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The Simav Graben: An Example of Young E-W Trending Structures in the Late Cenozoic Extensional System of Western Turkey

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Abstract: The Simav graben is a Pliocene(?)-Quaternary structure which clearly cuts the NE-SW trending Demirci, Selendi and Akdere basins. The south side of the graben is bounded by the north dipping Simav fault. Corrected epicentre locations and fault-plane solutions of the 1969.3.23 Demirci earthquake demonstrate that the Simav fault was recently active and has a listric shape. The graben is regarded as one of the latest products of N-S extensional tectonics which began to affect the Aegean region in latest Oligocene-early Miocene times.

Simav Grabeni: Batı Türkiye'nin Geç Senozoyik Genişlemeli Sisteminde Genç D-B Gidişli Yapılara Bir Örnek

Özet: D-B gidişli Simav grabeni bir Pliyosen(?) - Kuvaterner yapı olup, KD-GB gidişli Demirci, Selendi ve Akdere havzalarını keser konumdadır. Grabenin güney kenarı kuzeye eğimli Simav fayı tarafından sınırlanmıştır. 1969.3.23 Demirci depremine ait fay mekanizması çözümlerinin düzeltilmiş lokasyonları Simav fayının aktif ve listrik şekilli bir fay olduğunu göstermektedir. Bu graben en geç Oligosen - erken Miyosen'de Ege'yi etkilemeye başlayan K-G genişlemeli tektoniğin en son ürünlerinden biri olarak değerlendirilmektedir.

Introduction

In western Turkey, there are three prominent approximately E-W trending grabens. The Alaşehir and Büyük Menderes grabens are better studied than the Simav graben (see Fig. 1-inset). The Simav graben is located to the north of NE-SW trending Demirci and Selendi basins and shows a WNW-ESE trend between Söğütçük and Simav town. Here the graben has a distinct topographical expression, with approximately 1100m of elevation separating the rift shoulders from the basin. Further to the north lies a NE-SW trending depression called the Akdere basin. This basin is located between Akdağ and Katrandağ and joins the WNW-ESE trending Simav graben at a high angle (Fig. 1).

An early study of the region by Zeschke (1954) produced an introduction to the characteristic lithologies found within the graben. MTA reports by Akdeniz and Konak (1979) divided their investigation area into separate basins, but established a broadly similar stratigraphy throughout the region. This Neogene stratigraphy begins with Miocene conglomerates and sandstones (Taşbaşı formation) which are overlain by alternations of marl and marly limestone (Kızılbük formation). Agglomerate and volcanic units are called the Civandağ tuffs and Akdağ volcanics respectively. According to Akdeniz and Konak (1979) the Pliocene is represented by sandstones and marls of the Hisarcık formation and lacustrine limestones of Emet formation. Quaternary rocks of the Toklargölü formation and the Naşa volcanics constitute the uppermost part of the Neogene succession.

Konak (1979) suggested that the Simav fault was active since early Miocene and determined it as right lateral strike-slip fault with a post-late Miocene displacement of 6km based on offset of metamorphic zones east of Simav (Konak 1982).

Eyidoğan and Jackson (1985) reported that the north and south sides of the Simav graben are bounded by faults and proposed that the northern fault is presently dominant. This was proposed because of the northward tilting valley floor and location of axial drainage at the northern side of the basin. However, Westaway (1990) argued that the major normal fault is located to the south side because of the southerly dip of Neogene sediments in the basin.

This paper especially focus on the tectono-sedimentary development of Simav graben and its geological relationship with NE-SW trending basins (Fig. 1).

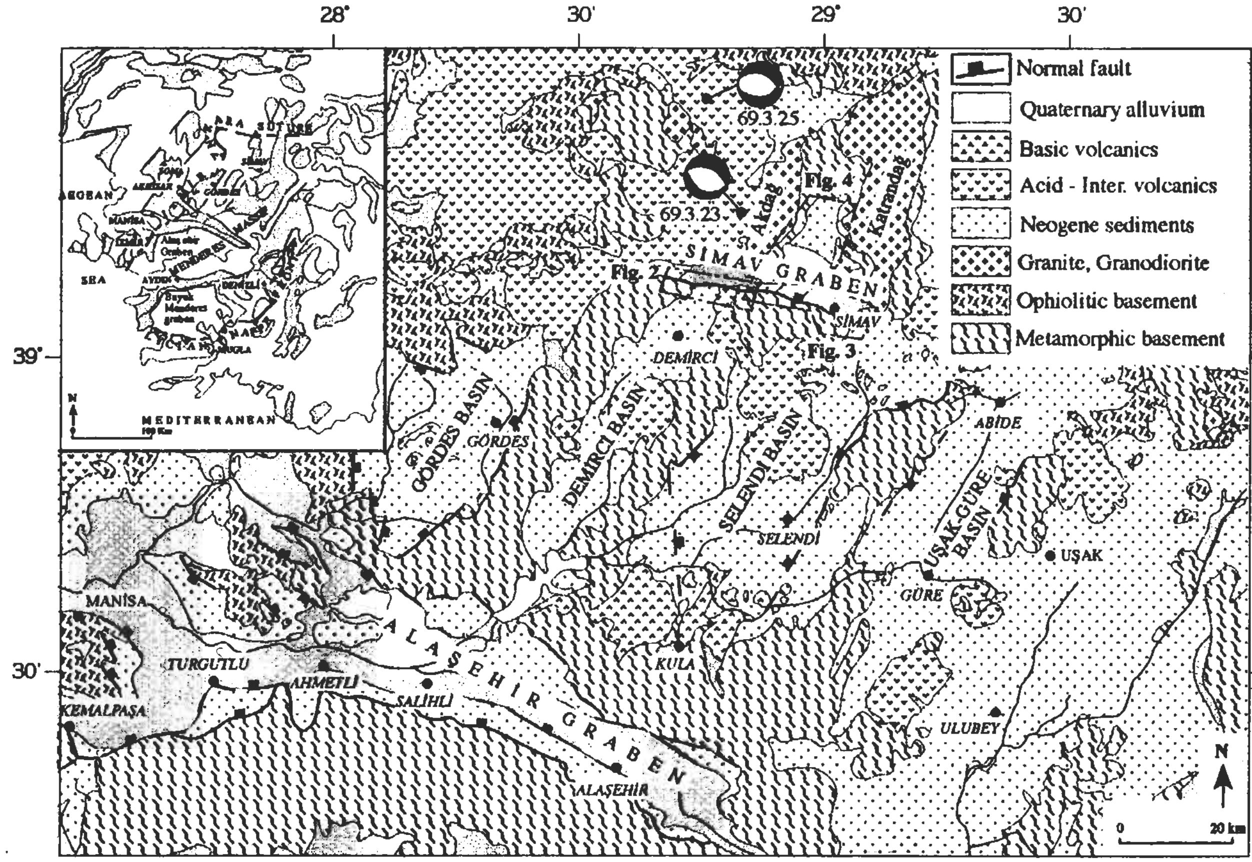

Figure 1. General location map of Simav graben.
(Modified from the Geological map of Turkey-Izmir [1/500.000] by using the fault traces from Arpat & Bingöl 1969; Akdeniz &Konak 1979; Seyitoğlu & Scott 1994, 1996; Hetzel et al. 1995; Seyitoğlu 1997. Fault mechanism solutions from Eyidoğan & Jackson, 1985 and its locations from Eyidoğan 1988).

Western Part of Simav Graben and Northern Sector of Demirci Basin

The western sector of Simav graben is located between Söğütçük and Ahmetli (Fig. 2). The graben bounding Simav fault has a normal sense with a negligible oblique slip component (SW of Yeniköy). The fault shows an E-W trend and a 65°-70° dip towards the north at outcrop. The trace of the fault on topography gives an average dip of 45°-50°. An approximately 90° change in fault trend east of Söğütçük is attributed to a N-trending accommodation fault (Fig. 2). The graben-bounding Simav fault can easily be followed to the south of Ahmetli and Yeniköy where unlithified boulder conglomerates and coarse sandstones form a contact with metamorphic basement rocks. However, south of Hacıhüseyinefendi and Hisarbey, the sedimentary units of Demirci basin become the footwall to the Simav fault which becomes difficult to trace due to the similar lithologies both hangingwall and footwall. At this location the only criteria for differentiation between the hangingwall and footwall lithologies is degree of lithification. Boulder conglomerates of the Demirci basin are very well lithified relative to that of the Simav graben. In the Demirci basin, very angular, well lithified, boulder conglomerates which are derived from metamorphic rocks, pass into coarse sandstone and yellowish sandstone/mudstone alternations within a short vertical distance (~10m). This immediate fining upward sequence may mislead researchers who observe only this relatively fine sedimentary unit on the surface without seeing the underlying angular boulder conglomerates near the basement contact and they can come to conclusion that the unit took its position after the faulting of a wider single basin. A similar lithology is examined under the title of Hacıbekir group in Selendi and Uşak-Güre basins (Seyitoğlu, 1997 after Ercan et al., 1978; 1983).

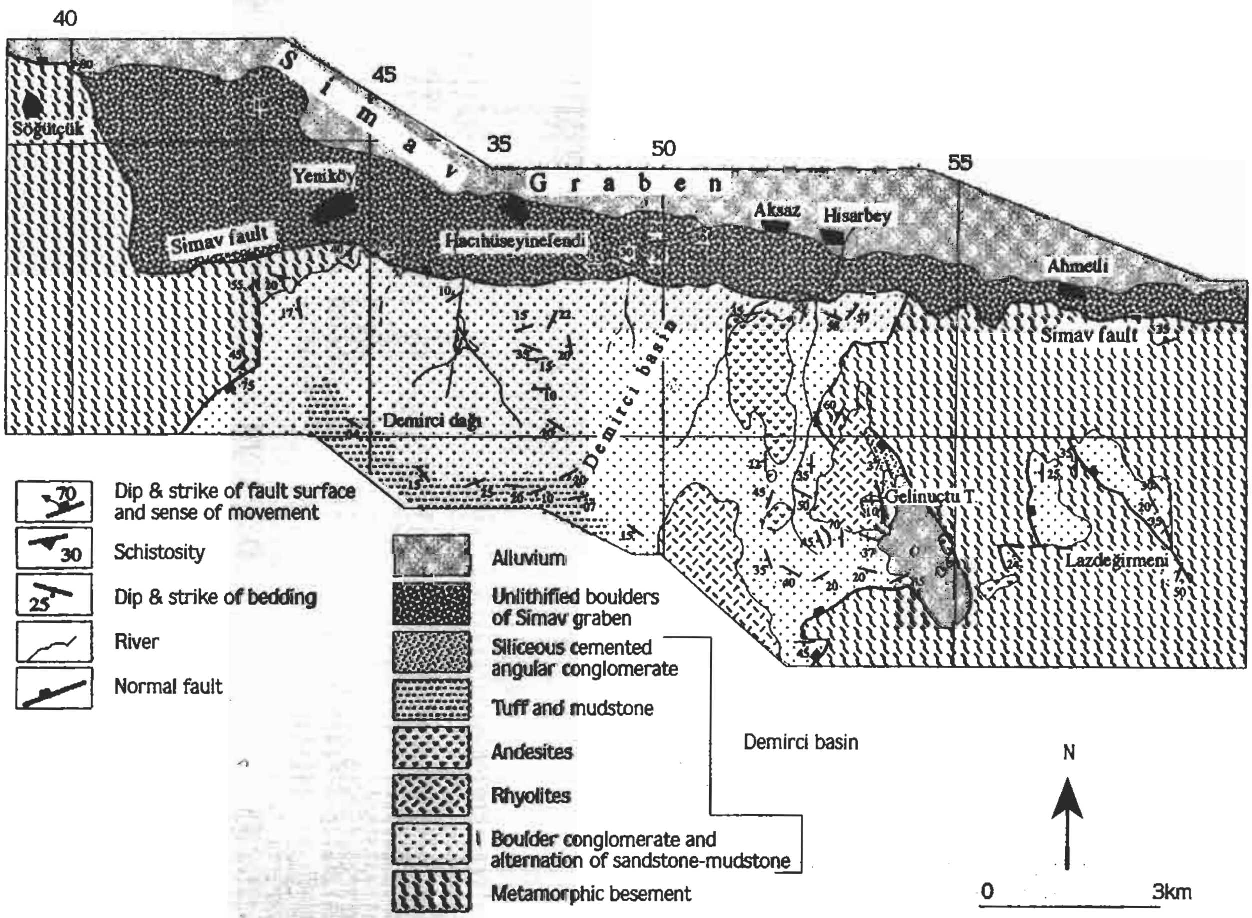

Figure 2. Geological map of western Simav graben (Modified from Akdeniz &Konak 1979).

Alternations of tuff and mudstone are observed in the upper levels of the Demirci basin fill. In the NE-part, rhyolitic-andesitic volcanic rocks cut the lower part of Demirci basin fill, and at Gelinuçtu Tepe a rhyolite dome occurs which is overlain by siliceous cemented clastics (Fig. 2). Generally, in western Turkey acidic-intermediate volcanism developed during early Miocene times (Yılmaz, 1989; Seyitoğlu & Scott, 1992a; Seyitoğlu et al., 1997) therefore age of the lower part of the Demirci basin is also suggested to be early Miocene and the basin fill sediments probably continued to accumulate during middle Miocene times, as is found within the Selendi and Uşak-Güre basins (Seyitoğlu, 1997). South of Ahmetli, around Lazdeğirmeni, on the footwall of the Simav fault, yellowish sandstone and mudstone alternations dip to west and southwest, towards North and NW trending normal faults (Fig. 2). These Neogene successions are likely to belong to the Demirci and/or Selendi basin successions rather than the Simav graben. The graben bounding Simav fault clearly cuts the Demirci basin and is responsible for the accumulation of unlithified to semi-lithified boulder conglomerates and coarse sandstones which are observed between Söğütçük and Beyce (Fig. 2 & 3). This lateral accumulation of sediment pushed the location of axial Simav river towards the northern side of the graben (cf. Eyidoğan & Jackson, 1985, see above).

Eastern Part of Simav Graben and Northwestern Sector of Selendi Basin

In the eastern part of Simav graben the WNW-ESE trending Simav fault is dispersed in several branches that lie between Simav town and Simav dağı. Their continuation east is difficult to recognise due to sedimentary successions of the northern part of the Selendi basin (Fig. 3) masking differences between hangingwall and footwall rocks. Branches of the Simav

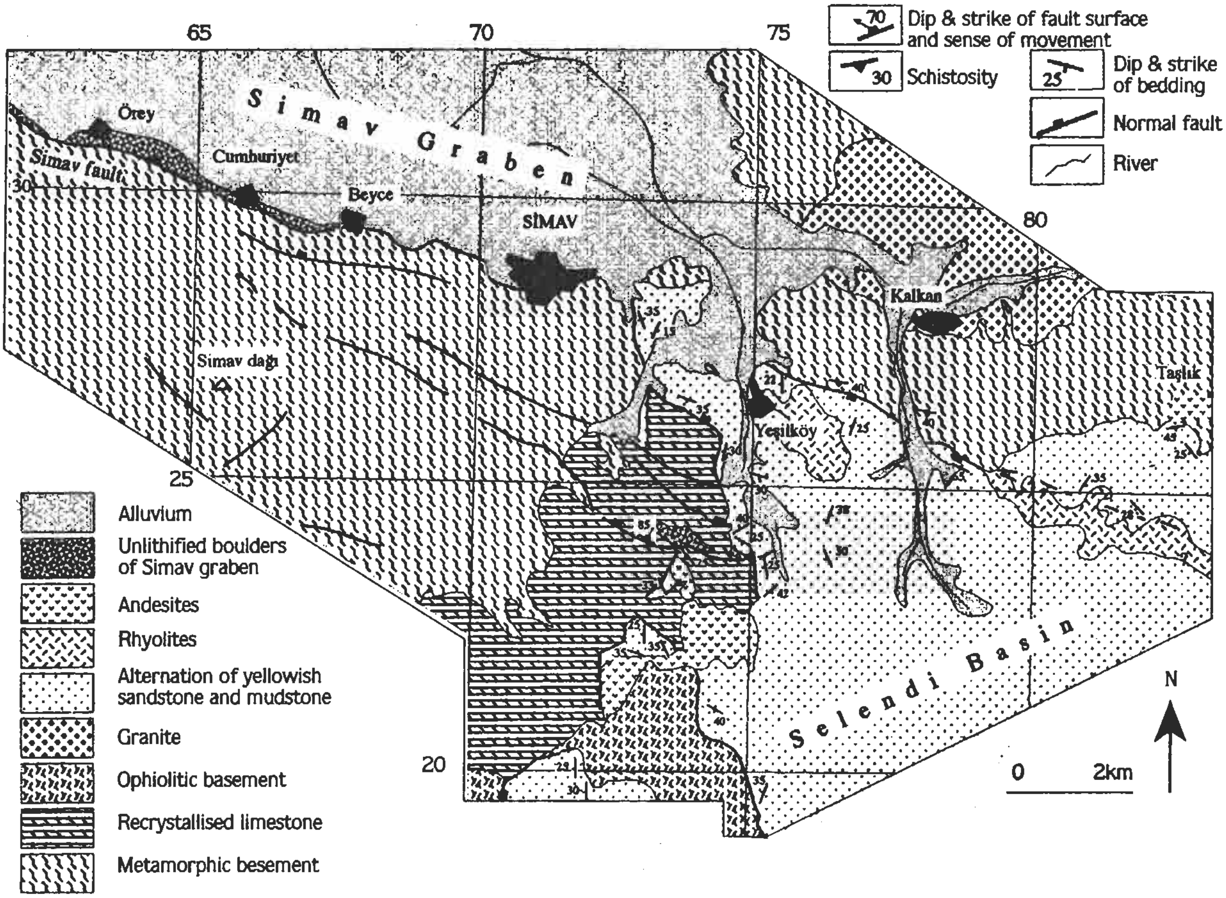

Figure 3. Geological map of eastern Simav graben (Modifed from Akdeniz & Konak 1979).

fault cut the early Miocene aged Hacıbekir group of the Selendi basin (Seyitoğlu, 1997). This group is composed of yellowish sandstone and mudstone alternations and is limited by a NNW-SSE trending fault to the west and a WNW-ESE trending normal fault to the north (Fig. 3). It is important to note that sedimentary layers within the Selendi basin dip, in the range of 30 to 60 degrees, towards these boundary faults in which rhyolitic volcanic rocks are emplaced probably during early Miocene times (see above; Fig. 3).

Northern Part of Simav Graben, Akdere Basin

The Akdere basin is located to the north of the Simav graben (Fig. 4). Its sedimentary deposits start with semi-lithified boulder conglomerates, coarse sandstones and continue with a white tuff unit. It passes up into pink granule conglomerates and sandstones that alternate with white tuffaceous layers. These rocks are covered by lava flows of the Naşa volcanics (basaltic trachyandesites: Seyitoğlu et al., 1997). The Akdere basin began to form as a symmetrical graben as both the western and eastern boundary faults are overlapped by later sediments and must thus have existed early in the basin's history (Fig. 4). To the west of Yeniler, the tuff unit overlaps the western basin bounding fault whilst on the eastern side between Yemişli and Eğirler, the granule conglomerates and sandstones of the upper part of the sedimentary succession overlap the eastern boundary fault (Fig. 4). These relationships demonstrate that the activity of the eastern boundary fault was longer than that of the western one. The overall sedimentary succession shows a general dip towards the east, towards the boundary fault. The sedimentary units of the Akdere basin are covered by Naşa volcanics between Naşa and Eğirler. The chemical composition of the Naşa volcanics is similar to the composition of volcanics from the Uşak-Güre basin which are dated as ~15 Ma in age (see Seyitoğlu et al., 1997). Recent isotopic ages from

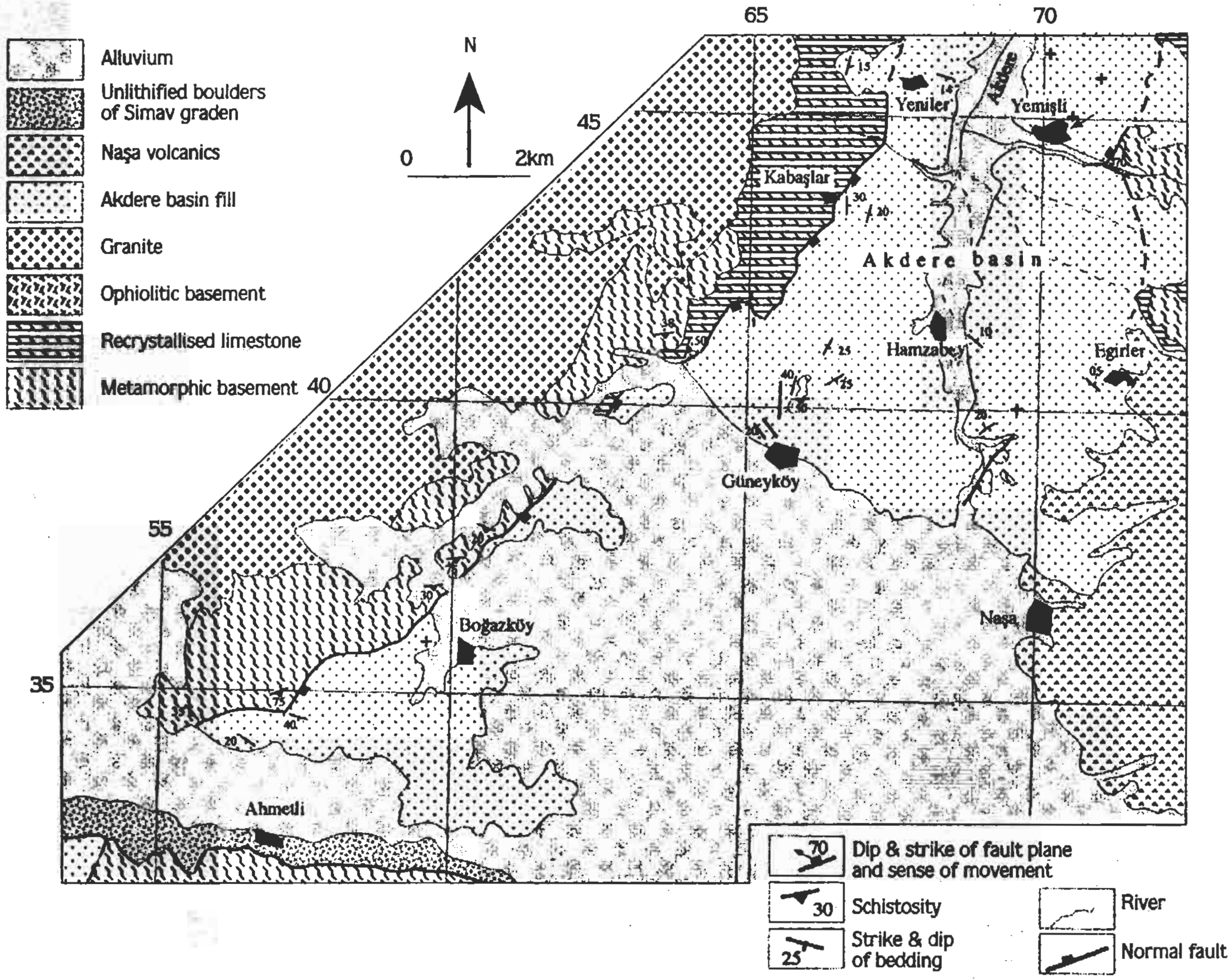

Figure 4. The geological map of NE-SW trending basin located to the north of Simav graben. (Modified from Akdeniz &Konak 1979).

the Naşa volcanics (15.8±0.3 Ma and 15.2±0.3 Ma: Ercan et al. 1996) confirm the correlation of the Akdere basin and the Uşak-Güre basin volcanics made by Seyitoğlu (1996). Therefore, the sedimentary succession within the Akdere basin is older than 15.8 Ma (early Miocene).

Discussion and Conclusion

Recent works in the E-W trending grabens of western Turkey suggest that Alaşehir and Büyük Menderes grabens start to develop during the early Miocene (Seyitoğlu & Scott, 1992b; 1996; Hetzel et al., 1995; Purvis & Robertson, 1997) which place the initiation of N-S extensional tectonics to the latest Oligocene-early Miocene period (Seyitoğlu et al., 1992). Studies on the NE-SW-trending basins, i.e. Gördes, Selendi and Uşak-Güre basins (Seyitoğlu & Scott, 1994; Seyitoğlu, 1997) demonstrate further that they start concominatly with the E-W trending grabens (Seyitoğlu & Scott, 1996).

The southern side of the Simav graben is marked by the north-dipping Simav fault which shows a normal sense of displacement, with negligible oblique slip. This fault clearly cuts the early Miocene Demirci, Selendi and Akdere basins. Graben fill associated with the major graben bounding Simav fault is composed dominantly of unlithified, semi-lithified boulder conglomerates.

Fault mechanism solutions of the 1969.3.23 Demirci earthquake and its 1969.3.25 aftershock are reported by Eyidoğan and Jackson (1985; Fig. 2). There is an inconsistency regarding location of these fault mechanism solutions and the coordinates given

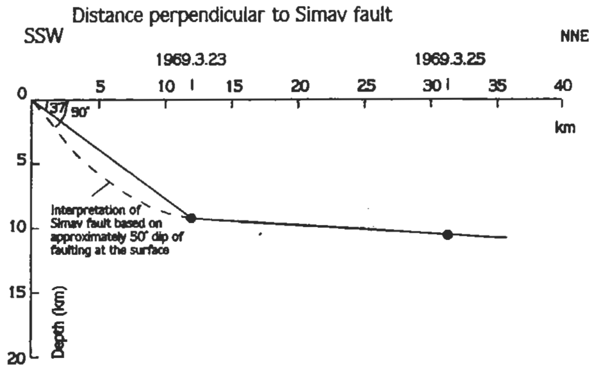

Figure 5. The shape of Simav fault based on Demirci earthquake following Eyidoğan & Jackson (1985).

by Eyidoğan (1988; tab. 1) which, in fact, clearly demonstrate that the epicentres are in the hangingwall of the Simav fault (Fig. 1). The Demirci earthquake is probably related to the north dipping Simav fault because the reported area of maximum damage (VI; Eyidoğan & Jackson, 1985) is in the Simav valley and apparent fresh fault surfaces can be observed south of Yeniköy and south of Yeşilköy to the west of Kıbletepe (Figs. 2 & 3). If the surface break of the 1969.3.23 Demirci earthquake occurred along the Simav fault, a similar approach to that of Eyidoğan and Jackson (1985) on the 1969.3.28 Alaşehir and the 1970.3.28 Gediz earthquakes can be applied here to determine the shape of Simav fault. Figure 5 demonstrates that Simav fault has a listric shape which flattens out at a depth of approximately 9 km. This interpretation creates further questions about how this presently active Simav fault is linked with the relatively old detachment system which is described by Işık et al. (1997).

The data documented above reveal that Simav graben is a Pliocene(?) - Quaternary tectonic feature and thus represents one of the latest products of the N-S extensional tectonics in western Turkey.

As pointed out in the discussion of Seyitoğlu (1997), it is to be expected that younger structures cut the older ones and the Simav graben forms an excellent example of this. This observation does not change the status of E-W trending Alaşehir, Büyük Menderes grabens and N-trending Gördes, Selendi and Uşak-Güre basins.

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