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Suture-parallel extension of Lake Van basin, Eastern Anatolia Accretionary Complex (EAAC), E-Turkey: An implication for the Highlands extensional paradigm

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Intra-plate "Highlands Tectonics" is not subduction-generated, at least in the sense of conventional plate-tectonic theory [1] and related magmatism is so concentrated along the spine of the highlands. The zone of alkaline magma generation is centered over the highest plateau region-strike to precisely parallel the spine of the collision-generated mountain belt and alkaline magmas apparently prefer to intrude weaknesses of the very highest parts, propagating into extensional interfaces. The concentration of magmatism along the axis of the highlands, and the highest part no less, should actually be expected [1]. Because of the tectonic importance placed on the suture complexes, some concepts of this feature are now warranted to clarify its geodynamic significance in Lake Van accretionary wedge basin, Eastern Anatolia Accretionary Complex (EAAC), E-Turkey (Fig. 1). This significance views that the focused magmatic belt in Lake Van basin block in EAAC was not generated by steady-state subduction of Arabian plate, but by slab delamination process [8], [4], [10] (Fig. 1a, b). This creates the alkaline source of basalts from intra-plate setting of E-Turkey and several geodynamic enigmas in and around Lake Van basin (Fig. 1c, d). Some models have been also proposed to explain the origin of the magmatism in the highlands [1] and in E-Turkey [10].

Slab delamination-induced events, controlling crustal deformation of accretionary orogeny, have strongly dominated in and around Lake Van region during Plio-Quaternary. Tectono-magmatic effects of these events on E-Turkey and the significance of crustal anisotropies are specifically emphasized by contributing to basin block fragmentation and separation of Lake Van during post-orogenic period (Fig. 1a, c). The surficial effects of slab delamination process are well expressed by anomalous structural development of Lake Van basin placed on the "Highlands" (Fig. 1a, c). The "Highlands" mean dome-shaped development of the highest elevation with 2 km centered on orogenesis, as referred to "Lake Van Dome" termed by [10]. This term specifically refers to the thinnest and hottest crustal section dynamically supported by doming hot asthenosphere, also recently termed as "squashy zone" by [10]. Doming hot asthenosphere directly underlies the lake and heating of the crust both conductively and from advection by rising magmas is at a maximum rate. The rock strength beneath the lake in the squashy zone is the lowest and seismicity is limited [7]. This study aims to interpret seismic reflection evidences of suture-parallel extension of an orogenic lake basin, providing an implication for the Highlands extensional paradigm in E-Turkey orogeny and thus, indicating the unusual rifting event in Lake Van Dome. Evaluation of extensional tectonic events in the lake considering seismic reflection data leads to conclude the following seismic structural observations.

Seismic structural analysis clearly gives some certain clues about extensional and strike-slip periods and tectonic intensity of extension, which controls depositional characteristics and structural architecture of lacustrine sequences in the lake. Overall sedimentation in Lake Van is strongly interrupted by alternating phases of strike-slip faults, major uplifting (erosion) and downlifting (subsidence) periods. Seismic structural interpretation shows that initial extensional and strike-/oblique-slip movements were concentrated in the highlands section of the Lake Van Dome. At this time, the crust directly overlies upwelling asthenosphere, and magma has advected much heat to very shallow depths, even into the sediments. Near the surface, the nature of strike-/oblique-slip motions in the highlands is strongly controlled by the local mechanical anisotropy of the upturned bedding and major high-angle fault zones. Magmas rise from lower crustal chambers or upper crustal pointed stocks commonly by passive intrusion into pull-apart pathways along extensional and strike-/oblique-slip faults in the lake. Concurrent faulting and intrusion had a profound effect on hydrothermal fluid flow and magma-sediment deformation. It is essential to add that, in a section of heterogeneous convergent crust (anisotropic media), extension-controlled magma propagation is concentrated in weak fault zones and along the lake margins that move. This is the case excellently recognized along suture-parallel S-margin of the lake, confirming that extensional magma flow is concentrated in pre-existing thrust or suture contacts, recently reactivated. Consideration of suture-parallel extension of Lake Van basin (S-margin) and its extensional boundary faults (W-margin), along with the structural complexity of its highest morphology may explain, to a certain degree, the post-collisional, intra-plate extensional observations and the derived faults.

Seismic reflection data across the lake, integrated with previous seismological studies presents the critical evidences of how extensional events can give a clue to both the Highlands extensional event and reactivation of accretionary basement beneath the lake. The extensional mechanisms effecting Lake Van suggets that, due to delamination, differential shearing movements from normal plate motions are concentrated into the hotter, basal part of the accretionary crust beneath the lake. In this case, the base of the crust should be thought of as a zone across which there is a large strain rate gradient anytime the crust and asthenosphere are moving with respect to one another. The contrast between asthenospheric flow directions and GPS velocity vectors in the lake [3] indicates that the upper crust is detached from the lower crust and behaves independently from below. Given the weakness of the very ductile lower crust beneath the lake, some degree of differential strain between different crustal layers is most likely [1]. All these mainly argue that deformation of crust is likely to be strongly influenced by both rheological (hot/weak accretionary crust) and mechanical layering (intra-crustal accretionary anisotropy). This has led to the suggestion that a weak lower crust may have undergone channel flow, while a brittle upper crust has undergone active deformation under the topographic load of the high plateau. Consideration of shear-wave splitting studies beneath Lake Van (see tomographic data in [3]) along with the mechanical complexities of accretionary crust gives an idea of Muş suture-parallel/oblique mantle flow pattern through dextral transtensional S-margin of lake, and thus effecting tectonic stability of accretionary wedge beneath the lake. It may be considered, at least for S-margin of Lake Van that a short-range flow might have localized or concentrated in and along the W-E-striking major suture discontinuity in S. This is thought to have acted as magma migration channel and interpreted as indicating major extensional event in S-margin. Finally, during post-collisional period, Lake Van shows the extensional dome morphology and extensional magma propagation across intra-plate setting, implying a new paradigm in the Highlands section of E-Turkey orogeny. This paradigm considers phenomenal structural evolution of the “Highlands Lake Basins” of Turkic-type accretionary orogens [10] with no mantle lid.

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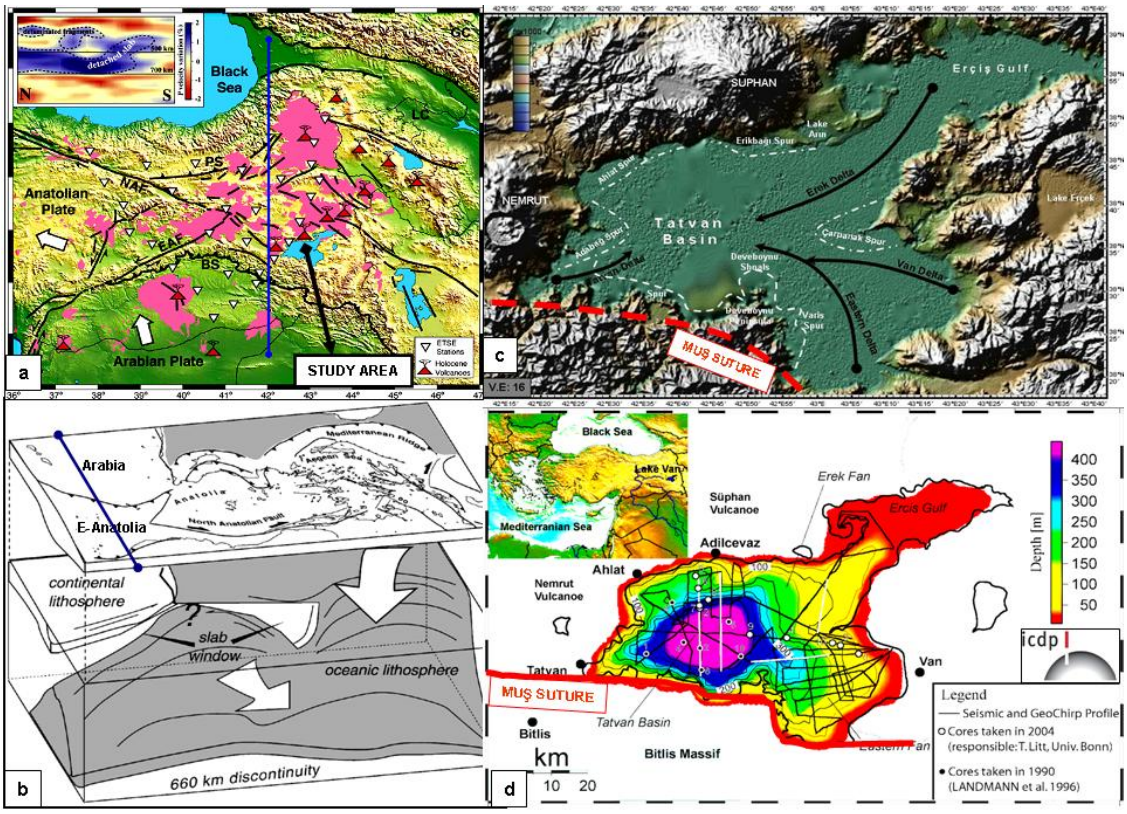

Figure 1: a) Pn tomographic image of E-Turkey from ETSE project, Holocene volcanics and Lake Van basin (Özacar et al., 2008), b) slab delamination and break off model of E-Mediterranean and E-Turkey (Facenna et al., 2006), c) 3D-Model of Lake Van and its morpho-physiography, d) ICDP seismic reflection survey, reflection profiles, core locations and bathymetry. Note that Muş suture is parallel to S-margin of the lake.