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MATTERS ARISING

Reply of K. Zoghlami & T. Haji, Université de Carthage, Faculté des Sciences de Bizerte, Département de Géologie, Laboratoire Ressources Minérales et Environnement (LRME)

on the Critique by Ramzi Azizi

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INTRODUCTION

We first wish to reaffirm the objective of this research work (Zoghlami, Zaddem, Haji, Gómez-Gras, & Azzaiez, 2024), given that there seems to have been a misunderstanding on the part of R. Azizi regarding this objective as well as the methodology employed for its realization. The fundamental objective of this study lies in the development of an appropriate formulation enabling the manufacture of substitute bricks exhibiting increased resistance to deteriorating agents while remaining compatible with the original bricks, which exhibit a remarkable state of preservation. Initially, it was necessary to identify the raw material used in the manufacture of the original bricks, followed by determining the firing parameters and finally establishing their technical characteristics. This preliminary phase represents the primary objective of this initial research document.

It is important to emphasize that the issue addressed in this article is not within the scope of tectonics or structural geology, and I am not attempting to provide geological updates as claimed by R. Azizi. It is crucial to understand that the geological aspect of the study was undertaken solely to locate the clay samples extracted to identify the source of the raw material used in the manufacture of bricks in the 17th century. I would also like to point out to R. Azizi that the creation of a stratigraphic column or a section synthesizing geological data constitutes an essential part of the research methodology when investigating the origin of construction materials for a given monument, as clearly demonstrated in my previous publications on this topic (Zoghlami & Gómez-Gras, 2009; Zoghlami et al., 2017).

Regarding the similarities between the sections: in order to achieve the objective of this work, we sampled all clay outcrops in the area for analysis. The section created had to pass through as many outcrops as possible and thus have the same orientation. I also remind R. Azizi that we all start with the same basic document, namely the geological map (Figure 1). As for the stratigraphic-thicknesses and Structorology—Cross section, we sought to be as faithful as possible to the field data confirmed by the bibliographic references (further details will be provided by my colleague and co-author Taoufik Haji, who is a specialist in the field). However, if Mr. Azizi expresses doubts, he is encouraged to redo the fieldwork and challenge our results. This is how science progresses: through questioning and constant verification of data and conclusions.

REPLAY ON THE STRUCTURAL COMMENT OF R. AZIZI (BY DR. HAJI. T)

Thicknesses and Lithology

On pages 4 and 5 (Zoghlami et al., 2024), we presented all the measured thicknesses that are confirmed by several authors who have worked in this study area:

[The study area of Ghar El Melh is formed essentially by a Neogene series about 4000 m thick, have been extensively studied by Burollet (1951). The Miocene consists of a 525 m thick variegated detrital series of the Hakima formation (Rehault, Boillot, & Mauffret, 1984; Yaich, Durlet, & Renard, 2000; Ait Brahim, Sossey Alaoui, Siteri, Tahri, & Baghdada, 2002; Bouaziz, Barrier, Soussi, Turki, & Zouari, 2002). In detail:

Hakima Formation: This formation consists of sands, sandstones, and marls with varied colors, reaching over 500 meters in thickness.

Oued El Melh Formation: This formation is over 630 meters thick and primarily composed of grey clays and marls rich in gypsum (El Euch-El Koundi, 2007).

Kechabta Formation: This formation features alternating clay-sandstone and clay-sandy layers, often exceeding 2000 meters in thickness (Burollet, 1951).

Oued Bel Khédim Formation: This formation spans 483 meters and primarily consists of alternating grey and black clays rich in gypsum (El Euch-El Koundi, 2007; Burollet, 1951).

The Raf Raf Formation includes grey and greenish clayey marls with sporadic yellowish indurated sandstone layers. It exhibits varying thicknesses, such as 966 meters in the Utique exploration drilling well and 133 meters south of Jebel Kechabta (Burollet, 1951).

The Porto Farina formation outcrops at Ghar El Melh, Jebel El Nadhour, and Jebel Ed Demina to the east of Sidi Ali el Makki (Burollet, 1951). The Porto Farina sandstones represent a significant detrital series that can reach a thickness of up to 504 meters (Melki et al., 2011; Harrab, Mannai-Tayech, Rabhi, & Zargouni, 2013)].

In addition, the thicknesses of lithological formations are measured locally at the sample level (the location is indicated by a blue box, in Figure 1). Still, some confusion is committed by some researchers in the field; they do not pay attention to real and apparent thickness: the real thickness = apparent thicknesses, with “It’s a dip of layers; in our case, it's 15 to 20° SE”. In addition, thicknesses change from one place to another as a result of paleogeography, paleo bathymetry, the vacuities, and the paleotectonic.

Structurology and Cross Section

On page 4 of Zohglami et al. (2024), we presented the structural work established principally on the field excursions that is confirmed by several authors who have worked in this area of study.

[NB: The study area is part of the large structural edifice of northern Tunisia, which is the Neogene basin of Kechabta, which itself constitutes the dip, towards the northeast, of the diapir zone. The tectonic structures of the Neogene Kechabta basin have been the subject of several geological (sedimentological and structural) and geophysical works whose objectives are the geometric characterization of the tectonic structures (mainly folded) as well as the understanding of the roles of major faults in the Mesozoic structural evolution of the Kechabta basin (Ennabli, 1980; Haj Ltaief, 1995; Melki et al., 2011)].

The map (Figure 1) clearly shows the signs of a dip in sandstone beds and conglomerate layers along our x section: these signs of dip are confirmed by all the authors who have worked in the region! By ourselves, we follow the field trips with our students. Moreover, measurements were performed on the surfaces of the stratifications.

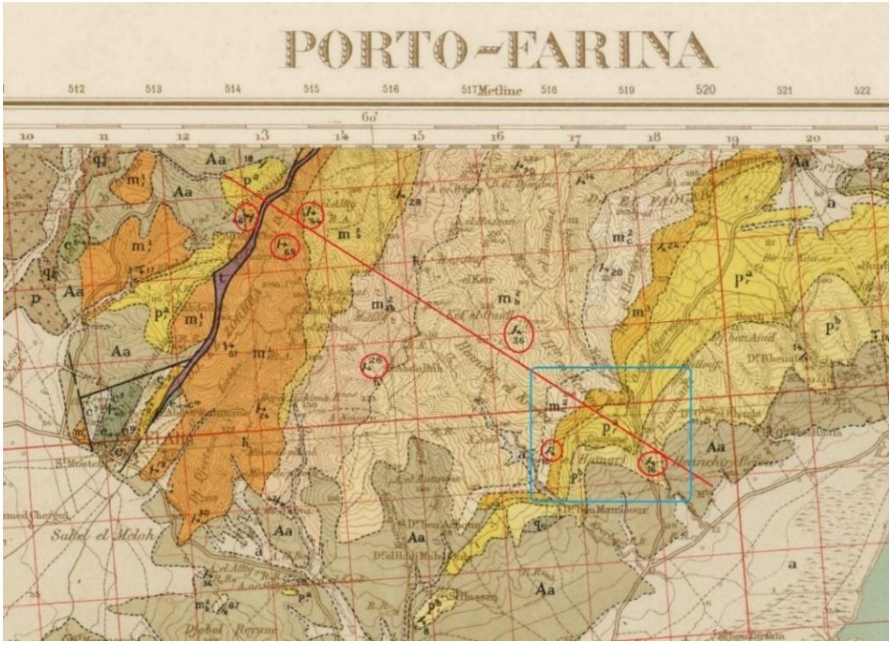

Figure 1. Excerpt from the Geological Map of Porto Farina (the Geological Raises Were Carried out by P. F. Burollet in 1948-49 with all Standard Cartographic Signs)

Here, we emphasize that the geological section presented by Azizi in 2017 contains no signs of dip.

The question that arises is how R. Azizi identified the direction of the dip of the layers? And, on what basis and with what data was this field section carried out?

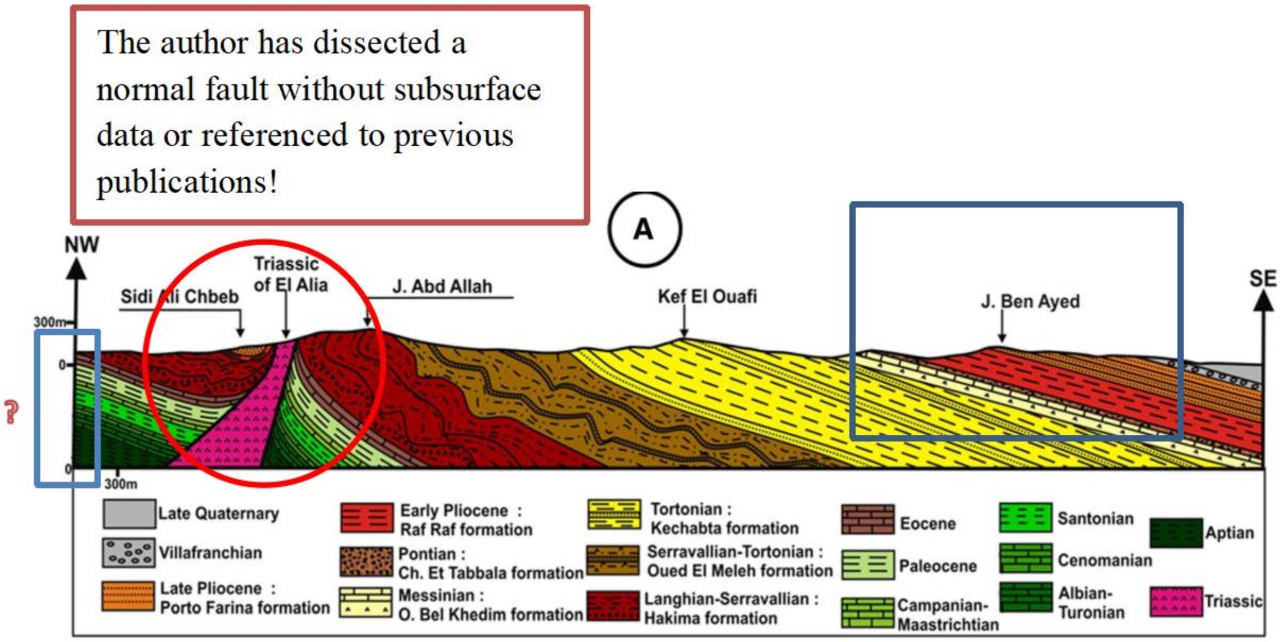

Figure 2. The geological section presented by R. Azizi in 2017 has no signs of dip, wrong scales and mistaken fault, it's a beginner's work (Azizi, 2017)

This section is without any signs of dip. To the NW and below the structure of Sidi Ali Chbeb and that of J. AbdAllah how the author was able to highlight the series of Paleocene to the Aptian age? Without any subsurface data, moreover, both vertical and horizontal scales (Figure 2) are wrong. Even the cross-section profile is mistaken. This is in fact an elementary thing in geology.

Towards the NW of this geological section, the ElAlia-Teboursouk fault is a reversed overlap fault and not normal fault. In detail, this fault is a left-strike-slip reverse compressive fault, injected by the salty Triassic facies, with a SE-verging in the forelimb. The subsurface study of this sub-vertical strike-slip deep-seated fault confirmed his reverse play. All the researchers confirm this reverse fault. It is the famous El Alia-Teboursouk Fault (ETF), well described by several geologists. In the following figures, you can identify the red circle, which indicates the play of this fault confirmed and assigned by many researchers, from 1951 to present (Burollet, 1951; Burollet, 1956; Perthuisot & Jauzein, 1974; Rouvier, 1985; Ben Ayed, 1993; Dlala & Rebai, 1994; Boukadi & Bédir, 1996; Rigo, Garde, El Euchi, Bandt, & Tiffert, 1996; Kacem, Dlala, & Hfaiedh, 2001; Mejri, Regard, Carretier, Brusset, & Dlala, 2010; Melki, Alouani, Talbi, & Zargouni, 1996; Melki, Zouaghi, Chelbi, Bedir, & Zargouni, 2010, 2012; Melki et al., 2011; Bejaoui, Aïfa, Melki, & Zargouni, 2017; Mejri et al., 2010; Zouaghi et al., 2010; Alyahyaoui, Gabtni, Zouari, & Mzali, 2013; Haji, Dhahri, Marco, & Boukadi, 2013; Andolssi et al., 2015; Touati & Haji, 2019; Zaghdoudi, Kadri, Alayet, Bounasri, & Gasmi 2021; Zaghdoudi, Alayet, Aydi, Ghouma, & Gasmi, 2022).

It's possible that R. Azizi didn't conduct fieldwork, or perhaps only undertook a basic introductory survey typical of a newcomer to this study area. Therefore, we cannot cite this purported geological section, as it does not accurately reflect the field's reality. Moreover, even though our work is far from tectonics and structurology, we have shown an adequate representation that goes with our scientific objectives (locating the sampling sites, thicknesses, and giving a brief and explicit picture of the structure of the region).

The blue case (Figure 3) shows the location of the brick raw material mine that was used in the construction of the fortress of Ghar el Melah (called Porto farina) the location is accessible and known by all the researchers. Our X section coincides with the orientation of the sections carried out in the region (Melki et al., 2011; Bejaoui et al., 2017), even if the themes of the work are too different. Furthermore, no information was copied from the section made by R. Azizi, for the simple reason that his work does not rely on real field data or on prior works carried out in this region by the other researchers cited before.

On the SE side, our geological x section passes through Jebel Demna and the Oed ELJraia and the section of R. Azizi passes by Jebel Ben Ayed (Figures 2 and 3). In our geological X section, there are too many topography details, signs of dip, a correct scale, sedimentary discordances/hiatus showing also the reverse play of ElAlia - Teboursouk fault with his Triassic extrusion (Figure 3, red circle). It is a meticulously section, true to reality, even though our primary goal is to showcase the sampling site for the case study.

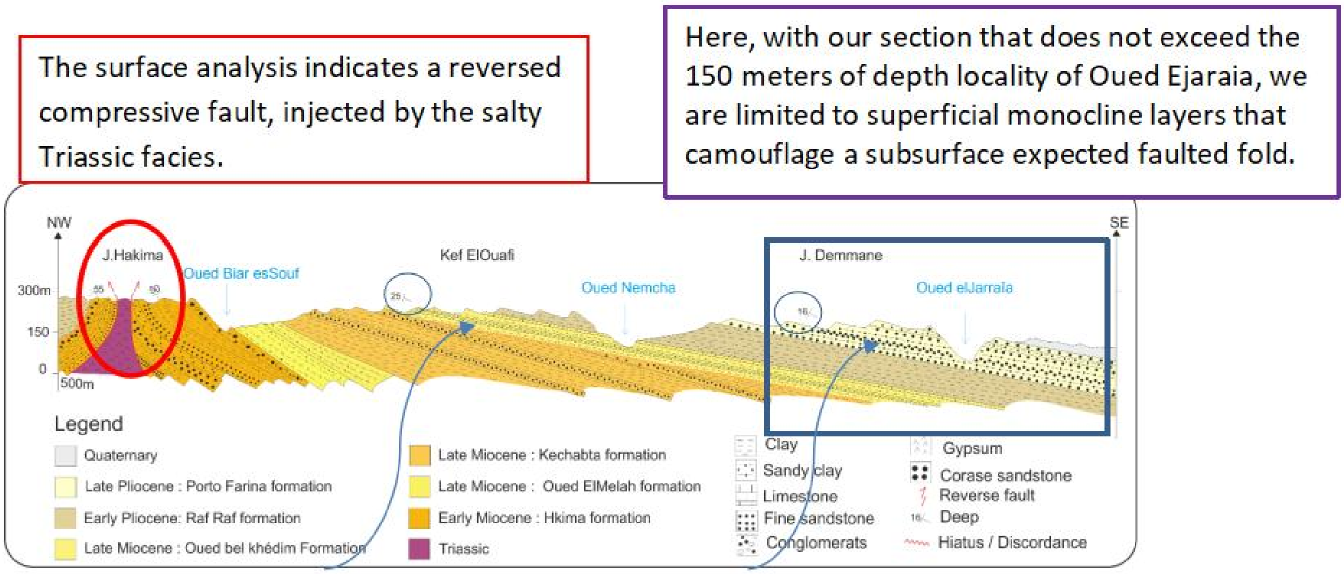

Figure 3. Cross section (Zoghlami et al., 2024)

The surface analysis indicates a reverse compressive fault, injected by the salty Triassic facies (Figure 3, red circle). Measurements of Layer Dips are Carried Out at the Level of Sandstone and Conglomerate Layers (Figure 3, blues circle). In the locality of Oued Ejaraia, the section does not exceed 150 meters in depth; we limited ourselves to representing only the superficial monocline layers that conceal an expected faulted fold in the subsurface.

Regarding the overlooked or omitted anticlinal, highlighted by Mr. Azizi, it is a surface-concealed anticlinal by sedimentary layers, which form a monocline structure dipping from 15 to 22° southeastward in the section (Figure 3, blue rectangle), particularly at Jebel Demna, representing a prospective folded fault. The axis of this mega-fold extends to Ras Etarf in the east. This partially sealed anticlinal structure is confirmed by our fieldwork as well as by subsurface data given by several authors (Melki et al., 2011; Bejaoui at al., 2017 and Zaghdoudi et al., 2022) (Figures 5, 6, 7 and 8).

In the subsequent sections (Figures 4 to 9), we present compelling data from diverse sources that align with the geological and structural characteristics of the study area. These findings both challenge and contradict the conclusions drawn by Azizi.

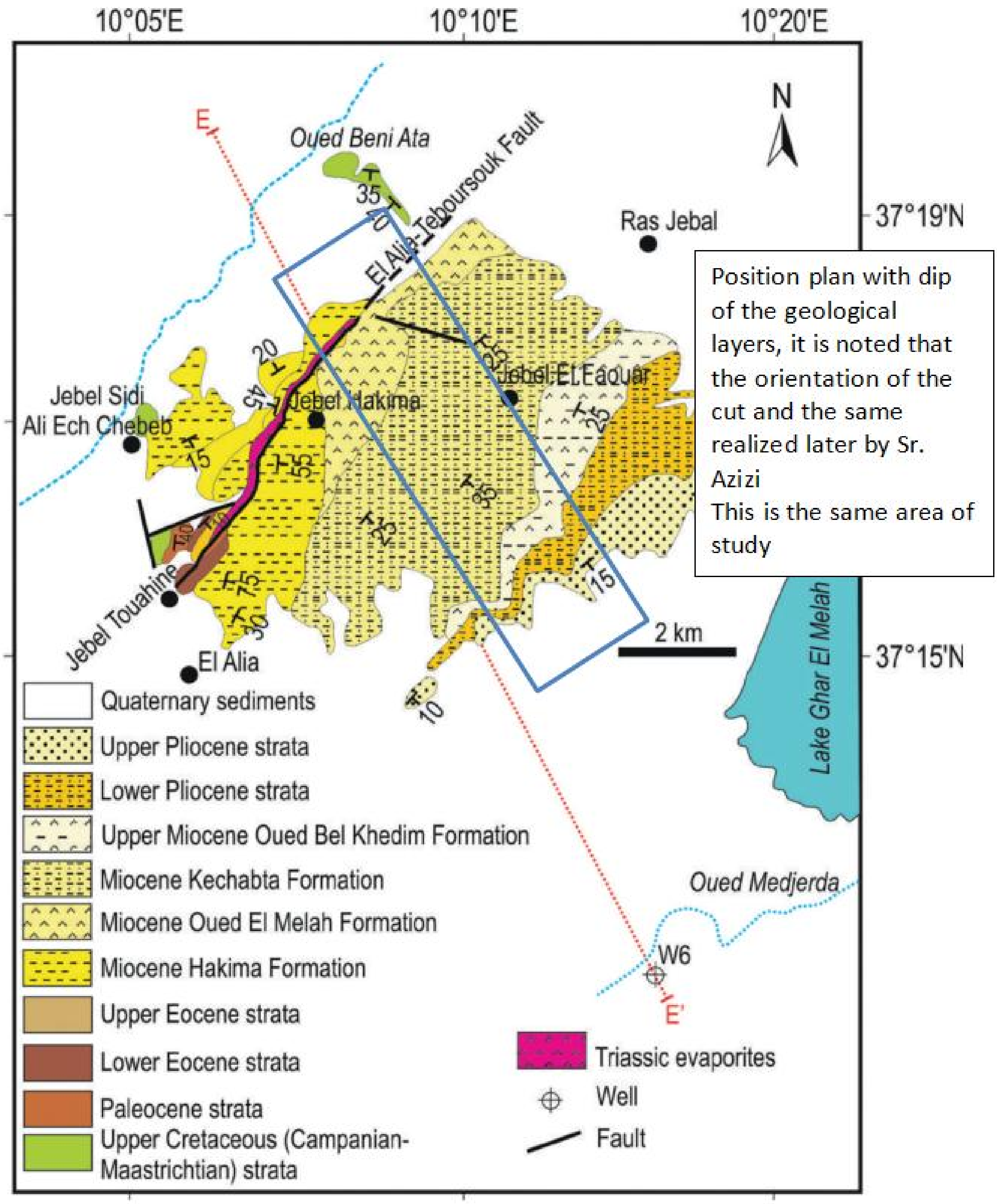

Figure 4. Simplified Geological Map of the El Alia Basin, and Location of Geological Cross Section E-E' (Bejaoui et al., 2017).

This figure (Figure 4, blue rectangle) shows the dip of the geological layers indicates that both the initial cut's orientation and the subsequent one carried out by Azizi are also identical. This is the same area of study.

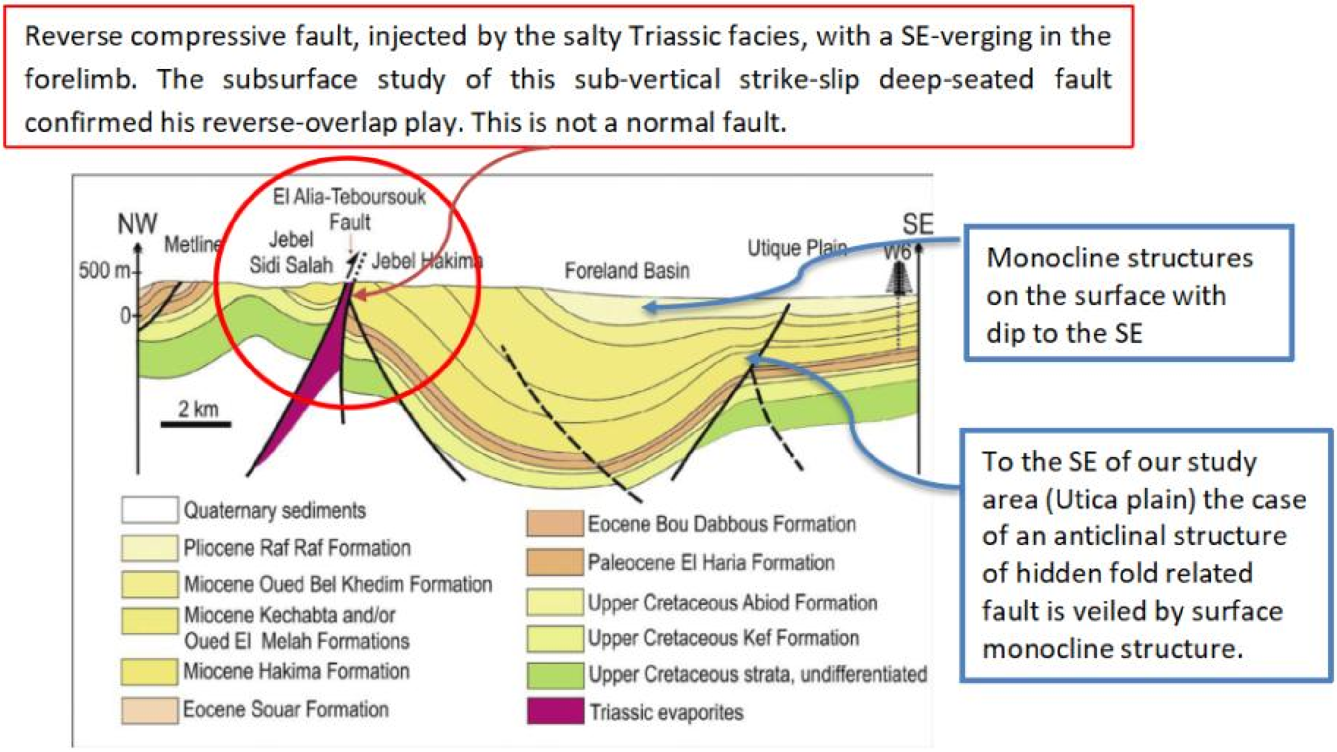

Figure 5. Geological Cross Section E-E' Through the El Alia Basin (Bejaoui et al., 2017)

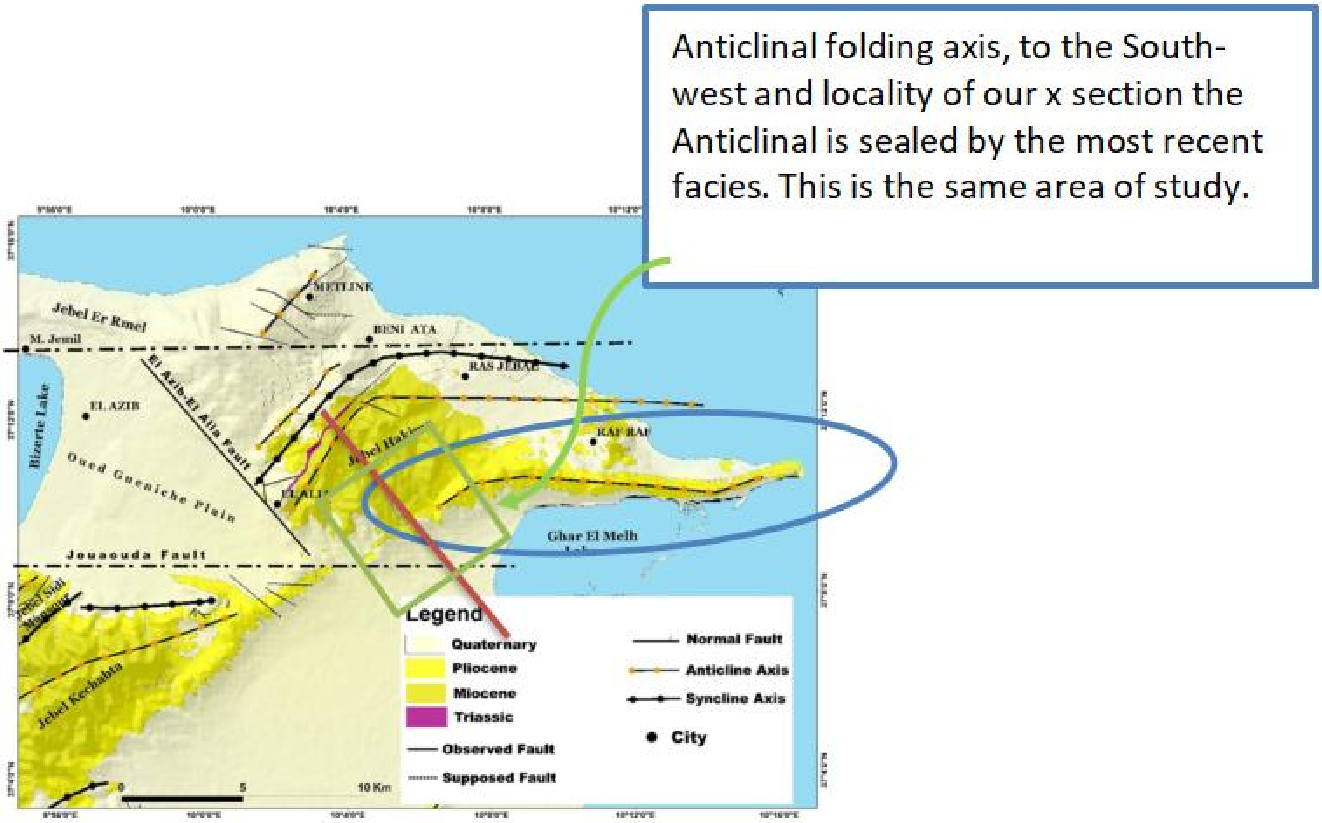

Figure 6. Structural Scheme of the Study Area (Zaghdoudi et al, 2022)

The figure (Figure 6) shows that towards the South-west of our x section (red line), the anticlinal is sealed by the most recent facieses.

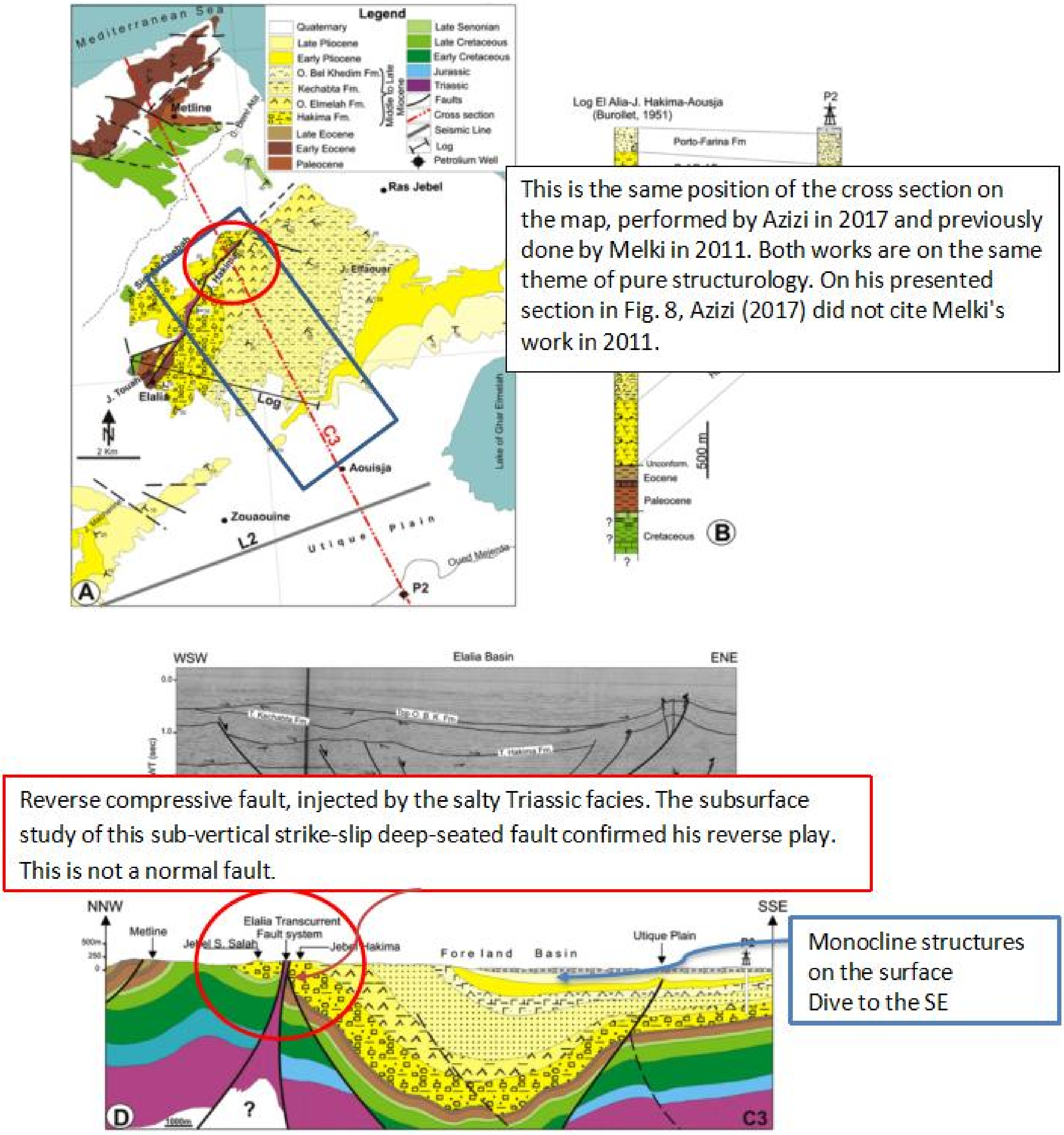

Figure 7. Surface and Subsurface Geological Data of the ElAlia basin; (A) Geological and Structural Map; (B) Lithological Correlation Between the ElAlia-Metline Synthesis Log (Burollet, 1951) Kechabta Outcrop and P2 Petroleum well; (C) ENE WSW Interpreted Seismic Line (L2); (D) NNW-SSE Geological and Structural Interpretative Cross Section Through the Basin (Melki et al., 2011)

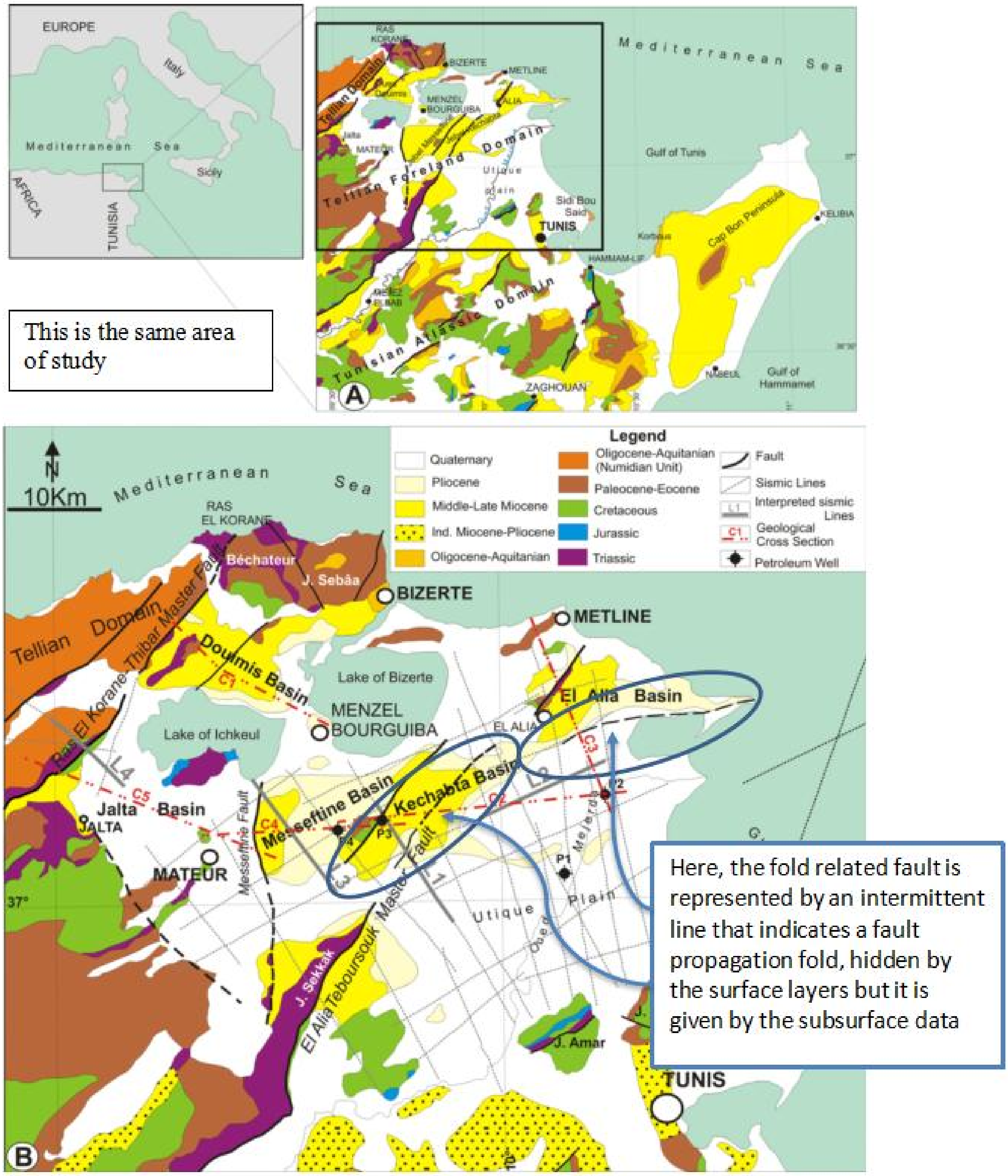

Figure 8. (A) Geological Setting of Onshore Northeastern Tunisia; (B) Detailed Geological Map Showing location of the Main Tectonic Features Including Distribution of the Neogene Basin Sand Paleo Highs in the NE-SW Transcurrent Shear Zone.

This figure (Figure 8) shows the Data Set Used in this Study (Reflection Seismic Section Sand Petroleum Wells) (Melki et al., 2011).

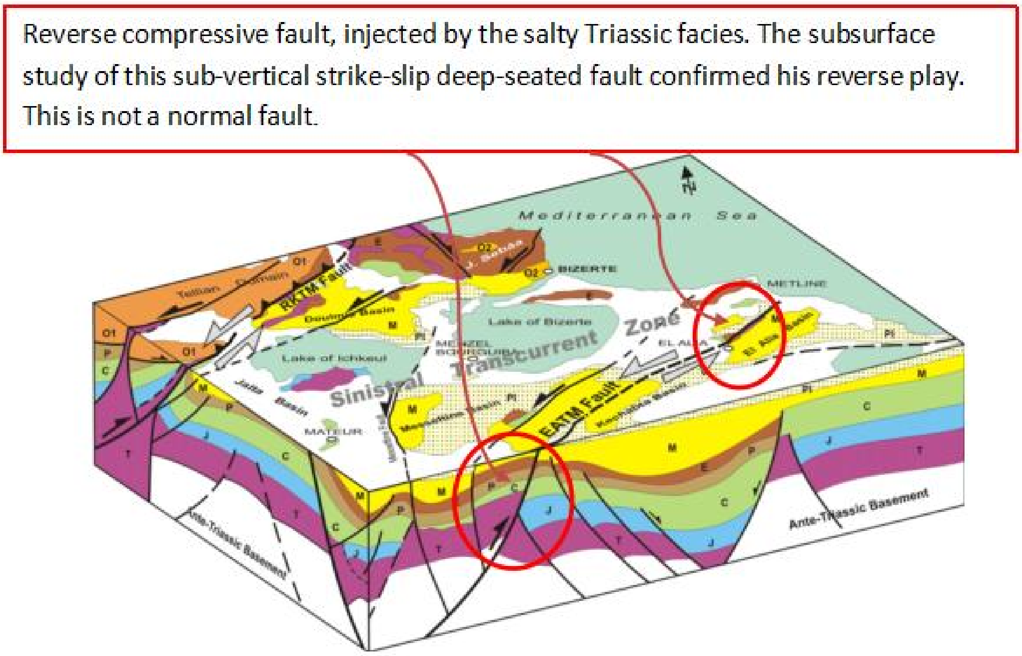

Figure 9. 3D Block-diagram of the Study Area, Showing Relationships between the NE-SW Master Transcurrent Fault Sand the Structuring of the Neogene Basins in the Tellian Fore Land Domain (Melki et al., 2011) (Note: EATM Fault: ElAlia Teboursouk Master Fault; RKTM Fault: Ras ElKorane-Thibar Master Fault; Pl, Pliocene; M, Miocene; O1, Oligocene-Aquitanian (Numidian unit); O2, Oligocene Aquitanian; E, Eocene; P, Paleocene; C, Cretaceous; J, Jurassic; T, Triassic).

CONCLUSION

From a geological standpoint, in this study, we tried to locate the sampling carried out from the locate outcropping adjacent to the studied monument and to provide the maximum reliable geological information concerning the local geological formations. A geological cross-section and a stratigraphic log have proven to be highly valuable tools for guiding systematic sampling and identifying the source area of the raw materials used in manufacturing the 17th-century bricks, which are the primary focus of the present research.

We have provided scientific responses to Mr. Ramzi Azizi's criticisms regarding the two figures (the geological cross-section and the stratigraphic log), presenting all possible arguments. In our study, the thicknesses accurately reflect the sampling site, corroborated by several authors. The geological cross-section faithfully represents reality without any aesthetic alterations, as evidenced in the discussion. However, it is important to emphasize that these figures have not affected our research in any way, neither methodologically nor in terms of results.

Finally, for the benefit of the scientific community we ask Sr. Azizi to withdraw his article for correction and reassessment. Furthermore, it is important to emphasize that while everyone has the right to critique the work of others, it should be done with respect and without manipulation. Also, researchers have the right to publish on areas that have been previously studied by others without being obliged to mention works that do not conform to the reality of the field.

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