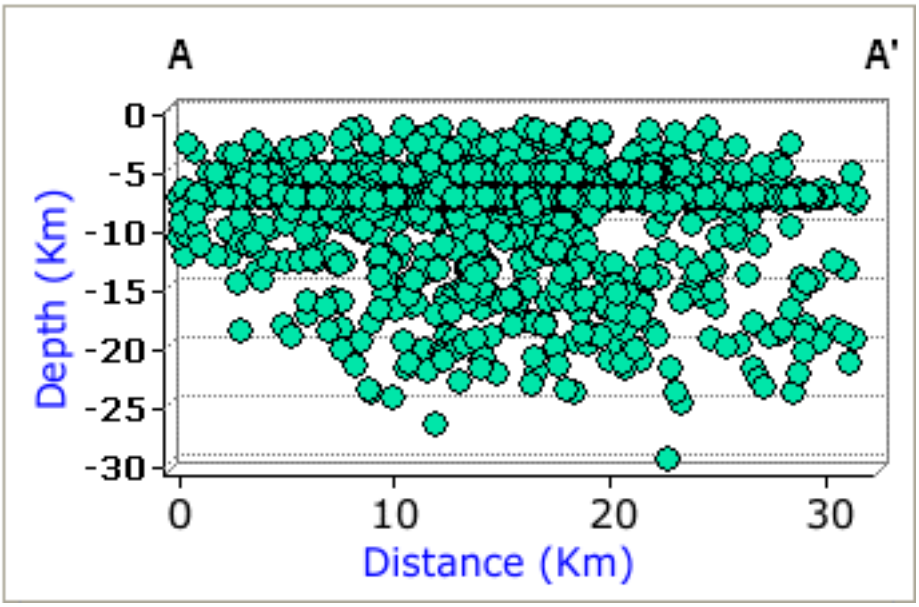
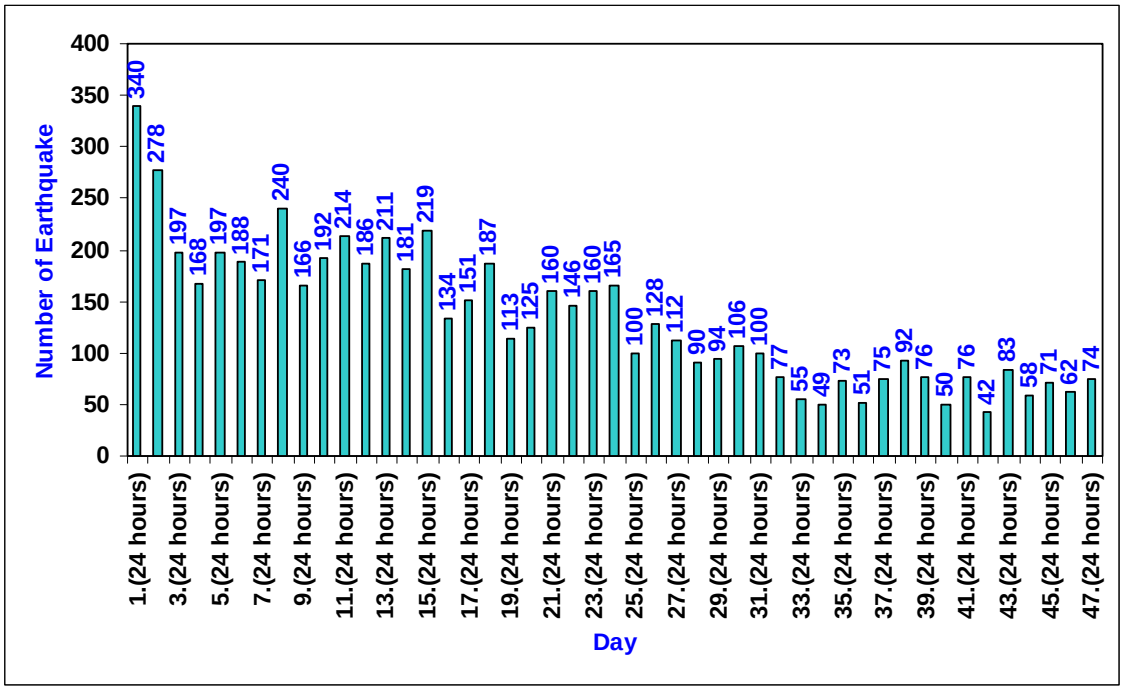
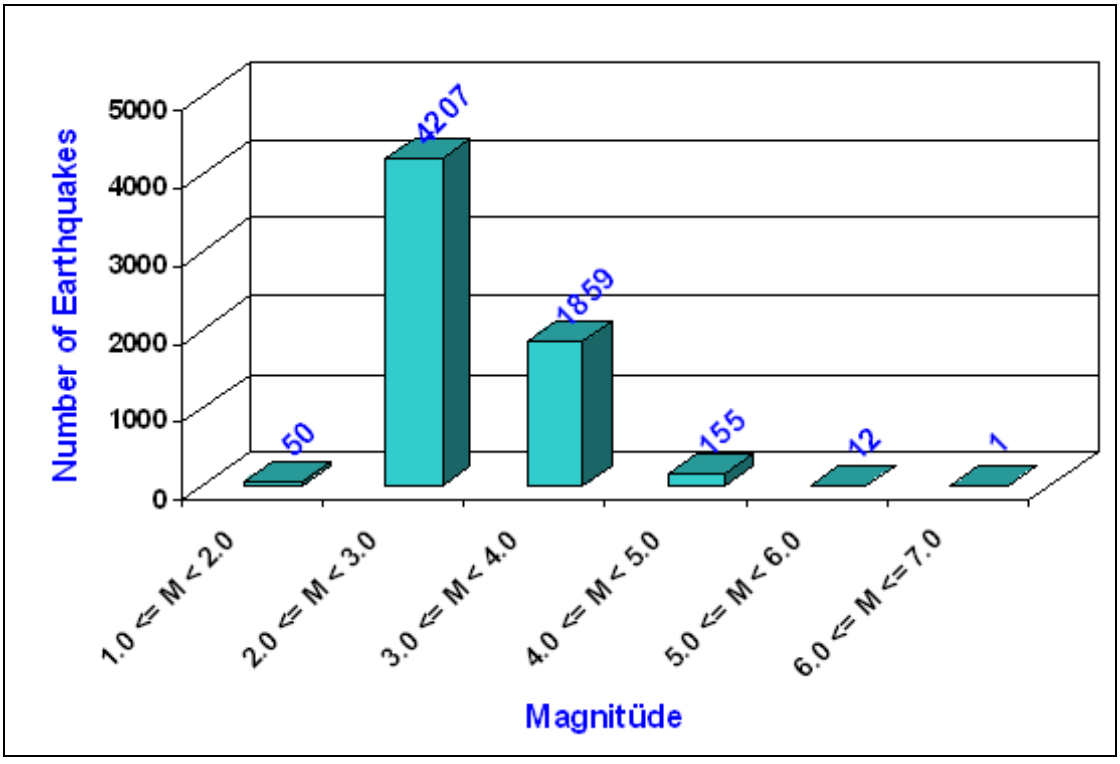


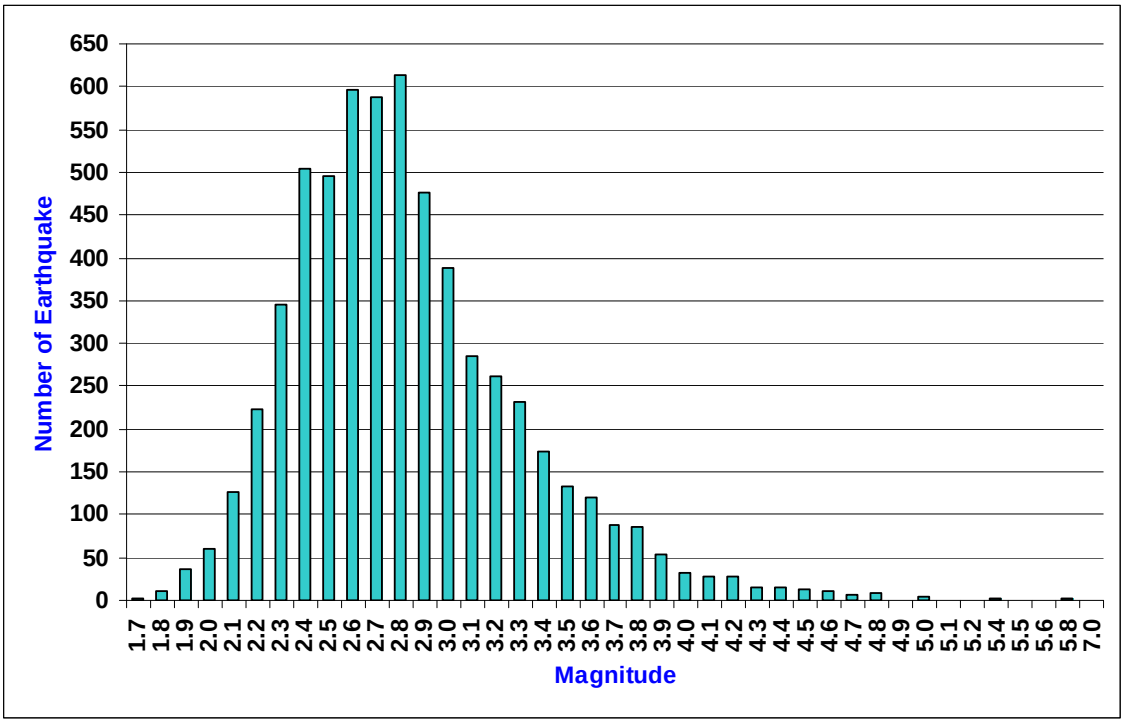

Figure 1.4: Distribution of depth (AA' cross-section)




Graph 1.1: Aftershock activity in approximately 45 days.




Graph 1.2: Magnitude-Count graph (between September,23 and December,09)




Graph 1.3: Magnitude-Count graph (according to magnitude range)

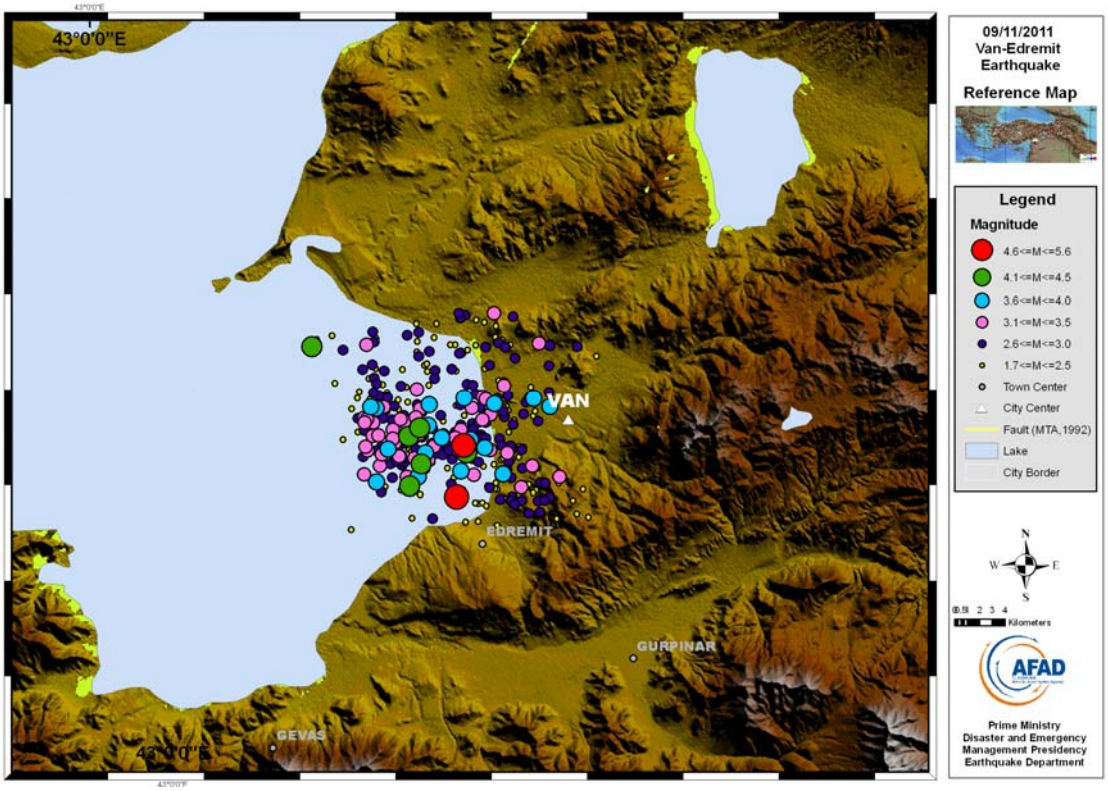
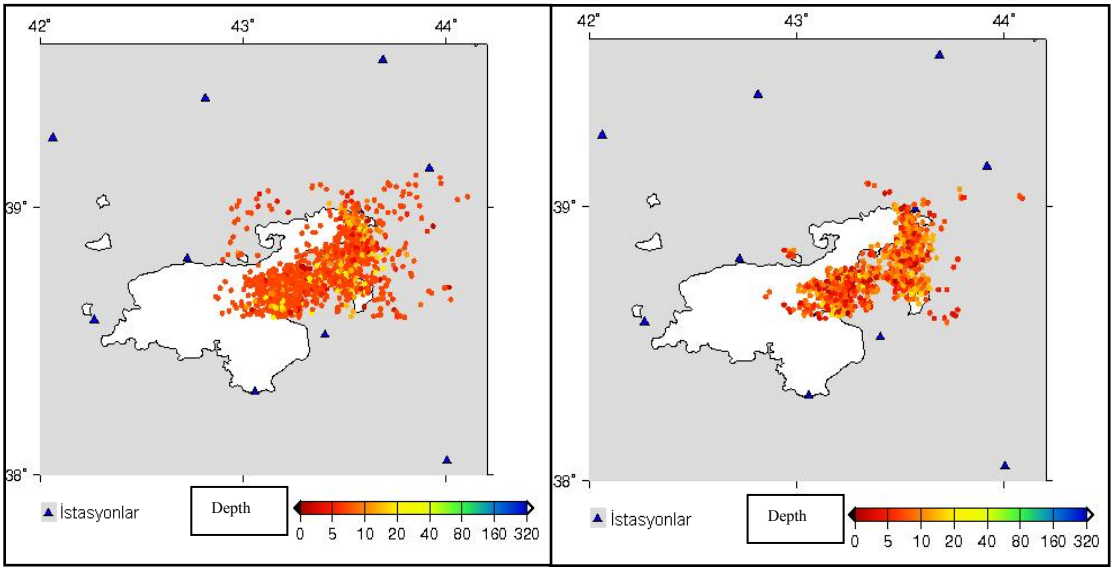



Figure 1.5: Van Edremit earthquake (Ml=5.6) and aftershocks distribution.

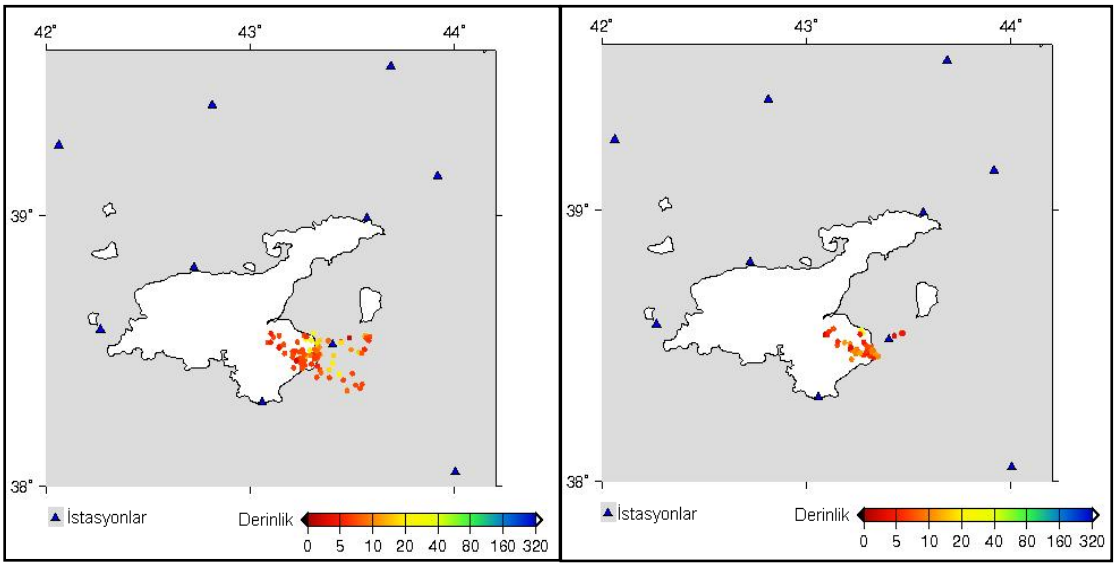
## 2. Re-Location Studies by the Help of HYPODD *(Double-Difference Hypocenter Location)*

In this study, 1400 aftershocks data (M>=3.0) for Van Earthquake (Mw=7.0) and 150 aftershocks data (M>=2.6) for Van-Edremit earthquake (Ml=5.6) were used from 1900 to present. Aftershock distribution were re-located by the help of Hypodd (Fig.2.1,2.2).




(a) (b)

Figure 2.1:Distribution of Van Earthquake (Mw=7.0) aftershocks ((a) before hypodd, (b) after hypodd)




(a) (b)

Figure 2.2:Distribution of Van-Edremit (Ml=5.6) Earthquake aftershocks ((a) before hypodd, (b) after hypodd)

## 3. Focal Mechanism Solutions

The area between Van and Erciş is tectonically complex and there are several faults with different characteristics (Fig.3.1). The reason for such big amount of aftershocks and diversity of the focal mechanism solutions are due to this tectonic complexity. Very generally, earthquake with Mw:7.0 at 19 km. depth activated this systems and small scaled faults triggered one and each other within this period and increased the earthquake activity.

Focal mechanism solutions of Mw:7.0 earthquakes reveal East-West oriented thrust fault mechanism. Since there were no evidence to thrust faulting in the field as fault rupture, morphological indicators, secondary effects of earthquake like mass movements show that east-west oriented thrust fault named as "Everek Fault" is the primary source of this event. The location of the event also supports this relation. During field studies performed around Van and Erciş, several earthquake triggered secondary events like landslides, rockfalls, liquefaction and lateral spreading were observed.

Focal mechanism solutions of 160 earthquakes after 23 October and 09 November earthquakes were analysed and correlated with regional fault maps of the region in order to reveal their occurrence mechanisms (Fig 3.2,3.3,3.4).

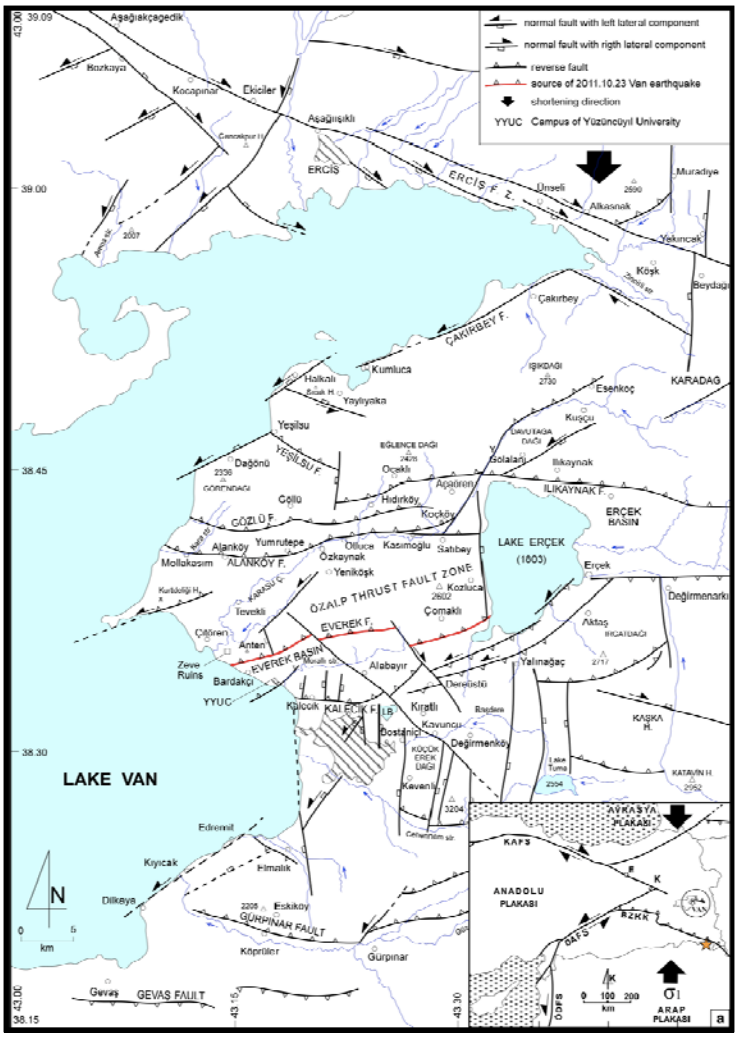



Figure 3.1: Tectonic lines in Van and surroinding region. (Koçyiğit, A.2011, verbal discussing)

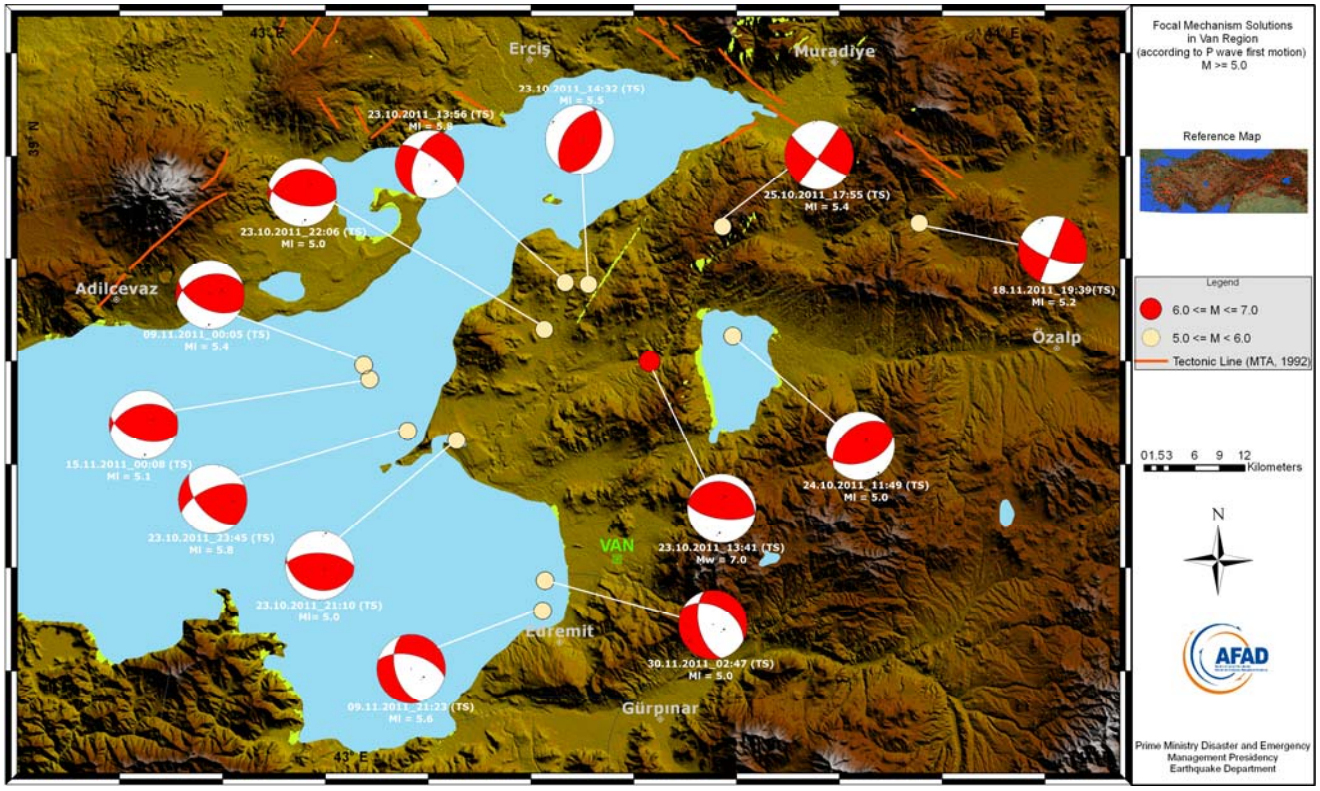



Figure 3.2: Focal mechanism solutions of M ≥ 5 earthquakes (according to P wave first motion)

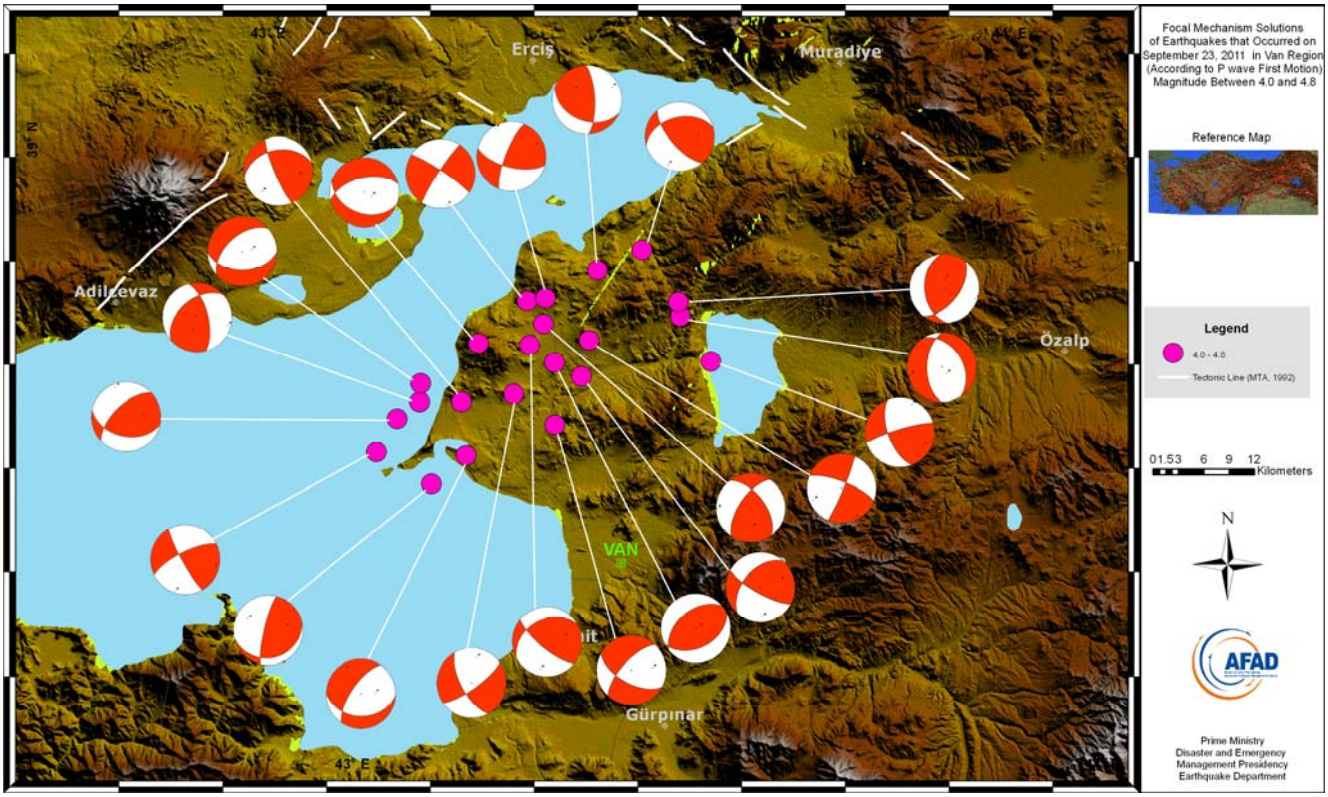
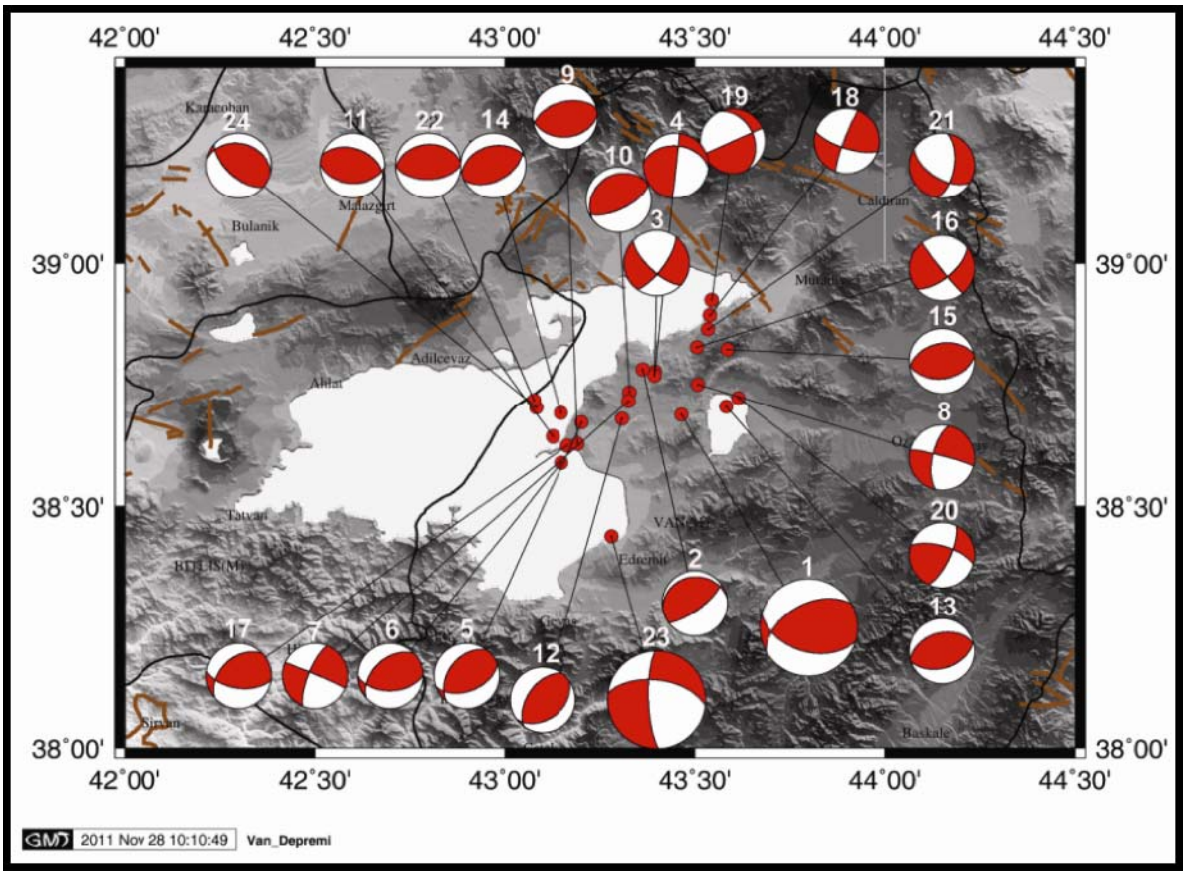



Figure 3.3: Focal mechanism solutions of some earthquakes magnitude between 4 and 4.8 (according to P wave first motion)




| No | Date (UTC) | Latitude | Longitude | Depth | ML | Mw | Mo | Strike | Dip | Rake | Agency Code |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 23/10/2011 10:41 | 38.689 | 43.4657 | 19.02 | 6.7 | 7.1 | 5.60E+19 | 106 | 49 | 123 | USGS |
| 2 | 23/10/2011 10:56 | 38.7825 | 43.3633 | 19.92 | 5.8 | 5.3 | 6.84E+16 | 53 | 73 | 81 | DDA |
| 3 | 23/10/2011 11:10 | 38.7702 | 43.3945 | 6.34 | 4.8 | 4.8 | 1.29E+16 | 133 | 70 | -161 | DDA |
| 4 | 23/10/2011 11:32 | 38.7778 | 43.3947 | 22.61 | 5.5 | 5.5 | 1.40E+17 | 275 | 39 | 178 | DDA |
| 5 | 23/10/2011 13:07 | 38.673 | 43.2019 | 11.68 | 4.4 | 4.2 | 1.64E+15 | 69 | 50 | 111 | DDA |
| 6 | 23/10/2011 15:24 | 38.5905 | 43.149 | 21.55 | 4.7 | 4.5 | 4.70E+15 | 89 | 51 | 119 | DDA |
| 7 | 23/10/2011 15:57 | 38.7173 | 43.3265 | 21.78 | 4.6 | 4.4 | 3.10E+15 | 293 | 87 | -164 | DDA |
| 8 | 23/10/2011 16:05 | 38.7518 | 43.508 | 20.85 | 4.8 | 4.5 | 3.98E+15 | 192 | 65 | -6 | DDA |
| 9 | 23/10/2011 18:10 | 38.629 | 43.192 | 19.81 | 5 | 4.8 | 1.12E+15 | 86 | 38 | 98 | DDA |
| 10 | 23/10/2011 19:06 | 38.7358 | 43.328 | 22.09 | 5 | 4.5 | 4.11E+15 | 64 | 66 | 94 | DDA |
| 11 | 23/10/2011 20:45 | 38.6447 | 43.1275 | 6.79 | 5.8 | 5.6 | 2.27E+17 | 92 | 45 | 78 | DDA |
| 12 | 24/10/2011 04:18 | 38.6808 | 43.31 | 12.58 | 4.5 | 4 | 9.84E+14 | 216 | 52 | 79 | DDA |
| 13 | 24/10/2011 08:49 | 38.706 | 43.5823 | 17.27 | 5 | 4.5 | 5.21E+15 | 256 | 42 | 93 | DDA |
| 14 | 24/10/2011 18:28 | 38.693 | 43.1475 | 18.71 | 4.8 | 4.7 | 1.11E+16 | 64 | 51 | 83 | DDA |
| 15 | 25/10/2011 14:55 | 38.823 | 43.5857 | 17.44 | 5.4 | 5.4 | 8.88E+16 | 259 | 45 | 88 | DDA |
| 16 | 26/10/2011 02:59 | 38.828 | 43.5063 | 14.81 | 4.6 | 4.2 | 1.37E+15 | 50 | 65 | -4 | DDA |
| 17 | 26/10/2011 23:42 | 38.6252 | 43.1637 | 18.68 | 4.6 | 4 | 9.15E+14 | 98 | 58 | 123 | DDA |
| 18 | 27/10/2011 15:41 | 38.8937 | 43.539 | 6.96 | 4.1 | 4.2 | 1.46E+16 | 108 | 72 | 173 | DDA |
| 19 | 29/10/2011 22:24 | 38.9245 | 43.5438 | 16.67 | 4.8 | 4.9 | 1.83E+16 | 66 | 90 | -125 | DDA |
| 20 | 30/10/2011 01:55 | 38.724 | 43.6143 | 21.45 | 4.5 | 4.1 | 1.35E+16 | 287 | 68 | 159 | DDA |
| 21 | 2/11/2011 04:38 | 38.865 | 43.534 | 12.27 | 4.1 | 4.3 | 2.52E+15 | 9 | 60 | -39 | DDA |
| 22 | 8/11/2011 22:05 | 38.7192 | 43.0778 | 8.36 | 5.4 | 5 | 2.59E+16 | 266 | 35 | 88 | DDA |
| 23 | 9/11/2011 19:23 | 38.4382 | 43.2825 | 21.47 | 5.6 | 5.6 | 1.26E+17 | 178 | 76 | -34 | DDA |
| 24 | 14/11/2011 22:08 | 38.7038 | 43.0833 | 23.32 | 5.1 | 5 | 1.88E+16 | 282 | 32 | 65 | DDA |

Figure 3.4: Moment tensor solution map and table of some earthquakes (M≥4)

## 4. Seismic Energy

The amount of energy released after 23 October 2011 earthquake is calculated as $2.09x10^{15}$ Joule (Table 4.1). which is 33.2 times bigger than the amount of atom bomb released to Hiroshima-Japan. When considering the aftershocks, the amount increases to $2.36x10^{15}$ Joule which is equal to 37 atom bombs (Table 4.2, Graph 4.1).

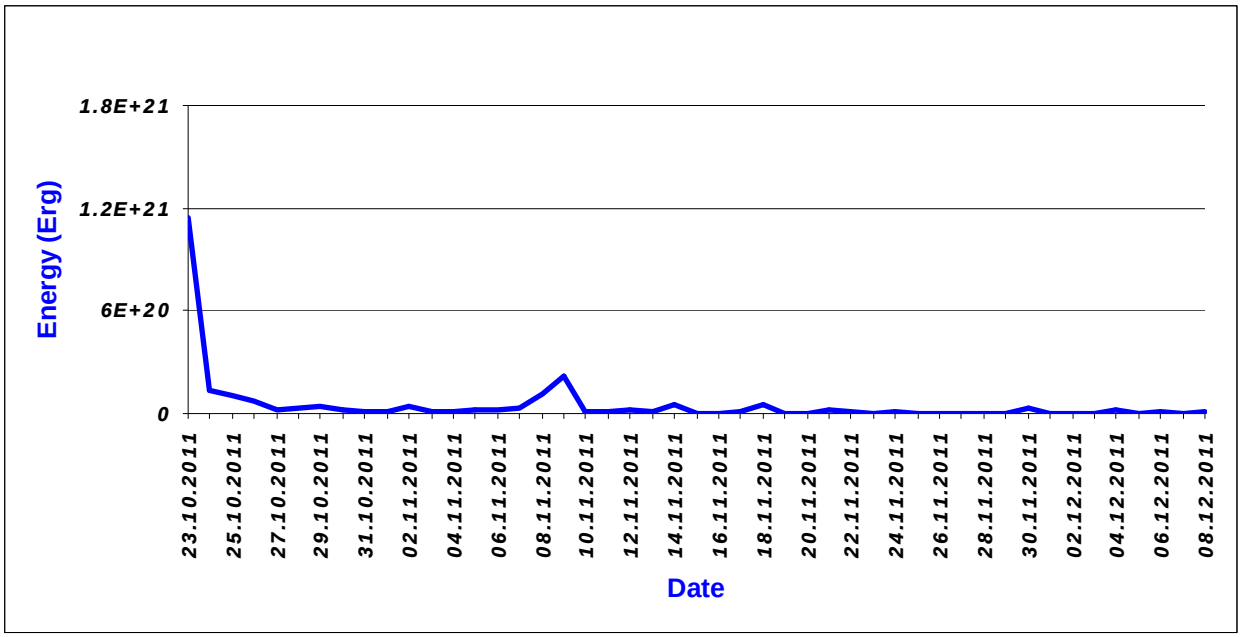
Table 4.1: Released energy (Mw=7.0)

| Magnitude | Energy (erg) | Energy (joule) |
|---|---|---|
| **Mw=7.0** | **$2.09x10^{22}$** | **$2.09x10^{15}$** |

Table 4.2: Total released energy between 23 October – 09 December

| Day | Energy (Erg) | Energy (Joule) |
|---|---|---|
| ***23.10.2011 (except main shock)*** | ***$1.15x10^{21}$*** | ***$1.15x10^{14}$*** |
| ***24.10.2011*** | ***$1.33x10^{20}$*** | ***$1.33x10^{13}$*** |
| ***25.10.2011*** | ***$1.03x10^{20}$*** | ***$1.03x10^{13}$*** |
| ***26.10.2011*** | ***$7.11x10^{19}$*** | ***$7.11x10^{12}$*** |
| ***27.10.2011*** | ***$2.30x10^{19}$*** | ***$2.30x10^{12}$*** |
| ***28.10.2011*** | ***$2.99x10^{19}$*** | ***$2.99x10^{12}$*** |
| ***29.10.2011*** | ***$4.60x10^{19}$*** | ***$4.60x10^{12}$*** |
| ***30.10.2011*** | ***$1.93x10^{19}$*** | ***$1.93x10^{12}$*** |
| ***31.10.2011*** | ***$1.01x10^{19}$*** | ***$1.01x10^{12}$*** |
| ***01.11.2011*** | ***$1.15x10^{19}$*** | ***$1.15x10^{12}$*** |
| ***02.11.2011*** | ***$4.23x10^{19}$*** | ***$4.23x10^{12}$*** |
| ***03.11.2011*** | ***$8.05x10^{18}$*** | ***$8.05x10^{11}$*** |
| ***04.11.2011*** | ***$8.32x10^{18}$*** | ***$8.32x10^{11}$*** |
| ***05.11.2011*** | ***$1.58x10^{19}$*** | ***$1.58x10^{12}$*** |
| ***06.11.2011*** | ***$1.85x10^{19}$*** | ***$1.85x10^{12}$*** |
| ***07.11.2011*** | ***$3.05x10^{19}$*** | ***$3.05x10^{12}$*** |
| ***08.11.2011*** | ***$1.16x10^{20}$*** | ***$1.16x10^{13}$*** |
| ***09.11.2011*** | ***$2.2x10^{20}$*** | ***$2.2x10^{13}$*** |
| ***10.11.2011*** | ***$5.74x10^{18}$*** | ***$5.74x10^{11}$*** |
| ***11.11.2011*** | ***$6.16x10^{18}$*** | ***$6.16x10^{11}$*** |
| ***12.11.2011*** | ***$1.83x10^{19}$*** | ***$1.83x10^{12}$*** |
| ***13.11.2011*** | ***$6.81x10^{18}$*** | ***$6.81x10^{11}$*** |
| ***14.11.2011*** | ***$5.70x10^{19}$*** | ***$5.70x10^{12}$*** |
| ***15.11.2011*** | ***$4.39x10^{18}$*** | ***$4.39x10^{11}$*** |
| ***16.11.2011*** | ***$2.95x10^{18}$*** | ***$2.95x10^{11}$*** |
| ***17.11.2011*** | ***$9.17x10^{18}$*** | ***$9.17x10^{11}$*** |
| ***18.11.2011*** | ***$5.69x10^{19}$*** | ***$5.69x10^{12}$*** |
| ***19.11.2011*** | ***$2.37x10^{18}$*** | ***$2.37x10^{11}$*** |
| ***20.11.2011*** | ***$3.13x10^{18}$*** | ***$3.13x10^{11}$*** |
| ***21.11.2011*** | ***$1.86x10^{19}$*** | ***$1.86x10^{12}$*** |
| ***22.11.2011*** | ***$1.17x10^{19}$*** | ***$1.17x10^{12}$*** |
| ***23.11.2011*** | ***$1.13x10^{18}$*** | ***$1.13x10^{11}$*** |
| ***24.11.2011*** | ***$6.90x10^{18}$*** | ***$6.90x10^{11}$*** |
| ***25.11.2011*** | ***$2.40x10^{18}$*** | ***$2.40x10^{11}$*** |
| ***26.11.2011*** | ***$4.59x10^{18}$*** | ***$4.59x10^{11}$*** |

| | | |
|---|---|---|
| ***27.11.2011*** | ***$1.12x10^{18}$*** | ***$1.12x10^{11}$*** |
| ***28.11.2011*** | ***$1.38x10^{18}$*** | ***$1.38x10^{11}$*** |
| ***29.11.2011*** | ***$1.91x10^{18}$*** | ***$1.91x10^{11}$*** |
| ***30.11.2011*** | ***$3.19x10^{19}$*** | ***$3.19x10^{12}$*** |
| ***01.12.2011*** | ***$1.81x10^{18}$*** | ***$1.81x10^{11}$*** |
| ***02.12.2011*** | ***$3.36x10^{18}$*** | ***$3.36x10^{11}$*** |
| ***03.12.2011*** | ***$4.13x10^{18}$*** | ***$4.13x10^{11}$*** |
| ***04.12.2011*** | ***$2.15x10^{19}$*** | ***$2.15x10^{12}$*** |
| ***05.12.2011*** | ***$1.51x10^{18}$*** | ***$1.51x10^{11}$*** |
| ***06.12.2011*** | ***$1.25x10^{19}$*** | ***$1.25x10^{12}$*** |
| ***07.12.2011*** | ***$9.50x10^{17}$*** | ***$9.50x10^{10}$*** |
| ***08.12.2011*** | ***$6.37x10^{18}$*** | ***$6.37x10^{11}$*** |
| ***Total Energy: $2.36x10^{14}$ Joule*** | | |




Graph 4.1: Daily released energy (except main shock)

## 5. Historical and Instrumental Seismicity

This region is a very active in terms of seismicity. Distribution of the earthquakes that occurred in Van and surrounding region from 1900 to present (M>4), historical and instrumental seismicity are given Fig 5.1, Table 5.1, 5.2 and Fig 5.2.

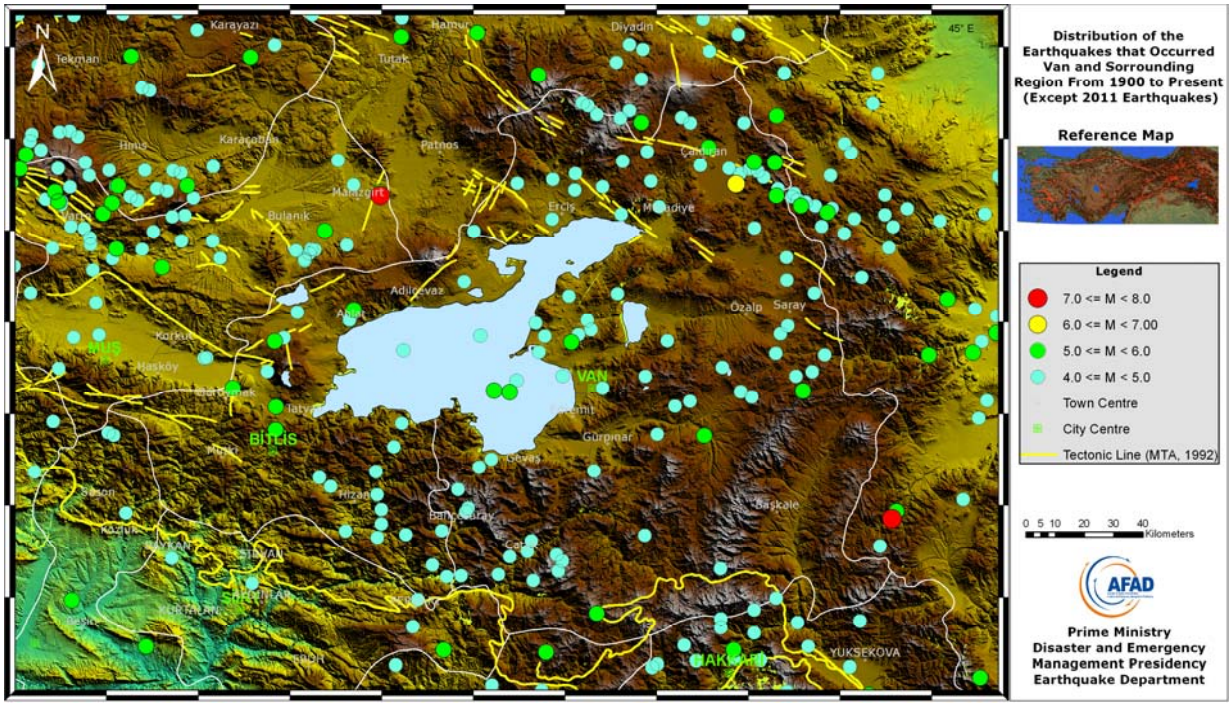



Figure 5.1: Distribution of the earthquakes that occurred Van and Surrounding region from 1900 to present M> 4 (except 2011 earthquakes)

Table 5.1: Historical period seismicity

| Begining | Year | Latitude | Longitude | Location | Explanation | Intensity | Reference | References |
|---|---|---|---|---|---|---|---|---|
| **M.S** | 1881 | 39 | 43 | Van, Bitlis, Muş | I=x(20),M=7.3(20),Van da 400 ev yıkıldı. Bu deprem 40,20,8 nolu kaynaklarda 30.05-07.06 tarihli iki deprem olarak veriliyor | 9 | A2 | **2,40,20,8** |
| **M.S** | 1871 | 39 | 43 | Van Yöresi | 25.03.1871(40), 05-25.03.1871(20), M=5.5 | 7 | B2 | **8,20,40** |
| **M.S** | 1715 | 38.95 | 43.65 | Van ve Erciş yöresi | | 8 | B3 | **2,8** |
| **M.S** | 1704 | 39 | 43 | Van | | 7 | B2 | **2,8** |
| **M.S** | 1701 | 39 | 43 | Van | 606 No.lu depremin artçısı olabilir | 5 | B1 | **16** |
| **M.S** | 1701 | 39 | 43 | Van ve yöresi | r5=300 km.,43,65 E(8) | 8 | B1 | **16,2,8** |
| **M.S** | 1648 | 38 | 44 | Hoşap'ın yakın batısı Van | | 8 | C1 | **19** |
| **M.S** | 1647 | 39 | 44 | Van, Tebriz, Muş, Bitlis | 02.04.1648(16),1646(2),1646 veya 1648(8), 38.47N(8),39.7N(5),43.3E(8),43.0E(5), I=VI(8,5),M=3.8(5),h=10km(5) | 9 | A1 | **2,16,8,5** |
| **M.S** | 1441 | 38 | 42 | Van,Bitlis,Muş | I=X(20),30.000 ölü(8,2), Nemrut Dağı'nın volkanik etkinliğiyle birlikte(2,21) | 8 | A1 | **8,2,20,21** |
| **M.S** | 1282 | 39 | 43 | Ahlat,Erciş | 427 No.lu Depremle idantik olabilir | 0 | C3 | **16** |
| **M.S** | 1276 | 39 | 43 | Ahlat,Erciş,Van | I=VII(8),r5=200km. | 8 | B2 | **8,2** |
| **M.S** | 1245 | 39 | 43 | Ahlat,Van,Bitlis,Muş | I=VI(8) | 7 | B2 | **8,2** |
| **M.S** | 1110 | 39 | 44 | Van | I=IX(8),1111(8) | 8 | B2 | **16,8** |

Table 5.2: Damaging earthquakes in instrumental period

| Date | Time | Latitude | Longitude | Magnitude |
|---|---|---|---|---|
| 28.04.1903 | 23:39 | 39.14 | 42.65 | 6.3 |
| 06.05.1930 | 22:34:23 | 38.22 | 44.66 | 7.2 |
| 10.09.1941 | 21:53:57 | 39.45 | 43.32 | 5.9 |
| 20.11.1945 | 06:27:58 | 38.63 | 43.33 | 5.2 |
| 25.06.1964 | 00:11:52 | 39.13 | 43.19 | 5.3 |
| 24.11.1976 | 22:15.6 | 39.0506 | 44.0368 | 7.2 |
| 17.01.1977 | 19:24.7 | 39.2703 | 43.7006 | 5.1 |
| 25.06.1988 | 15:38.3 | 38.5034 | 43.0727 | 5.0 |
| 15.11.2000 | 05:34.9 | 38.51 | 43.01 | 5.7 |

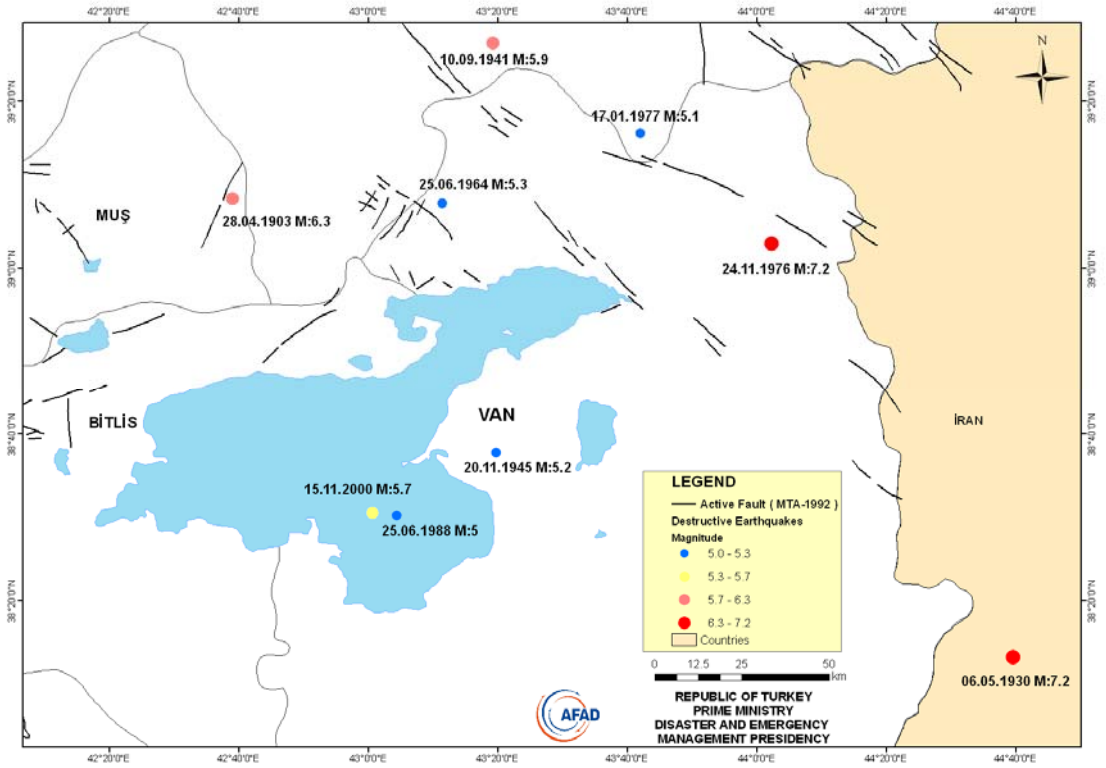



Figure 5.2: Damaging earthquakes in instrumental period

Centroid moment tensor of two earthquakes that occurred in the same region in 2001 and 2004 were done by Switzerland Seismology Center (SED) Fig 5.3.

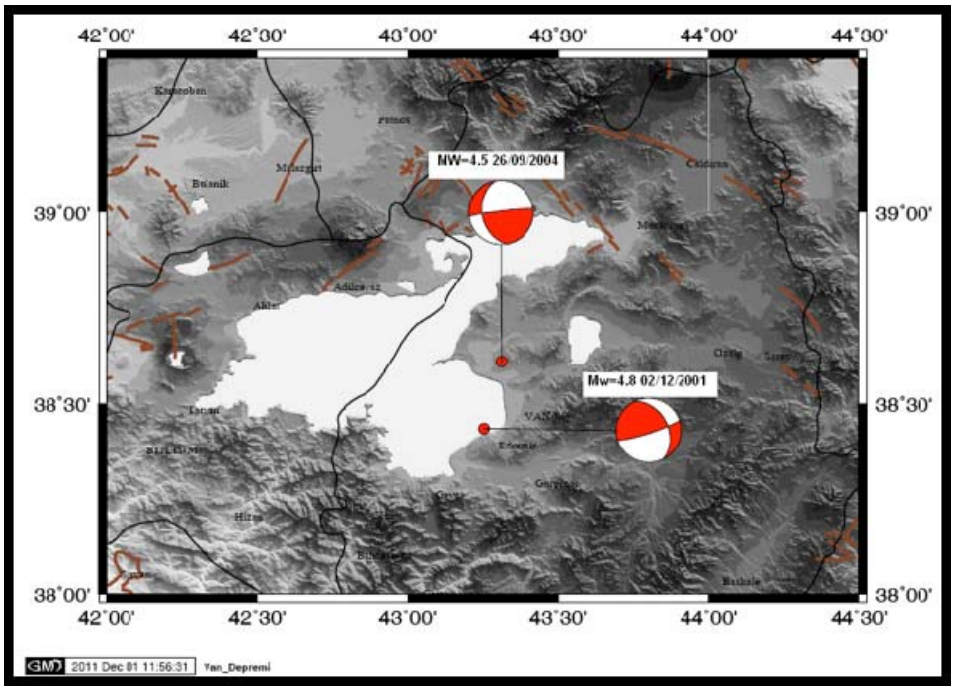



Figure 5.3: Centroid moment tensor solutions of 2001 and 2004 earthquakes

## 6. Effects of Earthquake on the Field

After the earthquake, one team who tasked in the AFAD Presidency went to earthquake area in the same day for the investigation of surface deformation on the field. Investigation areas are given Fig.6.1 and geographical descriptions related to these areas are given Table 6.1.

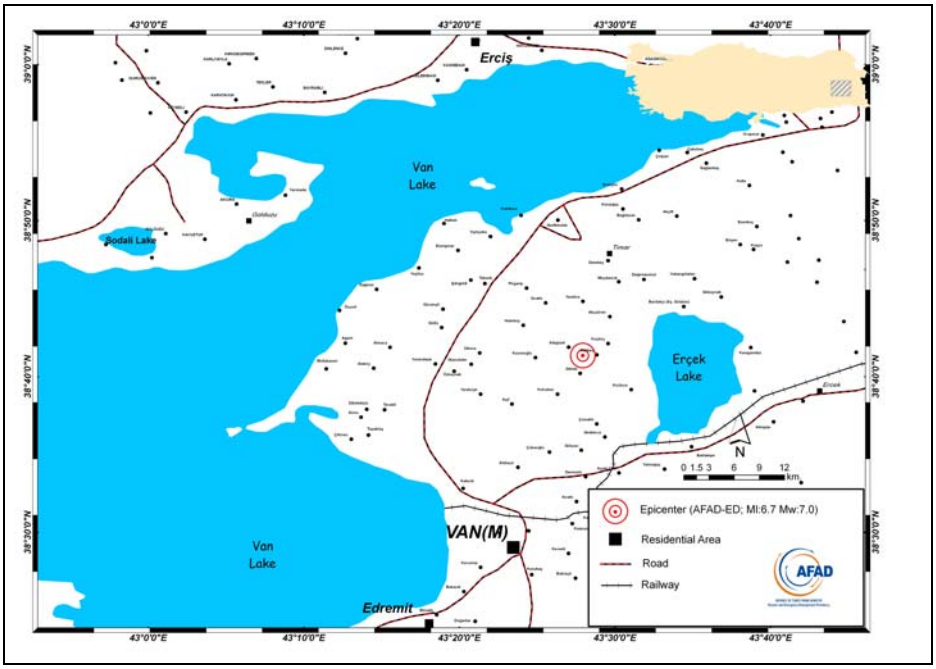



Figure 6.1: Investigation areas in the field

Table .6.1: Geographical descriptions related to investigation area.

| Investigation areas | Location | Longitude | Latitude (UTM) | Explanation |
|---|---|---|---|---|
| 1 | K70D | 351970 | 4271839 | Van-Erciş Highway |
| 2 | K70D | 349315 | 4271478 | Bardakçı-Topaktaş Stablized Road |
| 3 | | 353282 | 4272200 | Organized Industrial Site (OIS) Irrıgation Canal Deformation |
| 4 | | 357187 | 4273393 | 10 cm rise, Irrigation Canal 4 km NE of OIS |
| 5 | | 357205 | 4273891 | Fault escarpment and morphological trace.South part of Asit Village |
| 6 | | 371971 | 4281956 | Erçek Lake West Coast |
| 7 | | 338832 | 4247507 | Edremit Town Köşk Village |
| 8 | | 355404 | 4280776 | Yeniköşk Road |
| 9 | | 355679 | 4287567 | Van-Erciş Highway |
| 10 | | 363382 | 4299794 | Van-Erciş Highway West Part of Gedikbulak Village |
| 11 | | 351772 | 4297239 | Rock Fall in between Halkalı-Yeşilsu Villages |
| 12 | | 345725 | 4275992 | Landslip and Lateral Spreading in Topaktaş Village |
| 13 | | 346493 | 4274840 | Liquefaction and Lateral Spreading |

## 7. Surface Faulting Studies

Earthquake did not caused any apparent faulting on the surface however some deformation trace is observed on the man-made structures such as irrigation channels, asphalt roads depends on the NW compression (Fig.7.1-7.5).

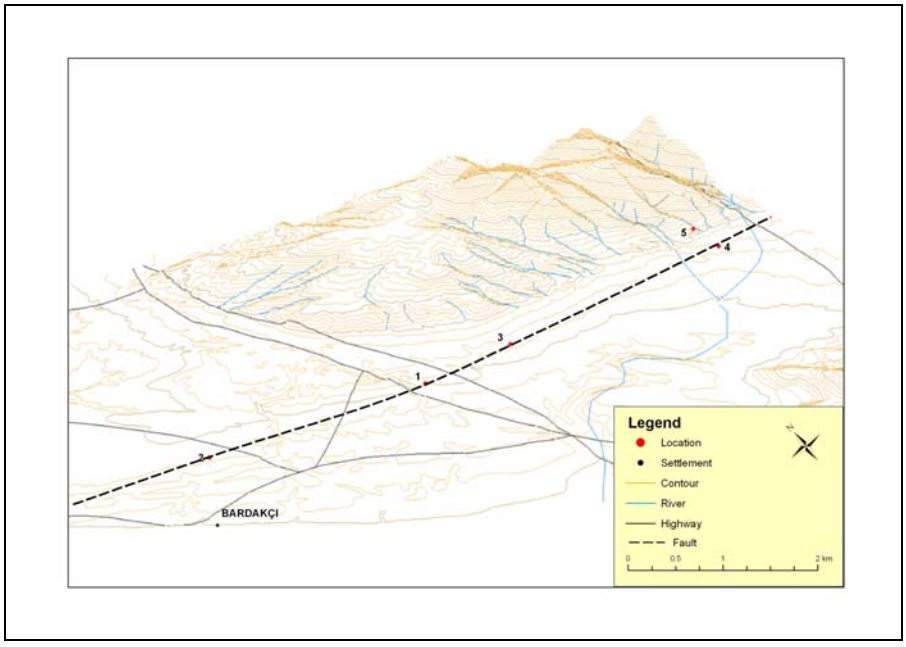



Figure 7.1: 3D Topographic map showing the fault

(a)

(b)

(c)

(d)

Figure 7.2: Deformation that is observed on the Van-Erciş Highway

a

b

Figure 7.3: a) Surface break on the Topaktaş way.
b) Deformation on the irrigation canal.

Figure 7.4: Deformation on the irrigation canal depends on the compression regim

(a)

(b)

(c)

(d)

Figure 7.5: Surface deformation and fault escarpment (NE part of organized industrial site)

It was observed, as a result of the field studies, the fault (N60,70E) that caused earthquake was a buried fault. Morphological trace of fault is observed on the shaded relief map and 3D digital elevation model map (Fig.7.6, 7.7).

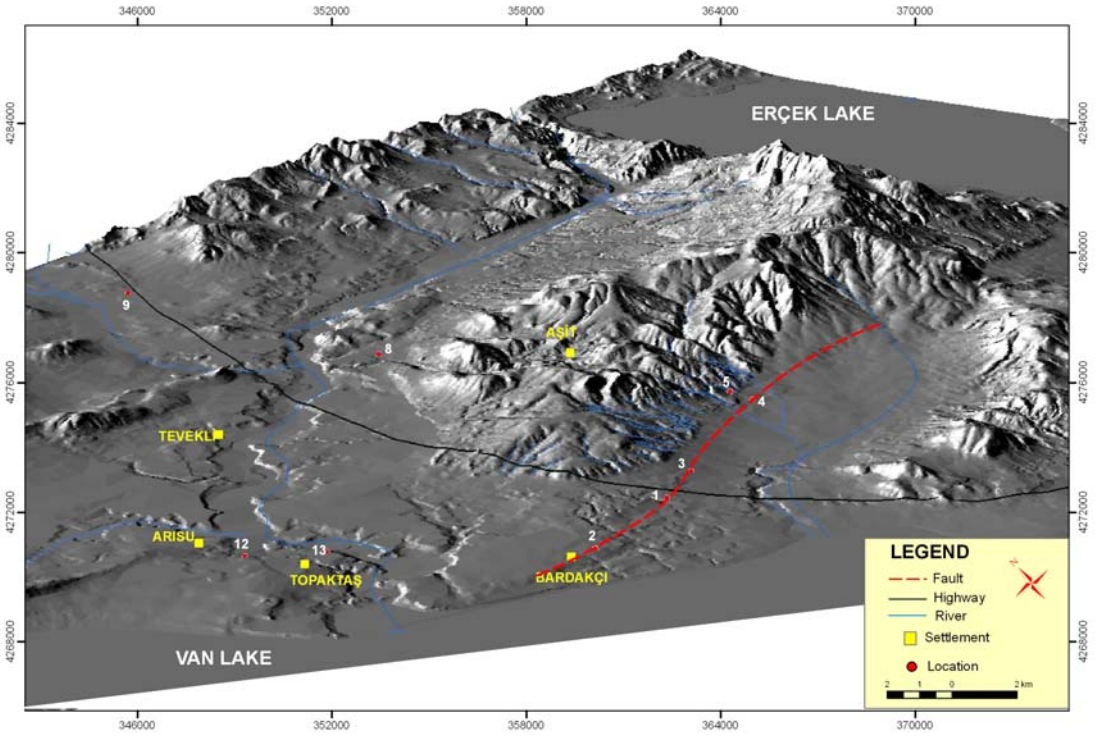



Figure 7.6: 3D Digital elevation model map

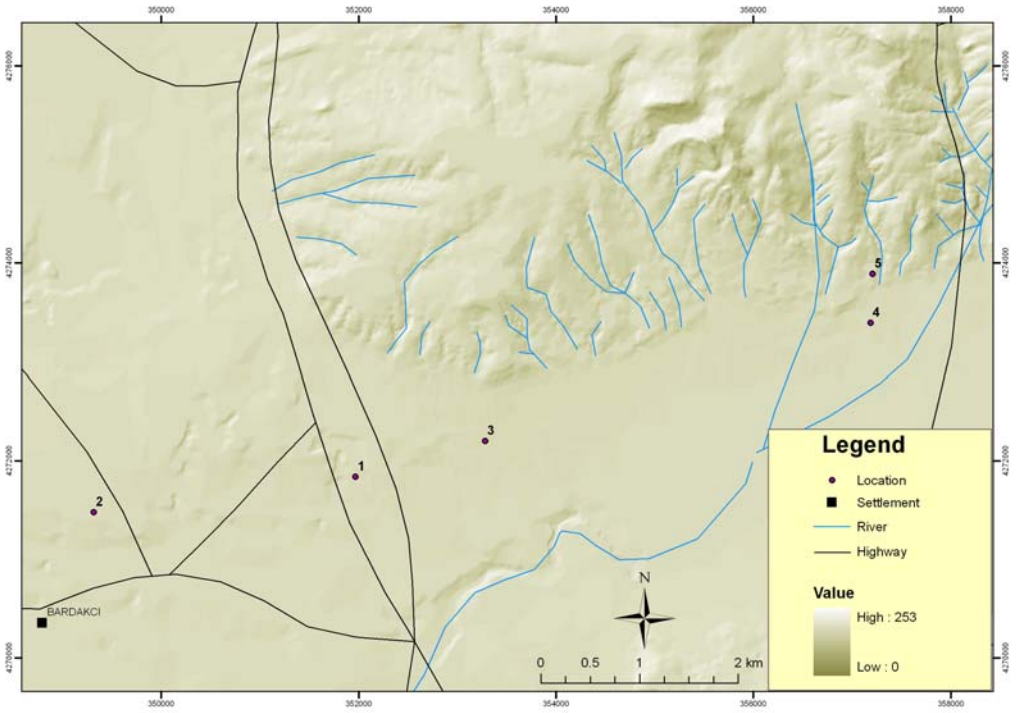



Figure 7.7: Shaded relief map showing the morphology of the fault

## 8. In-SAR Studies

It was seen displacement that occurred after the earthquake on the interferogram that was produced by NASA according to COSMO Skymed image which was taken from Italy Space Agency between 10-26 September (Fig.8.1). It is projected on the interferogram, as a topographic maximum 80 cm rise in the north part of fault and between 5-40 cm rise in the west part of Erçek Lake. Based on this information, some traces were investigated which signified on the interferogram however level change did not observe lake level and rocks which is near the lakeshore (Fig.8.2).

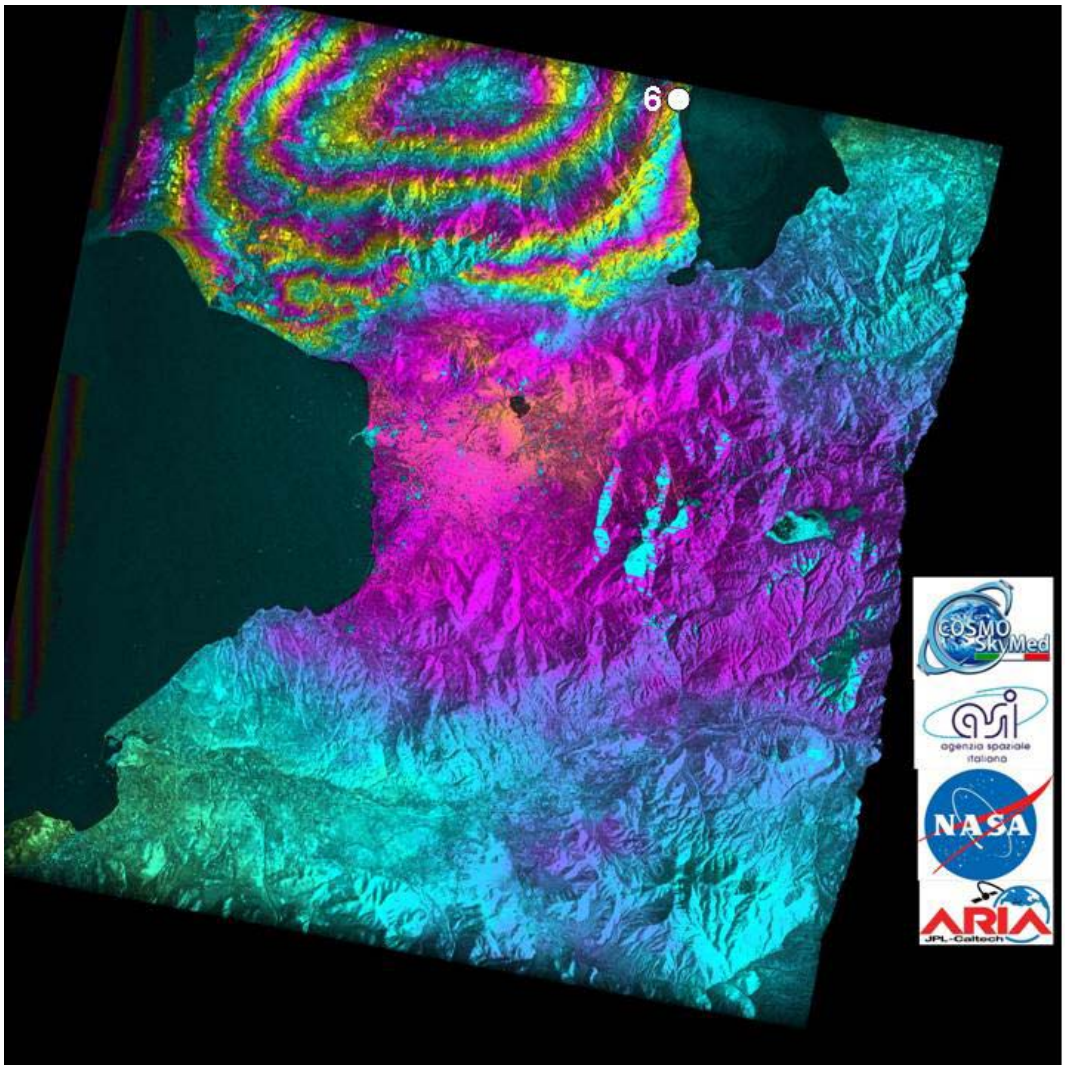



Figure 8.1: COSMO-SkyMed (CSK) interferogram (InSAR) image (20 cm between the same colors in the circle) for detailed information http://supersites.earthobservations.org/van.php

Figure 8.2: Photos about traces of algae on the limestone (west cost of Erçek Lake)

## 9. Secondary Effects Caused by the Earthquake

After the earthquake it was observed landslip, rock fall, liquefaction and lateral spreading in the study area (Fig.9.1-9.3).

(a)

(b)

(c)

(d)

(e)

(f)

Figure 9.1. Secondary effets examples;
(a) Surface failure on the Yeniköşk way, (b) Subsidence in Van-Erciş way,
(c) Landslip in the west of Gedikbulak village, (d) Liquefaction ,
(e) Activation on the old landslip block,
(f) Rock fall between Halkalı-Yeşilsu villages


Figure 9.2: Liquefaction between Arısu-Topaktaş villages (Orthophoto image produced by General Command of Mapping)


(a)


(b)


(c)


(d)

Figure 9.3. Surface deformation examples:
(a) Lateral spreading near the Topaktaş village,
(b) Current landslip near the Topaktaş village,
(c and d) Landslip near the Köşk village.

## 10. Evaluation of Strong Motion Records

National Strong Motion Network operated by AFAD also calculated the acceleration values for these earthquakes. The peak ground acceleration value recorded at Muradiye Station after 23 October 2011 earthquake and the values are 178.5 cm/sn$^2$ (N-S Component), 168.5 cm/sn$^2$ (E-W Component) and 75.5 cm/sn$^2$ (Vertical Component) (Table 10.1) (Fig.10.1) .The peak ground acceleration value recorded at Van Station after 09 November 2011 earthquake and the values are 148.1 cm/sn$^2$, (N-S Component) 245.9 cm/sn$^2$ (E-W Component) and 150.5 cm/sn$^2$ (Vertical Component). The values of Edremit Station are 65.7 cm/sn$^2$ (N-S Component), 102.6 cm/sn$^2$ (E-W Component) and 44.3 cm/sn$^2$ (Vertical Component) (Table 10.2) (Fig.10.2). The peak ground acceleration value recorded at Van Muradiye Station after 18 November 2011 earthquake and the values are 13.5 cm/sn$^2$ (N-S Component), 16 cm/sn$^2$ (E-W Component) and 10 cm/sn$^2$ (Vertical Component) (Table 10.3) (Fig.10.3). When records of Muradiye and Van Stations area analyzed in terms of response spectra, both ground motions are below the design spectra defined for 1$^{st}$ degree earthquake zone.

Table 10.1: Acceleration values and site information for the 23 October 2011, Ml=6.7, Mw=7.0 Van Earthquake.

| | STATION | | TYPE OF RECORDER | ACCELERATION (gal) | | | Distance of between epicenter and station $R_{epi}$ (km) | Shear Wave Velocity $V_{S30}$ (m/sn) |
|---|---|---|---|---|---|---|---|---|
| N | CITY | TOWN | | NS | EW | UD | | |
| 1 | Van | Muradiye | SMACH | **178.5** | 168.5 | 75.5 | 42 | 293 |
| 2 | Muş | Malazgirt | SMACH | 44.5 | **56.0** | 25.5 | 95 | 311 |
| 3 | Bitlis | Merkez | CMG-5TD | 89,66 | **102,24** | 35,51 | 116 | Alluvium* |
| 4 | Ağrı | Merkez | CMG-5TD | **18,45** | 15,08 | 7,21 | 121 | 295 |
| 5 | Siirt | Merkez | CMG-5TD | **9,90** | 9,16 | 7,04 | 158 | Alluvium* |
| 6 | Muş | Merkez | CMG-5TD | **10,3** | 6,86 | 4,64 | 170 | 315 |
| 7 | Bingöl | Solhan | CMG-5TD | **4,58** | 4,19 | 2,46 | 211 | 463 |
| 8 | Bingöl | Karlıova | CMG-5TD | 7,52 | **11,08** | 4,65 | 222 | Stiff* |
| 9 | Batman | Merkez | CMG-5TD | 8,29 | **8,58** | 3,74 | 223 | 450 |
| 10 | Mardin | Merkez | CMG-5TD | **2,00** | 1,90 | 1,58 | 284 | Stiff* |
| 11 | Elazığ | Beyhan | CMG-5TD | **1,20** | 1,19 | 0,99 | 289 | Stiff* |
| 12 | Elazığ | Palu | CMG-5TD | **2,11** | 1,64 | 1,72 | 307 | 329 |
| 13 | Elazığ | Kovancılar | CMG-5TD | 1,45 | **1,66** | 1,20 | 313 | Alluvium* |
| 14 | Erzincan | Tercan | CMG-5TD | 2,37 | **3,43** | 2,26 | 289 | 320 |
| 15 | Erzincan | Merkez | CMG-5TD | **1,53** | 1,29 | 0,71 | 358 | 314 |
| 16 | Bayburt | Merkez | CMG-5TD | **1,35** | 1,14 | 1,27 | 327 | Stiff* |
| 17 | Gümüşhane | Kelkit | CMG-5TD | 1,05 | 0,88 | **1,25** | 378 | Alluvium* |
| 18 | Şanlıurfa | Siverek | CMG-5TD | 2,00 | **3,06** | 0,96 | 378 | Alluvium* |
| 19 | Malatya | Pötürge | CMG-5TD | **0,99** | **0,99** | 0,94 | 405 | Stiff* |
| 20 | Adıyaman | Kahta | CMG-5TD | **2,96** | 2,70 | 1,64 | 437 | Alluvium* |
| 21 | Adıyaman | Gölbaşı | CMG-5TD | **1,12** | 0,74 | 0,35 | 521 | 469 |
| 22 | K.Maraş | Merkez | CMG-5TD | 1,74 | **2,18** | 0,96 | 590 | 317 |

*Site information was determined as a result of observations.

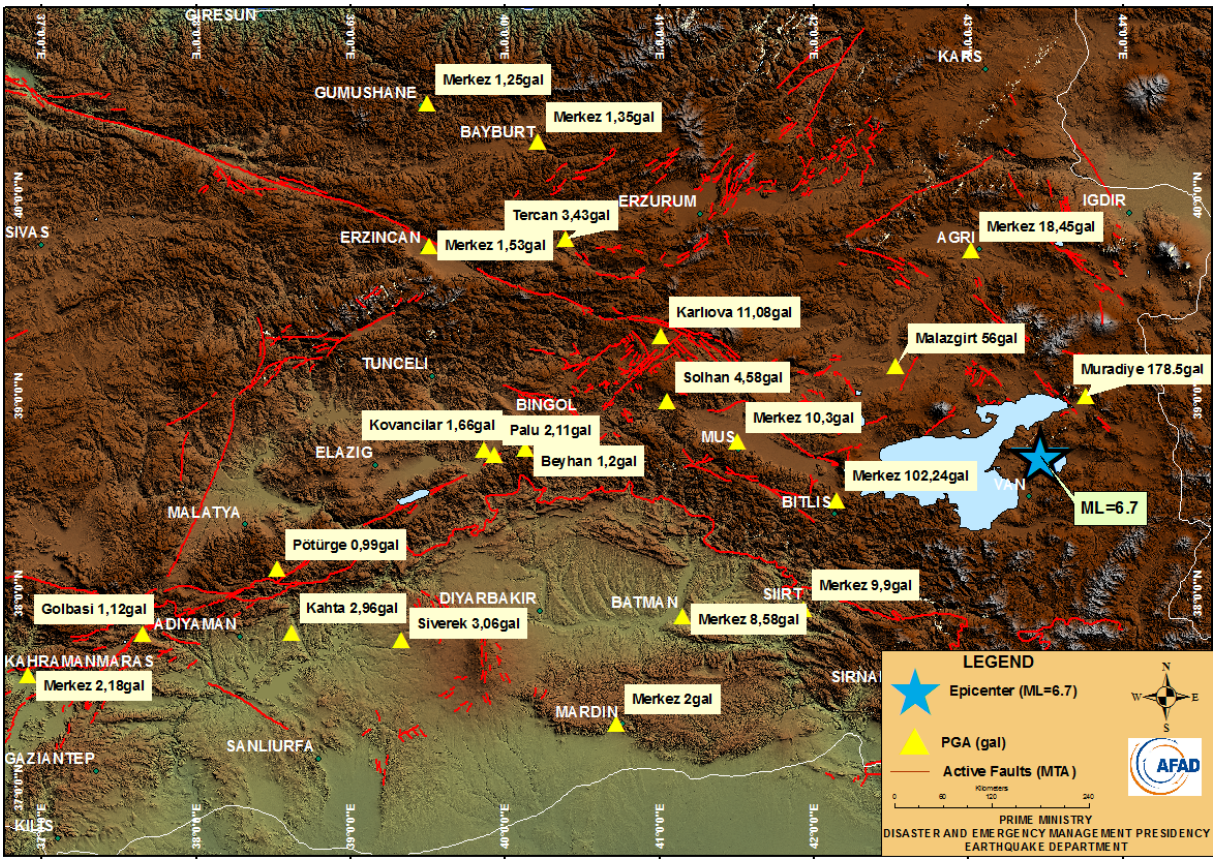



Figure 10.1: Distribution of the recorded stations and peak ground accelerations for 23 October 2011, Ml=6.7, Mw=7.0 Van Earthquake.

Table 10.2: Acceleration values and site information for the 09 November 2011, Ml=5.6 Van-Edremit Eartquake.

| | STATION | | TYPE OF RECORDER | ACCELERATION (gal) | | | Distance of between epicenter and station $R_{epi}$ (km) | Shear Wave Velocity $V_{S30}$ (m/sn) |
|---|---|---|---|---|---|---|---|---|
| N | CITY | TOWN | | NS | EW | UD | | |
| 1 | Van | Merkez | CMG-5TD | 148,1 | **245,9** | 150,5 | 12.7 | 363 |
| 2 | Van | Edremit | GSR-16 | 65,7 | **102,6** | 44,3 | 2.9 | Stiff* |
| 3 | Muş | Malazgirt | SMACH | 3.0 | **4.0** | 2.0 | 101 | 311 |
| 4 | Van | Muradiye | SMACH | **13** | 9,5 | 4,5 | 74.1 | 293 |
| 5 | Bitlis | Merkez | CMG-5TD | 3,9 | **5,8** | 2,1 | 97.8 | Alluvium* |

*Site information was determined as a result of observations.

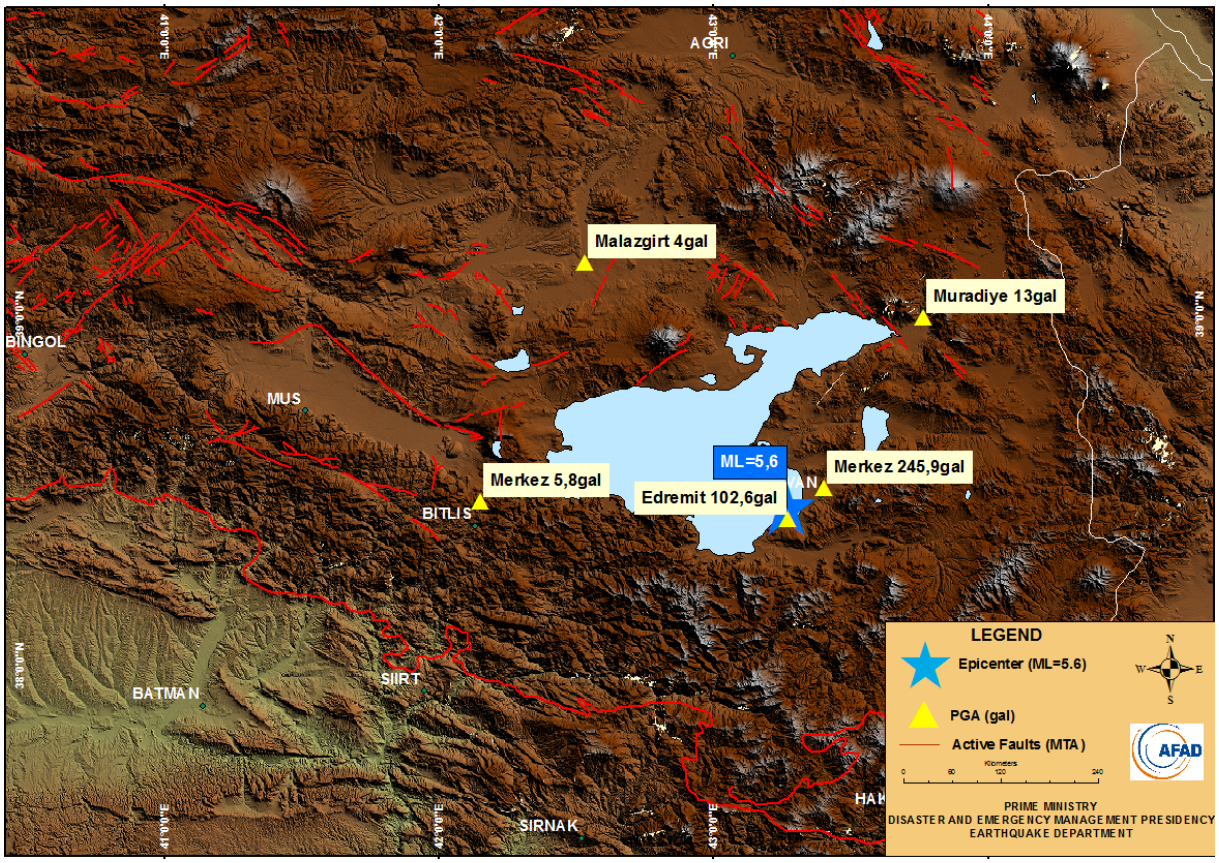



Figure 10.2: Distribution of the recorded stations and peak ground accelerations for 09 November 2011, Ml=5.6 Van-Edremit Earthquake.

Table 10.3: Acceleration values and site information for the 18 November 2011, Ml=5.2 Van Muradiye Earthquake.

| | STATION | | TYPE OF RECORDER | ACCELERATION (gal) | | | Distance of between epicenter and station $R_{epi}$ (km) | Shear Wave Velocity $V_{S30}$ (m/sn) |
|---|---|---|---|---|---|---|---|---|
| N | CITY | TOWN | | NS | EW | UD | | |
| 1 | Van | Muradiye | SMACH | 13,5 | **16** | 10 | 18,9 | 293 |
| 2 | Van | Özalp | CMG-5TD | **9,25** | 7,36 | 2,32 | 23,7 | Stiff* |
| 3 | Van | Çaldıran | CMG-5TD | 1,34 | **1,43** | 0,56 | 35,7 | Alluvium* |
| 4 | Van | AFAD | CMG-5TD | 3,24 | **6,27** | 2,33 | 51,3 | Alluvium* |

*Site information was determined as a result of observations.

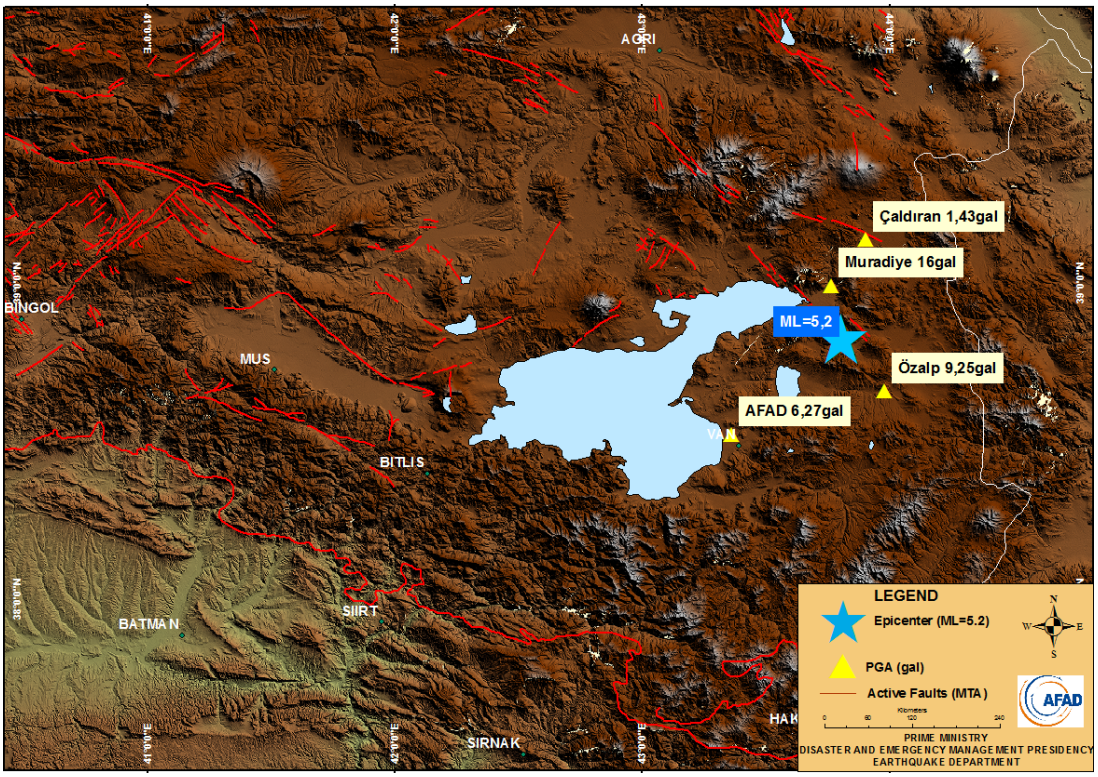



Figure 10.3: Distribution of the recorded stations and peak ground accelerations for 18 November 2011, Ml=5.2 Van Muradiye Earthquake.

## 11. Corrected Acceleration-Time, Velocity-Time and Displacement-Time Waveforms

Corrected acceleration-time, velocity-time and displacement-time waveforms that refers to 23 October 2011 Earthquake (Ml=6.7) , and 09 November 2011 Earthquake (Ml=5.6) are given Fig. 11.1-11.9.

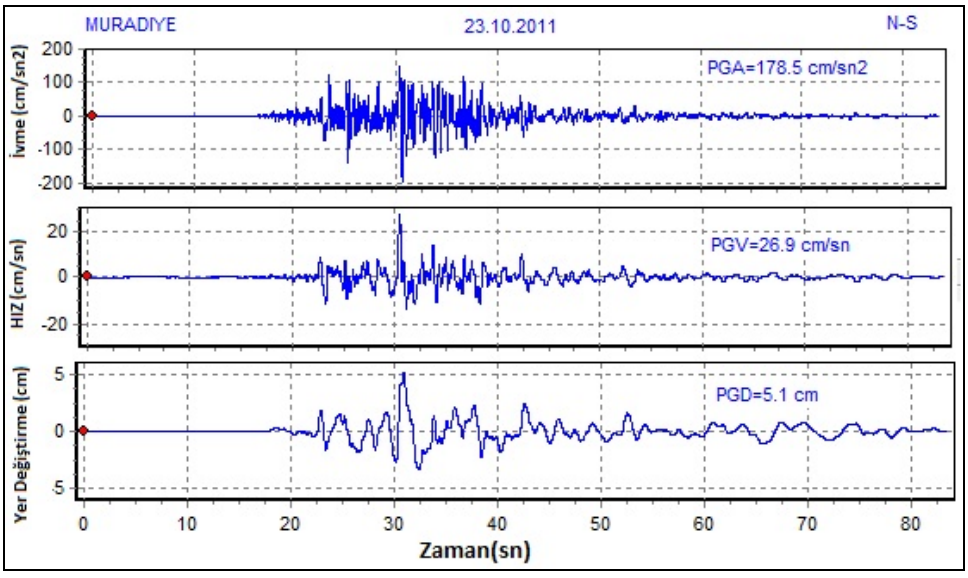



Figure 11.1: NS direction acceleration, velocity and displacement components for 23 October 2011, Ml=6.7 Van-Merkez Earthquake (Muradiye station)

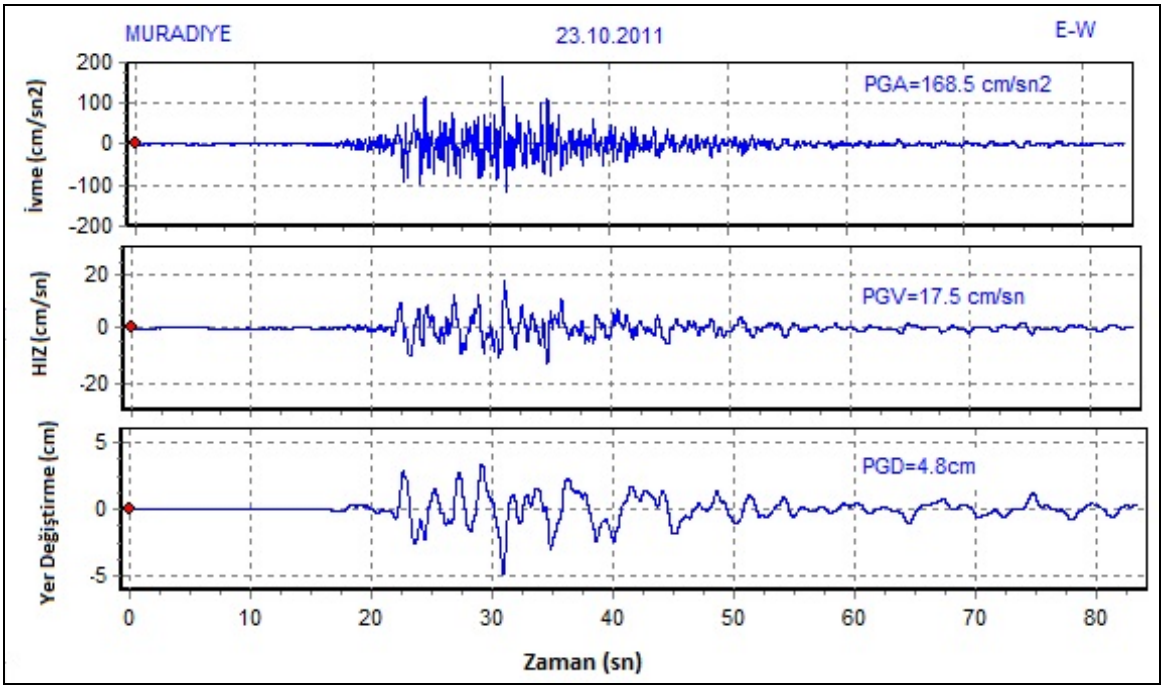



Figure 11.2: EW direction acceleration, velocity and displacement components for 23 October 2011, Ml=6.7 Van-Merkez Earthquake (Muradiye station)

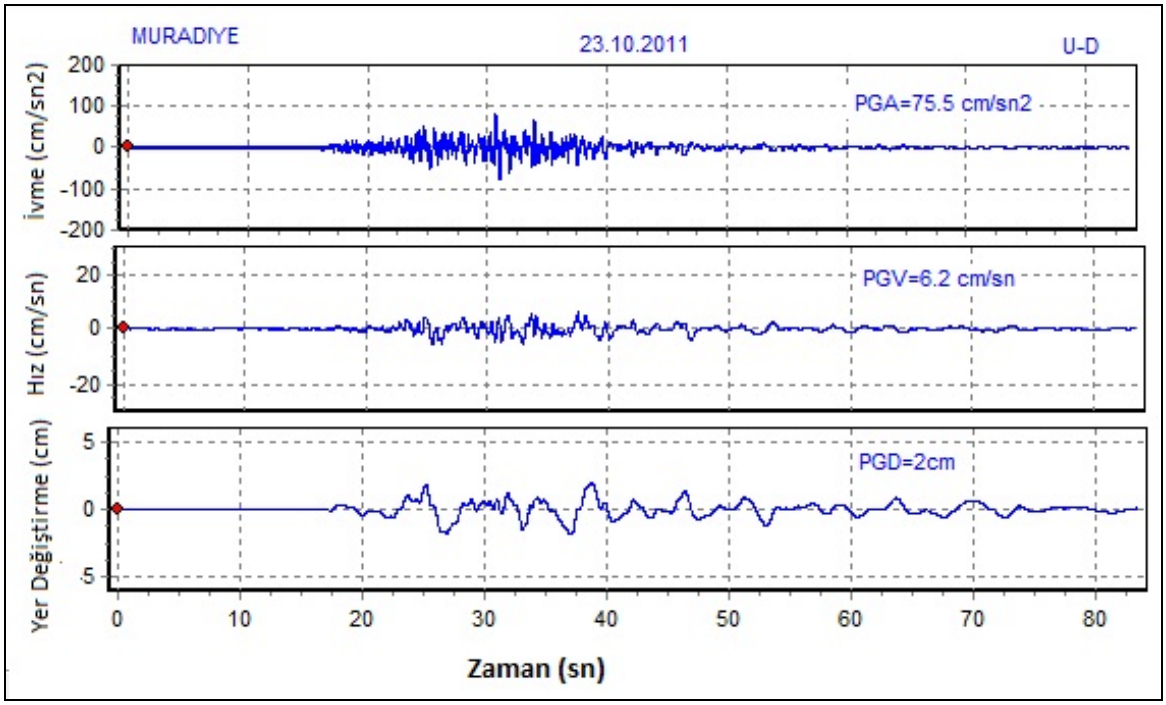



Figure 11.3: Vertical direction acceleration, velocity and displacement components for 23 October 2011, Ml=6.7 Van-Merkez Earthquake (Muradiye station)

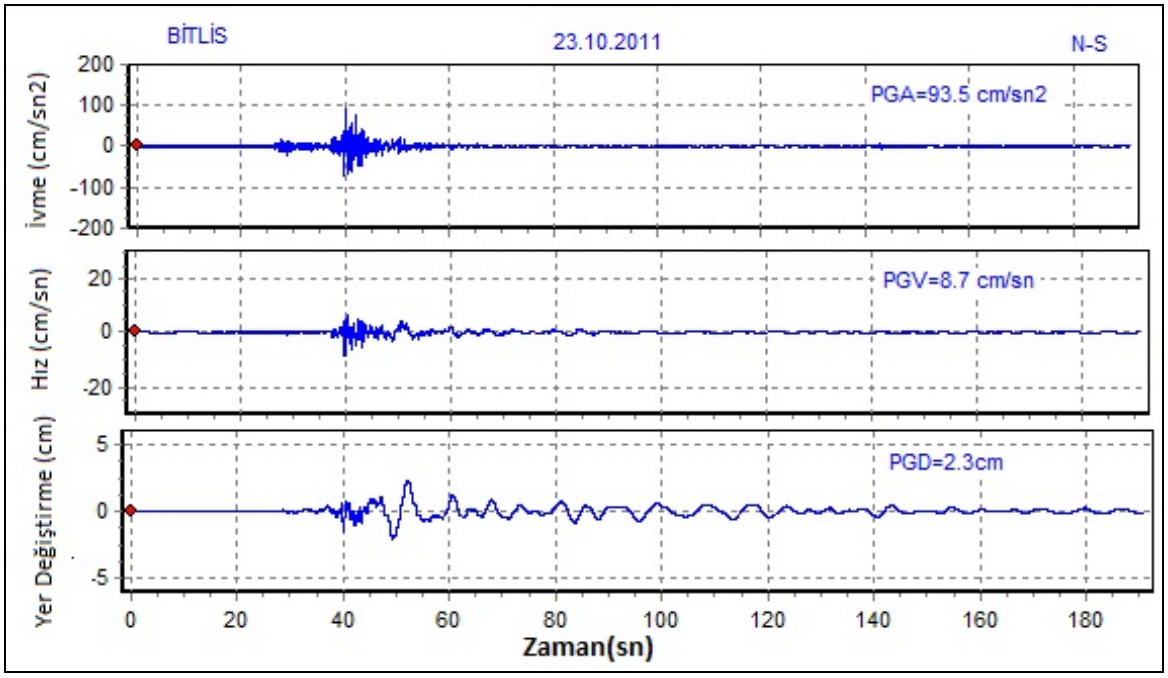



Figure 11.4: NS direction acceleration, velocity and displacement components for 23 October 2011, Ml=6.7 Van-Merkez Earthquake (Bitlis station)

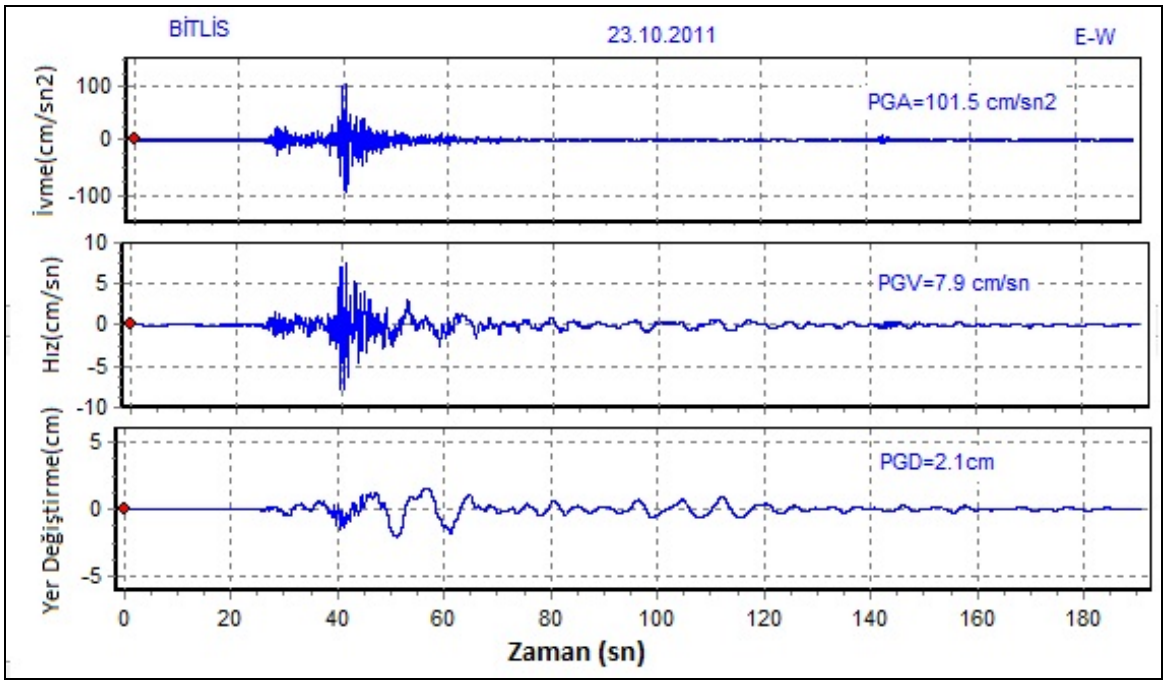



Figure 11.5: EW direction acceleration, velocity and displacement components for 23 October 2011, Ml=6.7 Van-Merkez Earthquake (Bitlis station)

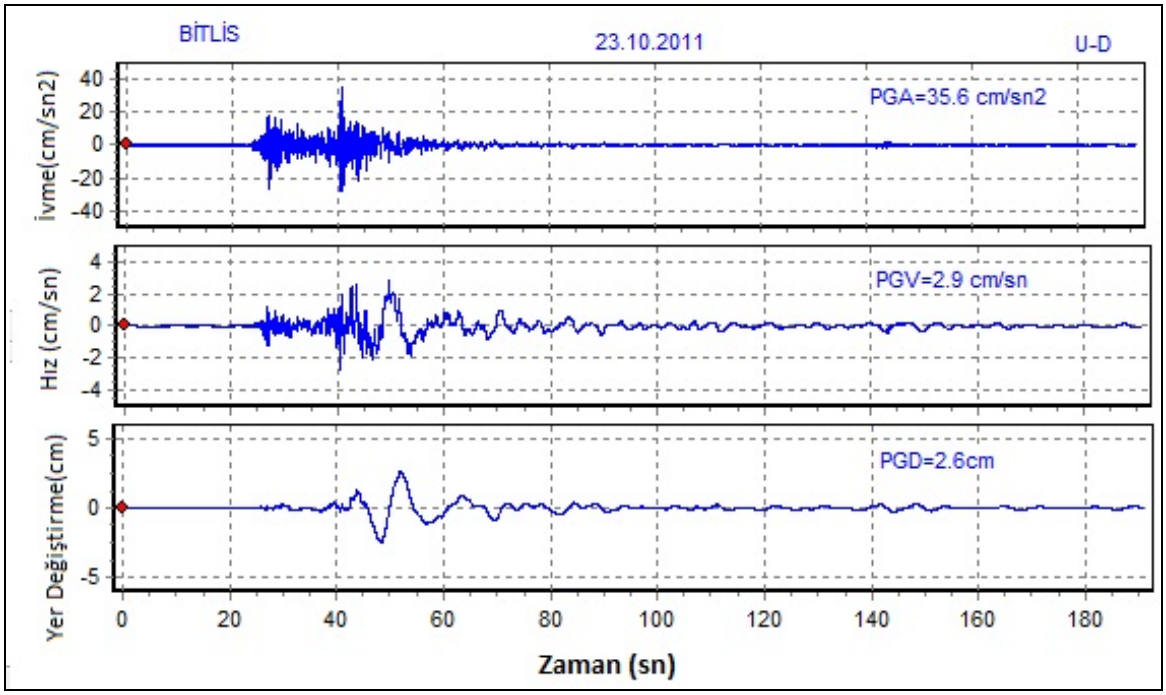



Figure 11.6: Vertical direction acceleration, velocity and displacement components for 23 October 2011, Ml=6.7 Van-Merkez Earthquake (Bitlis station)

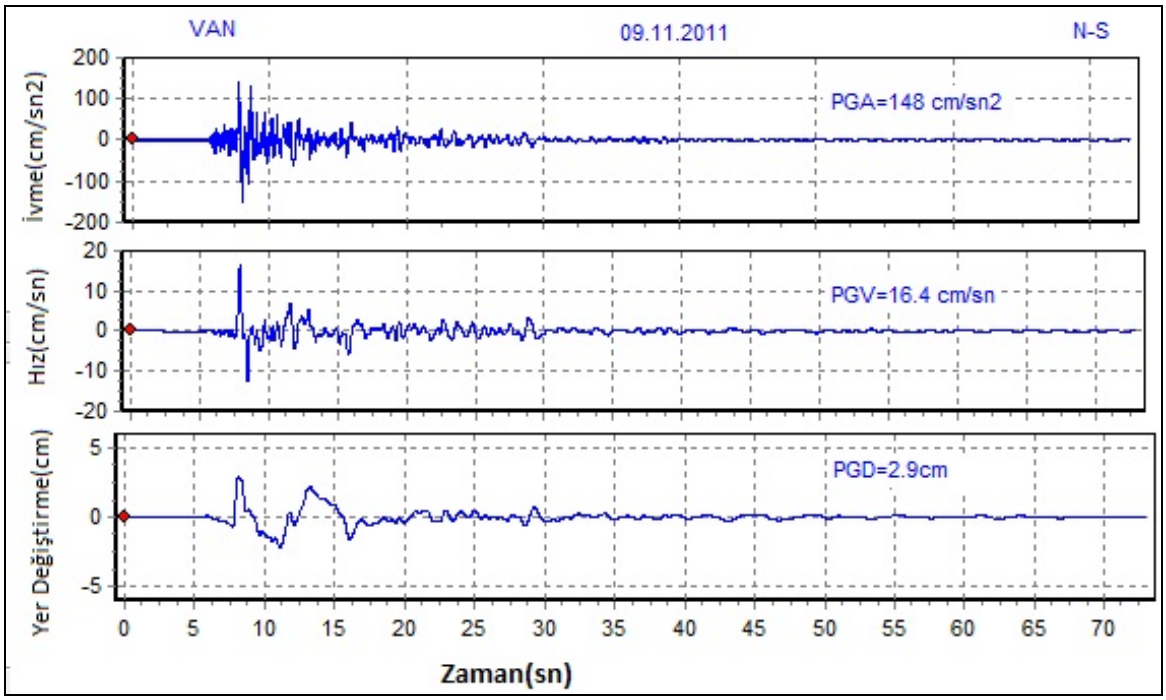



Figure 11.7: NS direction acceleration, velocity and displacement components for 09 November 2011, Ml=5.6 Van-Edremit Earthquake (Van-Merkez station)

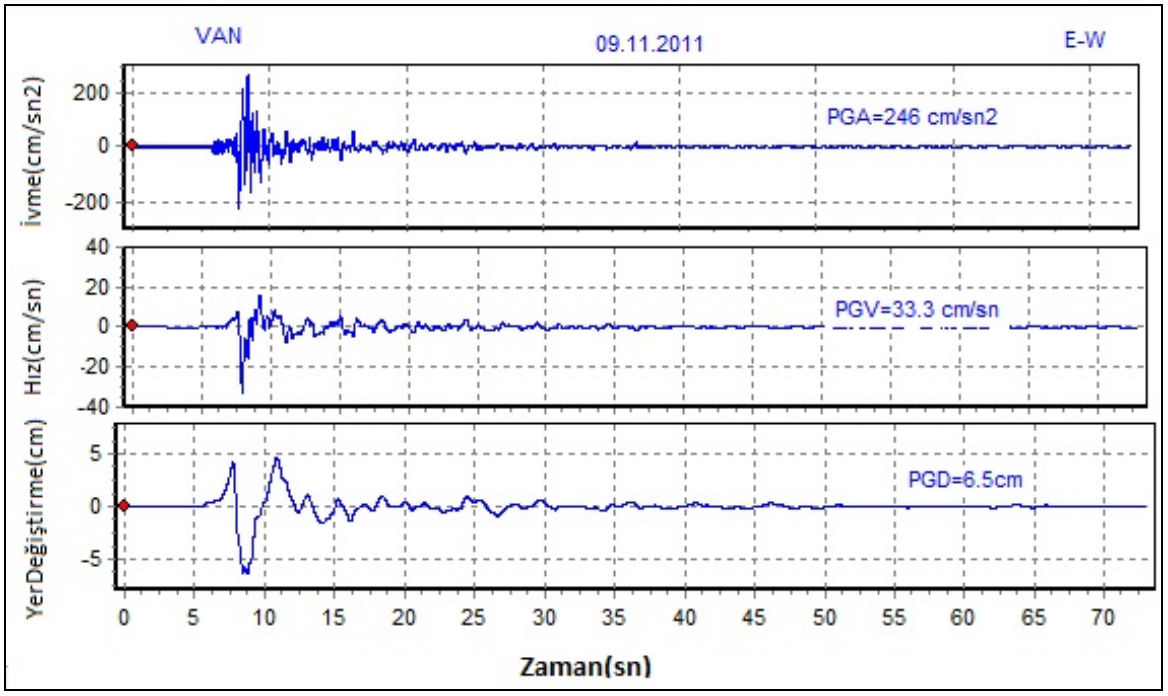



Figure 11.8: EW direction acceleration, velocity and displacement components for 09 November 2011, Ml=5.6 Van-Edremit Earthquake (Van-Merkez station)

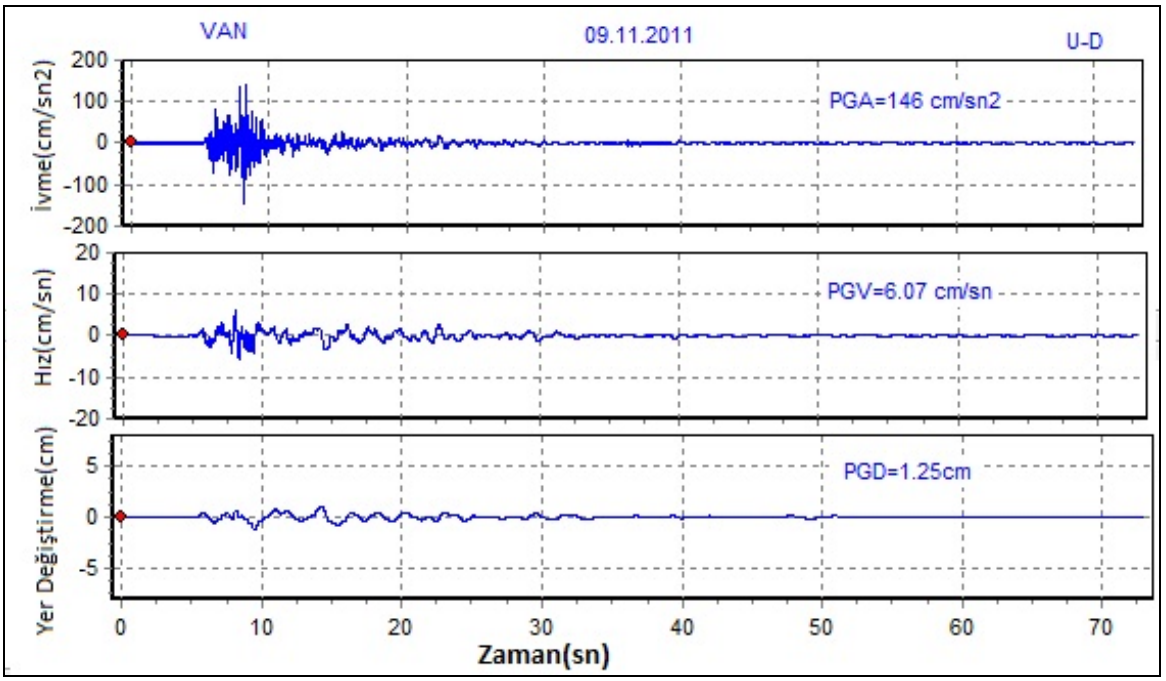
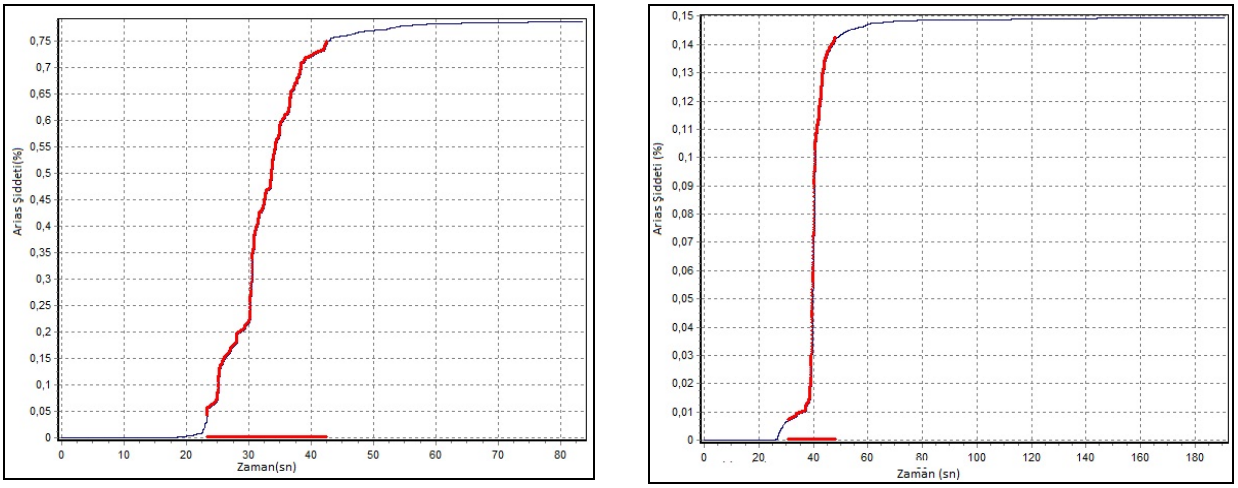



Figure 11.9: Vertical direction acceleration, velocity and displacement components for 09 November 2011, Ml=5.6 Van-Edremit Earthquake (Van-Merkez station)

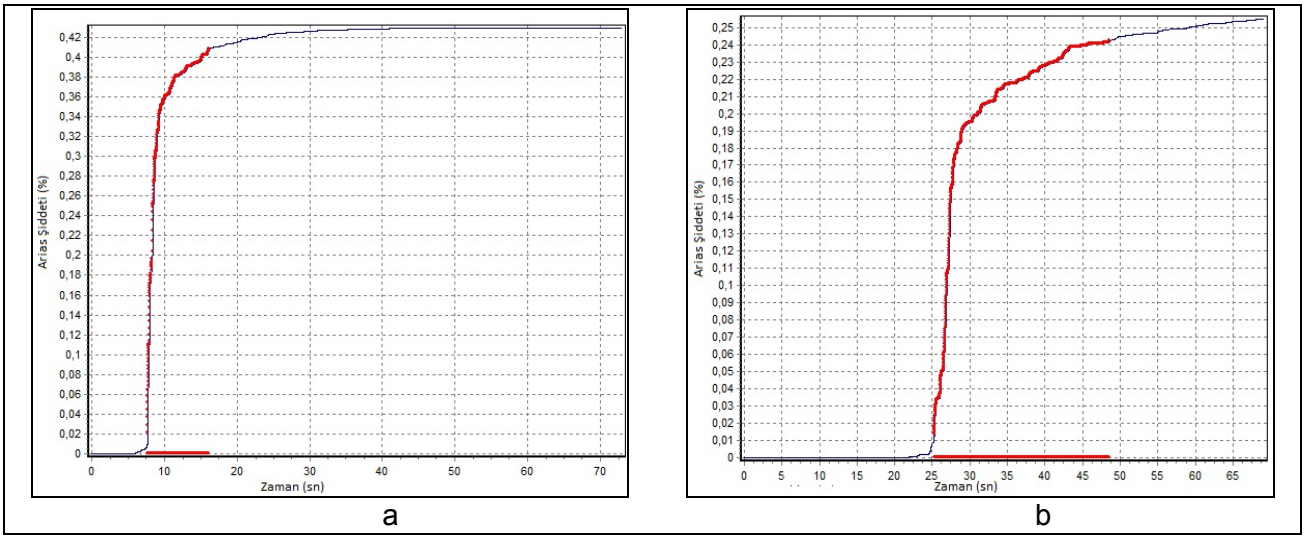
## 12. Effective Durations of 23 October 2011 Van Earthquake Ml=6.7 and 09 November 2011 Van-Edremit Earthquake Ml=5.6

One of the important parameters during the earthquake is a duration of strong ground motion. Duration of strong shaking play an essential role on the structural damage and engineering construction problems. Therfore effective duration changes was calculated for Ml=6.7 earthquake and Ml=5.6 earthquake (Fig.12.1, 12.2).




a b

Figure 12.1: 23 October 2011 Ml=6.7 Van-Merkez Earthquake effective durations a) Muradiye station record N-S direction, b) Bitlis station record E-W direction.

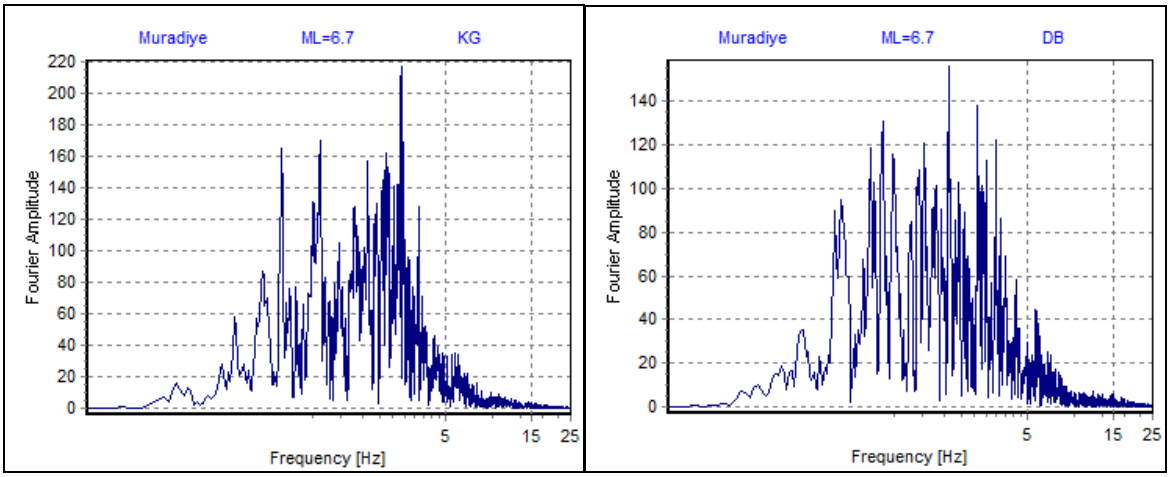



a b

Figure 12.2: 09 November 2011 Ml=5.6 Van-Edremit Earthquake effective durations a) Van station record E-W direction, b) Van-Edremit station record E-W direction.

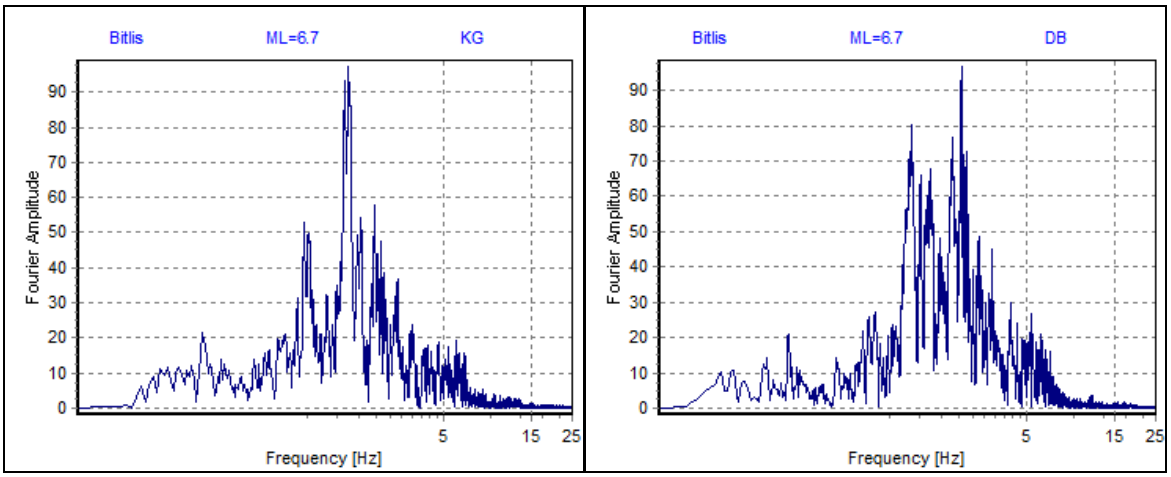
## 13. Fourier Spectrums of 23 October 2011 Van Earthquake Ml=6.7 and 09 November 2011 Van-Edremit Earthquake Ml=5.6

Fourier spectrums of Ml=6.7 earthquake was calculated by using horizontal component of Muradiye and Bitlis station records (Fig. 13.1,13.2). Similarly, horizontal component of Van and Edremit station record used for Ml=5.6 earthquake (Fig 13.3, 13.4).



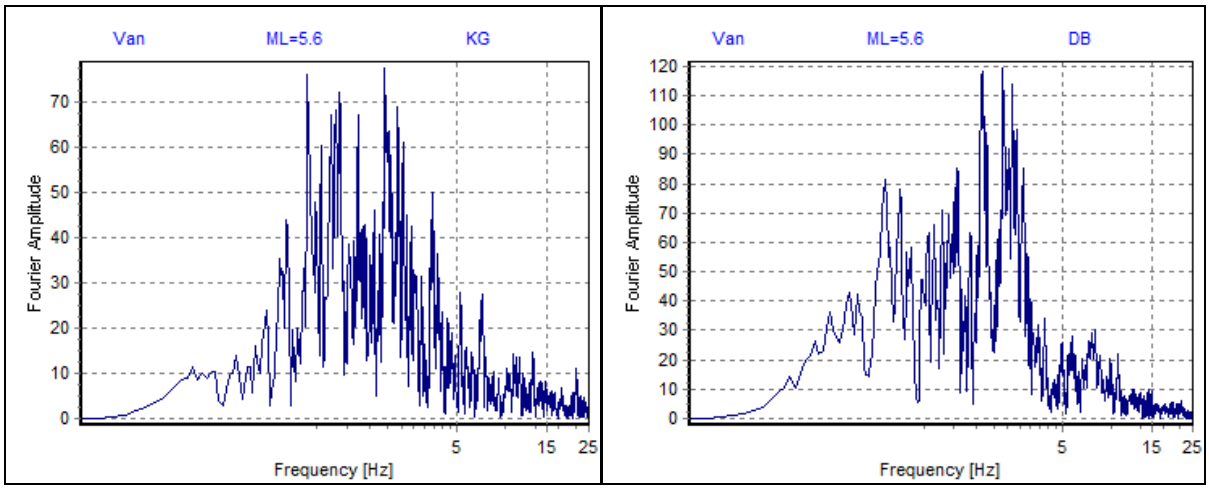

(a) (b)

Figure 13.1: Fourier spectrums of 23 October 2011, Ml=6.7 Van-Merkez earthquake
a) Muradiye record NS direction,
b) Muradiye record EW direction.



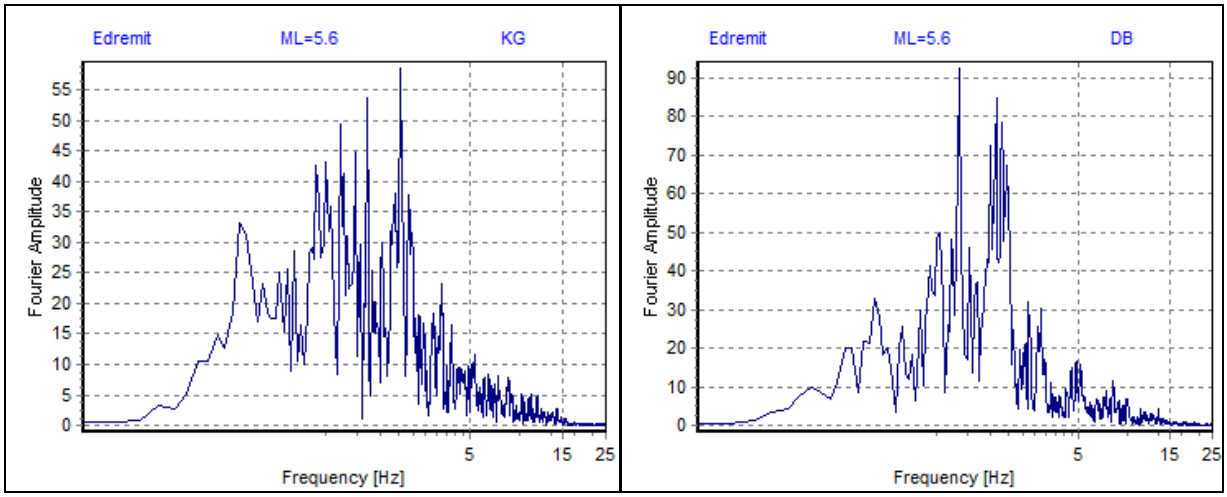

(a) (b)

Figure 13.2: Fourier spectrums of 23 October 2011, Ml=6.7 Van-Merkez earthquake
a) Bitlis record NS direction,
b) Bitlis record EW direction.




**(a)** **(b)**

Figure 13.3: Fourier spectrums of 09 November 2011, Ml=5.6 Van-Edremit earthquake
a) Van record NS direction,
b) Van record EW direction.

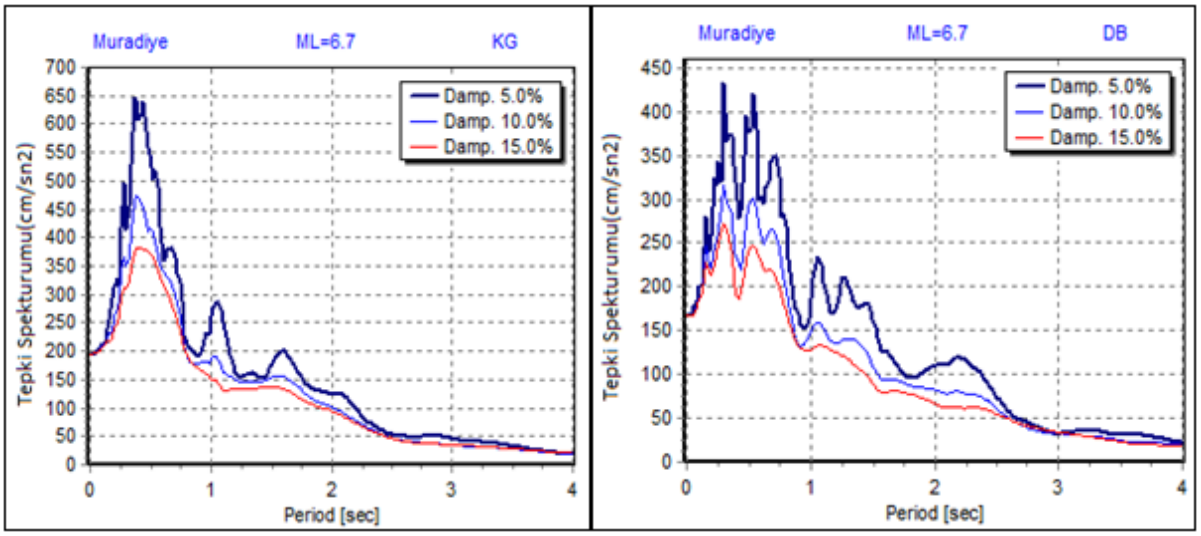



(a) (b)

Figure 13.4: Fourier spectrums of 09 November 2011, Ml=5.6 Van-Edremit earthquake
a) Edremit record NS direction,
b) Edremit record EW direction.

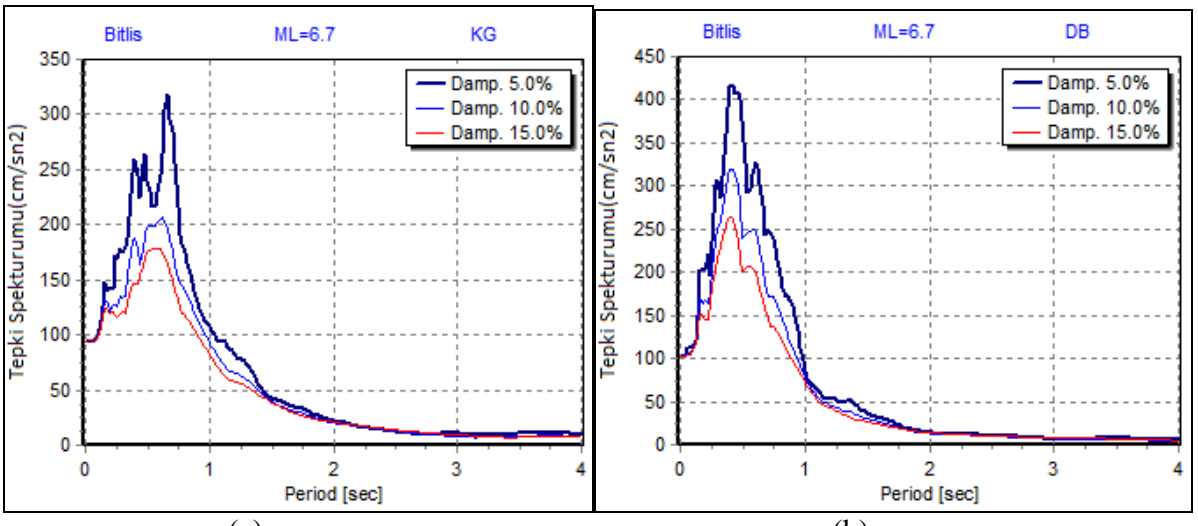
## 14. Response Spectrums of 23 October 2011 Van Earthquake Ml=6.7 and 09 November 2011 Van-Edremit Earthquake Ml=5.6

To describe earthquake force; Acceleration, velocity and displacement response spectrum of acceleration records are calculated. This method is commonly used approach in engineering application (Ohsaki,1991). In order to Ml=6.7 Van-Merkez earthquake and Ml=5.6 Van-Edremit earthquake, response spectrum that obtained from acceleration records were calculated for %5, %10 and %15 damping ratio (Fig 14.1-14.4).



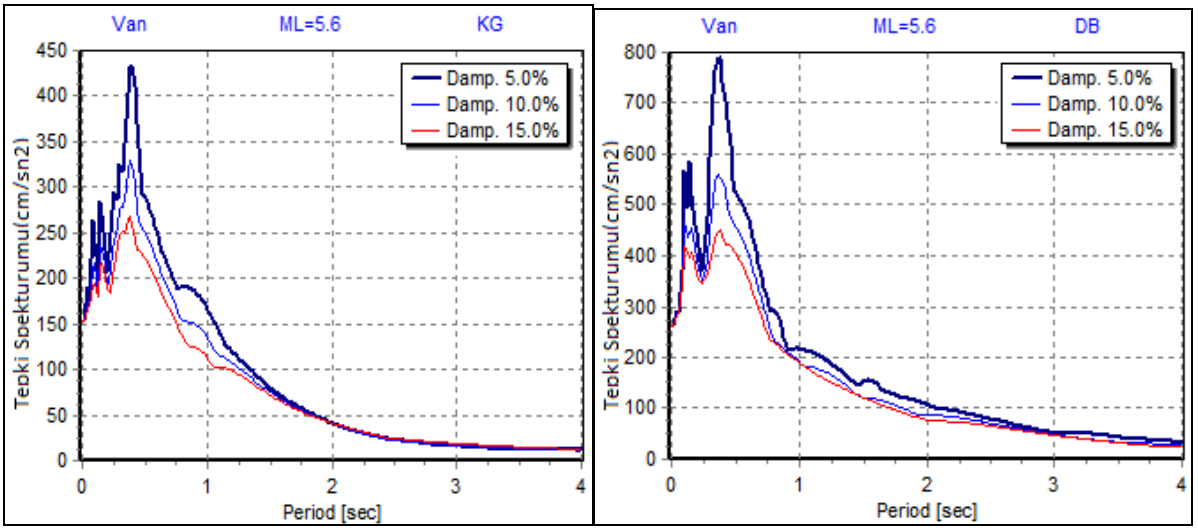

a) b)

Figure 14.1: Response spectrums of 23 October 2011, Ml=6.7 Van-Merkez earthquake
a) Muradiye record NS component
b) Muradiye record EW component.



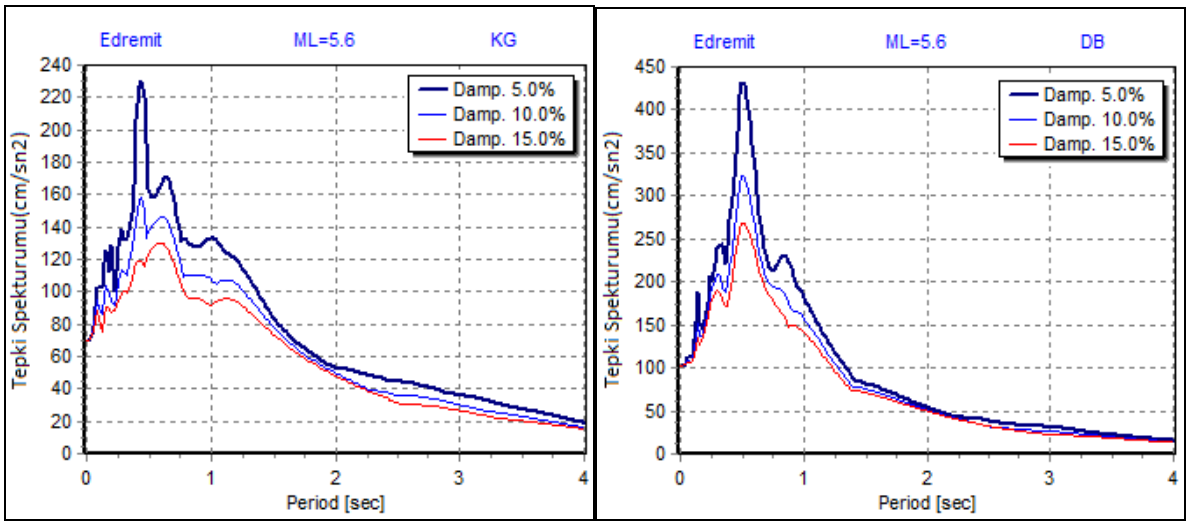

(a) (b)

Figure 14.2: Response spectrums of 23 October 2011, Ml=6.7 Van-Merkez earthquake
a) Bitlis record NS component
b) Bitlis record EW component.




(a) (b)

Figure 14.3: Response spectrums of 09 November 2011, Ml=5.6 Van-Edremit earthquake
a) Van-Merkez record NS component
b) Van-Merkez record EW component.




(a) (b)

Figure 14.4: Response spectrums of 09 November 2011, Ml=5.6 Van-Edremit earthquake
a) Van-Edremit record NS component
b) Van-Edremit record EW component.

## 15. Compare with Acceleration Response Spectrum and Design Spectrum of 23 October 2011 Van Earthquake Ml=6.7 and 09 November 2011 Van-Edremit Earthquake Ml=5.6

Compare with acceleration response spectrum and design spectrum (according to Turkish Earthquake Resistant Code (TDY) 2007) of 23 October 2011 Van earthquake Ml=6.7 and 09 November 2011 Van-Edremit earthquake Ml=5.6 are given Fig. 15.1,15.2. When examined that calculated response spectrum curve, it is seen each of two ground motion under the design spectrum that identified for first degree earthquake zone.

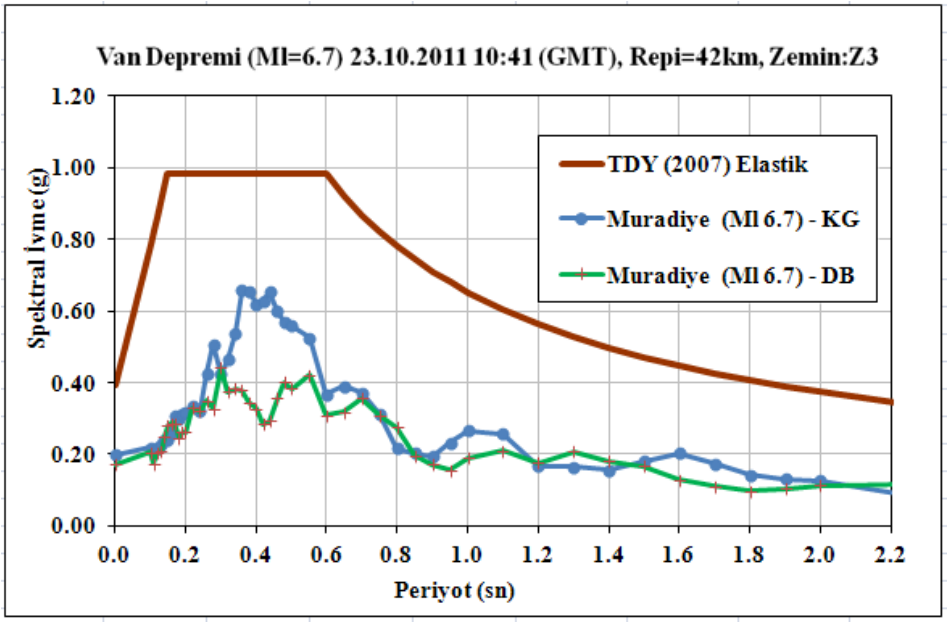



Figure 15.1: Compare with Muradiye station NS and EW component response spectrum and TDY 2007 design spectrum

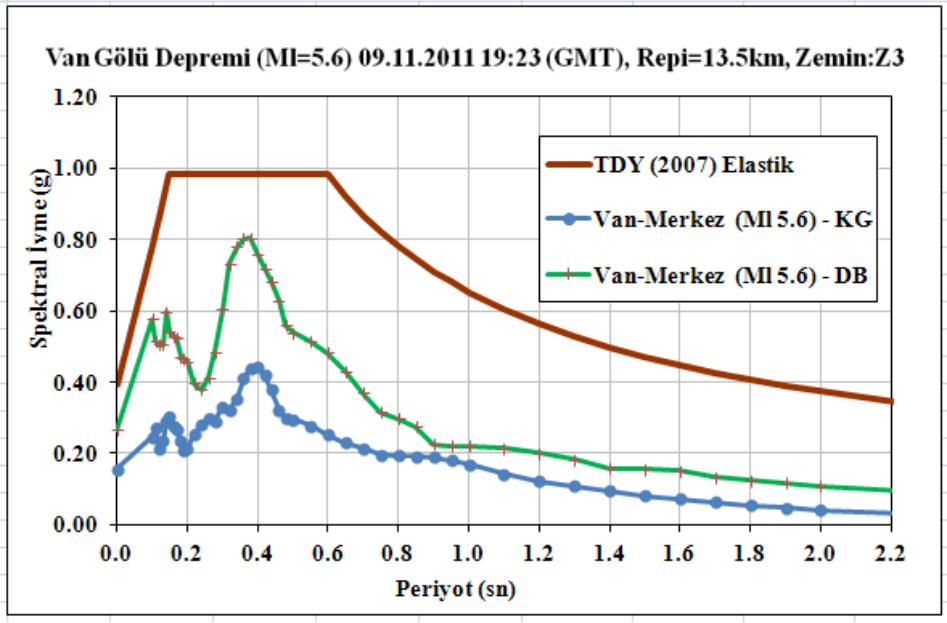



Figure 15.2: Compare with Van-merkez station NS and EW component response spectrum and TDY 2007 design spectrum.

## 16. Compare with Some Attenuation Relationship of 23 October 2011 Van Earthquake Ml=6.7 and 09 November 2011 Van-Edremit Earthquake Ml=5.6

Peak ground acceleration that refers to horizontal component compared with some attenuation relationship that proposed by some researchers (Fig.16.1-16.4).

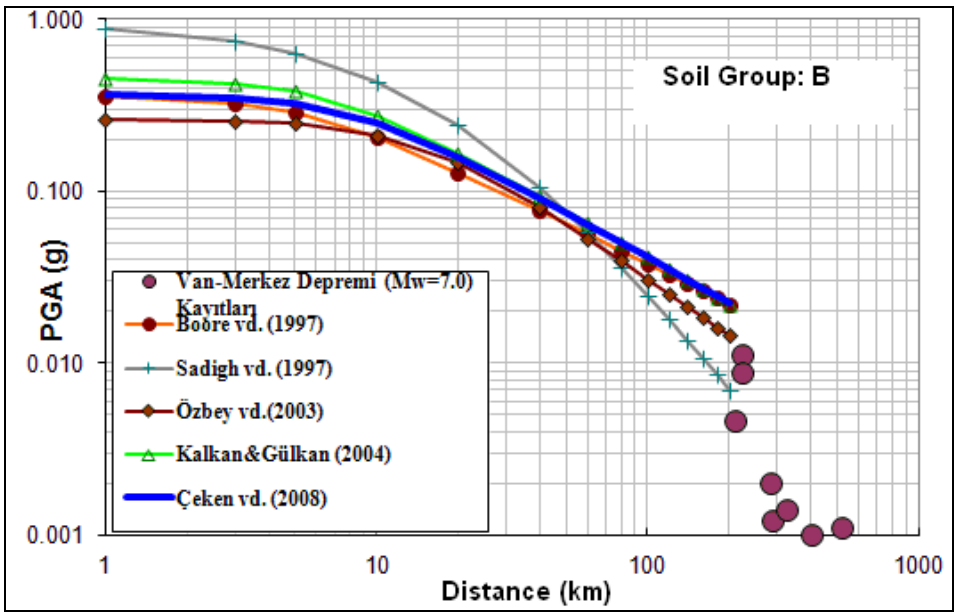



Figure 16.1: Compare with peak ground horizontal acceleration value and some attenuation relationship for 23 October 2007 Mw=7.0 Van-Merkez earthquake(soil group:B)

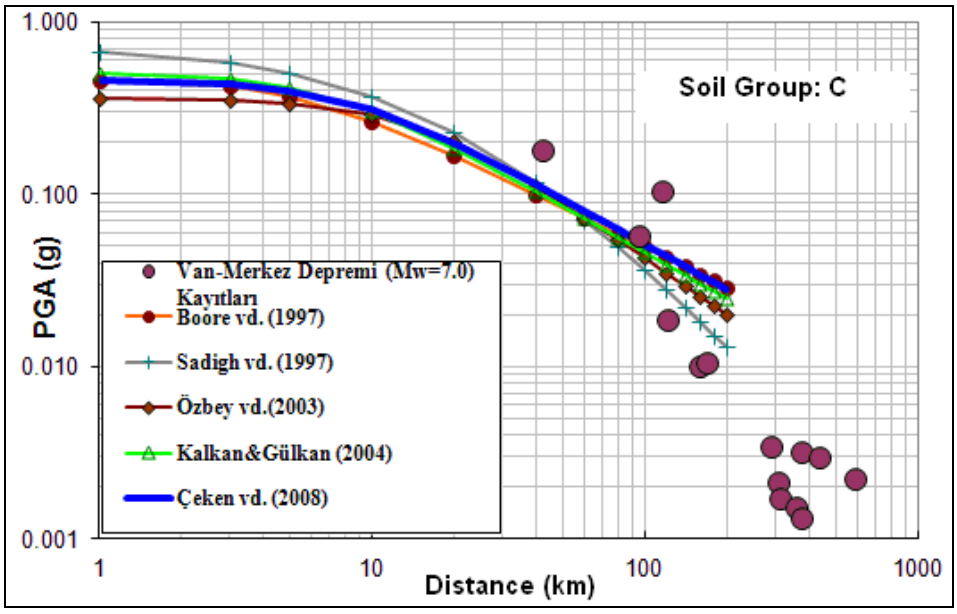



Figure 16.2: Compare with peak ground horizontal acceleration value and some attenuation relationship for 23 October 2007 Mw=7.0 Van-Merkez earthquake(soil group:C)

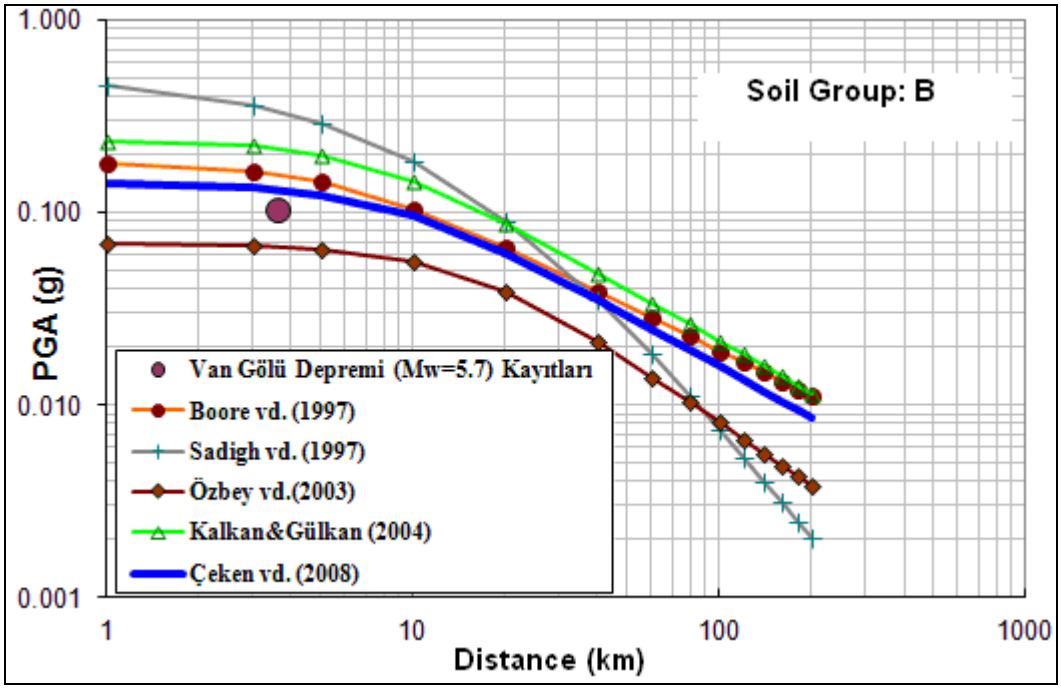



Figure 16.3: Compare with peak ground horizontal acceleration value and some attenuation relationship for 09 November 2011 Mw=5.7 Van-Edremit earthquake(soil group:B)

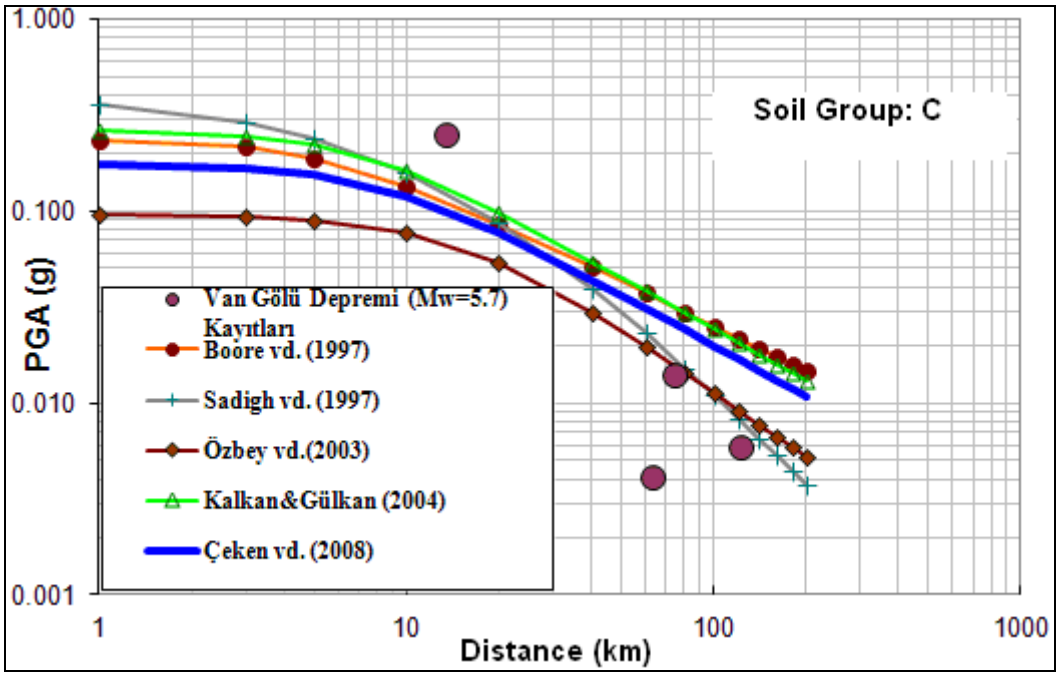



Figure 16.4: Compare with peak ground horizontal acceleration value and some attenuation relationship for 09 November 2011 Mw=5.7 Van-Edremit earthquake(soil group:C)

## 17. Structural Damage Assessment

Building stock in Van and Erciş Center generally consists of 4-8 storey reinforced concrete structures, which is very common in our country. In most of the buildings, asmolen slab (infilled joist slab) is used. Especially in collapsed buildings, shops having almost two times normal floor height have been determined. In villages, most of the existing building stock comprises of adobe, stone and brick masonry buildings with ages longer than their service life. They are constructed as one or two-storey by local people without taking into consideration any regulation, standard and earthquake resistant design rules. It is observed in the masonry structures at this region that horizontal and vertical supporting members, used to distribute loads safely, are made from wood, number of these members is inadequate and they are placed irregularly. Also, it is determined that lengths of their connections to load carrying walls are very short and weak. Briefly, poor quality construction material, structures with non-conforming earthquake code and lack of inspection are the main reasons of damage in the region (Fig.17.1-17.6).

**Weak Story and Slab Effect**


Figure 17.1:Examples of weak storey and slab effect. (a. Weak storey, b. Weak storey and asmolen slab, c. Ground floor destroyed. d. Heavy slab)

**Concrete Effect**

Figure 17.2: Crumbly concrete example

Figure 17.3: Crumbly concrete example

Figure 17.4: Weak storey example

**Reinforcement Effect**


Figure 17.5: a) Striped reinforcement , b) Striped reinforcement
c) insufficient stirrup and shell concrete.

**Damage to Masonry Construction**


Figure 17.6: a) Briquet filled collapsed building, b) Adobe filled collapsed building
c) Adobe+briquet filled collapsed building, d) Fine grained binding material (cat litter) e) Collapse to corner join .

## 18. Seismic Intesity Analysis

After both Van-Merkez and Edremit earthquakes, peak ground acceleration and seismic intensities were predicted for earthquake and surrounding areas. The highest acceleration value is calculated as 351 cm/sn$^2$ near Kasımoğlu and Yumru villages close to the epicenter of the Van-Merkez earthquake. For the Van-Edremit earthquake the highest acceleration values are calculated as 53 cm/sn$^2$ at Van City Center and 58 cm/sn$^2$ in Edremit. Seismic intensity values calculated by using these acceleration values and for Van-Merkez earthquake, maximum intensity is predicted as *IX* whereas the maximum intensity value is predicted as *VI* for Van-Edremit earthquake (Fig.18.1-18.4).

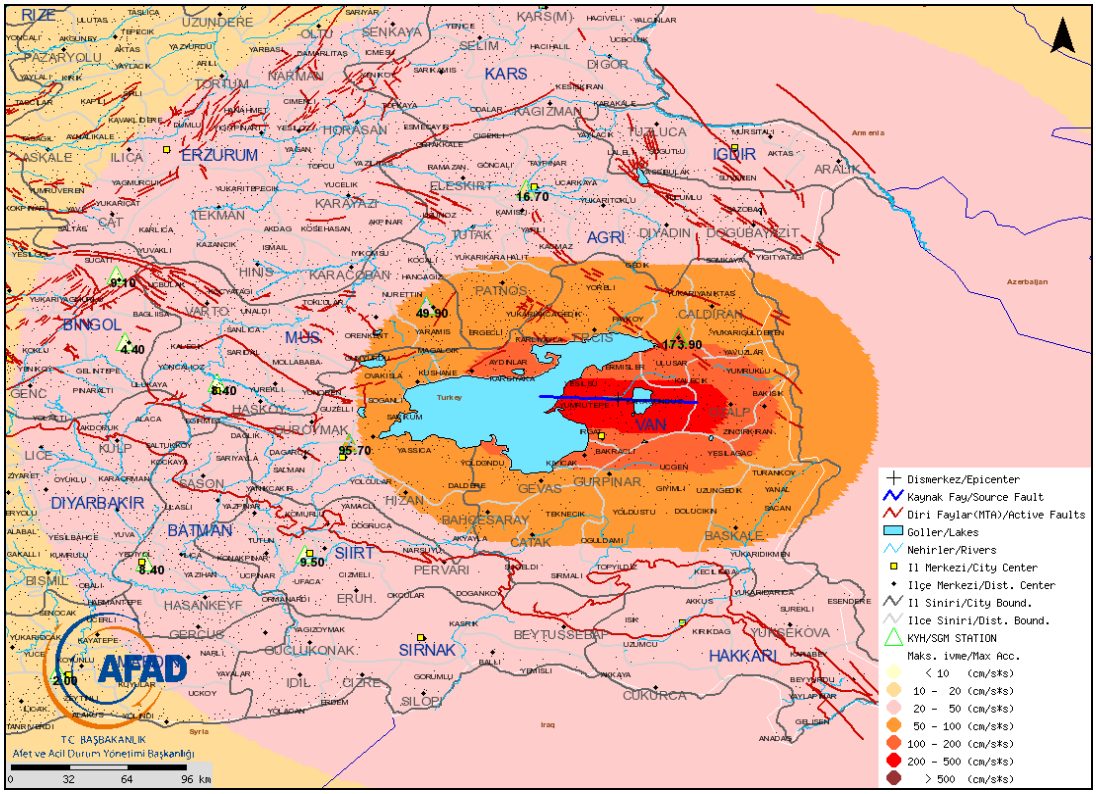



Figure 18.1: Peak ground acceleration distribution of 23 October 2011, $M_w$=7.0 Van-Merkez earthquake

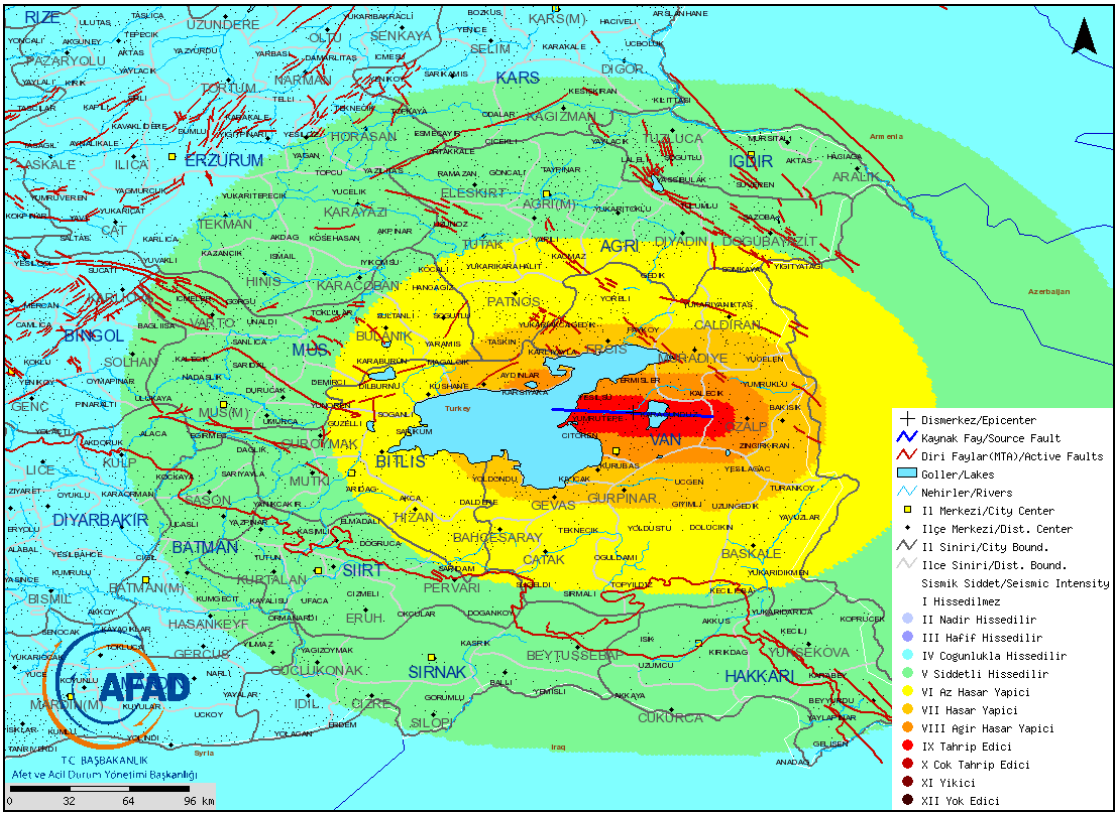



Figure 18.2: Seismic intensty map of 23 October 2011, $M_w$=7.0 Van-Merkez earthquake


Figure 18.3: Peak ground acceleration distribution of 09 November 2011, $M_w$=5.7 Van-Edremit earthquake

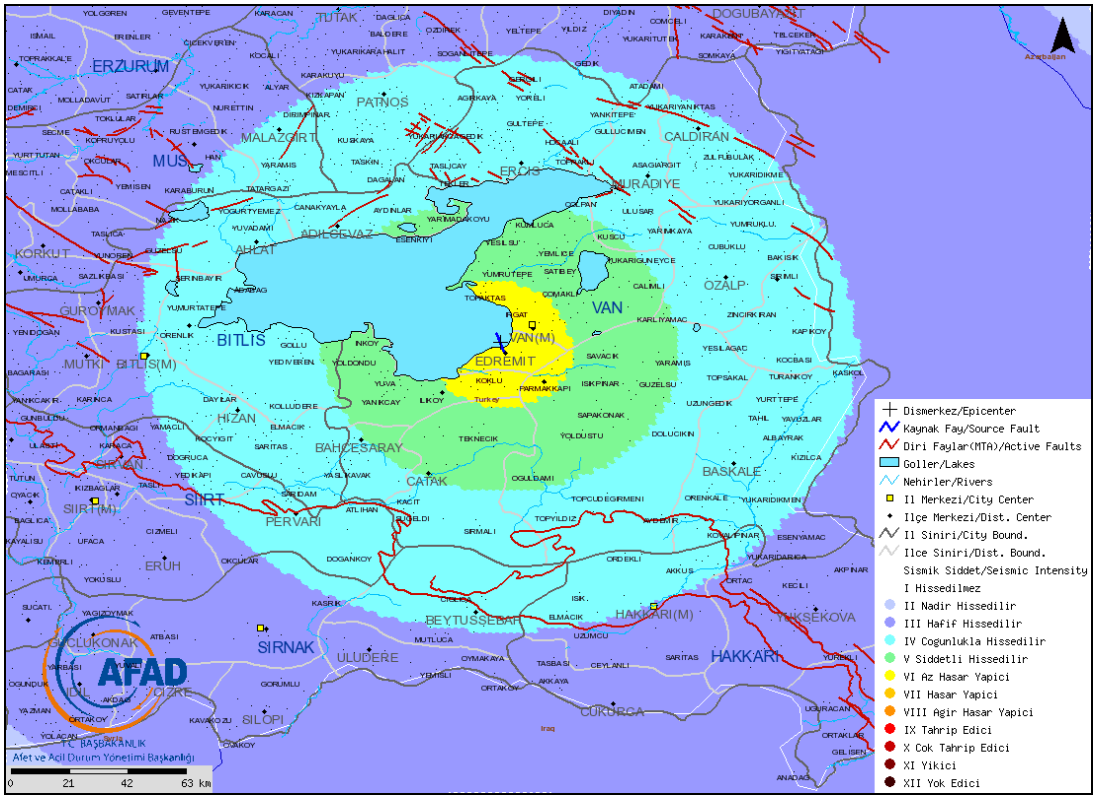



Figure 18.4: Seismic intensty map of 09 November 2011, $M_w$=5.7 Van-Edremit earthquake

## 19. Using Orthophoto and Satellite Image in Van Earthquake

During our studies after Van Earthquake, we have benefited from the opportunities of high technology products as much as possible. As Authorized User to International Charter "Space and Major Disasters", AFAD activated the system immediately and following intense collaboration with Charter, pre and post earthquake satellite images and their analysis were sent to the relevant authorities both in Van and Ankara (Table 19.1-19.2) (Fig. 19.1-19.4). Similarly, orthophotos produced by General Command of Mapping (HGK) provided benefits to the post-disaster rehabilitation and recovery activities (Table 19.3,19.4) (Fig.19.5-19.7). Those images were provided by HGK very promptly and contributed to the monitoring of temporary settlement areas of tents, site selection activities. It also revealed the fact that very fact acquisition of those images will be very useful for also future events.

Table 19.1 Satellite image and features before the earthquake

| Satellite Image | Resolution | Band | Image Date | Location |
|---|---|---|---|---|
| WorldView-2 | 2.0 m. | Multi band | 06 May 2011 | Van |
| WorldView-2 | 0.5 m. | Single band | 27 June 2011 | Erciş |
| | 2.0 m. | Multi band | | |
| WorldView-2 | 0.5 m. | Single band | 06 May – 24 June 2011 | Güvenli- Alaköy |
| | 2.0 m. | Multi band | | |
| QuickBird-2 | 0.6 m. | Single band | 02 October 2011 | Bitlis |
| | 2.5 m. | Multi band | | |


Figure 19.1: WorldView-2 (2.0 m resolution) image before earthquake.(Van)


Figure 19.2: WorldView-2 (0.5 m resolution) image before earthquale (Erciş)

Table 19.2 Satellite image and features after the earthquake

| Satellite Image | Resolution | Band | Image Date | Location |
|---|---|---|---|---|
| QuickBird-2 | 0.6 m. | Single band | 26-28 October 2011 | Erciş |
| | 2.5 m. | Multi band | | |
| Ikonos | 1.0 m. | Single band | 26-28 October 2011 | Erciş |
| | 4.0 m. | Multi band | | |
| QuickBird-2 | 0.6 m. | Single band | 26 October 2011 | Erciş |
| | 2.5 m. | Multi band | | |
| QuickBird-2 | 0.6 m. | Single band | 26 October 2011 | Bitlis |
| | 2.5 m. | Multi band | | |

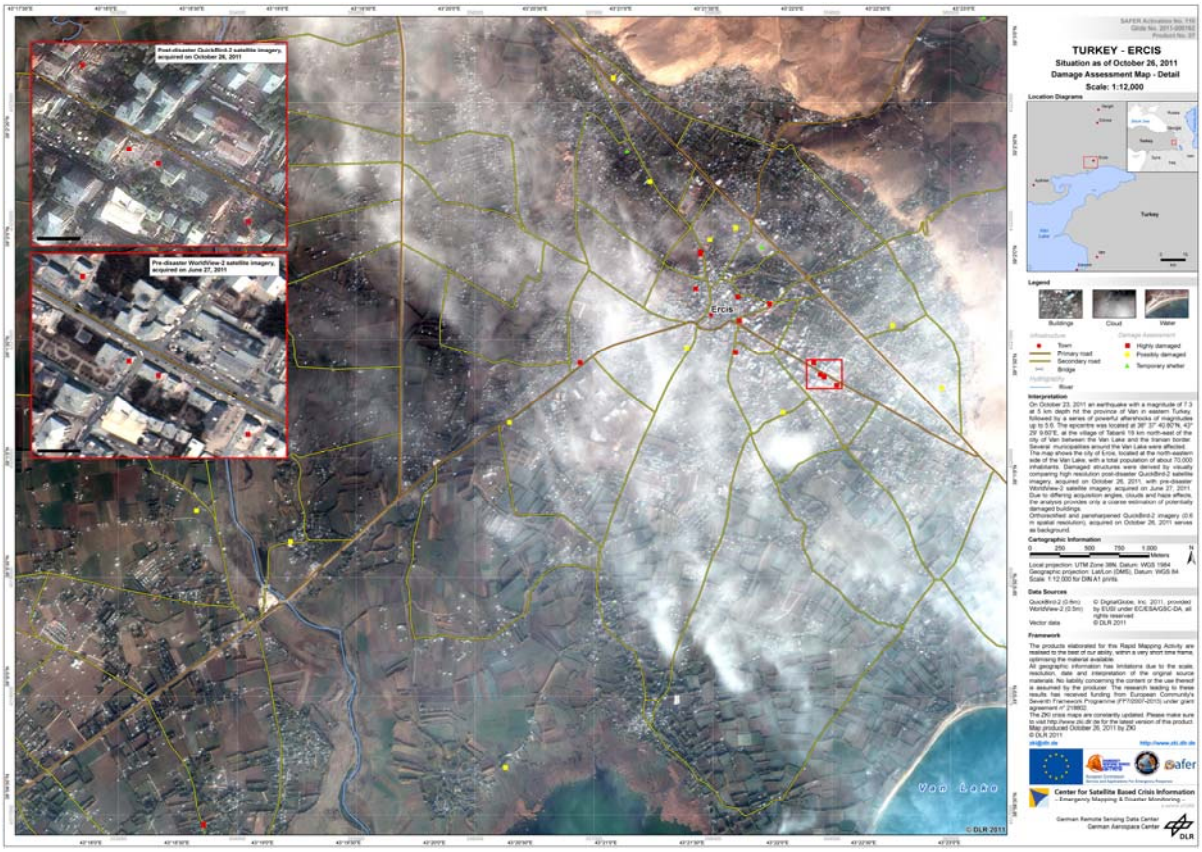



Figure 19.3: QiuckBird-2 (0.6 m resolution) image after the earthquake (Erciş)

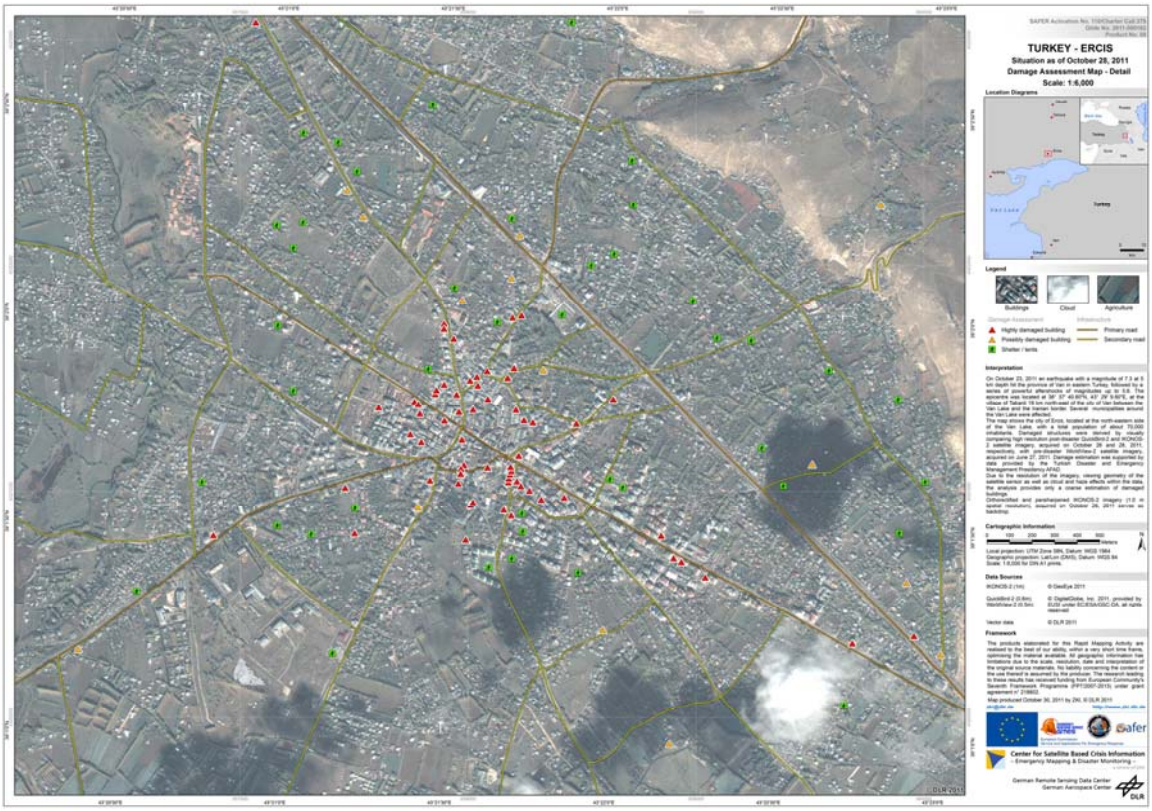



Figure 19.4: QiuckBird-2, Iconos images after the earthquake (Erciş) (red triangles show a heavy damage collapse building, yellow triangles show a potantial damage building and green polygons show a tent city).

## Orthophoto Image that was Produced by General Command of Mapping

Table 19.3 Orthophoto image and features before the earthquake

| Coverage Area of Orthophoto Image | Image Date | Coordinate System |
|---|---|---|
| Erciş | 2010 | UTM ED-50 |
| Van Merkez | 2010 | UTM ED-50 |
| Van Alaköy | 2010 | UTM ED-50 |
| Van Güvençli | 2010 | UTM ED-50 |
| Van Topraktaş | 2010 | UTM ED-50 |
| Van Tevekli | 2010 | UTM ED-50 |

Table 19.4 Orthophoto image and features after the earthquake

| Coverage Area of Orthophoto Image | Image Date | Coordinate System |
|---|---|---|
| Erciş | 2011 | UTM ED-50 |
| Van Merkez | 2011 | UTM ED-50 |
| Van Alaköy | 2011 | UTM ED-50 |
| Van Güvençli | 2011 | UTM ED-50 |
| Van Topraktaş | 2011 | UTM ED-50 |
| Van Tevekli | 2011 | UTM ED-50 |


(a)


(b)

Figure 19.5: Determination of collapsed building in Erciş village a) before earthquake, b) after earthquake.

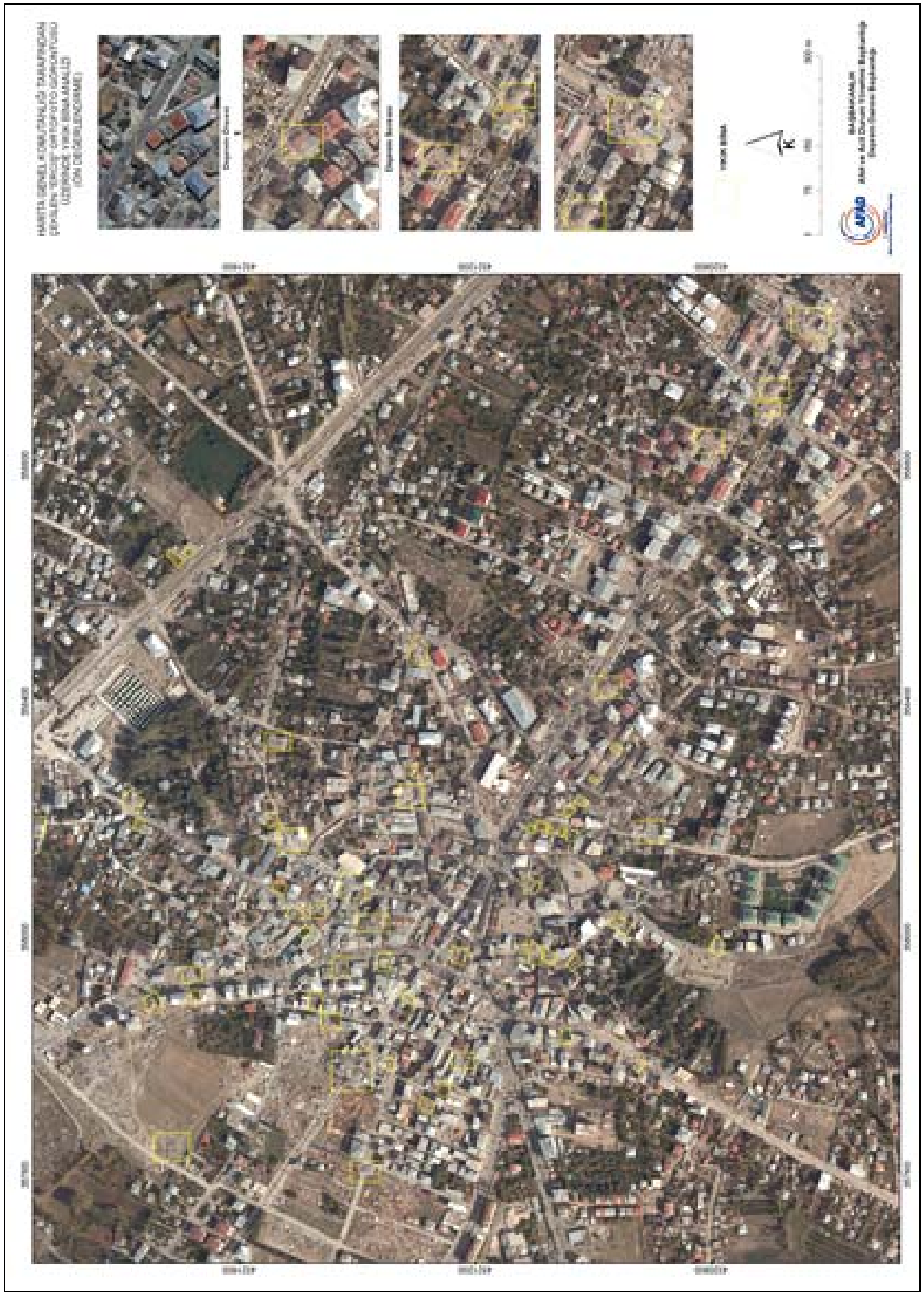


Figure 19.6: Erciş village image after the earthqauke

Figure 19.7: Van city center image after the earthqauke

3D orthophoto images of earthquake zone were produced by the help of CIS methods (Fig.19.8).

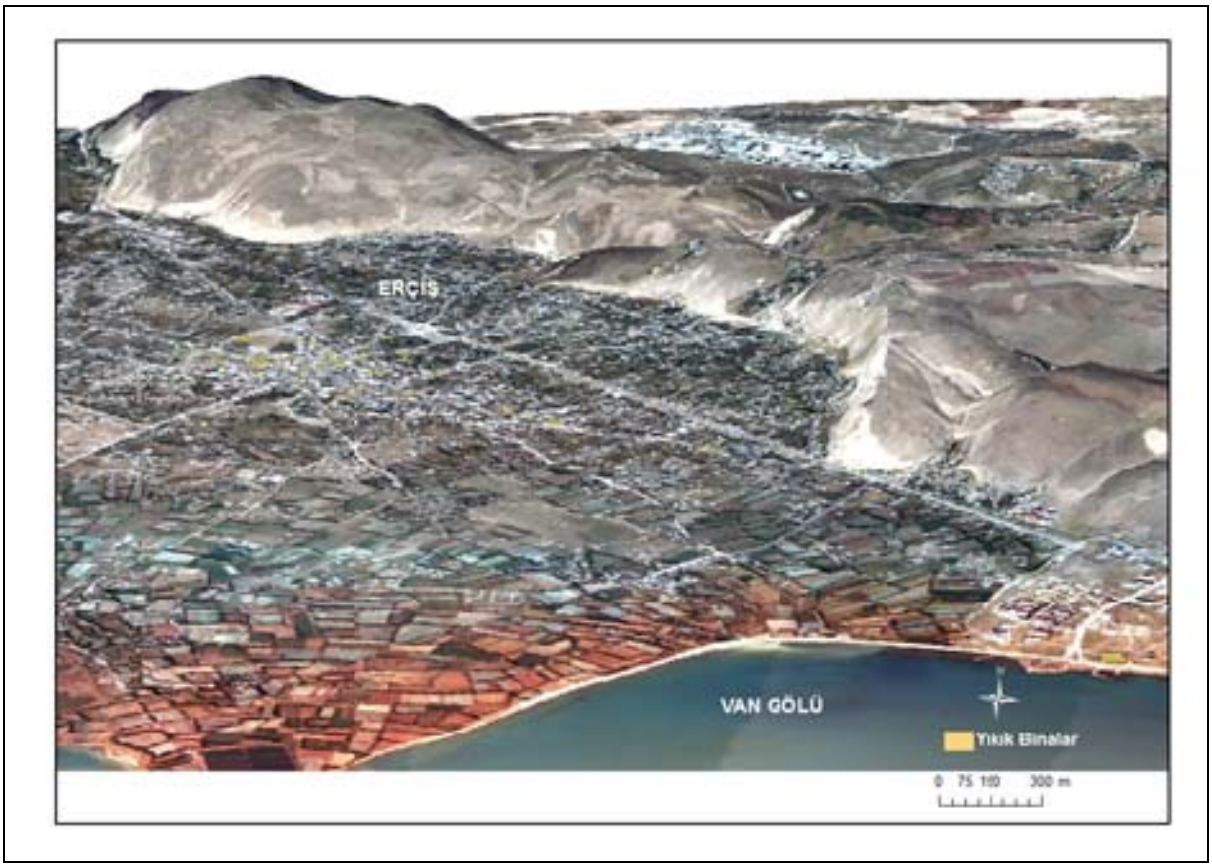



Figure 19.8: 3D orthophoto image of Erciş

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**A1** Kaynak sayısı üç'den fazla bilgi ve belge düzeyi yüksek

**A2** Kaynak sayısı üç'den az bilgi ve belge düzeyi yüksek

**A3** Kaynak sayısı üç'den fazla bilgi ve belgeleri geliştirilmeye gereksinim gösteriyor.

**B1** Kaynak sayısı üç veya daha az,bilgi ve belge düzeyi orta

**B2** Kaynak sayısı üç veya daha az,bilgi ve belgeleri geliştirilmeye gereksinim gösteriyor düzeyi orta

**B3** Kaynak sayısı üç veya daha az,bilgi ve belgeleri yetersiz.

**C1** Kaynak sayısı yetersiz.

**C2** Bilgi ve belgeleri yetersiz.

**C3** Hem kaynak sayısı ,hemde bilgi ve belgeleri yetersiz.

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