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Growth, destruction and volcanic facies architecture of three volcanic centres in the Miocene Uşak–Güre basin, western Turkey: Subaqueous–subaerial volcanism in a lacustrine setting

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ABSTRACT

Early to Mid-Miocene extension in western Anatolia, related to plate tectonic motions, resulted in the development of a number of normal fault-bounded sedimentary basins as well as different styles and compositions of volcanic activity. The Uşak and Güre basins accumulated a thick fluvio-lacustrine fill in which three distinct volcanic edifices (*Elmadağ*, *İtecektepe* and *Beydağı*) and their deposits can overlap with each other and with the sediments produced by the background sedimentation. In addition, complete facies architectures of small-volume (monogenetic) volcanoes have been recognised in association with the three large complex (polygenetic) volcanoes providing a complex mixed siliciclastic and volcaniclastic basin infill in the respective basins where volcanism took place.

All three volcanic centres display a complex succession of effusive and explosive volcanisms and their reworked deposits, with abundant evidences of magma–water interaction such as peperites for non-explosive magma-water interaction with the lacustrine water-saturated sediment and standing water body in a large alkaline lake. During the constructive phase, proximal successions of pyroclastic flows, pyroclastic falls, and rarely surge deposits are associated with distally-emplaced debris flow deposits, sometimes of mixed volcanogenic and terrestrial origins, and are interbedded with lacustrine sediments of the Inay Group. All three volcanic centres then experienced a phase of volcano growth and degradation between 17 and 15 Ma ago, most likely related to a combination of tectonic movements on NE–SW-trending basement faults, which triggered multiple flank collapses and volcanic debris avalanches (Elmadağ), and voluminous ignimbrite eruptions that triggered caldera formation (İtecektepe and Beydağı volcanic centres). Lacustrine conditions persisted during the destruction and post-destruction stages of the volcano's evolution, as evidenced by indications of magma–water interactions within the central collapse structures, which also contain uplifted basement metamorphic rocks now exhumed in their eroded cores.

1. Introduction

Over the past few decades pivotal studies of Late Oligocene–Early Miocene extensional tectonics, which are responsible for core complex formation, magmatism and volcano-sedimentary basin development, have informed new concepts for the evolution of the western Anatolian crust since the Late Cenozoic (e.g., Bozkurt and Park, 1994; Hetzel et al., 1995; Ring et al., 1999; Gessner et al., 2001). Lithospheric extension started c. 25 Ma ago in the Aegean and west Anatolian regions due to plate tectonic motions (Fig. 1; Jolivet, 2001). Crustal-scale extensions in western Turkey since the Early Miocene created numerous basins within the hanging-walls of low-angle normal faults (Lips et al., 2001; Bozkurt and Sözbilir, 2004; Purvis and Robertson, 2004, 2005; Ersoy et al., 2010; Karaoğlu and Helvacı, 2012) as well as contemporaneous volcanism spanning a range of styles and compositions.

With the exception of a few volcano-stratigraphic studies (Aydar et al., 1998; Karacık and Yılmaz, 1998; Ulusoy et al., 2004; Karacık, 2006), previous works on the western Anatolian volcanics were mainly geochemically oriented (e.g., Yılmaz, 1989; Güleç, 1991; Aldanmaz et al., 2000; Innocenti et al., 2005; Ersoy et al., 2008; Karaoğlu et al., 2010), and focused on post collision-related volcanism at a regional scale, rather than the systematic study of individual volcanic centres (Fig. 1) and their petrology.

In this paper, we present the geological evolution of the three volcanic centres (Elmadağ, İtecektepe and Beydağı) that occur within the Uşak and Güre basins (Fig. 2). In order to reconstruct the eruptive phases, we present detailed geologic maps (1:25.000 scale), several columnar sections, simplified geologic sections, and numerous field photographs.

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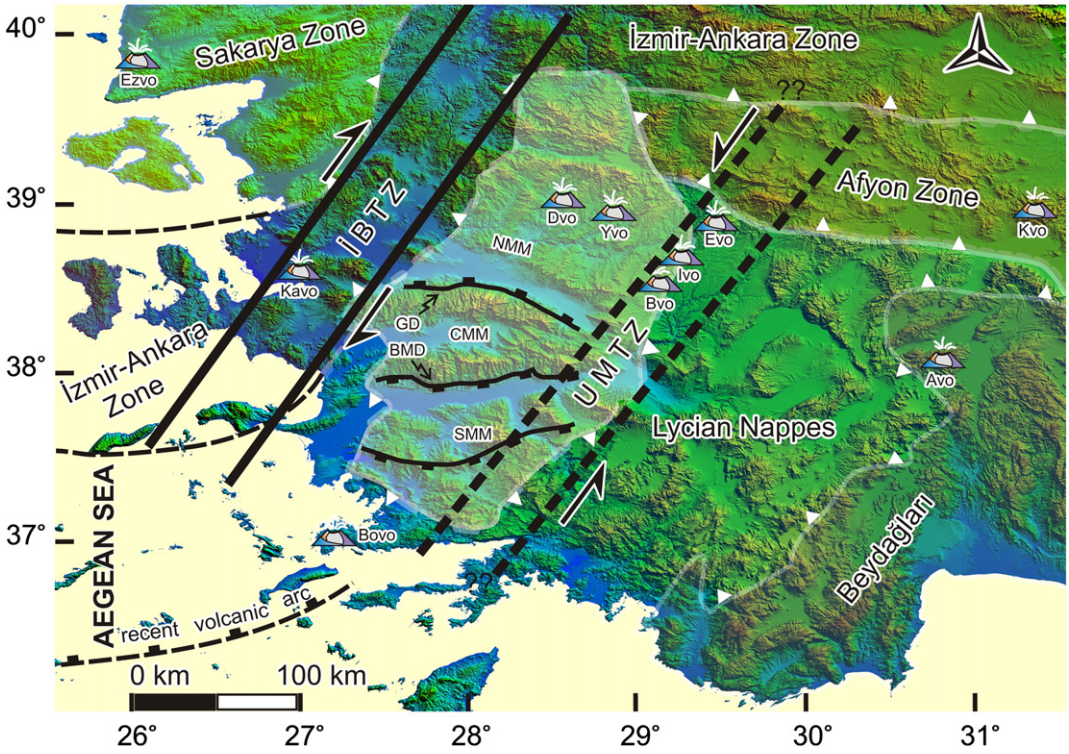

Fig. 1. Simplified map showing some prominent Neogene volcanic centres, over topography of western Turkey derived from 90 m SRTM digital elevation model. Key volcanic centres are as follows: İzmir–Balıkesir Transfer Zone (IBTZ) is modified from Uzel and Sözbilir (2008); Uşak–Muğla Transfer Zone (UMTZ) is modified from Karaoğlu and Helvacı (2012). Labelled: Kvo, Köroğlu; Avo, Afyon; Bovo, Bodrum; Kavo, Karşıyaka; Ezvo, Ezine; Dvo, Demirci; Yvo, Yağcıdağ; Evo, Elmadağ; Ivo, İtecektepe; and Bvo, Beydağı stratovolcanoes.

2. Geologic setting and geochemical outline of the Uşak–Güre basin

The Uşak–Güre basin is a well-preserved Neogene NE–SW-trending extensional volcano-sedimentary basin situated in western Anatolia (Fig. 2a). Basement units are made up of the Menderes Massif, represented by augen gneisses, schist and marble, and the structurally overlying Upper Cretaceous ophiolitic mélange rocks of the İzmir–Ankara zone (e.g., Ercan et al., 1978; Şengör and Yılmaz, 1981) (Fig. 3).

Basin fill units of the Uşak–Güre basin comprise the fluvio-lacustrine sedimentary packages of the Lower Miocene Hacıbekir Group, the Lower–Middle Miocene İnay Group and the Upper Miocene Asartepe Formation. The Hacıbekir Group is exposed north of the city of Uşak (Fig. 2a), and is composed of dark yellow conglomerate of the Kürtköy Formation and sandstone–mudstone alternations of the Yeniköy Formation. The İnay Group is a thick volcano-sedimentary package that interfingers with the Beydağı and Payamtepe volcanic units described below (Fig. 3). The Asartepe Formation is represented by reddish, coarse-grained deposits composed of clasts of metamorphic and minor ophiolitic rocks that crop out around the basin (Karaoğlu and Helvacı, 2012), and unconformably overlie the older units in the Uşak–Güre basin.

Karaoğlu et al. (2010) have recently proposed three distinct volcanic successions in the Uşak–Güre basin: (1) the Beydağı volcanic unit, composed of shoshonite, latites and rhyolitic lavas followed by dacitic and andesitic pyroclastic deposits; (2) the Payamtepe volcanic unit composed of potassic-intermediate lavas (latites and trachytes); and (3) the Karaağaç dikes composed of andesite and latite (Fig. 3).

3. Volcanologic evolution of the volcanic centres

The volcanic forms in the Uşak–Güre basin can be classified as monogenetic and polygenetic according to their eruptive history. Monogenetic volcanic forms (or monogenetic volcanoes) are defined as volcanoes formed during single events (eruptions) of short-lived (days to years) volcanic activity, without subsequent eruptions, such as intermediate and felsic lava flows and coulees erupted from monogenetic vents — volcanic cones of explosive or effusive type, and solitary extrusive domes or intrusions (e.g., Kereszturi et al., 2010; Lexa et al., 2010; Németh, 2010). Polygenetic volcanic forms (polygenetic volcanoes) have experienced more than one, and usually many, eruptive events during their history. They are usually associated with the prolonged and complex eruption history of a volcanic system. Such volcanic systems can either consist of a single volcanic edifice, or nested and/or overlapping volcanic edifices such as stratovolcanoes (e.g., Kereszturi et al., 2010; Lexa et al., 2010).

Three volcanoes exhibit some fundamental characteristics of volcano growth and degradation along the following lines: (i) three volcanoes have a central core that is surrounded by a ring plain (Fig. 4) that hosts primary and reworked volcaniclastic successions interfingered along its margin with the sediments produced by the background sedimentation of the lacustrine–terrestrial processes of the İnay Group (e.g. Smith et al., 1993), (ii) the ring-plains (Fig. 4) or coalesced linear aprons collect sediments from the edifice in different fashions in times of activity and non-activity (e.g. Smith, 1986; Palmer and Walton, 1990; Palmer et al., 1993), (iii) the volcano degradation

Fig. 2. (a) Geological map of the Uşak–Güre basins and related volcanic centres and cross-sections across the (b) Beydağ and (c) İtecektepe stratovolcanoes. Panel (a) is modified from Karaoğlu et al., 2010.