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Geology and tectonic setting of the volcaniclastic succession of the Eocene, Aliabad area, central Iran

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Abstract

The volcaniclastic rocks of the Eocene are exposed throughout the Aliabad area near the Hoz-e-Soltan lake. The study area is located in central Iran and is a part of Urumieh–Dokhtar volcanic belt. These volcanic rocks generally comprise basic volcanic rocks, volcanic conglomerate and breccias, sandstone, mudstone, and ash beds, deposited by various processes of sediment gravity flows. The article details discussion on the field and laboratory studies in Aliabad, central Iran. The area consists of the Eocene volcanic, volcanosediment, and sedimentary units formed in the marine environments. In thisstudy, we explore the concepts of petrography and sedimentology on the volcaniclastic deposits. The study utilizes modal analysis of sandstones from Aliabad for inferring the sediment provenance in detail.

Keywords: Pyroclastic, Central Iran, Sedimentary environments, Urumieh–Dokhtar.

Introduction

The term provenance, also spelled provenience, is derived from the French word *provenir*, meaning to originate or come forth[1]. Sometimes, words such as source area and source land are used as synonyms for provenance. As sedimentologists commonly use the word provenance, it has a broader meaning than just a source area. Three essential elements of tectonics exchange, eustasy and atmosphere identified with lithosphere, hydrosphere, and air covers weathering of hinterland source rocks and creation penecontemporaneous volcanic, substance, and biogenic grains, working together with disintegration, transport, and depositional forms on the surface of the Earth. A progression of occasions significantly affects stratal designs and stratigraphic engineering, for example, subjective and quantitative sand compositional changes through transaction[2]. Definite sand petrography has been restricted to root look into and paleogeographic reproductions.

Three essential elements of tectonics exchange, eustasy and atmosphere identified with lithosphere, hydrosphere, and air supports atmosphere of rocks of hinterland and the formation of penecontemporaneous volcanic, materials, and biogenic grains, in concert with erosion, movement, and depositional processes on the surface of Earth. A progression of occasions significantly affects designs and stratigraphic engineering, such as qualitative and quantitative sand compositional turns via interplay[2]. Enough bottle petrography has been upper-class to dawning discontinuance and paleogeographic reconstructions. Pyroclastic sediments are difficult to recognize, as they are readily devitrified, altered, and replaced during weathering and diagenesis. The basic adjustment items are mud minerals and zeolites[3].

Urumia–Dokhtar volcanic zone has been formed as magmatic arc, and basin formation in central Iran with a wide spread of sedimentary Eocene volcanic rocks has provided a back-arc basin. Previous studies are vital to understand paleogeography. The studies as accompany with studies of depositional environments, they assist us to explain the relative positions of ancient oceans and highlands at given times in the geologic past. From such studies, we can reconstruct the location, size, and lithologic composition of mountain systems. The study aimd to utilizing the modal analyses of sandstones from Aliabad for inferring the sediment provenance.

Materials and methods

The rock layers had been selected with a different lithology. Identification of the sequence boundary was also important, as many of the lateral and vertical facies patterns could be clarified by a sequence stratigraphic approach, and most of the diagenesis also ties with these boundaries. Moreover, because of the low scale of study area and thickness change lithology, the sampling was done at every 50 cm. A total of 165 samples of rock were selected from the Aliabad sediments, and 39 samples were isolated for Dickinson method[4]. Collection of the rock samples was conducted with the GPS, on the basis of slope and trend of the layers; physical characteristics; thickness of the layer; and mineralogical composition in terms of grain size, composition, texture, and fossil content. In this study, we gave importance to the orientation and size of the structures. Most of the detailed work was undertaken on the thin sections that were cut from impregnated unconsolidated sediments or sedimentary rocks. A thin section of a rock was investigated with a petrographic microscope at Tehran University. On the other hand, the frequency of minerals was calculated by point counting using the Gazzi–Dickinson method. It was proposed by Garrels and Mackenzie[5] through an explanation of the rocks in the laboratory and fieldworks on the collected samples.

Geological setting

Eocene sediments in central Iran are located near the Tehran–Qom highway and 55–57 km from Tehran. This area has a height of about 1,100 m above the sea level. Its longitude is 50°, 55′ East and latitude is 35°, 08′ North (Figure-1). The main reasons for choosing this level are easy accessibility, suitable topography, continuous sequence stratigraphy, lithological changes in thin intervals, not affected by tectonic processes, and finally have not been studied by other researchers. The study area is shown in Figures-1 and 2.

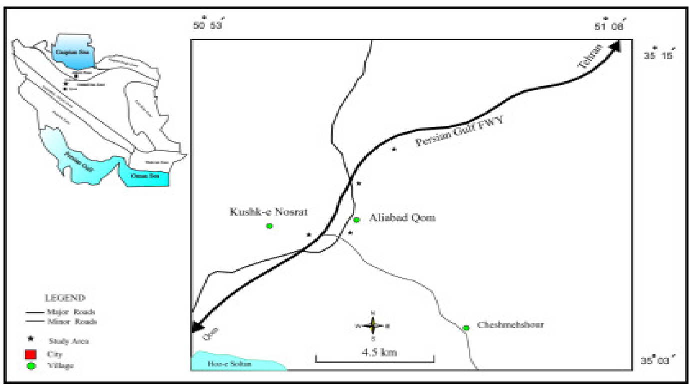

Figure-1: Index map of Iran showing the study location of Aliabad area and extension of central Iran basin.

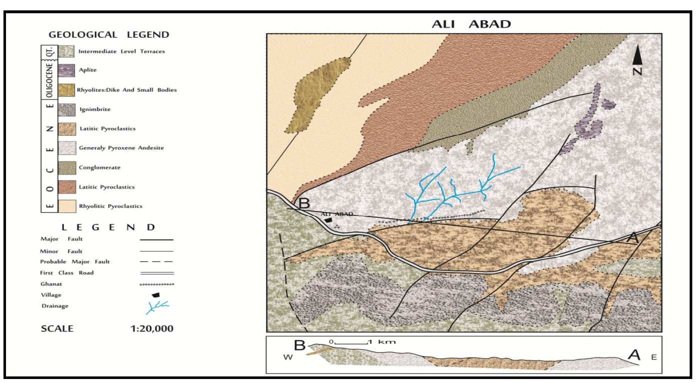

Figure-2: The geological map of Aliabad area.

Sedimentary basins

Arenite petrography by various components might be impacted in the multicomponent frameworks on an assortment of time measures. Tectonics, eustasy, and atmosphere are three most critical components driving compositional changes in the sort and level of residue supply. These variables are drawn as diagram in extent to the association between the three noteworthy allogenic controlling components assosiate arenite petrographic changes to the improvement of the main surfaces for grouping stratigraphic elucidation (Figure- 3).

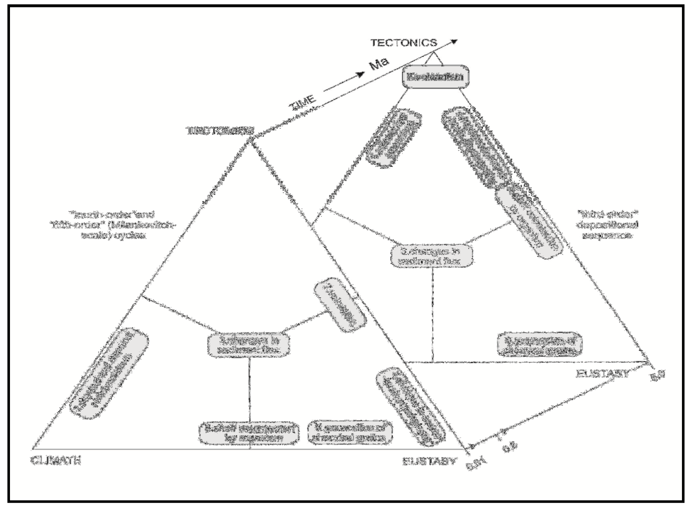

Figure-3: Primary allogenic factors controlling arenite compositional changes, classified according to the relative influence of tectonics, climate, and eustasy. The triangles do not include autogenic factors, nor factors controlling petrofacies changes over timescales of N>million years[26].

This obviously covers a major concept of sediment accumulation that requires creating space as a result of a depression of the base or a rise in the sea level. Generally, sedimentary basins can be distinguished by their position in the geological cycle: i. active sedimentary basins, ii. nonfunctional areas but not distorted, and iii. ancient basins, which are usually heavily distorted and incomplete, integrated into a mountain. It is likewise viewed as autogenic procedures ready to deliver compositional changes in arenites with no critical relationship potential over the bowl. The affectability of sand piece is to elements, for example, disintegration, movement, and the conveyance of dregs to the bowl.

Mineralogical composition

There are some compositional alternation has been administered by tectonics i. forming accessible hinterland source stone and in a roundabout way changes bowl settlement through inspire, augmentation, and flexural stacking of the lithosphere and, ii. giving new pyroclastic items from contemporary volcanism on extrabasinal and additionally intrabasinal ranges derived. Eustasy has been investigated alternation in the sea-water, and leading changes in sea-level, and also the sort and amount of intrabasinal and extrabasinal grain supply, weight, temperature, and moistness as atmosphere controls compositional changes of clastic grains. These have been made by substance and physical stop of source lithotypes and additionally it can make new synthetic and biogenic grains. The elements that make compositional changes crosswise over stratigraphic unconformities after some time ranges of thousands to a large number of years enacted through the relationship between three main impetuses. An imperative control on the petrogenesis of siliciclastic residue may represent via chemical weathering and pedogenesis. Weathering feldspars and mafic minerals, and conatant minerals, for example, quartz and zircon in detrital residue prompt to the exhaustion of insecure minerals[6].

Low relief ratio of soil in watersheds and high water release per unit region prompt to the most broad concoction weathering, and dregs got from these watersheds incorporates the base rate of feldspars and shake pieces. The survival of shake pieces relies on upon their structure and damp versus parched atmosphere conditions[7]. Climate and effective precipitation is directly related to the intensity of chemical weathering in single sub-bowls, so the period of chemical weathering is inversely related to the relief ratio of the watershed[8]. Weathered sand reincorporated to stream bedload amid channel relocation, bringing about net weakening and substitution of recently kept sand by more seasoned, compositionally more develop mineral grains, creating increment in proportions of quartz-lithic and monocristalline-polycrystalline quartz.

We can consider the mineralogical composition of sandstone under very different aspects. The mineralogical nature of the binder, siliceous cement sandstone, limestone, ironstone, etc., is based on the presence of exceptional mineral constituents that can also oppose the stable constituents.

The study of the major components of sandstone is as follows: i. Quartz: due to its resistance to changes by most common constituent of sandstone. It is attempted to determining the origin of quartz, but in general, the results were disappointing. However, monocrystalline quartz undulating extinction come from igneous or metamorphic precursors, so quartz uniform extinction come from volcanic rock or recycled sandstone. Cathodoluminescence can also assist to distinguish between different sources of quartz[9]. ii. Feldspars: Following their fragility (cleavage) and high weathering, feldspars form rarely more than 10–15% of sandstone. A significant proportion of feldspars in sandstone should be considered abnormal. It may indicate either a climate where chemical weathering is low (aridity, permafrost), or the presence of reliefs, responsible for a rapid transit of sediments into the basin[10]. iii. Lithic fragments: As plutonic rocks tend to disintegrate before their incorporation into the sediment, the most common lithic fragments are pieces of volcanic rocks, shales, and cherts. iv. Mica and clay minerals: Micas are common in sandstone. Their size stores them in the silty and sandy fractions. Clays form the matrix, and it is generally difficult to determine if their original mineralogy (detritus) is the result of diagenesis[11].

Geotectonic study

As of late much exertion on the detrital organization of sandstone for the structural state of its provenance locale conducted[12-15]. Erosional unroofing of different tectono-stratigraphic structure cause structural elevate of an orogenic wedge experiencing pushing and square. Compositional patterns of lithic parts, developing from sedimentary to lower and middle range transformative and steady unroofing of more profound rate of the crash orogen portrayed by prominent elevate[16]. In multi- stage extensional structure, disintegration of the pre-crack sedimentary cover investigated as main phase of fracturing started with, trailed by unroofing of the storm cellar, along these lines prompting to solid changes in detrital states.

Sandstone formed in fore arc basin and the basin between the arc (inter arc) will include pieces of volcanic rock comprising often andesite composition and microcrystalline. Tectonics rules in respect to eustatic changes; structural action may bring about source/bowl rearrangement, which changes the waste bowls, source-shake sorts, and their relative extents in impact edge condition[17]. This demonstrates imperative changes in arenite arrangement because of structural elevate, pushing, or bowl subsidence happen at bouncing surfaces of depositional successions. In similarly profound bowl settings depositional groupings are limited by correlative comparable surfaces, petrofacies alter inside turbidite or gravity-stream stores might be slow crosswise over arrangement limits. On dynamic racks of detached mainland edges, rehashed cycles of rack rise and submergence because of ocean level vacillations may bring about changes in the sort and extent of lithologic units trimming out in the source ranges. In a simple quartz–feldspar–lithics plot of modern deep-sea sand[15,18], five major tectonic settings were distinguished but there was much overlap (Figure-3). In the work of Dickinson[13] on ancient sand, four major provenance terranes are distinguished: stable craton, basement uplift, magmatic arc, and recycled orogeny. Stable cratons and basement uplifts form the continental blocks, tectonically consolidated regions of amalgamated ancient orogenic belts which have been eroded to deep levels. Magmatic arcs include the continental and island arcs associated with subduction, and these are areas of volcanics, plutonic rocks, and metamorphosed sediments. Recycled orogens are uplifted and deformed supracrustal rocks, which form mountain belts, and they mostly consist of sediments and include volcanics and metasediments[4]. Detritus from the various provenance terranes generally has a particular composition, and the debris is deposited in associated sedimentary basins which occur in a limited number of plate-tectonic settings[5].

For modal analysis of sandstones, different amounts of constituent components should be measured to obtain the appropriate source. Table-1 shows the categories of grain determined and defines each of them. This table has been selected based on the point counting method[16,19,20]. Accumulation of different types of grains with different proportions of stone facies shows the combination of new sand origin, which can be introduced in any facies-specific origin. According to this concept, Dickinson offers basin facies and origin of each of them: i. Quartz facies (quatrzose): Often a single-crystal quartz (Qm) with some multicrystalline quartz (Qp) and feldspar (K>P)F, mass cratonic severely weathered or sedimentary this cycle is included (representing the basin all platforms). ii. Volcanosediment facies (volcaniclastic): (P>K)F, LV, (LV>F) dominant with small amounts of active volcanic areas Qm indicates frontal arc basin (fore arc) behind the arc (back arc). iii. Arkosic facies: F (with different values of K/P) and with a bit dominant Qm, Qp, following continental rocks of magmatic arc above or influence eroded, from about rift basins and to aulacogen.

A few variables, for example, disintegration, movement, and the conveyance of residue to the bowl driving change in dregs flux. Stream slopes and atmosphere monitored through structural inspire and ocean level alter, furthermore administers waterway release and collaborate in view of complex exchange, bringing about various dregs sort/accessibility and effectiveness of silt exchange to the terminal sink.

Low-to high alternation of residue flux attributable to expanded structural movement or ideal atmosphere conditions will be set apart by diminishing compositional development, simultaneously with an expansion in the lithic populace. What's more, long stretches of structural peacefulness will be showed as develop sand stores. Changes in sand arrangement might be incited by breaking down of weathered grains from most labile shake sorts amid resulting transport. Alternation in release administrations and silt supply reflecting climatic controls may initiate either dregs stockpiling or residue creation, with direct impact on stratigraphic engineering, particularly of fluvial stores[21].

Detritus from the various provenance stones generally has a particular composition, and the debris is deposited in associated sedimentary basins which occur in a limited number of plate-tectonic settings. From modal analysis of a sandstone, the percentages of various combinations of grains are plotted on triangular diagrams, and these are used to differentiate and the different provenance terrane then. Accordingly, the study area is a strick–slip basin, and sediments are poured into a back-arc basin (Figures 4–6).

Tectonic

The volcaniclastic rocks in the north of Hoz-e-Soltan lake (Aliabad region) belong to Urumieh–Dokhtar magmatic belt (UDMB), which forms a subduction-related magmatic arc along the active margin of the Iranian plate. These belts contain magmatic rocks and have Andean-type magmatic arc characteristics[22]. Maximum magmatic activity in UDMB belong to Eocene—quaternary age. These volcanic rocks have compositions ranging from basaltic andesites to dasites.

Using the tectonic–geochemical record, we need to understand the dynamic–sedimentary rock that we see in the series of arc sediments. The lower surface of these volcanic rocks is exposed only in the Aliabad region, while their upper surface displays an angular unconformity underneath the lower red formation. The upper part of the Aliabad or volcanic rock column is mainly strongly weathered, and rock samples formed are very soft.

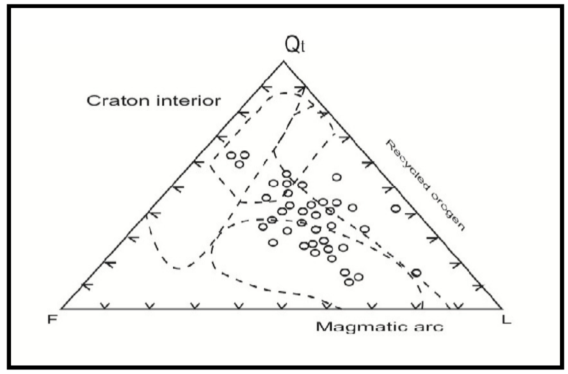

Figure-4: Graph Qt, F, L shows the total thickness of the study area. The 39 sample points were compared with defined ranges from Dickinson[13], which displayed the Chinese line, showing provenance tectonic zone (magmatic arc). Qt = total quartz grains; L, F = total feldspar grains. (In this diagram, scattering data are given with acceptable error rate of 5%).

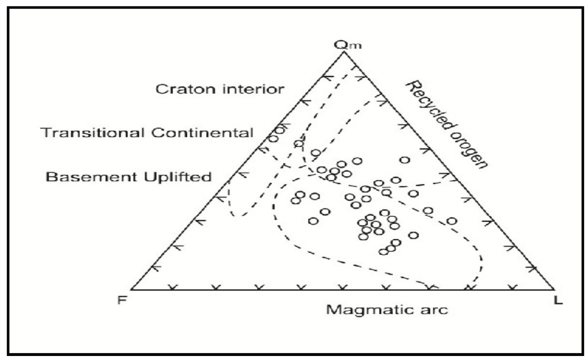

Figure-5: Graph Qm, F, L shows total cross-section thickness of the study area. The data were compared with defined limits from Dickinson[13]. Origin of these tectonic region can express the magmatic arc. Series of points are also a mixed zone. Qm = mono crystalline quartz; F = total feldspar; L = total lithic fragments (L + Qp).

In arc volcanics, debris flow and turbidity currents form a mass of volcaniclastic deposits[23]. The study of 39 thin sections reveals that their conditions were consistent with point–counting methods[24]. Comparing data obtained from ranges defined by Yerino and Maynard[15] showed that Aliabad tectonic basin features are of provenance type: magmatic arc; tectonic setting: island arc or continental arc; derivative composition: feldspatholithic (F-L) volcaniclastic sand with high P/K and Lv/Ls ratios grading to quartzofeldspathic (Qm-F) batholith-derived sand. A modal analysis of sandstone combinations of grains plotted on triangular diagrams has shown Aliabad is a strike–slip (SS) basin where sediments fall in the back-arc basin. According to geochemical rocks in this area, magma was formed in two tectonic environments: island arc and active continental margins[24]. It is believed that the amount of K_2O to SiO_2 is the way that refers to the islands arc. However, active continental margin can be seen scattering in these diagrams. In the triangular diagram, TiO_2, P_2O_5, K_2O rocks are categorized in the orogenic zone. The only significant correlation was observed between MgO and Fe_2O_3, and an inverse relationship between the TiO and CaO and TiO, respectively[25].

Table-1: Results of Microscopic Chemical Study of Thin Sections of 39 Samples (Aliabad).

Sample	Thickness (cm)	Lt (%)	Acc (%)	F (%)	L (%)	Qm (%)	Qp (%)	Qt (%)
FR.1	10	50	0	25	50	25	0	25
FR.6m	50	51.6	5	3.3	46.6	40	5	45
FR.7m	50	41.6	0	33.3	40	25	1.6	26.6
FR.11l	80	37.05	2.85	17.1	34.2	42	2.85	45.7
FR.11m	300	4203	4.7	29.4	37.6	23.5	4.7	28.2
FR.14l	80	55	1	28	40	16	15	31
FR.15m	50	52	8	28	44	12	8	20
FR.15t	90	45	2	30	38	23	7	30
FR.7t	50	26.6	2.2	35.5	22.2	35.5	4.4	40
FR.12l	10	72	4.4	11.1	53.3	13.3	17.7	31.1
FR.15t	100	32	0	40	20	28	12	40
FR.16l	10	29.9	3.3	35.5	26.6	31.1	3.3	34.4
FR.16t	70	42.8	0	28.5	40	28.5	2.8	31.4
FR.16m	100	33	3	24	32	40	1	41
FR.16.t	100	21	0	34	20	45	1	46
FR.16	60	36.6	0	10.2	35.5	52.2	1.1	53.5
FR.16.m	40	22	8	30	20	40	2	42
FR.17l	10	49	0	29	46	22	3	25
FR.17t	40	34.6	1.3	26.6	32	37.3	2.6	40
FR.18l	10	43	0	30	40	28	3	30
FR.19t	210	8	0	32	5	60	3	63
FR.20l	40	9	0	31	6	60	3	63
FR.20t	80	18.3	8.3	26.6	8.3	46.6	10	56.6
FR.22l	20	10	0	30	10	60	0	60
FR.22t	50	23	0	27	23	50	0	50
FR.23t	40	22	8	30	12	40	10	50
FR.24l	10	29	0	21	25	50	4	54

Sample	Thickness (cm)	Lt (%)	Acc (%)	F (%)	L (%)	Qm (%)	Qp (%)	Qt (%)
FR.25t	100	24	0	26	22	50	2	52
FR.26l	10	44	0	15	43	41	1	42
FR.26t	100	25	0	25	25	50	0	50
FR.27l	10	39	1	20	36	40	3	43
FR.27t	60	43	0	25	40	32	3	35
FR.28t	70	53	0	15	28	32	5	37
FR.30l	10	38	0	20	36	42	2	44
FR.30t	60	34.6	1.3	26.6	32	37.3	2.6	40
FR.31t	150	34	2	24	32	40	2	42
FR.32m	70	42	0	26	40	32	2	34
FR.33t	50	29	0	40	28	31	1	32
FR.33m	70	53	1.5	24.6	43	10	10	30.7

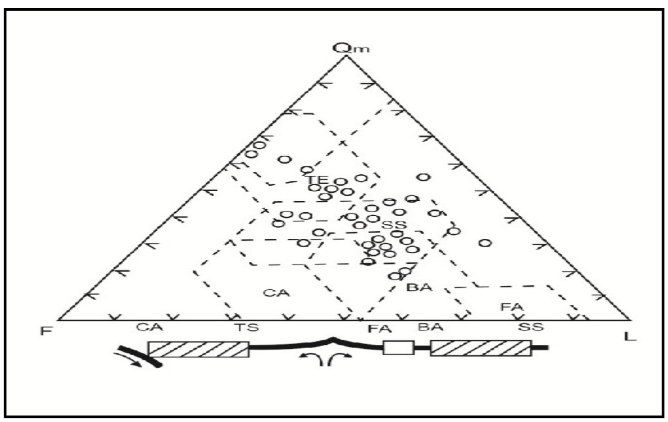

Figure-6: Graph Qm, F, L shows total thickness of the study area (tectonic settings). SS = strick–slip; CA = continental arc; TE = trailing edge; BA = back arc to island arc; FA = for arc to island arc; Qm = monocrystalline quartz; F = total feldspar grains; L = stone pieces. The data were compared with defined ranges from Yerino and Maynard.[15]

Conclusion

Petrography studies of the volcanic rocks in the Aliabad reveal that these rocks could be divided into distinct facies assemblages including: Tuff (vitric, lithic, and crystal)**,** Lapilli tuffs, lapillistone, tuff-breccia, volcanic breccias, ignimbrite, andesite porphyry, and tuffites. By comparing the results of the study, the overall regional tectonic position, possibly an “arc magmatic” eruptions, was directly thrown into a shallow basin behind the arc. On the other hand, this basin was near and a kind of SS basin, respectively (Magmatic arcs include the continental and island arcs associated with subduction, and these are areas of volcanic, plutonic rocks and sediments), and Aliabad is a SS basin, where sediments were fallen into the back-arc basin.

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