REASSESSMENT OF FIFTY YEARS OF SEISMICITY IN SIMAV-GEDIZ GRABENS (WESTERN TURKEY), BASED ON CALIBRATED EARTHQUAKE RELOCATIONS

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Western Turkey is a rapidly deforming continental region with a long history of large normal faulting earthquakes. However, the locations and slip rates of the responsible faults are poorly constrained. Here, we reassess a series of large earthquakes in the Simav-Gediz region, an area exhibiting a strong E-W gradient in N-S extension rates, from low rates bordering the Anatolian Plateau to much higher rates in the west. We start by investigating a recent Mw = 5.9 earthquake at Simav (19 May 2011) using Synthetic Aperture Radar Interferometry (InSAR), teleseismic body-waveform modeling and field observations. This event provided the impetus to reassess older instrumental events in the region using a calibrated earthquake relocation method which is based on the hypocentroidal decomposition (HD) method for multiple event relocation (*Jordan & Sverdrup,*1981; *Bergman & Solomon,* 1990; *Walker et al.*, 2011). Of particular interest to us are the Mw ~7.1 Gediz earthquake of 28 March 1970, which remains the largest instrumentally-recorded event in western Turkey, and the Mw ~5.9 Demirci earthquakes of 23 and 25 March 1969. These improved locations in turn provide an opportunity to reassess the regional tectonics. One interesting aspect of these earthquakes is that the largest (the Mw 7.2 Gediz earthquake, March 1970) occurred in an area of slow extension and indistinct surface faulting, while the well-defined and more rapidly extending Simav graben is associated with several smaller, Demirci events (Mw 5-5.9).

We divided the seismicity of our study area into three subregions according to the events' temporal and spatial variation: (Figure 1): (1) Simav sequence which includes the Mw 5.9 event and its aftershocks in the eastern Simav depression (2) Gediz sequence with the Mw 7.2 event near Gediz, in the eastern part of our study area, (3) Demirci sequence starting in 1969 in the western Simav depression, with magnitudes as high as Mw 5.9.

Body-waveform modeling of the Simav earthquake suggests a normal faulting mechanism with a strike of 289°, dip of 54° and a centroid depth of 8 km. This information is complemented with the InSAR data (Figure 2) and calibrated earthquake relocations, which altogether suggests that the north-dipping Simav fault (Figure 1) has slipped during this event. The Demirci earthquakes, on the other hand, occurred on the western end of the Simav graben and our relocations hint that the mainshock and the large aftershocks ruptured the south-dipping faults on the northern side of the Simavgraben. Our calibrated location for the Mw~7.2 Gediz earthquake is situated 14 km southwest of its previous location (ISC) and is now more consistent with the mapped L-shaped surface rupture (Ambraseys and Tchalenko, 1972). Aftershock epicenters are concentrated on the E-W leg of the surface rupture (Figure 1) and agree well with previous seismological and geological observations (e.g. Eyidogan and Jackson, 1985).

The HD method can estimate focal depths if enough data are available at close epicentral distances. In this study we initially determined a cluster depth that minimizes the trade-off between the available arrival times and the predicted travel times. This cluster depth is kept fixed for all the events in the cluster until the events in the cluster are stable and arrival data fits well to the theoretical data. Then, a free depth solution is performed for the events that have enough Pg and Sg data. Free depth solution determines the depths using direct phase arrivals for all the events in the cluster. However, our data sets include old earthquakes from 1970s and availability of near source data varies greatly through time. Therefore, focal depth determination for some events is done manually, using only near-source readings. This analysis revealed hypocentroid depths of 9-22 km (Figure1) with an error of 3km.

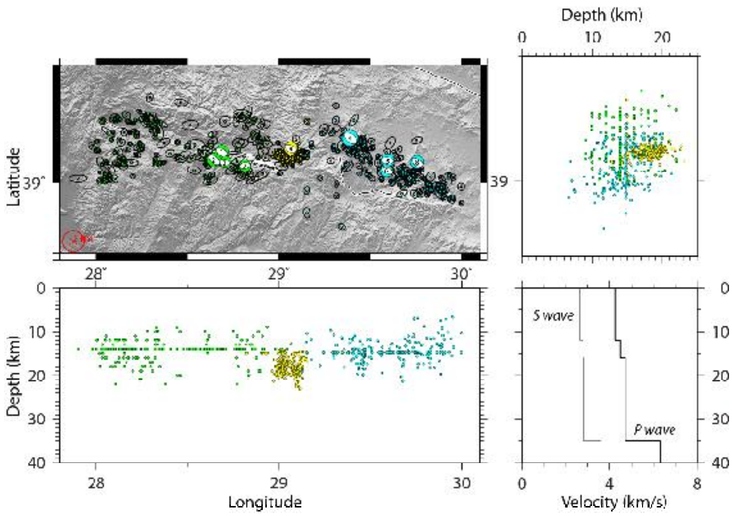

Figure 1. Earthquake locations after relocation for Demirci, Simav and Gediz clusters, indicated by green, yellow and magenta respectively. Velocity model obtained during the relocation process is shown in the lower left panel. See Table 1 for the focal mechanism information

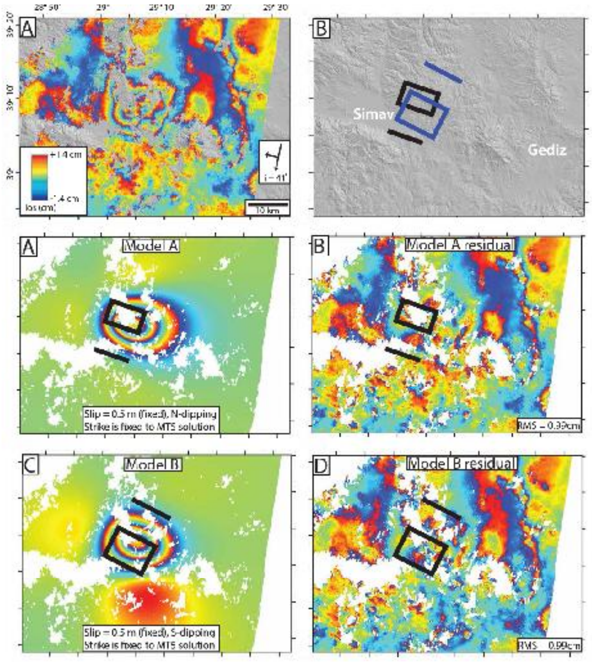

Figure 2. Observed, model and residual interferograms for the 19 May 2011 earthquake (Mw = 5.8)

Table 1. Focal mechanism parameters of the earthquakes shown in Figure 1. Data is taken from body-waveform modelling or the Global Centroid Moment Tensor (GCMT) or National Earthquake Information Center (NEIC) catalogs

No.	Date	Time	Long.	Lat.	Mw	Strike	Dip	Rake	Cluster
1	1969.03.23	21:08:43	28.49	39.124	5.9	296	54	-92	Demirci
2	1969.03.25	13:21:32	28.467	39.199	6	307	44	-96	Demirci
3	1969.04.30	20:20:32	28.553	39.14	5.1	78	39	-114	Demirci
4	1970.03.28	21:02:23	29.545	39.175	7.1	304	41	-87	Gediz
5	1970.04.16	10:42:18	29.914	39.003	5.6	283	38	-102	Gediz
6	1970.04.19	13:29:36	29.772	38.992	5.9	278	50	-87	Gediz
7	1970.04.23	9:01:24	28.676	39.13	5.2	77	50	-96	Demirci
8	1971.05.25	5:43:27	29.73	39.029	5.9	297	51	-102	Gediz
9	2011.05.19	20:15:23	29.124	39.115	6	285	60	-90	Simav

REFERENCES

Ambraseys N and Tchalenko JS (1972) Seismotectonic aspect of the Gediz, Turkey, earthquake of March 1972: Geophysical Journal of the Royal Astronomical Society, 30: 229–252

Bergman EA and Solomon SC (1990) Earthquake swarms on the Mid-Atlantic Ridge - Products of magmatism or extensional tectonics?, Journal of Geophysical Research, 95, p. 4943

Eyidoğan H and Jackson J (1985) A seismological study of normal faulting in the Demirci, Alaşehir and Gediz earthquakes of 1969–70 in western Turkey: implications for the nature and geometry of deformation in the continental crust, Geophysical Journal International, 81(3): 569-607

Jordan TH and Sverdrup KA (1981) Teleseismic location techniques and their application to earthquake clusters in the South-Central Pacific, Bulletin of the Seismological Society of America, 71(4): 1105–1130

Walker RT, Bergman EA, Szeliga W and Fielding EJ (2011) Insights into the 1968-1997 Dasht-e-Bayaz and Zirkuh earthquake sequences, eastern Iran, from calibrated relocations, InSAR and high-resolution satellite imagery: Geophysical Journal International doi: 10.1111/j.1365-246.2011.05213