Pamukkale Univ Muh Bilim Derg, XX(X), XX-XX, 20XX

Pamukkale Üniversitesi Mühendislik Bilimleri Dergisi

Pamukkale University Journal of Engineering Sciences

The origin and emplacement dynamics of the volcaniclastic and sedimentary clastic dykes in volcanic fields: A case study from the Erenlerdağ-Alacadağ Volcanic Complex (Konya-Türkiye)

Volkanik sahalarda yer alan volkaniklastik ve sedimanter klastik daykların kökeni ve yerleşim dinamikleri: Erenlerdağ-Alacadağ Volkanik Kompleksinden (Konya-Türkiye) bir durum çalışması

Mesut GÜNDÜZ[1], Ali Müjdat ÖZKAN[2], Kürşad ASAN[2]*

[1]TPIC-Türkiye Petroleum International Company, Ankara, Türkiye.
mesutgunduz@tpic.gov.tr

[2]Department of Geological Engineering, Faculty of Engineering and Natural Sciences, Konya Technical University, Konya, Türkiye.
amozkan@ktun.edu.tr, kasan@ktun.edu.tr

Received/Geliş Tarihi: 23.11.2024
Revision/Düzeltme Tarihi: 18.01.2025
doi: 10.5505/pajes.2025.57227
Accepted/Kabul Tarihi: 16.02.2025
Research Article/Araştırma Makalesi

Abstract

Distinguishing a volcaniclastic dyke from a sedimentary clastic dyke is one of the major tasks in volcanological field studies due to its different origins. As a volcaniclastic dyke, pyroclastic dykes have great importance in locating volcanic vent facies for ignimbrite-forming eruptions. Here, our purpose is to determine the origin of clastic dykes and find the vent facies for ignimbrites from the Mio-Pliocene Erenlerdağ-Alacadağ Volcanic Complex (ErAVC), Central Anatolia. The ErAVC covers a large area in the southwest of Konya (Central Anatolia, Turkey) and shows unimodal character. The ErAVC consists of calc-alkaline basaltic-andesite (enclaves), andesite, dacite, and rarely rhyolite. It comprises mainly lava domes/lava flows and their volcaniclastic counterparts (block and ash flows, ignimbrites). The ignimbrites (Erenkaya-1, 2, and 3) compositionally range from andesite to dacite. Clastic dykes cut the Erenkaya ignimbrites in three different locations along the northeast of the ErAVC. The first group of these three dykes consists of mainly very fine-grained ash-size material and lithic-rich wall side facies, exhibiting characteristics of a pyroclastic dyke emplaced by the fluidization of volcaniclastic materials. The other dyke (third), which is fine-grained material from the edges, while the middle part contains very coarse (block-sized) and dense pumice components. Field studies show that this dyke was emplaced by post-volcanic secondary processes (e.g. sedimentary clastic dyke) as a fissure fill. These clastic dykes indicate that a caldera collapse process in the north of the ErAVC may form the Erenkaya ignimbrites.

Keywords: Volcaniclastic and Sedimentary clastic dykes, Pyroclastic rocks and Ignimbrites, Volcanostratigraphy, Erenlerdağ-Alacadağ Volcanic Complex, ErAVC

Öz

Volkaniklastik bir daykın sedimanter klastik bir dayktan ayırt edilmesi, farklı köken ve yerleşimleri nedeniyle volkanik saha araştırmalarının ana konularından biridir. Volkaniklastik bir dayk olan piroklastik dayklar, ignimbirit oluşturan patlamalar için volkanizmanın merkezi fasiyesinin belirlenmesinde büyük öneme sahiptir. Bu çalışmadaki amaç, Orta Anadolu'daki Miyo-Pliyosen Erenlerdağ-Alacadağ Volkanik Kompleksi'ndeki (ErAVK) kırıntılı daykların kökenini belirlemek ve ignimbiritlerin çıkış (merkezi) fasiyesini tespit etmektir. ErAVK, Konya'nın güneybatısında (Orta Anadolu, Türkiye) geniş bir alanı kaplar ve unimodal bir jeokimyasal karakter gösterir. ErAVK kalk-alkali bazaltik-andezit (anklavlar), andezit, dasit ve nadiren riyolitten oluşur. ErAVK, domlar/lav akıntıları ve bunların volkaniklastik eşleniklerinden (blok ve kül akıntıları ve ignimbiritler) meydana gelir. İgnimbiritler (Erenkaya) bileşim olarak andezitten dasite kadar değişmekte olup kırıntılı dayklar, ErAVK'nin kuzeydoğusunda Erenkaya ignimbiritlerini (Erenkaya-1, 2 ve 3) üç farklı noktada kesmektedir. Bu kırıntılı dayklardan ilk ikisi çoğunlukla ince taneli kül boyutunda malzemeden oluşmakta olup kenar fasiyeslere doğru litikçe zengindir ve volkaniklastik malzemelerin akışkanlaşmasıyla yerleşen piroklastik dayk özelliği göstermektedir. Diğer dayk ise kenarlarından itibaren ince taneli ve kül boyutundaki malzemeden oluşurken, orta kısmı oldukça iri (blok boyutunda) ve yoğun pomza bileşenleri içermektedir. Saha çalışmaları, bu ikinci daykın volkanizma sonrası ikincil süreçler (örneğin sedimanter klastik dayk) tarafından çatlak dolgusu şeklindedir. Bu kırıntılı dayklar, Erenkaya ignimbiritlerini oluşturan volkanik faaliyetin ErAVK'nin kuzeyinde meydana gelen bir kaldera çökme süreci ile ileşkilendirilebileceğini ortaya koymaktadır.

Anahtar kelimeler: Volkaniklastik ve Sedimanter klastik dayklar, Piroklastik kayalar ve İgnimbiritler, Volkanostratigrafi, Erenlerdağ-Alacadağ Volkanik Kompleksi, ErAVK

1 Introduction

Clastic dykes, including volcaniclastic and sedimentary clastic dykes develop through volcanic or sedimentary processes in various geological settings (e.g., subaqueous to subaerial, phreatomagmatic to magmatic explosions). Sedimentary clastic dykes can be simply separated into two categories such as ''neptunian dykes'' and ''injection dykes''. However, volcaniclastic dykes are more complex and diverse [1 and reference therein]: (1) Pyroclastic dykes (e.g., PD) related to ignimbrite-forming eruptions, (2) Phreatomagmatic pipes, diatremes, and kimberlite pipes, (3) Peperite dykes, and (4) Intrusive breccias (e.g. tuffisite). Of these, of prime interest in modern volcanology due to being one PDs are of prime interest in modern volcanology because they provide strong evidence for the vent location of ignimbrite-forming eruptions. Gas-fluidization (e.g., an upward flow of gas exerts a drag force that partially supports clasts so that the dispersion behaves like a

*Corresponding author/Yazışılan Yazar

fluid) is thought to be one of the main mechanisms for the formation of PDs, its role is not well understood. Thus, this study aims to demonstrate the relationship between the ignimbrite-forming eruption center and the clastic dykes in a volcanic field. In addition, a new practical classification scheme is proposed for the clastic dykes in volcanic fields based on previous studies.

Despite the different emplacement characteristics and their importance, studies on volcaniclastic dykes are minimal due to their rarity in nature [1]-[6]. However, the volcaniclastic dykes provide a good opportunity to examine the processes and mechanisms that accompany subaerial magmatic explosions. Therefore, they are a guide in determining volcanic centers and subsequent processes. For example, Motoki et al. (2012) suggested that two different stages were proposed for the relationship between the eruption vent and volcaniclastic dyke emplacements in the Morro dos Gatos alkaline complex (Rio de Janeiro/Brazil). These are: 1) Fluidization of pyroclastic material (mostly composed of lapilli-ash), 2) Collapse of the eruption vent or chimney filling (characteristically contains lithics and large blocks). On the other hand, Vezzoli and Corazzato (2016) explained the emplacement mechanism of post-volcanic/eruption downward mass flow clastic dykes, which developed as a result of lateral collapses on Stromboli volcano (Italy), by the re-mobilization of pyroclastic sediments on the volcano slopes.

2 Regional Geology

The ErAVC covers a large area in the Beyşehir Basin (Located in the Central Taurus), characterized by a graben-like structure containing different stratigraphic, lithological, and tectonic structures (Figure 1). The Beyşehir Basin, where the ErAVC volcanism is located, is mostly controlled with parallel and/or sub-parallel normal faults in the northwest-southeast and northeast-southwest directions. The outcropping of Mio-Pliocene fluvial-lacustrine sediments in the Beyşehir Basin is evidence of the intermontane basin controlled by these regional faults. [7]-[9]. In addition, this graben system is bordering from the Taurus Belt (Central Taurides-southwest) and the Afyon Zone (Anatolide-northeast). The Central Taurides are grouped tectonically autochthonous and allochthonous assemblages of basement rocks such as metacarbonates and metaclastics. [10]-[19]. These crystalline-metamorphosed rocks consist of metaclastic rocks alternating with metacarbonates and metamarls from the Paleozoic to the end of the Mesozoic [14], [20]-[23]. These basement rocks are unconformably covered by terrestrial deposits such as limestone, conglomerate, sandstone, and siltstone, which represent the Neogene-Quaternary fluvial-lacustrine environment [22], [24]-[27].

The Neogene volcanic rocks (ErAVC) have an unimodal geochemical character [28]-[30]. The ErAVC can be classified as basaltic andesite (enclaves), andesite, dacite, and rhyolite, according to the total alkali-silica diagram [30]-[32]. Keller et al. (1977) geochemically first defined these rocks as a calc-alkaline series ranging from basaltic andesite to rhyolite. The authors also argued that the ErAVC was associated with the subduction-related volcanism, producing lava domes/lava flows, pyroclastic falls, and flows (i.e. block and ash flows and ignimbrites) [29]-[31], [33]. Also, Besang et al. (1977) presented the first geochronological (K/Ar radiometric age) data. The authors stated that volcanism continued for a long period from the Miocene (10.90±0.25 Ma) to the Pliocene (3.35±0.08 Ma). Based on the trace element and Sr-Nd isotope data, Temel et al. (1998) argued to be of the subduction-related origin of the ErAVC. Finally, Asan et al. (2021; 2024) suggested that the unimodal chemical character of the ErAVC was resulted from magma recharge and mixing processes in an extensional post-collision volcanic setting based on the Sr-Nd-Pb isotope data.

3 Methodology and Field observations

This study focuses mainly on the detailed field observations of volcaniclastic units, which are widely observed in the east and northeast of the ErAVC. Firstly, the detailed geological map and lithology descriptions of the study area given by Keller et al. (1977) were revised. The boundaries of volcaniclastic units and faults in the study area previous studies [7]-[9], [34], [35] were re-evaluated. The characteristics of the faults are shown in the geological map (Figures 1 and 2). Secondly, a general stratigraphic section was created to represent regional geology (Figure 3). The detail-stratigraphic sections have also been illustrated for two locations where clastic dykes are located within the discontinuities of the ignimbrites in the field. Strike and dip direction were measured to better understand the relationship between these two dykes and their host rocks

3.1 Volcanostratigraphy

The observed bedrock of the general stratigraphic section begins with re-worked volcanogenic conglomerates conformably overlying pre-volcanic fluvial-lake sediments in the study area. Then, the fine-grained ash and small-sized pumice-rich lapilli ash overlay harmoniously on these volcanogenic conglomerates, respectively. These units are conformably overlain by a limestone layer and alternations of conglomerate, sandstone, and mudstone, which occasionally contain well-rounded pumice layers (Figure 3).

Although there are many stratigraphic studies on the crystalline basement and terrestrial sediments outcropping around the ErAVC [19]-[21], [27], [36], all references to the detailed stratigraphy of the volcaniclastic sequences in the region are from Keller et al. (1977). The stratigraphy of volcaniclastic sequences was detailed within the scope of this study. Each of them was processed separately and defined according to the lithofacies classification scheme of ignimbrites proposed by Branney and Kokelaar (2002) (Table 1). The whole ignimbrite sequences were grouped under a single name as "Kilistra ignimbrites" [38], [39] because six different ignimbrite units (Erenkaya 1, 2, 3, Detse, Evliyatekke, and Sadıklar) cover a large area in the east of the ErAVC (Figures 1, 2, and 3). In addition, it has been determined that the Erenkaya ignimbrites consist of three different eruption stages separated by two paleosol levels (Figure 4) in the same study. Finally, these ignimbrites are mainly covered by lava domes/flows and debris flow/avalanche or lahars in the study area.

Table 1. Ignimbrite lithofacies classification scheme: Non-genetic lithofacies terms commonly used in this study [37].

mLT	Massive lapilli-tuff (or lapilli ash)
pmLT	Pumice-rich massive lapilli-tuff
pmL	Pumice-rich massive lapilli
//sT	Parallel-stratified (laminated) tuff

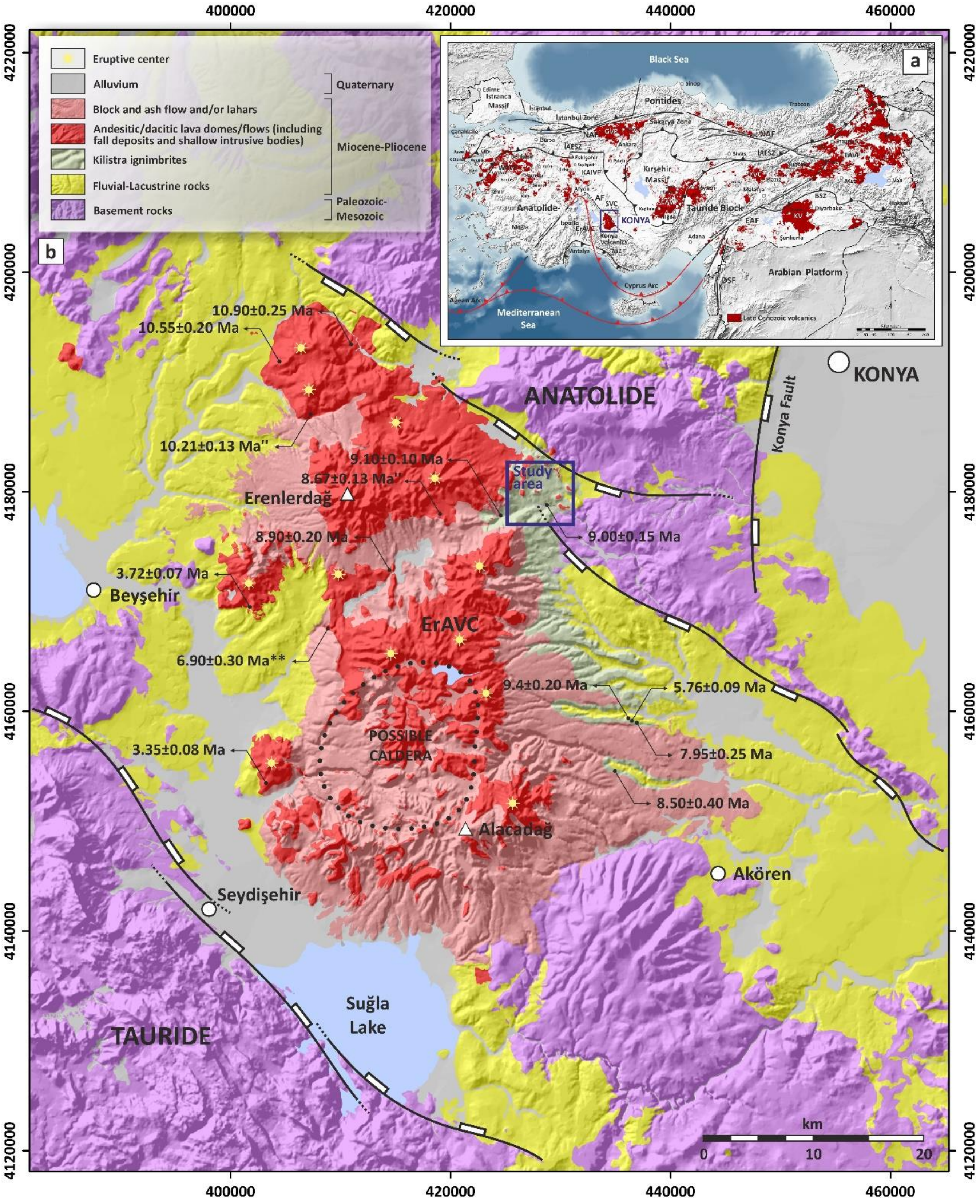


Figure 1. a) The major suture zones (solid black lines with the triangle), arc systems (red lines with the triangle), continental blocks [40], and distribution of the main Post-Collision (Late Cenozoic) volcanic fields [41]. b) Simplified geological map of the west of Konya [31], General Directorate of Mineral Research and Exploration 1/100000 geology map. Distribution of K/Ar [33], [42]**, and U-Pb [43]'' dating results.

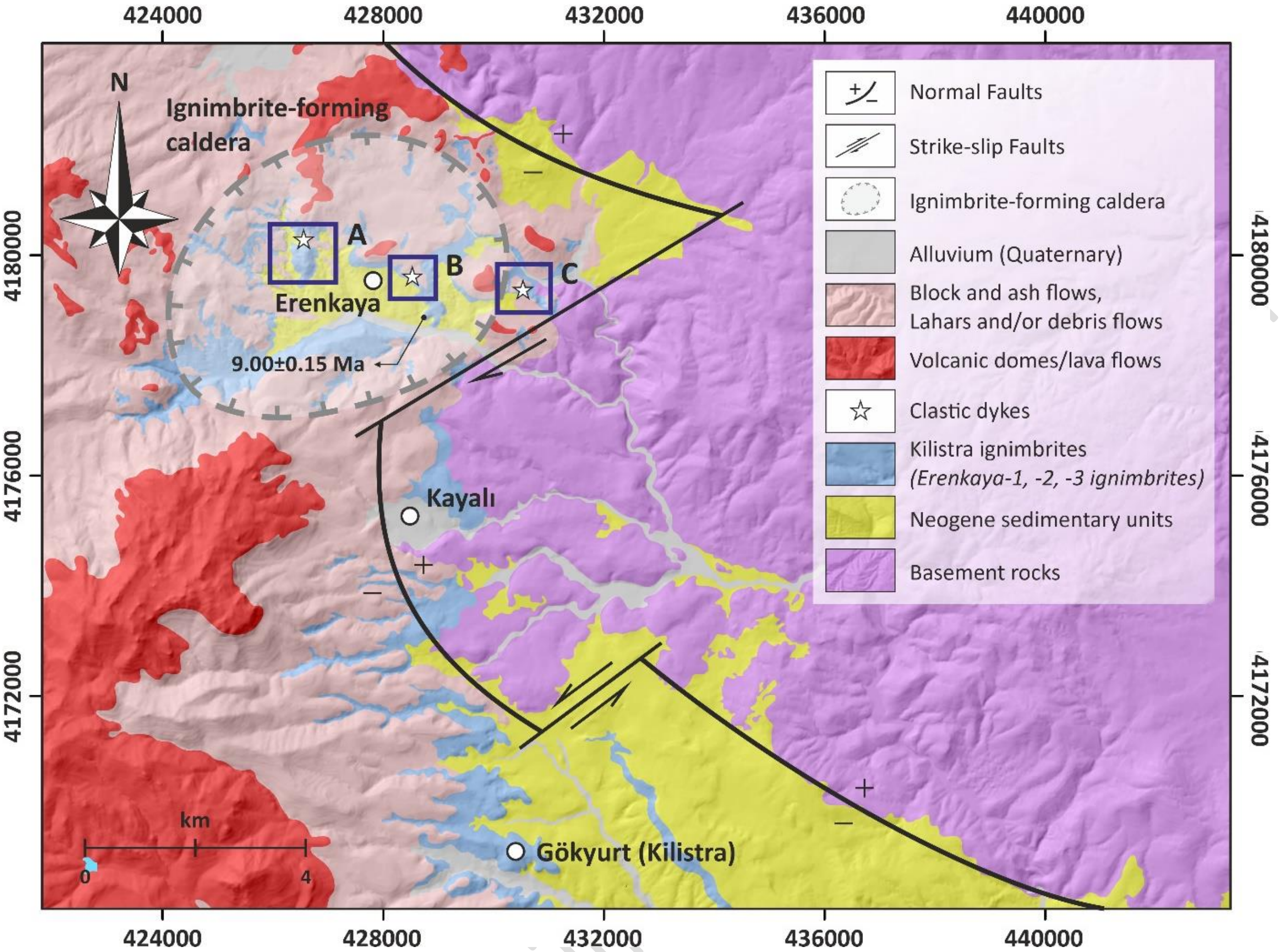


Figure 2. Map showing the detailed geology of the study area and the locations of the clastic dykes. K/Ar dating result from [33].

3.1.1 Erenkaya Ignimbrites

The Erenkaya ignimbrites were first described by Keller et al. (1977) and called "Bulumya ignimbrite". The Erenkaya ignimbrites, which were emphasized to consist of three different Pyroclastic Density Current (PDC) levels, are classified in this study as Erenkaya ignimbrites-1, -2, and -3, from bottom to top, respectively (Figures 3 and 4). Ignimbrites can also be easily separated from each other due to their field characteristics, components (e.g. pumice, lithics, volcanic glass, etc.), and petrographic features [37], [44], [45].

The fluvio-lacustrine sediments are overlain horizontally by the massive Erenkaya ignimbrite-1 (pmLT), which represents the beginning of the main volcanism in the field. The Erenkaya ignimbrite-1 contains large (>10 cm) and well-rounded pumices but lesser lithics. The Erenkaya ignimbrite-1 is covered by a paleosol level with a highly variable thickness that overlays on the erosion surface and separates from the Erenkaya ignimbrite-2 (Figures 3 and 4). The Erenkaya ignimbrite-2 begins with a level consisting of small-sized and sub-rounded pumices (pmLT; 15-20 cm in thickness). The Erenkaya ignimbrite-2 consists of a PDC containing pumices of variable sizes (mLT) reaching 150 meters. The Erenkaya ignimbrite-2 is the most common PDC in the study area and shows primary/hot emplacement features, such as occasionally containing welded pumice (fiamme) and columnar joints. On the other hand, Bozdağ et al. (2016) argued that the Erenkaya ignimbrite-2 is characterized by a vertical zonation of welding degree (e.g. non-welded-lower part and welded-upper part) around the ancient city of Kilistra. The Erenkaya ignimbrite-3 is separated from the Erenkaya ignimbrite-2 by another paleosol level in the west of the study area (Figures 3 and 4). The Erenkaya ignimbrite-3 contains large and well-rounded pumices (mLT) with lesser lithics, similar to the Erenkaya ignimbrite-1. Each eruption is also distinguished by characteristic pyroclastic fall deposits (//sT and pmL). Lastly, these three PDCs are covered by debris flows/lahars (Figure 2).

3.1.2 Clastic Dykes in the ErAVC

In this study, the clastic dykes are divided into two main groups; sedimentary clastic and volcaniclastic dykes (Table 2). The Erenkaya ignimbrite-1 and -2 are cut by a volcaniclastic dyke (Appendix A). This dyke (N20E/70SE), located in the northwest of the study area (Location-A), exhibits lithological and structural features indicating a pyroclastic dyke (PD) as a result of primary emplacement (juvenile). It is ~90 m long and ~1.5 m wide. Lithologically, it generally consists of partially consolidated fine ash and contains lithic fragments. The lithic components are mostly angular, small-sized and some of them highly silicified. These are also concentrated mostly in the dyke edge zones (Figures 5a and b). The second PD (Location-B; N8W/80SW) cut Erenkaya ignimbrite-2 (Appendix B) and show similar lithology characteristics to the pyroclastic dyke in the Location-A. But, this dyke is larger than the first one (~175 m long and ~12 m wide) (Figures 5c and d).

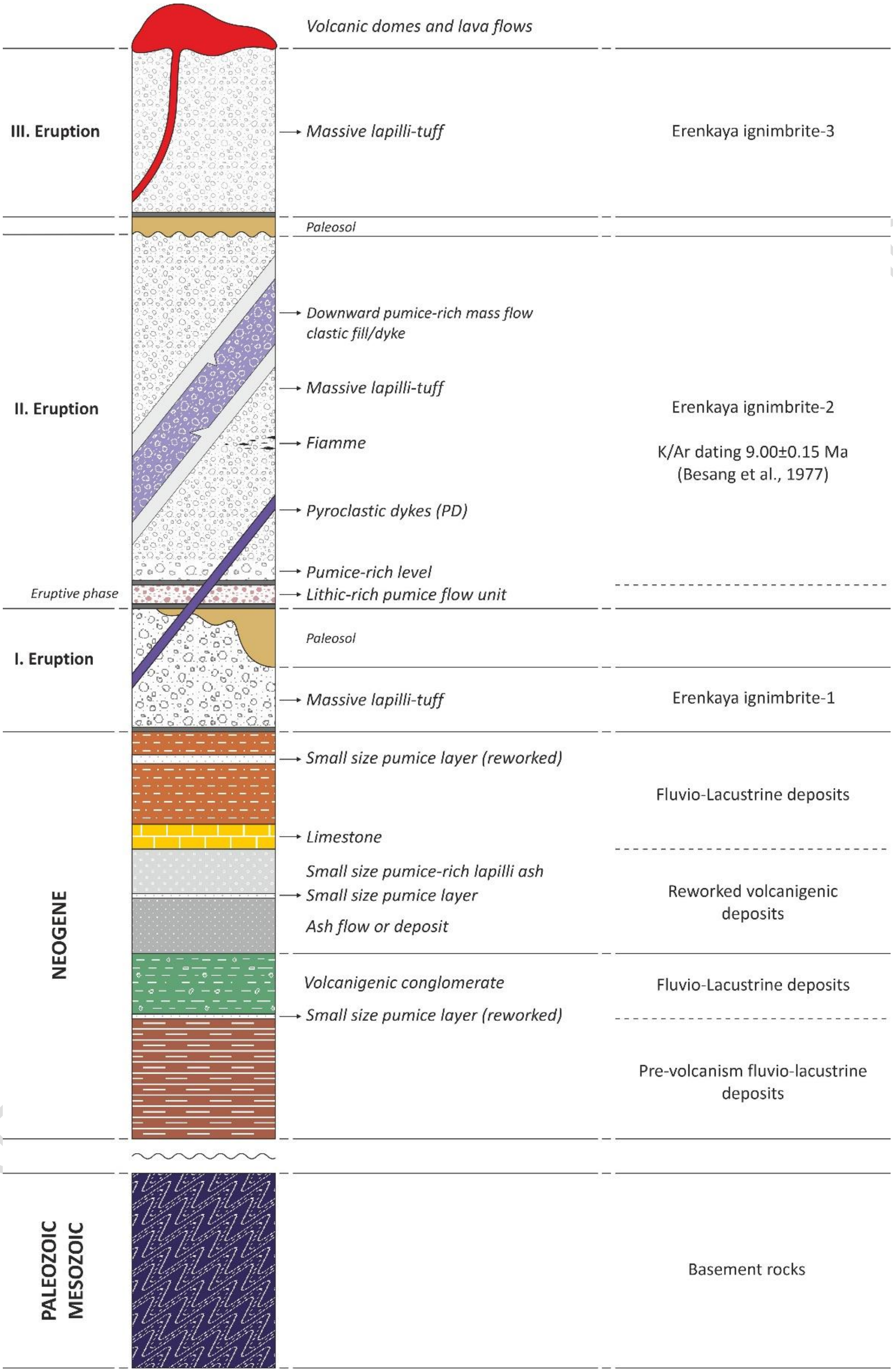


Figure 3. A generalized (unscaled) stratigraphic column section of the study area and its surroundings [38], K/Ar dating [33].

Figure 4. Field photos from the study area. Fluvio-lacustrine deposits, a) Reworked volcanigenic deposits (Characterized by intraclasts and decomposition, transportation, and deposition structures, etc.), b) Erenkaya ignimbrite-1 and -2, fluvio-lacustrine deposits and paleosol, c and d) Erenkaya ignimbrite-2 and fluvio-lacustrine deposits, e and f) Erenkaya ignimbrite-2 fairy chimneys and Columnar joints, g and h) Paleosol levels between the Erenkaya-1, -2, and -3.

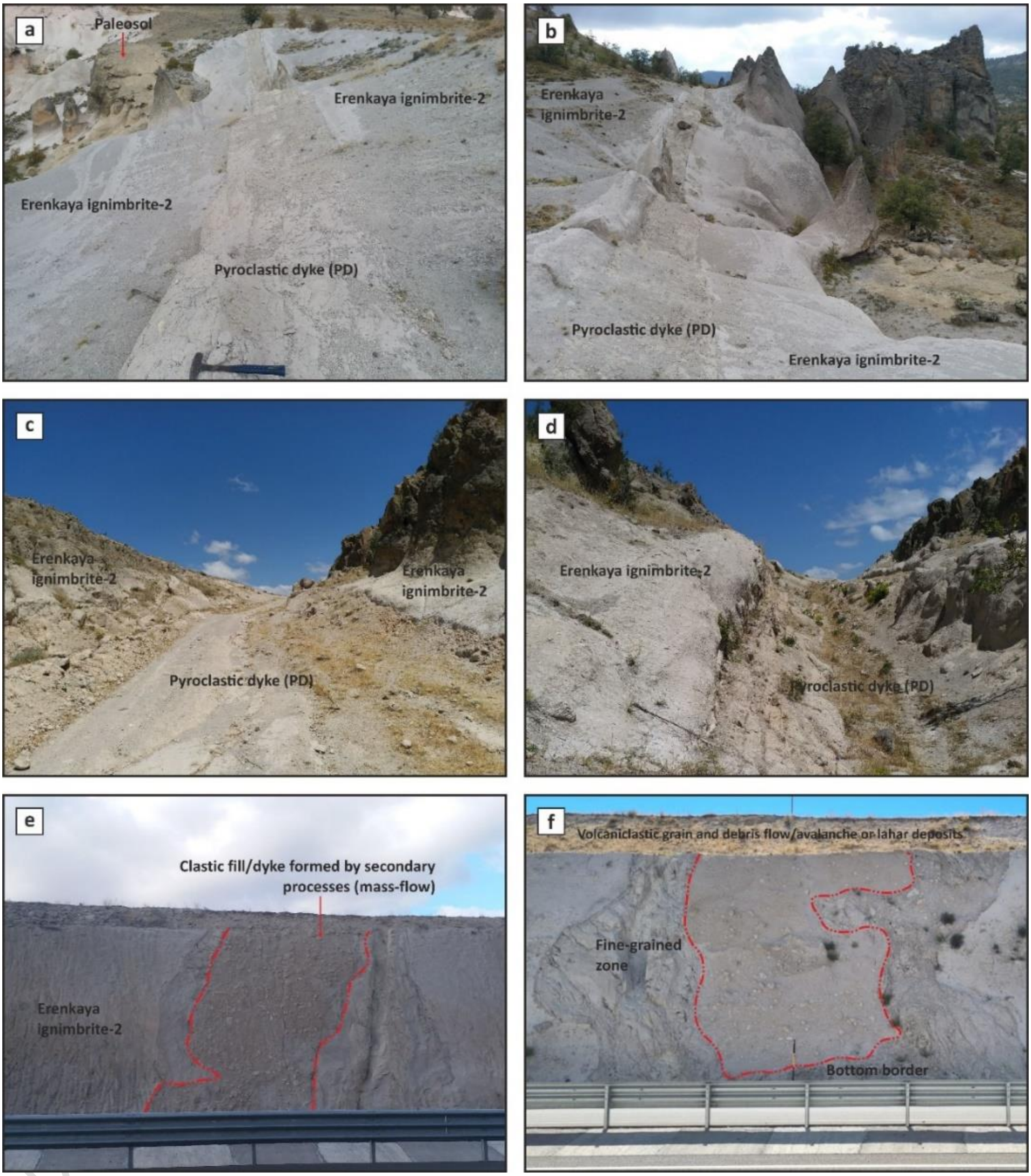


Figure 5. Landscapes of the pyroclastic dyke (PD) emplaced in the Location-A, N20E/70SE. Direction of views; a) northeast and b) southwest (UTM coordinate: 36S 426535m E; 4179983m N). Landscapes of the pyroclastic dyke (PD) emplaced in the Location-B, N8W/80SW. Direction of views; c) northwest and d) north (UTM coordinate: 36S 428511m E; 4179404m N). Landscapes of the sedimentary clastic dyke emplaced in the Location-C, N5E/75NW. Direction of views; e) north and f) South (UTM coordinate: 36S 430397m E; 4179138m N).

Another clastic dyke is located in the east of the study area (Location-C), relatively reflects the outer facies characteristics of volcanism, and consists of a thinner PDC (Erenkaya ignimbrite-2). This dyke (N5E/75NW) located here exhibits lithological and structural features indicating secondary emplacement (Appendix C). Its length could not be determined due to volcaniclastic debris flow/avalanche or lahar covers, but its width is large (>5 m). This dyke observed in Location-C exhibits two different lithological facies characteristics: Edge and center. The edge facies of this dyke have a very fine-grained lithology, and its middle (center) zone contains very coarse pumices, mostly with well-rounded block-sized. The bottom boundary of the middle zone of this clastic settlement can be observed clearly towards the south (Figures 5e and f).

4 Results and Discussion

4.1 Conceptual Model of the Clastic Dykes in the ErAVC

The very fine-grained ash lithology exhibited by the clastic dykes observed in Location-A and -B are pyroclastic dykes (PD) with primary emplacement features as a result of the fluidization of volcaniclastic material [1], [3], [4] (Figure 6a). However, clastic dykes in a volcanic complex can also emplace as channel fillings in fractures and cracks through post-eruption mass flow due to the re-mobilization of volcaniclastics on the volcano slopes [1], [47]. Depending on the composition of the clastic materials flowing into the fracture/crack systems, these can exhibit a highly complex lithology. As a result, a sedimentary clastic dyke observed in Location-C consists of two different facies, and the bottom boundary of the center (middle) zone is observed. It is also proof that the emplacement of this dyke is controlled by secondary processes from pre-existing volcaniclastic materials as a result of mass flow deposits (Figure 6b).

Table 2. Volcaniclastic and sedimentary clastic dyke classification scheme [Modified from 1].

1. Sedimentary clastic dykes
A. Fissure fills (Neptunian dykes)
B. Injection dykes
2. Volcaniclastic dykes
A. Pyroclastic dykes (PD)
B. Phreatomagmatic pipes, diatremes, and kimberlite pipes
C. Peperite dykes
D. Intrusive breccias

It is known that volcaniclastic dykes are very rare in volcanic areas and are primarily associated with caldera and fissure-vent eruptions [2], [5], [6], [48]-[52]. In particular, these dykes related to the injection of volcaniclastic material into fracture/crack systems from the depths (similar to Location-A and -B) or the collapse/filling of the eruption vent are a result of primary processes located in the eruption center and/or vicinity of the eruption vent. On the other hand, it is thought that the other clastic dykes were formed as a result of the caldera collapse and settled into cracks near the caldera walls by secondary processes in a volcanic field (Location-C). In addition, the Erenkaya ignimbrite-2, widely distributed in the region and observed at a very thick level within the study area, points to a caldera eruption by its large volume [53]. In summary, it is possible to explain the presence of pyroclastic activities and clastic dyke emplacements in the study area in three different periods; 1: The large volume ignimbrite eruption (Erenkaya ignimbrite-2; 9.00±0.15Ma), 2: Upward injection of volcaniclasts in the intra-caldera fracture as a result of fluidization, 3: Downward mass flow/re-mobilization and emplacement in the fracture/crack near the caldera walls (Figure 7).

4.2 The Importance of Clastic Dykes in a Volcanic Field

The detailed studies on the clastic (volcaniclastic) dykes are limited, and these dykes have been observed in different volcanic fields around the world related mostly to caldera environments [1], [2], [5], [54]-[57]. Firstly, the relationship between caldera and volcaniclastic dykes was emphasized by Aguirre-Díaz and Labarthe-Hernández (2003). On the other hand, some studies focused only on the settlement dynamics, lithological and structural characteristics of the clastic dykes in the volcanic fields rather than their relationship with regional volcanism [3], [4], [6], [58], [59]. In these studies, the emplacement of these clastic dykes was explained by primary volcanic processes. However, the emplacement models of the clastic dykes from the Stromboli were detailed by Vezzoli and Corazzato (2016). Therefore, we tried to explain the origin of the clastic dykes in the ErAVC, based on the models proposed by Vezzoli and Corazzato (2016).

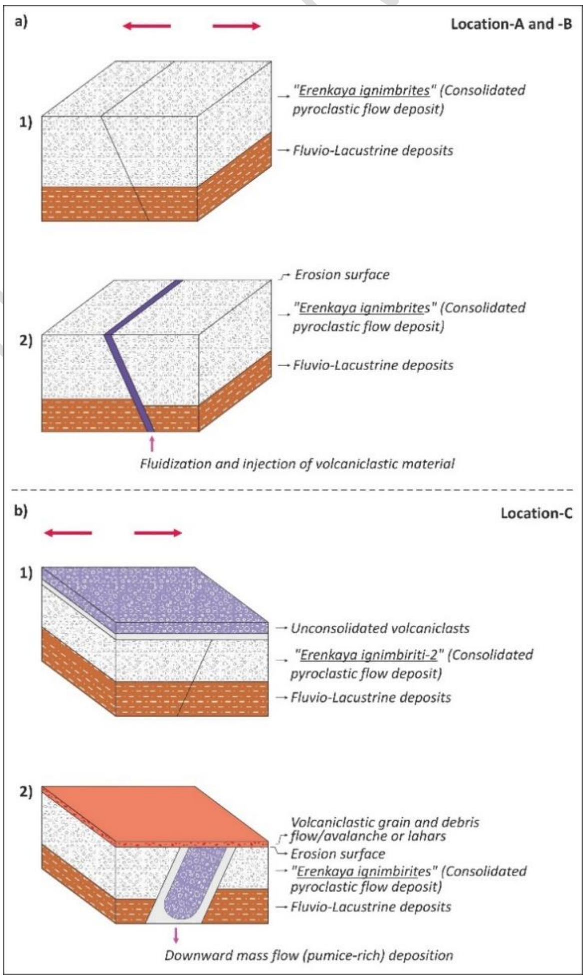


Figure 6. a) Location-A and -B: Schematic model of the pyroclastic dyke (PD) emplacement as a result of fluidization and injection forces. 1) Separating and/or faulting caused by extensional stresses, 2) Pyroclastic dyke emplacement in the cracks/fractures opened by strong injection of clastic materials. b) Location-C: Schematic model of the sedimentary clastic dyke emplacement as a result of secondary processes (decomposition, transport, and deposition). 1) Separating and/or faulting caused by extensional stresses, 2) Emplacement of unconsolidated clastic material in the form of a dyke into the cracks/fractures as a result of mass flow.

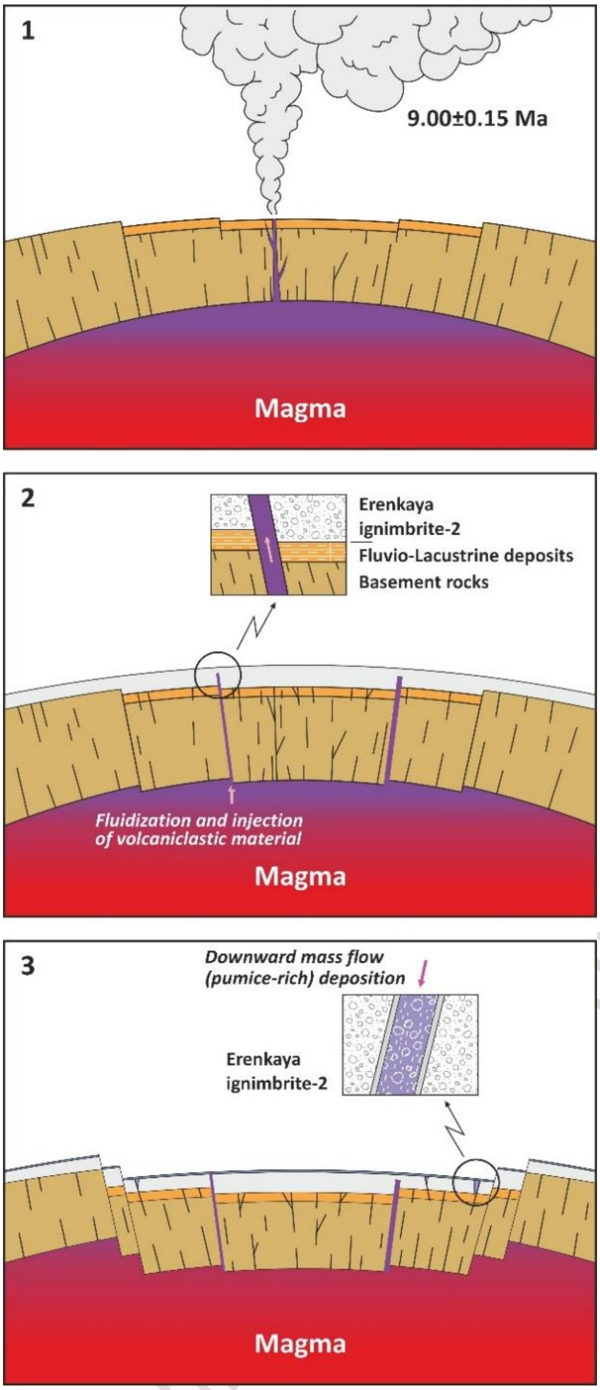


Figure 7. Conceptual models of pre-volcanism caldera collapse proposed for clastic dykes in the study area. 1: Eruption of the Erenkaya ignimbrite-2 (9.00±0.15 Ma); 2: Pyroclastic dykes (PD) emplacement as a result of fluidization and injection processes; 3: Sedimentary clastic dyke emplacement as a result of downward mass flow near the caldera wall.

Vezzoli and Corazzato (2016) emphasized that the emplacement of clastic dykes in the Stromboli volcanic field consists of three stages (polyphases) that follow each other. These stages can be defined as Phase I: Fluidization of pyroclastics and upward injection, Phase II: Collapse of the eruption vent and downward deposition, and Phase III: Post-volcanic downward mass/debris deposition. Phase I- and II represent primary processes, but the authors emphasize that Phase III is revealed due to post-eruption secondary processes. Vezzoli and Corazzato (2016) consecutively linked all three phases in their study. However, as stated by the authors, these relations may not be seen in every volcanic environment. Therefore, we decided to describe the clastic dykes in the ErAVC without any genetic relation and improved a classification schema based on Vezzoli and Corazzato (2016) for clastic dykes fundamentally under two main groups (Table-2).

In this study, the first group of these dykes (Location-A and -B; Figure 6a) from the ErAVC has been described as a result of fluidization and upward injection controlled by "extension processes" and/or "hydrofracturing" [1], [3], [4]. On the other hand, the second group (Location-C; Figure 6b) is completely associated with post-eruption processes, as described by Vezzoli and Corazzato (2016). As a result, these two dyke groups in the study area have different lithological, structural, and emplacement features. In other words, there is no genetic relationship between these two groups due to differences in their lithology, structure, and emplacement characteristics.

5 Conclusions

Clastic dykes are rarely observed in volcanic fields, but they can form in any setting under different types (e.g. lithology, etc.), stages, and conditions. Some of them are emplaced by primary processes (i.e. fluidization and injection of volcaniclastics) and are characteristic structures of eruption centers. Therefore, the pyroclastic dyke outcropping in Location-A and -B is very important as it points to the source and origin of the Erenkaya ignimbrites. In addition, the other dyke, which was controlled by sedimentary processes (e.g. decomposition, transportation, and deposition) in Location-C, has a different emplacement model with its characteristics (two different levels from edge to center). It is also predicted to be located in the cracks near the caldera border. Thus, considering the presence of these volcaniclastic dykes and the relationship with the Erenkaya ignimbrites, it can be proof that the eruption center forming the ignimbrites is located in the north of the ErAVC.

6 Acknowledgments

This study…

7 CRediT authorship contribution statement

Author 1: Writing - original draft, Methodology and Data collection, Field investigation, Visualization, Conceptualization, Formal analysis. **Author 2:** Field investigation, Stratigraphic-Sedimentological analysis. **Author 3:** Writing - original draft, Field investigation, Formal analysis.

8 Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

9 References

[1] Vezzoli L, Corazzato C. “Volcaniclastic dykes tell on fracturing, explosive eruption and lateral collapse at Stromboli volcano (Italy)”. *Journal of Volcanology and Geothermal Research*, 318, 55-72, 2016.

[2] Aguirre-Diaz GJ, Labarthe-Hernadez G. “Fissure ignimbrites: fissure-source origin for voluminous ignimbrites of the Sierra Madre Occidental and its relationship with Basin and Range faulting”. *Geology*, 31, 773-776, 2003.

[3] Motoki A, Geraldes MC, Iwanuch W, Vargas T, Motoki KF, Balmant A, Ramos MN. "The pyroclastic dyke and welded crystal tuff of the Morro dos Gatos alkaline complex, State of Rio de Janeiro, Brazil". *REM: Revista Escola de Minas, Ouro Preto*, 65, 35-45, 2012.

[4] Torres-Hernández JR, Labarthe-Hernández G, Aguillón-Robles A, Gómez-Anguiano M, Mata-Segura JL. "The Pyroclastic Dikes of the Tertiary San Luis PotosíVolcanic Field: Implications on the Emplacement of Panalillo Ignimbrite". *Geofísica Internacional*, 45, 243-253, 2006.

[5] Winter C, Breitkreuz C, Lapp M. *Textural analysis of a Late Palaeozoic coherent-pyroclastic rhyolitic dyke system near Bunkersdorf (Erzgebirge, Saxony, Germany)*. Editors: Thomson K, Petford N. Structure and emplacement of high-level magmatic systems, 199-221, London, Geological Society, Special Publications, 2008.

[6] Xu S-S, Nieto-Samaniego AF, Alaniz-Álvarez SA. "Emplacement of pyroclastic dykes in Riedel shear fractures: An example from the Sierra de San Miguelito, central Mexico". *Journal of Volcanology and Geothermal Research*, 250, 1-8, 2013.

[7] Doğan U, Koçyiğit A. "Morphotectonic evolution of Maviboğaz canyon and Suğla polje, SW central Anatolia, Turkey". *Geomorphology*, 306, 13-27, 2018.

[8] Koç A, Kaymakçı N, van Hinsbergen DJJ, Kuiper KF. "Miocene tectonic history of the Central Tauride intramontane basins, and the paleogeographic evolution of the Central Anatolian Plateau". *Global and Planetary Change*, 158, 83-102, 2017.

[9] Koç A, van Hinsbergen DJJ, Langereis CG. "Rotations of normal fault blocks quantify extension in the Central Tauride intramontane basins, SW Turkey". *Tectonics*, 37, 2307-2327, 2018.

[10] Dean WT, Monod O. "The Lower Paleozoic stratigraphy and faunas of the Taurus Mountains near Beyşehir, Turkey". *I. Stratigraphy. Bulletin of the British Museum (Natural History) Geology*, 19, 411-426, 1970.

[11] Göncüoğlu MC, Çapkınoğlu Ş, Gürsu S, Noble P, Turhan N, Tekin UK, Okuyucu C, Göncüoğlu Y. "The Mississippian in the Central and Eastern Taurides (Turkey): constraints on the tectonic setting of the Tauride-Anatolide Platform". *Geologica Carpathica*, 58, 427-442, 2007.

[12] Göncüoğlu MC, Kozlu H. "Early Paleozoic evolution of the NW Gondwanaland: data from southern Turkey and surrounding regions". *Gondwana Research*, 3, 315-323, 2000.

[13] Gürsu S, Kozlu H, Göncüoğlu MC, Turhan N. "Orta Torosların Batı Kesimindeki Temel Kayaları ve Alt Paleozoyik Örtülerinin Korelasyonu". *TPJD Bülteni*, C.15, 129-153, 2003.

[14] Karadağ MM. "Geochemistry, provenance and tectonic setting of the Late Cambrian-Early Ordovician Seydişehir Formation in the Çaltepe and Fele areas, SE Turkey". *Geochemistry*, 74, 205-224, 2014.

[15] Moix P, Beccaletto L, Kozur HW, Hochard C, Rosselet F, Stampfli GM. "A new classification of the Turkish terranes and sutures and its implication for the paleotectonic history of the region". *Tectonophysics*, 451, 7-39, 2008.

[16] Özgül N. "Torosların Bazı Temel Jeoloji Özellikleri". *Türkiye Jeol. Kur. Bült.*, 19, 65-78, 1976.

[17] Robertson AHF, Parlak O, Ustaömer T. *Late Palaeozoic-early Cenozoic tectonic development of southern Turkey and easternmost Mediterranean region: evidence from the interrelations of continental and oceanic units*. Editors: Parlak O, Ünlügenç UC. Geological Development of Anatolia and the Easternmost Mediterranean Region, 9-48, London, Geological Society, Special Publications, 2013.

[18] Şengör AMC, Nalan L, Gürsel S, Cengiz Z, Taylan S. "The phanerozoic palaeotectonics of Turkey. Part I: an inventory". *Mediterranean Geoscience Reviews*, 1, 91-161, 2019.

[19] Turan A. "Akören (Konya, Orta Toroslar) Çevresinin Jeolojik Özellikleri". *S.Ü. Müh.-Mim. Fak. Derg.*, 25, 17-36, 2010.

[20] Coşkuner B. Beyşehir Hüyük Derbent (Konya) Çevresindeki Temel Kayalarının Stratigrafisi ve Yapısal Özellikleri. Doktora Tezi, Konya Teknik Üniversitesi, Konya, 2022.

[21] Coşkuner B, Eren Y. "Tectonic transport direction of allochthonous units in the northwest of the Central Taurides (Türkiye)". *Journal of African Earth Sciences*, 214, 105245, 2024.

[22] Eren Y. "Sille-Tatköy (Bozdağlar masifi-Konya) kuzeyinde Alpin öncesi bindirmeler". *Türkiye Jeoloji Kurultayı Bülteni*, 11, 163-169, 1996.

[23] Eren Y, Kurt H, Rosselet F, Stampfli GM. "Paleozoic deformation and magmatism in the northern area of the Anatolide block (Konya), witness of the Palaeotethys active margin". *Eclogae geol. Helv.*, 97, 293-306, 2004.

[24] Hakyemez Y, Elibol E, Umut M, Bakırhan B, Kara İ, Dağıstan H, Metin T, Erdoğan N. "Konya-Çumra-Akören dolayının jeolojisi". MTA, Ankara, 73, 1992.

[25] Koç A, Kaymakci N, van Hinsbergen DJJ, Kuiper KF, Vissers RLM. "Tectono-Sedimentary evolution and geochronology of the Middle Miocene Altınapa Basin, and implications for the Late Cenozoic uplift history of the Taurides, southern Turkey". *Tectonophysics*, 532-535, 134-155, 2012.

[26] Özkan AM, Söğüt AR. "Dilekçi (Konya Batısı) Çevresindeki Neojen Çökellerinin stratigrafisi". *Pamukkale Üniversitesi Mühendislik Bilimleri Dergisi*, 15, 1131-1138, 1998.

[27] Turan A. "Akkise-Yalıhüyük (Konya) Arasının Stratigrafisi-Stratigraphy of Between Akkise and Yalıhüyük (Konya)". *DEÜ Mühendislik Fakültesi Fen ve Mühendislik Dergisi*, 22, 369-382, 2020.

[28] Asa K. "Çarpışma Sonrası Ortamda Ultra-potasikten Kalk-alkalen Volkanizmaya Geçişin Jeokimyasal ve Sr-Nd-Pb Izotopik Özellikleri, Konya-Türkiye". TÜBİTAK, Konya, 106, 2017.

[29] Asan K, Kurt H, Gündüz M, Gençoğlu Korkmaz G, Ganerød M. "Geology, Geochronology and Geochemistry of the Miocene Sulutas Volcanic Complex, Konya-Central Anatolia: Genesis of orogenic and anorogenic rock associations in an extensional geodynamic setting". *International Geology Review*, 63, 161-192, 2021.

[30] Asan K, Gündüz M, Gençoğlu Korkmaz G, Kurt H. "The role of magma recharge and mixing in producing compositional modality in post-collisional volcanic rocks, Konya Volcanic Field, Central Anatolia (Türkiye)". *Journal of Asian Earth Sciences*, 276, 106364, 2024.

[31] Keller J, Jung D, Burgath K, Wolff F. "Geologie und Petrologie des neogenen Kalkalkali Vulkanismus von Konya (Erenler Dağ-Alaca Dağ-Massiv, Zentral-Anatolien)". *Geologisches Jahrbuch*, B25, 37-117, 1977.

[32] Temel A, Gündoğdu MN, Gourgaud A. "Petrological and geochemical characteristics of Cenozoic high-K calc-alkaline volcanism in Konya, Central Anatolia, Turkey". *Journal of Volcanology and Geothermal Research*, 85, 327-354, 1998.

[33] Besang C, Eckhardt FJ, Harre W, Kreuzer H, Müller P. “Radiometrische Altersbestimmungen an neogenen Eruptivgesteinen der Turkei”. *Geologisches Jahrbuch*, B25, 3-36, 1977.

[34] Aksoy R. “Extensional neotectonic regime in west-southwest Konya, Central Anatolia, Turkey”. *International Geology Review*, 61, 1803-1821, 2019.

[35] Eren Y. “Konya’nın jeolojisi, Neo-tektonik yapısı ve depremselliği”. *I. Konya Kent Sempozyumu*, Konya, 111-120, 2011.

[36] Göğer E, Kıral K. “Kızılören dolayının jeolojisi”. MTA, Ankara, 1969.

[37] Branney MJ, Kokelaar BP. *Pyroclastic density currents and the sedimentation of ignimbrites*. London, 27. Geological Society Memoirs, 2002.

[38] Gündüz, M. The origin and eruption mechanism of the Kilistra ignimbrites deduced from chemostratigraphic, geochronologic, remote sensing, and GIS methods, Erenlerdağ-Alacadağ volcanic complex SW Konya-Central Anatolia. PhD Thesis, Muğla Sıtkı Koçman University, Muğla, 2023.

[39] Gündüz, M. “Kilistra ignimbiritlerinin uzaktan algılama yöntemleriyle yeniden haritalanması ve Beyşehir Havzası’nın (GB Konya/Türkiye) CBS tabanlı çizgisellik analizi”. *Geomatik*, 10, 75-90, 2025.

[40] Okay AI, Tüysüz O. *Tethyan sutures of northern Turkey*. Editors: Durand B, Jolivet L, Hovarth F, Séranne M. The Mediterranean Basins: Tertiary Extension within the Alpine Orogen, 475-515, London, Geological Society, 1999.

[41] MTA. “Magmatic Rocks Map of Turkey. General Directorate of Mineral Research and Explorations”. MTA, Ankara, 2013.

[42] Platzman ES, Tapırdamaz C, Şanver M. “Neogene anticlockwise rotation of central Anatolia (Turkey): preliminary palaeomagnetic and geochronological results”. *Tectonophysics*, 299, 175-189, 1998.

[43] Rabayrol F, Hart CJR, Creaser RA. “Tectonic Triggers for Postsubduction Magmatic-Hydrothermal Gold Metallogeny in the Late Cenozoic Anatolian Metallogenic Trend, Turkey”. *Economic Geology*, 114, 1339-1363, 2019.

[44] Koralay T, Kadıoğlu YK. “İgnimbiritlerin tavan ve taban ilişkilerini belirleyen petrografik veriler: İncesu (Kayseri) ignimbiriti”. *S.Ü. Müh.-Mim. Fak. Derg.*, 18, 43-54, 2003.

[45] Koralay T, Zoroğlu O, Kadıoğlu YK. “İncesu İgnimbiritindeki (İncesu-Kayseri) Fiamme Tiplerinin Kökeni: Petrografik Ve Jeokimyasal Özellikleri”. *S.Ü. Müh.-Mim. Fak. Derg.*, 24, 45-68, 2009.

[46] Bozdağ A, Bayram AF, İnce İ, Asan K. “The relationship between weathering and welding degree of pyroclastic rocks in the Kilistra ancient city, Konya (Central Anatolia, Turkey)”. *Journal of African Earth Sciences*, 123, 1-9, 2016.

[47] Ross P-S, White JDL. “Unusually large clastic dykes formed by elutriation of a poorly sorted, coarser-grained source”. *Journal of the Geological Society*, 162, 579-582, 2005.

[48] Almond DC. “Ignimbrite vents in the Sabaloka cauldron, Sudan”. *Geological Magazine*, 108, 159-176, 1971.

[49] Díaz-Bravo BA, Morán-Zenteno DJ. “The exhumed Eocene Sultepec-Goleta Volcanic Center of southern Mexico: record of partial collapse and ignimbritic volcanism fed by wide pyroclastic dike complexes”. *Bulletin of Volcanology*, 73, 917-932, 2011.

[50] González SN, Greco GA. “Diques piroclásticos en el complejo volcánico Marifil”. *XIII Congreso de Mineralogía, Petrología Ígnea y Metamórfica, y Metalogénesis (XIII MINMET y IV PIMMA)*, Córdoba, 79-86, 2019.

[51] Hernando IR, Petrinovic IA, Guzmán SR, Calvo L, Bucher J, Balbis C. “Emplacement and eruptive style of high-grade ignimbrites from fissure vents: The Las Mellizas Ignimbrite, Caviahue-Copahue volcanic complex, southern Andes”. *Journal of Volcanology and Geothermal Research*, 427, 107571, 2022.

[52] Miura D. “Arcuate pyroclastic conduits, ring faults, and coherent floor at Kumano caldera, southwest Honshu, Japan”. *Journal of Volcanology and Geothermal Research*, 92, 271-294, 1999.

[53] Giordano G, Cas RAF. “Classification of ignimbrites and their eruptions”. *Earth-Science Reviews*, 220, 103697, 2021.

[54] Henry CD, Castor SB, Starkel WA, Ellis BS, Wolff JA, Laravie JA, McIntosh WC, Heizler MT. “Geology and evolution of the McDermitt caldera, northern Nevada and southeastern Oregon, western USA”. *Geosphere*, 13, 1066-1112, 2017.

[55] Umezawa M, Mikami T, Satoguchi Y, Nakano S. “Pyroclastic dyke intruded into the Jurassic accretionary complex along the Sagami River, east of Mt. Otowa, Otsu City, Shiga Prefecture, Central Japan”. *Earth Science (Chikyu Kagaku)*, 76, 237-242, 2022.

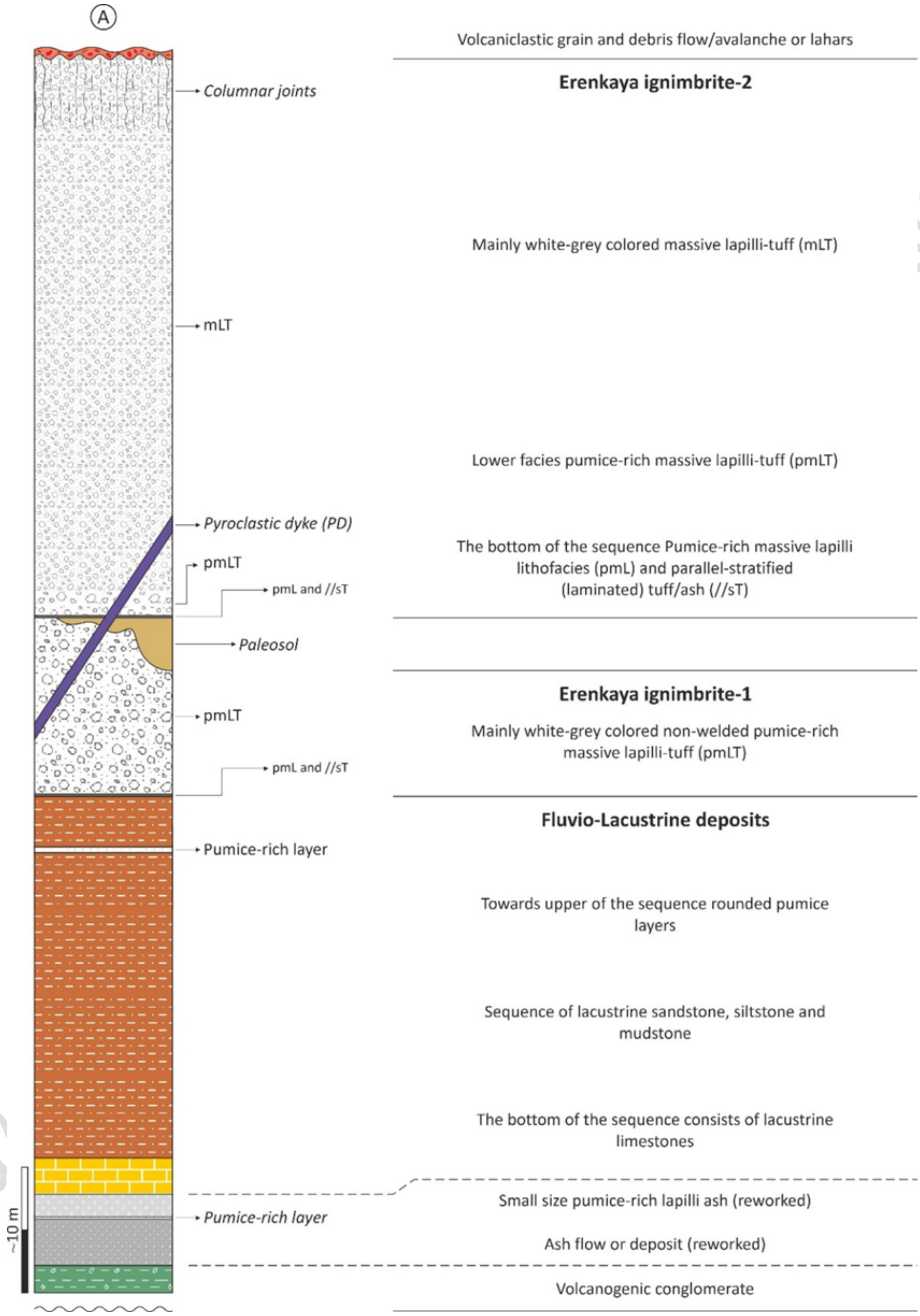
[56] Wada Y, Okuda A. “Field Occurrence and Inferred Emplacement Process of the Ebisu-Jima Pyroclastic”. *Bull. Nara Univ. Educ.*, 70, 11-21, 2021.

[57] Wada Y, Furuta E. "Field Occurrence and Inferred Emplacement Process of the Kuchiwabuka Pyroclastic Dike in Susami, Wakayama Prefecture". *Bull. Nara Univ. Educ.*, 73, 1-12, 2024.

[58] Kitajima A, Wada Y. “Nakaoku tuffite dike at the Hibora-dani section, central Kii Peninsula: Implications for magma emplacement in a conduit associated with caldera formation”. *The Journal of the Geological Society of Japan*, 116, 510-521, 2010.

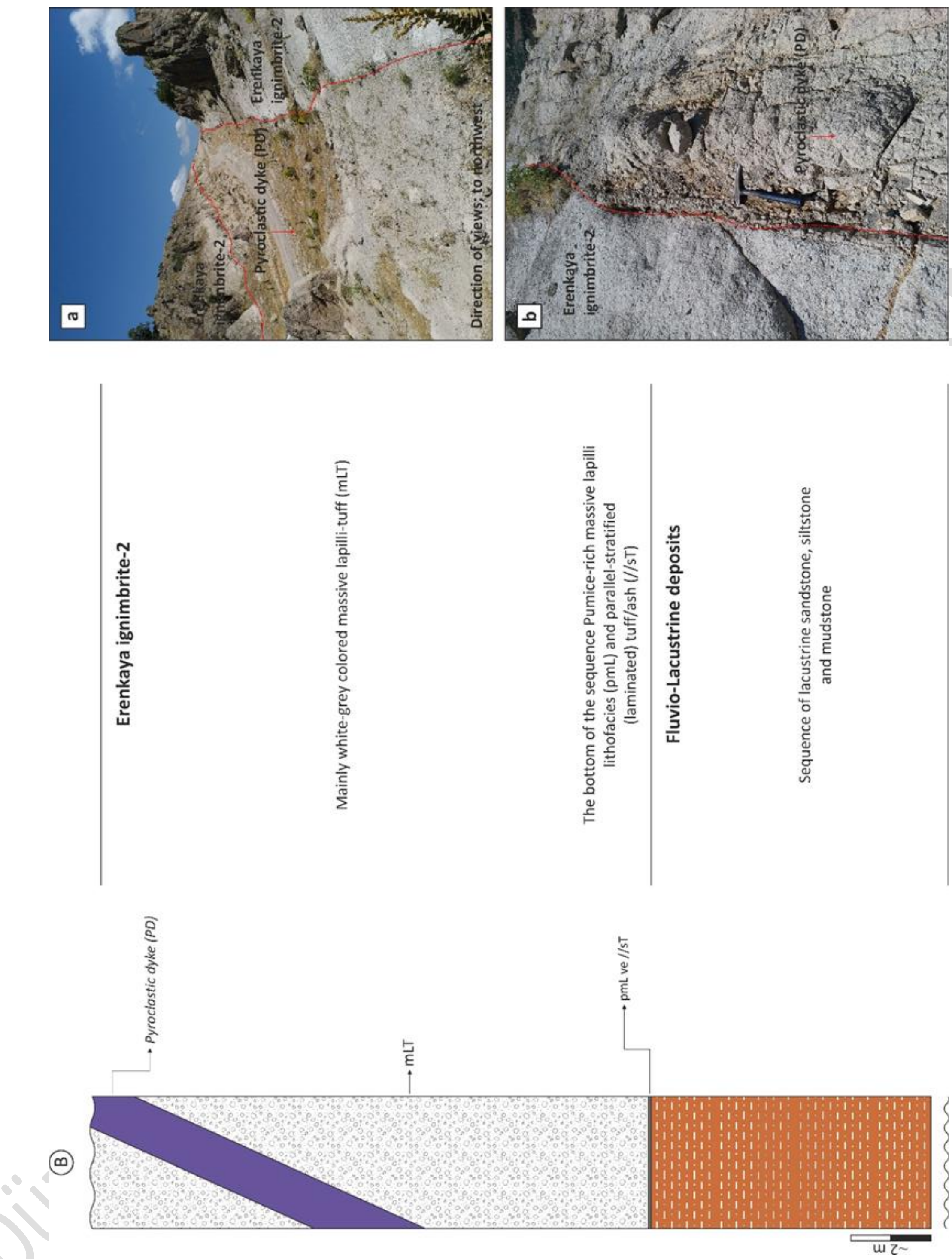
[59] Wada Y, Aoki M. "A Pyroclastic Dike, Mikoshi Pass, Wakayama Prefecture: Formation Process Inferred from Field and Laboratory Observations". *Bull. Nara Univ. Educ.*, 51, 25-35, 2002.

Appendix A



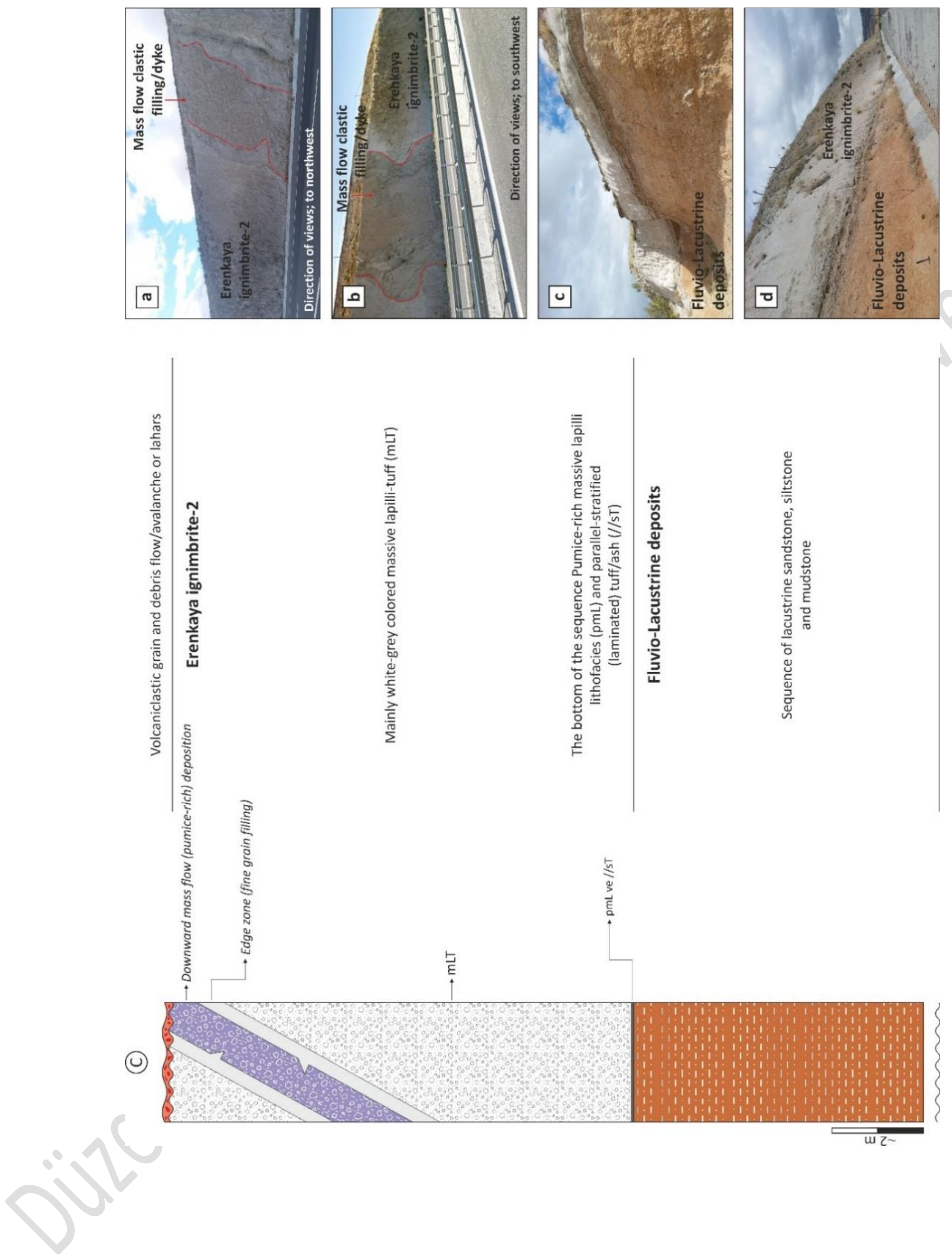
Appendix A. Detailed stratigraphic column section representing Location-A and its surroundings in the study [38].

Appendix B



Appendix B. Detailed stratigraphic column section representing Location-B and its surroundings in the study area.

Appendix C



Appendix C. Detailed stratigraphic column section representing Location-C and its surroundings in the study area [38].