

**PRELIMINARY AFTERSHOCK ANALYSIS OF THE BALA - ANKARA  
EARTHQUAKES (DECEMBER 20, 2007 - MI=5.6, DECEMBER 27, 2007-MI=5.5)  
IN CENTRAL TURKEY**

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## **INTRODUCTION**

An earthquake with magnitude  $M_I=5.6$  occurred at local time 11:48 on December 20, 2007 at about 70 km South of Ankara and 15 km South of Bala town. Epicentral coordinates of the earthquake is determined as 39.4173 N  $\hat{\circ}$  33.0453 E with focal depth 2.8 km.

After the earthquake, 117 small aftershocks recorded and determined with magnitude ( $M_d$ ) 2.1  $\hat{\circ}$  4.6 as of local time 10:01, December 21, 2007 by DDA network, Ankara..

## **AFTERSHOCK STUDIES (WEAK MOTION)**

Just after the earthquake, two teams consisting of researchers of TUBITAK Marmara Research Center, Earth and Marine Sciences Institute (TUBITAK-MRC-EMSI) and Ministry of Public Works and Settlement, General Directorate of Disaster Affairs (DDA), Earthquake Research Department moved immediately into the region within the framework of the State Planning Organization (SPO)-funded Urgent Earthquake Monitoring Studies (DEPAR) project, which is carried out by cooperation of these two organizations. The teams started collecting data by deployment of four earthquake monitoring stations 12 hours after the occurrence of the earthquake. After installation of 3 additional earthquake monitoring stations in the morning of December 21, 2007, a total of 7 units of earthquake monitoring stations (including three components Reftek-130 earthquake recording devices utilizing three component 4.5 Hz geophones), an earthquake monitoring network with the main shock as the center and an approximate 35 km radius, shown in the Figure below, became available to record the aftershocks (Fig. 1).

The data collected by the aftershock earthquake network were read and evaluated synchronously on a sharing basis by the DDA Earthquake Research Center and TUBITAK-MRC-EMSI and was made available both at EMSI and DDA websites for the public and interested parties.

During these studies which have an administrative and social purpose, for reliable evaluation, data has been collected and forwarded to the authorized people.

After this earthquake, at local time 01:47 on December 27, 2007 another strong earthquake at Bala occurred with Magnitude  $M_I=5.5$  epicentral coordinates 39.4112 N  $\hat{\circ}$  33.0782 E and focal depth 23.5 km.

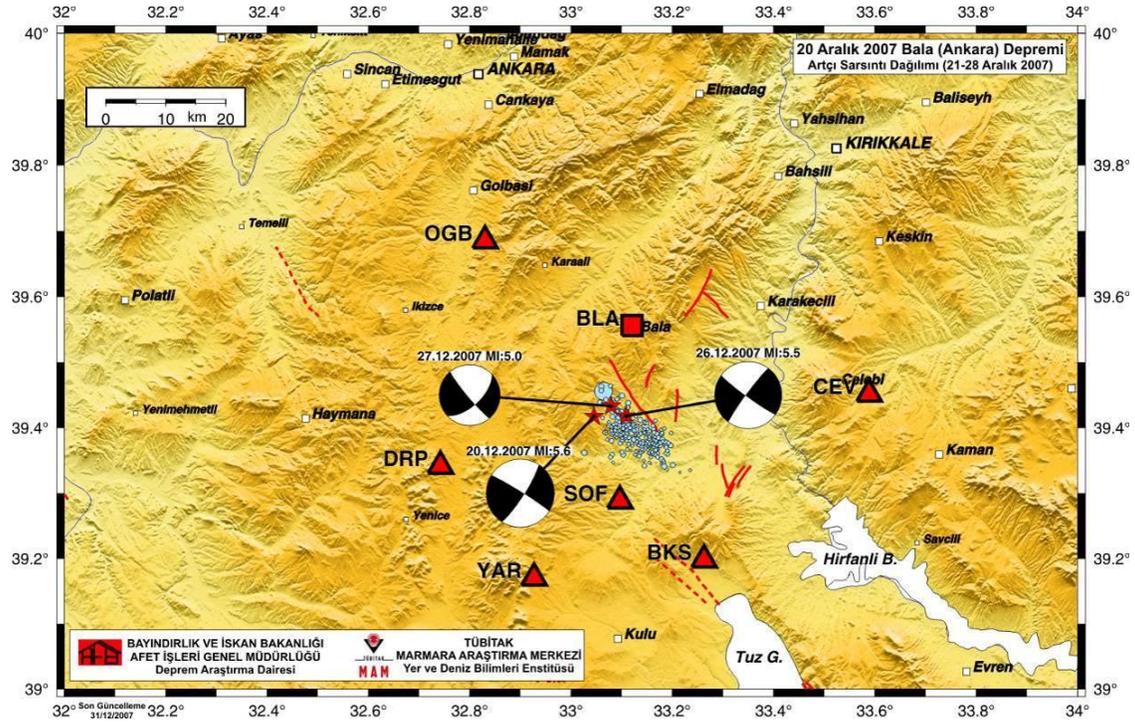
According to the data were determined in DDA Ankara Center: Between the dates December 20  $\hat{\circ}$  27, 284 aftershocks were determined with  $M_d$  magnitude range 2.7  $\hat{\circ}$  4.4 and after December 27, 2007 earthquake till Feb 6, 2008, number of located aftershocks with  $M_d$  magnitude range 2.0-4.9 are 515. The number of earthquakes has been decreased by time.

According the data obtained from DEPAR project temporary stations:

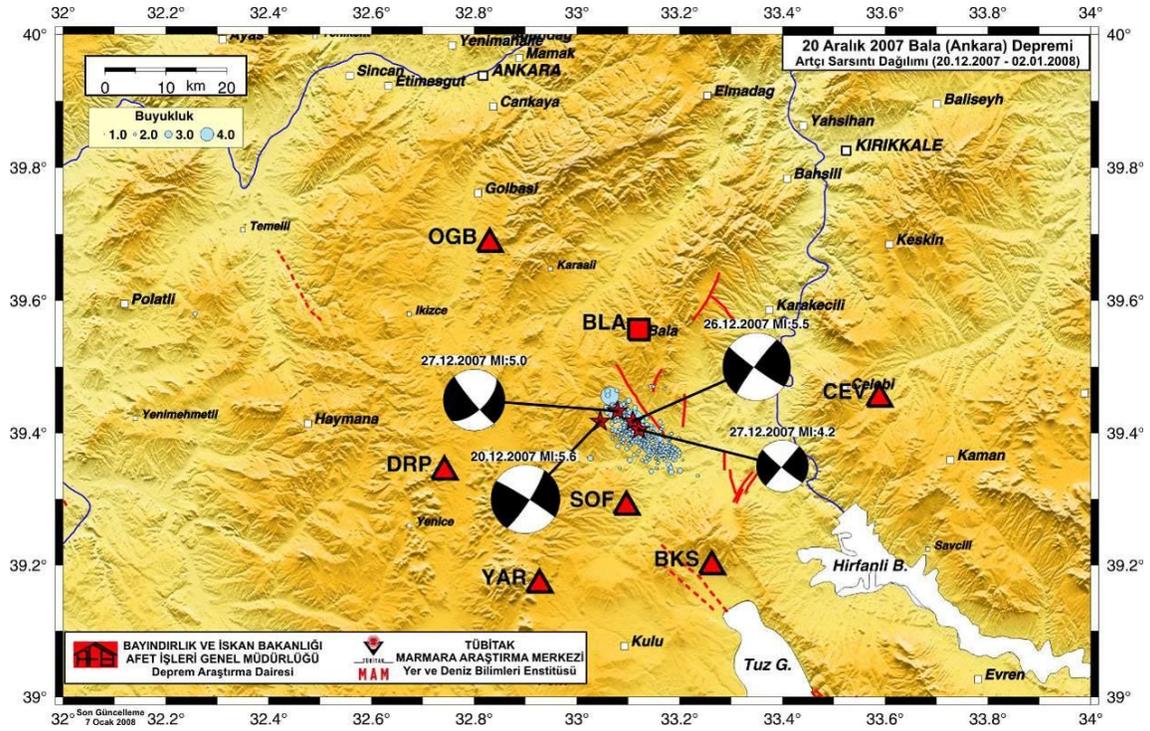
The Aftershock distribution of the Bala earthquakes in the period of December 21, 2007 and January 31, 2008 is shown in the following figures (Figure 1, 2, 3, 4 and 5). The aftershocks are concentrated in an area of approximately 20 km long in NW-SE direction. The depths of these earthquakes vary between 3 -15 km but most frequent between 5 -8 km. Also the parameters of fault plane solutions of the Bala earthquakes and some strong aftershocks are given in Fig. 1 - Fig. 5 and Table 1.

**Table 1. The parameters of fault plane solutions of the Bala earthquakes and aftershocks.**

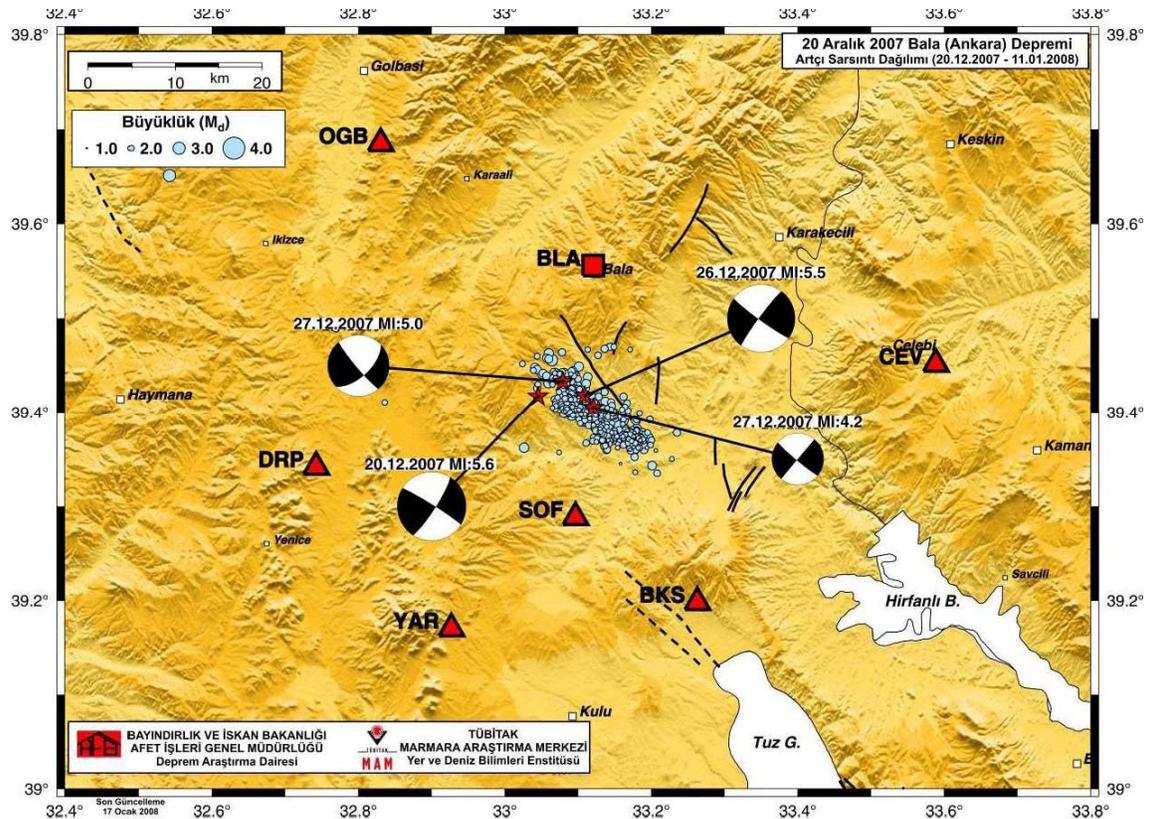
Date	Time	Latitude (N)	Longitude (E)	Depth (Km)	Md	Ml	Strike1	Dip1	Slip1	Strike2	Dip2	Slip2
20.12.2007	09:48:27	39,4173	33,0453	2,8	5,3	5,6	302	86	171	33	81	4
26.12.2007	23:47:10	39,4032	33,1012	5,7	5,3	5,5	126	85	175	217	85	5
27.12.2007	13:47:58	39,4273	33,0928	8,2	4,9		47	61	-7	140	84	-151
27.12.2007	17:56:12	39,3842	33,1350	10	4,2		40	90	-5	130	85	-180
01.02.2008	09:11:02	39,4480	33,0653	16,8			67	90	0	337	90	180



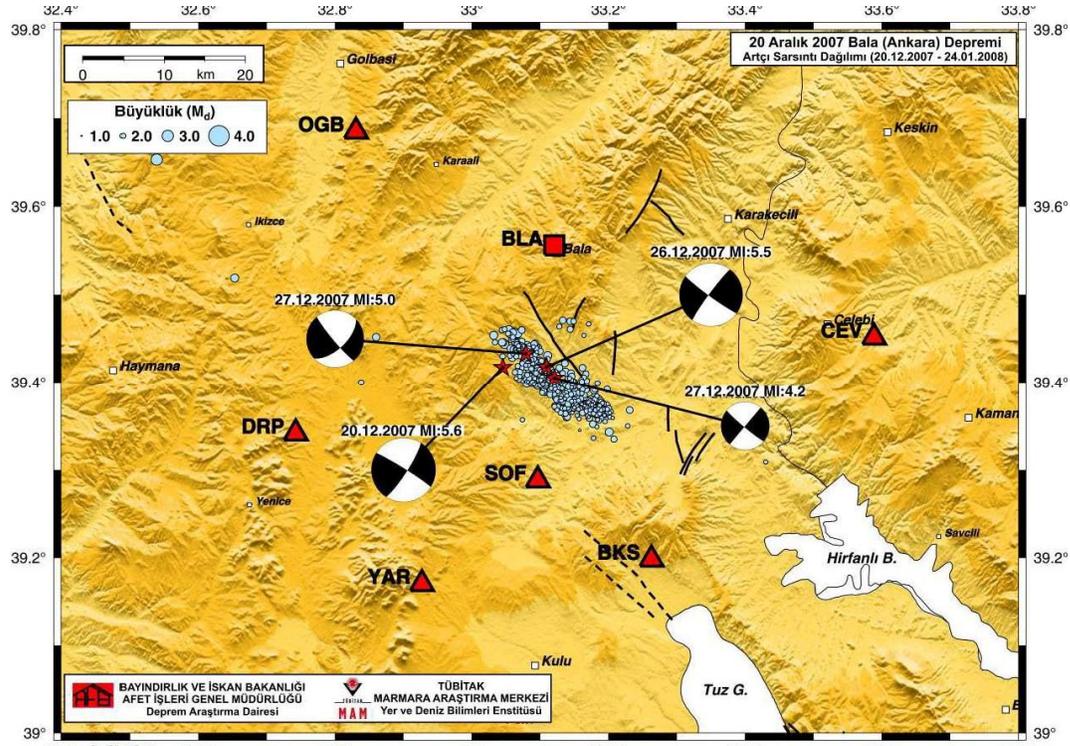
**Fig. 1.** The Location of the portable aftershock stations and the Aftershock distribution of Bala earthquake in the period of December 21-28, 2007. Fault plane solutions of the  $M_l > 5.0$  Earthquakes.



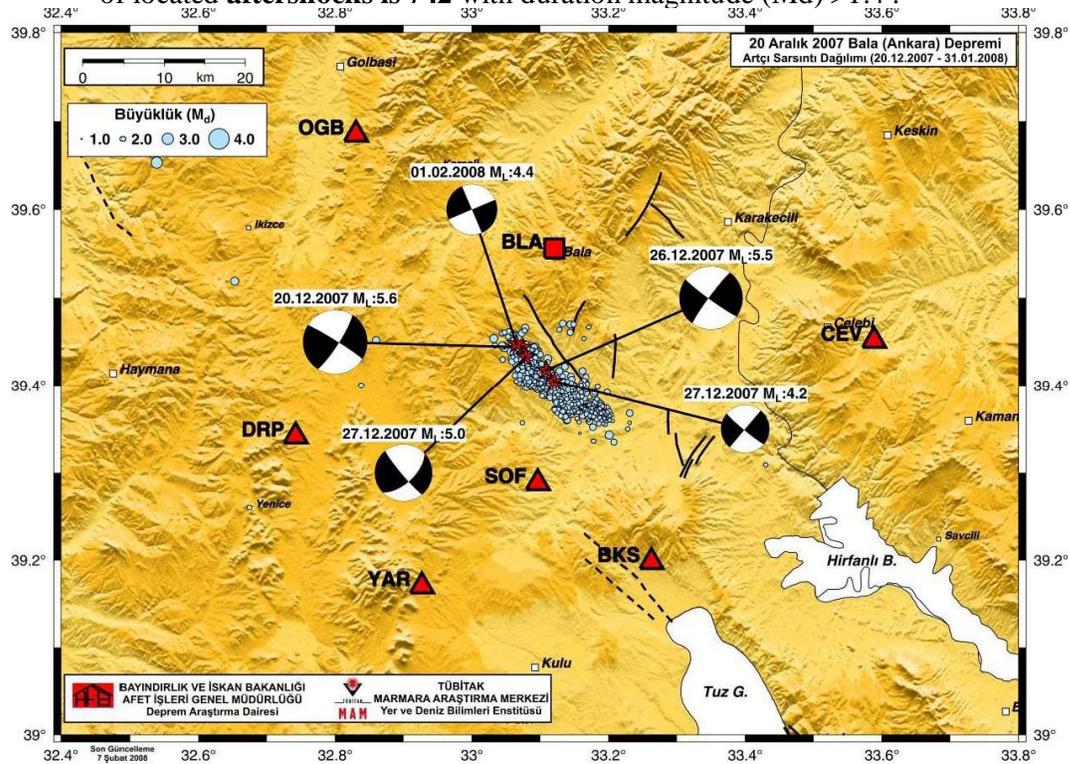
**Fig. 2.** Aftershock distribution of Bala earthquakes in the period of **December 21, 2007 and January 02, 2008**. Fault plane solutions of the  $M_I > 4.2$  Earthquakes. Number of located aftershocks is 433 with duration magnitude ( $M_d$ )  $> 1.4$ .



**Fig. 3.** Aftershock distribution of Bala earthquakes in the period of **December 21, 2007 and January 11, 2008**. Fault plane solutions of the  $M_I > 4.2$  Earthquakes. Number of located aftershocks is 589 with duration magnitude ( $M_d$ )  $> 1.4$ .



**Fig. 4.** Aftershock distribution of Bala earthquakes in the period of **December 21, 2007 and January 24, 2008**. Fault plane solutions of the  $M_l > 4.2$  Earthquakes. Number of located aftershocks is 742 with duration magnitude ( $M_d$ )  $> 1.4$ .



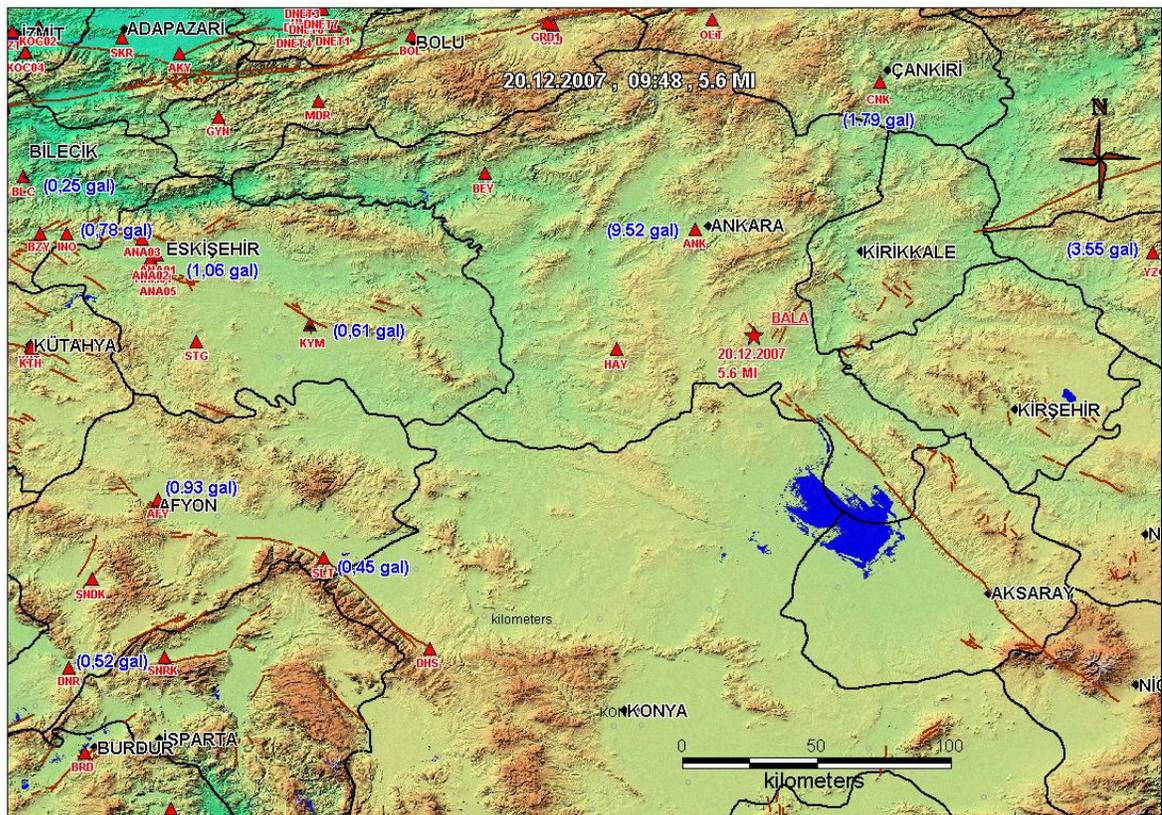
**Fig. 5.** Aftershock distribution of Bala earthquakes in the period of **December 21, 2007 and January 31, 2008**. Fault plane solutions of the  $M_l > 4.2$  Earthquakes. Number of located aftershocks is 785 with duration magnitude ( $M_d$ )  $> 1.4$ .

## STRONG MOTION RECORDS OF BALA EARTHQUAKES

Bala town where earthquake occurred is in the second degree earthquake zone according to the specifications for structures to be built in disaster areas. It is observed that recorded acceleration values are below the predominant acceleration values given in the mentioned specifications. When the damage distribution of region was investigated, 834 houses, 63 barns and 3 offices damaged heavily and 5 houses damaged moderately were found out. It is observed fairly much damage for a moderate shallow earthquake. This situation shows that the source of the damage is the construction method of the structures because they were not built appropriate to the specifications.

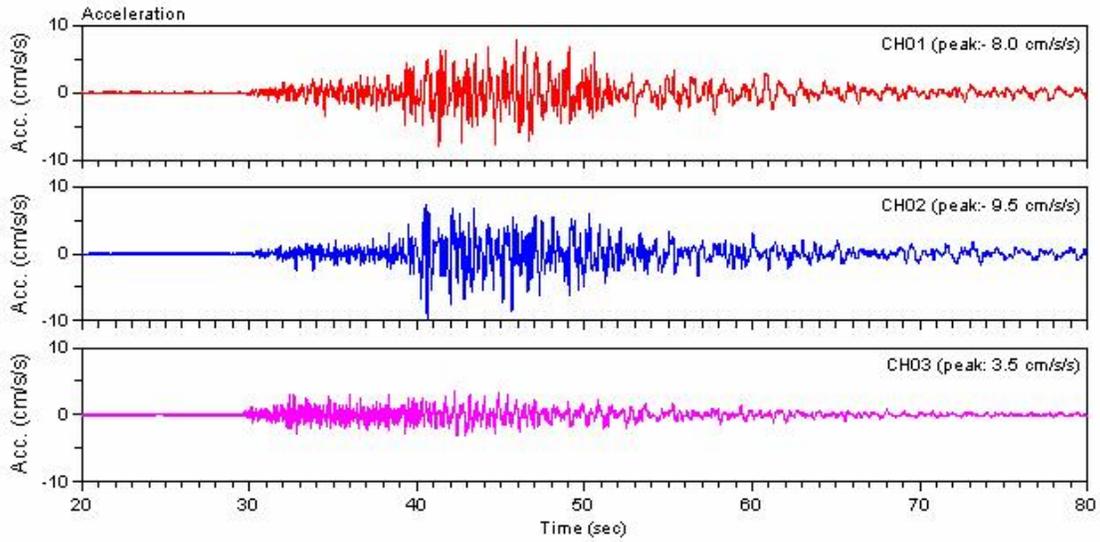
The recorded peak ground accelerations of the Bala Eq (Dec. 20, 2007, MI=5.6) given below:

20.12.2007_09:48, MI =5.6, Depth =2.8 km 39.417N633.0453E					
N-S gal	E-W gal	U-D gal	DIST. (km)	INST.	STA. CODE
7.95	9.52	3.48	60.06	VSE-355JE	ANK
3.55	3.24	1.33	157.28	VSE-355JE	YZG
1.55	1.79	1.41	139.93	VSE-355JE	CNK
0.93	0.77	0.24	225.34	CMG-5TD	AFY
0.96	1.06	0.45	220.01	CMG-5TD	ANA01
0.25	0.16	0.14	274.24	CMG-5TD	BLC
0.52	0.50	0.24	477.32	CMG-5TD	DNR
0.49	0.78	0.35	252.29	CMG-5TD	INO
0.61	0.43	0.31	160.69	CMG-5TD	KYM
0.44	0.39	0.45	185.00	CMG-5TD	SLT



**Fig. 6.** Distribution of the peak ground acceleration of the mainshock.

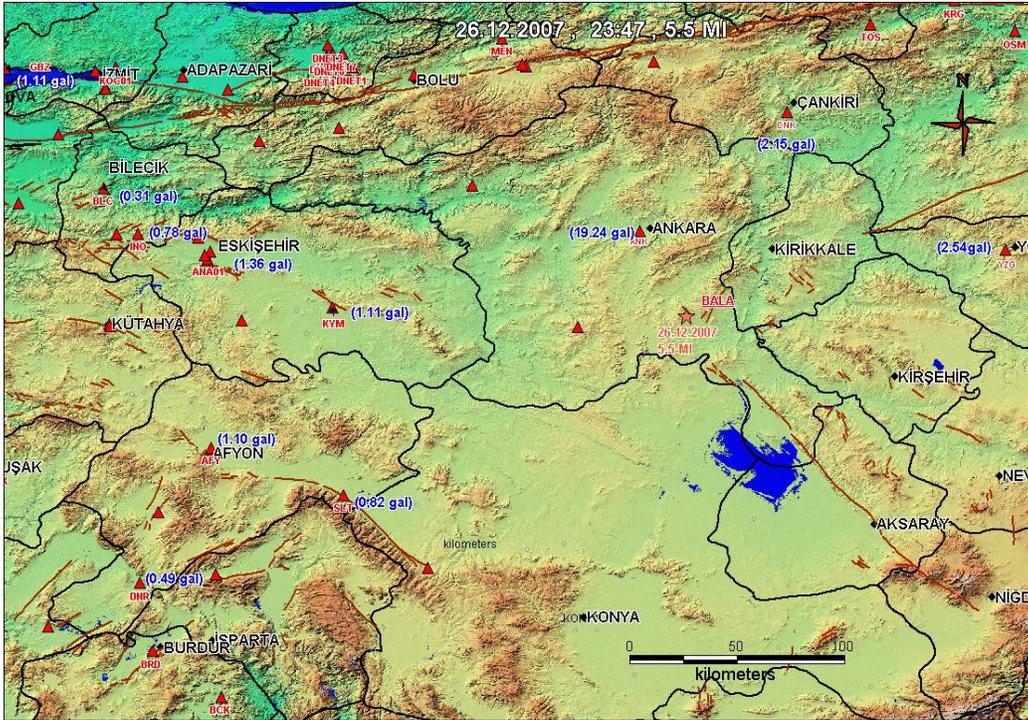
The Waveform record of the mainshock is shown below:



Earthquake was recorded by the nearest station Ankara (DAD) which is about 60 km from the epicenter and calculated effective time is  $t_{\text{eff}}= 29$  sec. for N-S component ,  $t_{\text{eff}}= 30$  sec for E-W component. The peak acceleration values recorded by Ankara Station (DAD) are given in the table bellow.

<b>DAD (20.12.2007_09:48, MI =5.6)</b>		
<b>Component</b>	<b>PeakAcc</b>	<b>Effective Duration</b>
N-S	-8.0	28.48
E-W	-9.5	29.93
U-D	3.5	30.76

## ACCELERATION DISTRIBUTION OF THE BIGGEST AFTERSHOCK



**Fig . 7.** Distribution of the peak ground acceleration of biggest aftershock

<b>26.12.2007_23:47, MI =5.5, Depth =5.7 km, 39.403N-33.101E</b>					
<b>N-S gal</b>	<b>E-W gal</b>	<b>U-D gal</b>	<b>DIST. (km)</b>	<b>INST.</b>	<b>CODE</b>
19.24	18.29	5.78	63.6	VSE-355JE	ANK
2.54	2.34	1.20	153	VSE-355JE	YZG
2.15	1.77	1.26	140	VSE-355JE	CNK
1.03	1.10	0.40	229	CMG-5TD	AFY
0.16	0.11	0.11	166	CMG-5TD	GBZ
0.77	0.87	0.32	188	CMG-5TD	KLS
1.28	1.36	0.86	225	CMG-5TD	ANA01
0.31	0.30	0.31	279	CMG-5TD	BLC
0.49	0.45	0.22	472	CMG-5TD	DNR
0.66	0.82	0.31	188.3	CMG-5TD	SLT
1.11	0.78	0.50	166	CMG-5TD	KYM

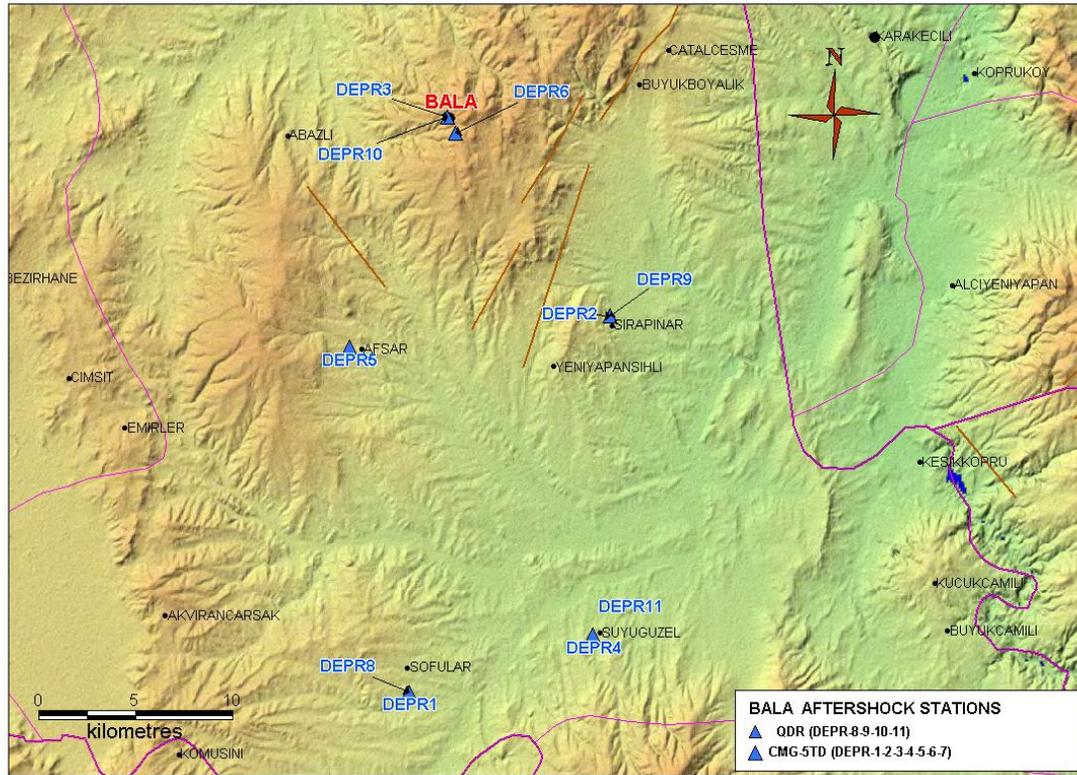
Earthquake has been recorded by the nearest station Ankara (DAD) which is about 63.6 km. from the epicenter and calculated effective time is  $t_{eff} = 20$  sec. for N-S component,  $t_{eff} = 20$  sec for E-W component. The peak acceleration values recorded by Ankara Station (DAD) are given in the table below.

<b>DAD (26.12.2007_23:47, MI =5.5)</b>		
<b>Component</b>	<b>PeakAcc</b>	<b>Effective Duration</b>
N-S	-19.2	19.54
E-W	18.3	19.65
U-D	5.8	26.53

## INSTALLED STRONG MOTION STATIONS FOR BALA EARTHQUAKES

After Bala Earthquake 11 temporary instruments (at 5 different locations) have been installed to record ground accelerations of aftershocks to the surrounding area:

CODE	LOCAL NAME	LAT.	LONG.	INST.
DEPR1	SOFULAR VILLAGE FEED FACTORY	39.2884	33.0964	CMG-5TD
DEPR2	SIRAPINAR VILLAGE DAIRY BUILDING	39.4634	33.2173	CMG-5TD
DEPR3	OLD GARAGE OF THE BUILDING OF HEAD OFFICIAL OF THE DISTRICT	39.5561	33.1198	CMG-5TD
DEPR4	SUYUGUZEL VILLAGE MOSQUE HOUSE	39.3152	33.2060	CMG-5TD
DEPR5	AF AR TOWN, HOUSE OF THE HEAD OF TOWN	39.4526	33.7188	CMG-5TD
DEPR6	BALA STUDENT DORMITORY, BASEMENT	39.5485	33.1247	CMG-5TD
DEPR8	SOFULAR VILLAGE FEED FACTORY	39.2884	33.0964	QDR
DEPR9	SIRAPINAR VILLAGE DAIRY BUILDING	39.4634	33.2173	QDR
DEPR10	OLD GARAGE OF THE BUILDING OF HEAD OFFICIAL OF THE DISTRICT	39.5561	33.1198	QDR
DEPR11	SUYUGUZEL VILLAGE MOSQUE HOUSE	39.3152	33.2060	QDR
DAD	ANKARA DDA- BUILDING, BASEMENT	39.9081	32.7530	CMG-5TD
DAD1	ANKARA DDA- BUILDING, BASEMENT	39.9081	32.7530	CMG-5TD



**Fig. 8. DEPAR Project Strong Motion Stations for BALA earthquakes.**

The aftershock 27.12.2007_ 07:47, Md=4.7, depth= 7.3 km, 39.448N-33.069E					
N-S gal	E-W gal	U-D gal	DIST. (km)	INST.	CODE
2.19	2.08	0.87	60.05	VSE-355JE	ANK
0.23	0.28	0.21	157.27	VSE-355JE	YZG
0.23	0.19	0.21	139.93	VSE-355JE	CNK

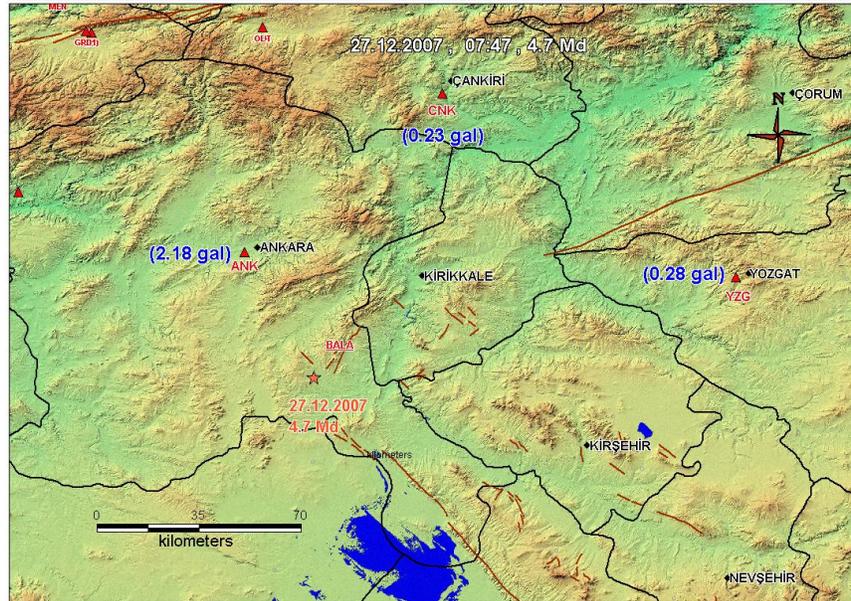


Fig. 9. Peak accelerations of the aftershock 27.12.2007\_ 07:47

The aftershock 27.12.2007_13:47, MI=5.0, Depth= 8.2 km, 39.454N-33.041E					
N-S gal	E-W gal	U-D gal	DIST. (km)	INST.	CODE
118.2	71.2	45.29	15.5	QDR	DEPR-9
26.93	25.30	16.58	13.21	QDR	DEPR-10
2.08	1.69	0.85	56.18	CMG-3T	DAD

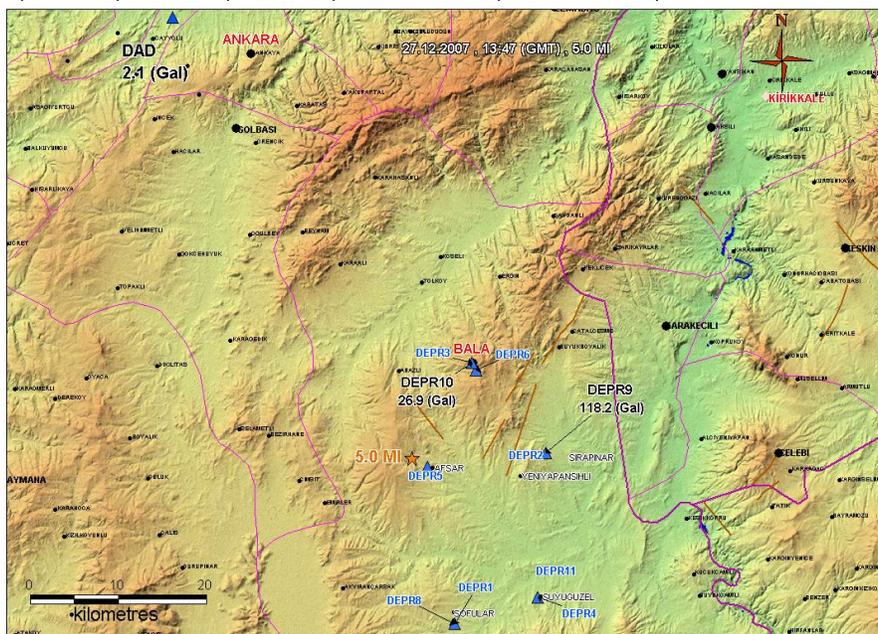


Fig. 10. Peak accelerations of the aftershock 27.12.2007\_13:47

The aftershock 27.12.2007_17:56, MI=4.4, Depth= 6.2 km, 39.279N-33.012E					
N-S gal	E-W gal	U-D gal	DIST. (km)	INST.	CODE
27.49	19.05	16.42	27.09	QDR	DEPR-9
20.34	14.89	15.61	7.30	CMG-5TD	DEPR-1
16.50	14.38	10.37	7.38	QDR	DEPR-8
0.95	0.61	0.27	47.74	CMG-3T	DAD

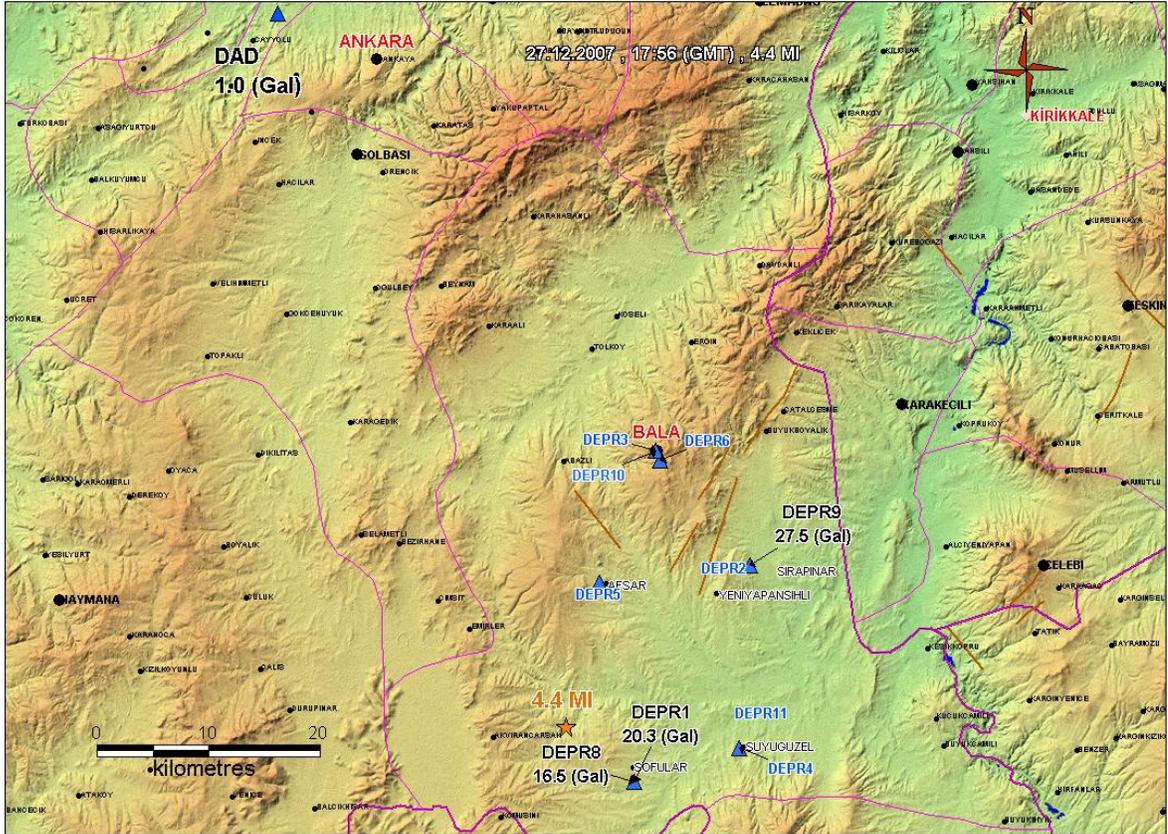


Fig. 11. Peak accelerations of the aftershock 27.12.2007\_17:56

The aftershock 04.01.2008_05:03, Md=3.8, Depth= 7.0 km 39.306N-33.231E					
N-S gal	E-W gal	U-D gal	DIST.(km)	INST.	CODE
145.3	102.2	48.84	72.87	QDR	DEPR-11
99.01	192.3	51.25	2.39	CMG-5TD	DEPR-1
85.13	157.6	35.96	11.86	QDR	DEPR-8
35.26	27.45	18.67	11.78	CMG-5TD	DEPR-2
38.59	22.52	17.58	17.41	QDR	DEPR-9
8.47	6.59	10.43	17.53	CMG-5TD	DEPR-5
4.81	6.32	9.56	44.81	CMG-5TD	DEPR-7
2.89	2.58	3.24	28.37	CMG-5TD	DEPR-6
0.33	0.36	0.17	78.43	CMG-3T	DAD

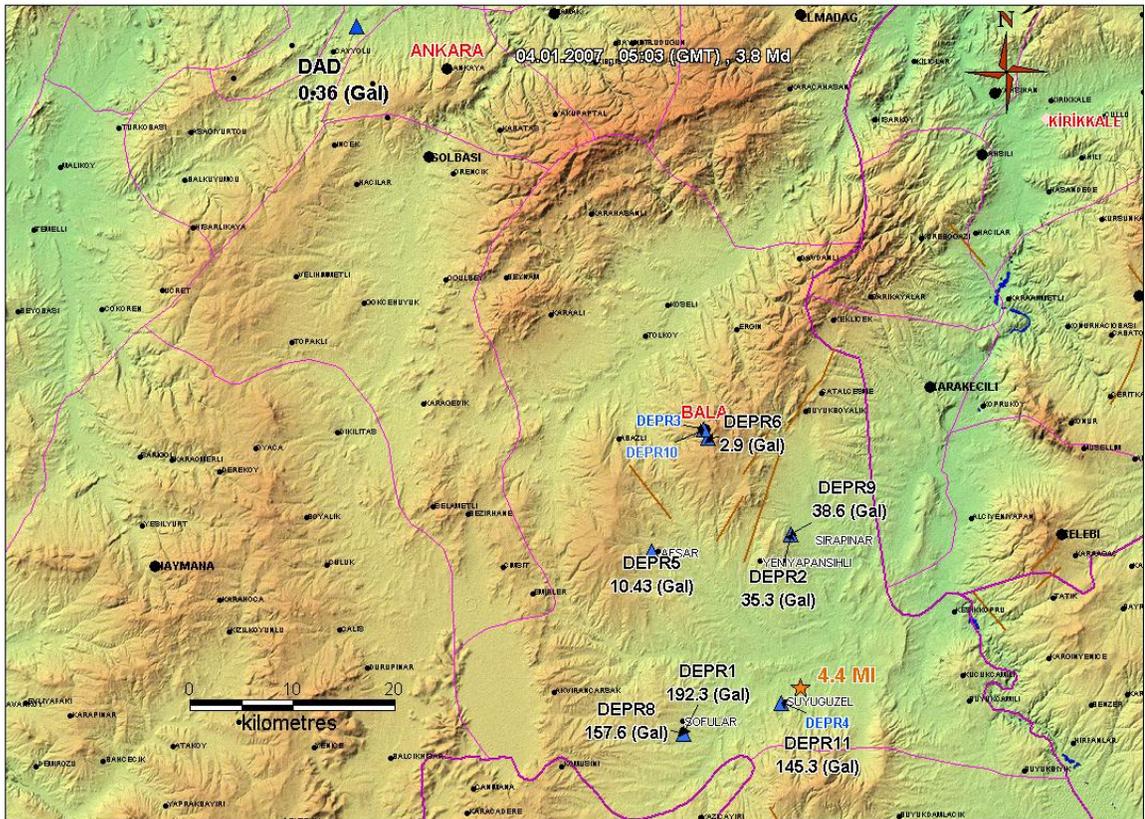


Fig. 12. Peak accelerations of the aftershock 04.01.2008\_05:03.

The aftershock 07.01.2008_18:26, MI=4.1, Depth= 7.7 km, 39.425N-33.109E					
N-S gal	E-W gal	U-D gal	DIST. (km)	INST.	CODE
25.02	16.45	12.86	10.19	CMG-5TD	DEPR-2
24.35	15.83	9.10	10.24	QDR	DEPR-9
14.74	9.43	11.19	13.74	CMG-5TD	DEPR-7
6.65	12.10	5.28	14.59	CMG-5TD	DEPR-3
8.03	5.20	3.71	13.74	CMG-5TD	DEPR-6
6.92	9.49	5.76	14.60	QDR	DEPR-10
5.00	3.96	11.45	15.27	QDR	DEPR-8
3.76	3.30	11.33	15.27	CMG-5TD	DEPR-1
0.39	0.26	0.26	61.75	CMG-5TD	DAD1
0.38	0.26	0.25	61.75	CMG-3T	DAD

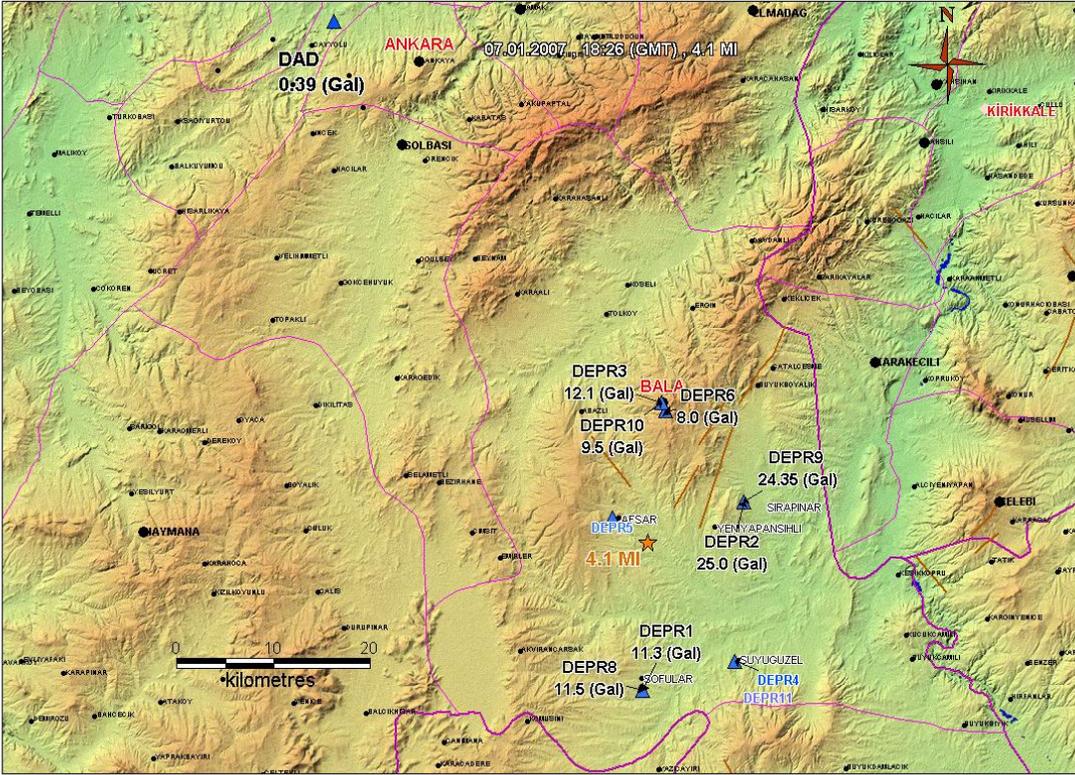


Fig. 13. Peak accelerations of the aftershock 07.01.2008\_18:26

## **ACKNOWLEDGEMENTS**

The region where earthquakes occurred is known as Central Anatolian deformation Zone and active secondary fractures exist in this area. During the earthquakes of December 20 (MI=5.6) and December 27 (MI=5.5) an active fault line in the length of 15 km extending in the NW-SE direction with right lateral strike-slip characteristics has been observed. This active fault exists in fault systems with the lengths between 5-20 km and in the NE-SW and NW-SE directions.

Updated and more detail info about the Bala-Ankara Earthquakes available at the web site <http://sismo.deprem.gov.tr> and <http://www.ydbye.mam.gov.tr> . Strong motion records of Bala Earthquakes can be find at <http://angora.deprem.gov.tr>.