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The Pelarda Fm., a prominent impact ejecta deposit from the Mid-Tertiary Azuara multiple impact event (Spain), geologists from the University of Zaragoza, and the *Revista de la Sociedad Geológica de España*: a commentary on the manipulation of science.

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Abstract. - We comment on a recently published (June 2026) article by geologists from the University of Zaragoza (lead author Prof. José L. Simón) in Spanish, titled (translated) *The controversial conglomerate complex of Sierra Pelarda (Central Iberian Mountain Range): clast recycling in a comprehensive morphotectonic-sedimentary model*. This article is a continuation of all previous efforts—primarily by geologists at the University of Zaragoza—to ignore or discredit the massive multiple impact event at Azuara-Rubielos de la Cérida, which has been described in extensive literature for decades. In the article by Simón et al., two related articles from 1990 and 1992 (i.e., 30 years old) are mentioned in a single brief sentence, but neither the Azuara impact structure nor the Pelarda Formation—one of the world’s largest and most significant impact ejecta deposits—is mentioned again, not even in the abstract. In recent years, the Pelarda Formation impact ejecta have been mentioned and discussed in greater detail in more than a dozen publications, including papers presented at conferences of the Meteoritical Society, the Lunar & Planetary Science Conference, and the American Geophysical Union. A 60-page article on the Azuara and Rubielos de la Cérida impact was printed and published in 2002 by the *Treb. Mus. Geol. Barcelona*, featuring a lengthy section on the Pelarda Formation. Extensive papers on the Azuara impact structure, including the Pelarda Formation ejecta, are available on publicly accessible websites and can be downloaded there. The most recent presentation also regarding the Pelarda Formation ejecta took place at the annual meeting of the Meteoritical Society in 2023. The impact-related presentations on the Pelarda Formation generally list the globally recognized geological and mineralogical-petrographic findings and evidence that prove the impact. These include widespread, intense shock effects such as impact melts, diaplectic glasses, planar deformation features (PDF and PF), and typical shock-spallation fractures, which are also described for the rocks of the Pelarda Formation. The abundant polymictic breccias in the diamictitic deposits of the Pelarda Formation—featuring polymictic breccia generations otherwise virtually unknown in “normal” geology—cannot be overlooked. This also applies to megaclasts made of Buntsandstein and Eocene rock, up to 9 m in size, that are intercalated within the Pelarda Formation and are difficult to explain

using the model proposed by Simón et al. The fact that geologists do not (or do not wish to) understand impact geology has been discussed extensively, but this does not justify the complete suppression of previous research and its extensive and publicly accessible literature. This serious accusation against the geologists at the university applies in particular to the first author, Prof. Simón, who sets a bad example for his students—who are apparently co-authors—of a scientific practice characterized by manipulation. A serious accusation is also directed at the journal *Revista de la Sociedad Geológica de España* for publishing this fundamentally unscientific article, as well as at the peer reviewers (assuming a peer review took place at all), who apparently condoned this manipulation of science. In the following commentary, we use examples to demonstrate how the authors undermine and contradict all clear impact evidence in favor of their untenable morphotectonic-sedimentary model of the Pelarda Formation.

RESPONSE TO THE ARTICLE: THE CONTROVERSIAL CONGLOMERATE COMPLEX OF SIERRA PELARDA (CENTRAL IBERIAN MOUNTAIN RANGE): CLAST RECYCLING IN AN INTEGRATED MORPHOTECTONIC-SEDIMENTARY MODEL. (José L. Simón¹, Luis E. Arlegui¹, Aránzazu Luzón¹, Alba Peiro², M^a Asunción Soriano¹, Carlos L. Liesa¹, Journal of the Geological Society of Spain, 39 (1), 2026; <https://doi.org/10.55407/rsge.120742>)

Before beginning our response to the aforementioned article—at least on this website—we would like to clarify a few points that will be addressed later in the response:

- A. First, we would like to highlight the lack of scientific rigor and fair play on the part of the article's authors. There is little, if any. When one writes a scientific article on a specific topic, one first seeks advice and gathers all available information on the subject (something for which we were criticized when the first articles on the Azuara impact began to be published, as they did not cite works published by regional geologists in the area). In the case of the Pelarda Formation, they intentionally ignore (and this is not the first time) what we have documented on our website and on ResearchGate. Specifically, the update on the Pelarda Formation that we posted in 2019 on our website and published on ResearchGate. Both are open access, so there can be no claim that they are difficult to access. This omission is particularly interesting because it is the first—if indeed the first—publication to accurately date the Pelarda Formation, as it identifies (and photographs) the area where it directly overlies the Upper Eocene–Upper Oligocene levels (ITGE, 1991) and the area where it underlies the Miocene strata. Its age is therefore precisely determined to fall between the Upper Eocene and the Lower Miocene, rather than being merely presumed. Furthermore, the type sequence of the Pelarda Formation is established and recorded (in a stratigraphic column), and its components are analyzed.
- B. When we refer to **rudite**, we are referring to a class of detrital sedimentary rock

composed mainly of rounded or angular fragments larger than 2 mm in diameter, such as gravel, boulders, pebbles, or blocks. The term constitutes one of the three major groups in the classical textural classification of clastic rocks, along with **sandstones** (sand-sized) and **mudstones** (silt- and clay-sized). Rudites, depending on the shape of their clasts (rock fragments) and their degree of consolidation, are divided into: **Conglomerates** (consolidated rock with mostly rounded clasts); **Breccias** (consolidated rock with angular clasts); and **Gravel** (the unconsolidated equivalent—loose sediment—of rounded or angular fragments). In the case of conglomerates—though not always—it is assumed that the roundness of the clasts is due to wear resulting from longer transport than in the case of breccias, where transport, and therefore wear, is less.

- C. There are differences between the terms **rudite** and **diamictite**. In a rudite, 2-mm fragments are typically in direct contact with one another (clast-supported) or sorted within a coarse size range. In a diamictite (an extremely poorly sorted rudite), the coarse clasts are completely isolated and “float” within an abundant fine matrix (of clay or sand).

D. In the rebuttal to the data presented in the article by Simón et al. (2026), see section 3 (Discussion–Rebuttal); the data from the non-impactists are presented in quotation marks and italics, followed by our rebuttal without quotation marks and in regular typeface.

1. Observations: data presented in the aforementioned article by Simón et al. (2026)

- The bulk of the deposits, referred to as Complex 1 (C1), is a thick, inclined sequence from the Middle to Upper Eocene, corresponding to UTS T2 of the Montalbán Basin. The subsequent complexes (C2, C3, C4) are Neogene–Quaternary deposits derived from the erosion of C1. The upper part of the mountain range is a residual relief that was not eroded by the Fundamental Erosion Surface (SEF) and was uplifted by the Cucalón-Pancrudo Fault, the largest extensional structure in the central-eastern Iberian Mountain Range
- The poor quality of the outcrops hinders their mapping and stratigraphic and structural characterization. These uncertainties have led to widely divergent interpretations: a subhorizontal Pliocene-Quaternary unit over the Paleogene of the Montalbán Basin (Carls and Monninger, 1974; Martín et al., 1977; Gabaldón et al., 1989, 1991); a conglomeratic unit within that same Paleogene, folded and then partially eroded by Neogene erosion surfaces (Moissenet, 1980; Adrover et al., 1982; Pailhé, 1984); ejecta from a meteorite impact (Ernstson and Claudín, 1990; Ernstson and Fiebag, 1992).
- Cortés Gracia and Casas Sainz (1996) apply the same model proposed by Moissenet (1980) to the conglomerates of Sierra Pelarda: Cenozoic continental materials overlain by Triassic and Paleozoic strata from Olalla-Collados. Aurell et al. (2022) do the same, considering the “Pelarda conglomerates” to be a continuation of the basal series of the Montalbán Basin.
- The third interpretation for the uppermost quartzitic conglomerates—clearly distinct from the previous ones—is based on the work of Ernstson et al. (1985), who argued for the existence of a Paleogene meteorite impact in the transition zone between the Iberian Mountain Range and the Ebro Basin. The impact crater would roughly correspond to the Cenozoic Azuara basin, filled with Oligo-Miocene sediments. Ernstson and Claudín (1990) and Ernstson and Fiebag (1992) propose that the Sierra Pelarda unit consists of meteorite ejecta—that is, material torn from the ground and projected outward as a result of the Azuara impact. This would be proximal ejecta, accumulated only about 10 km from the crater rim. The authors describe blocks of quartzite and schist that are striated, polished, fractured, or plastically deformed, which they present as evidence of shock deformation. Aurell et al. (1993) demonstrate the inconsistency of this interpretation, presenting solid arguments based on knowledge of stratigraphy and regional tectonics: the structure of the Azuara area is determined simply by arched folds and thrusts overlain by the discordant Miocene of the Ebro Basin; breccias and megabreccias attributed to the impact are, in reality, brecciated limestones of the Lower Jurassic (Cortes de Tajuña Formation) or Cenozoic conglomerates

deformed on a small scale by Alpine compression; the “ejecta” of Sierra Pelarda is a conglomerate of rounded pebbles typical of fluvial or alluvial environments. Therefore, of the three hypotheses regarding the area, this one is not considered.

- The evaluation of both hypotheses required undertaking two main tasks: (i) critically analyzing the evidence provided in the corresponding publications, rigorously applying the hypothetical-deductive method to identify which testable inferences the authors propose and to determine whether or not these have been verified; (ii) “revisiting” the conglomerates of Sierra Pelarda and test the hypotheses against new field observations and imagery (aerial photographs, satellite images, Digital Elevation Models).
- The published evidence regarding this unit is not very explicit: no detailed maps, panoramic photos, or outcrop photos are provided to support it; only a few photographs and descriptions of the materials, along with general considerations regarding their relationship to erosion surfaces and tectonic structures.
- In previous publications, the materials of La Pelarda were described as conglomerates consisting of rounded pebbles and blocks up to 1 m in diameter, composed mainly of siliceous rocks (quartzites and sandstones of Paleozoic and Triassic origin). The authors acknowledge that although this is the appearance of the deposit in some places, field surveys on the slopes and foothills and at the highest points of the mountain range (based on outcrops in certain deeply incised ravines or, alternatively, on exploratory test pits dug with a backhoe) have shown that the situation is more complex.
- In this study, four lithological assemblages have been distinguished that contain the characteristic rounded siliceous pebbles of the Pelarda facies but that clearly differ in their lithological and textural features, as well as in their arrangement and age. They lack stratigraphic continuity and have been designated as groups C1 through C4. From oldest to youngest, they correspond to: a stratified and inclined conglomerate series (C1); subhorizontal stratified conglomerates and sandstones (C2); uncemented, unstructured, and unstratified gravels at medium and high elevations of the mountain range (C3); and uncemented, unstructured, and unstratified gravels in the western foothills of the mountain range (C4).
- The C1 unit constitutes the majority of the Pelarda Formation. Its layers exhibit inclined stratification trending NW-SE to WNW-ESE, with a dip ranging from 25° to 40°S on the northern slope, which tends to decrease to 18–20°S in the summit area of the Sierra Pelarda and on its southern slope. Taking into account the dip and the outcrop width along the mountain range (greater than 2 km), the thickness of this entire sequence of conglomerates interbedded with sandstones and shales is estimated at 800–900 m. The Pliocene erosion surfaces SEF2 and SEF3 have affected C1.
- The stratified conglomerate deposits tilted toward the southwest (C1 complex) constitute the majority of the conglomerate material volume in the Sierra Pelarda. The source area of the siliceous pebbles that make up the thick conglomerate deposit of Sierra Pelarda assigned to C1 is believed to lie to the west of the range (Fig. 15A). The alluvial fans originating from this siliceous source area would converge, toward the central-eastern part of the Montalbán Basin (south and southeast of Segura de los Baños), with the predominantly carbonate alluvial fans of northern origin described by Pérez (1989). The source of the siliceous materials from Sierra Pelarda (group C1) is currently located in the Paleozoic substrate of the Calatayud Neogene Basin.

This substrate consists of Cambrian units (e.g., the Bámbola, Daroca, and Embid Formations) and, to a lesser extent, Ordovician units dominated by siliceous rocks (quartz arenites/quartzite sandstones and conglomerates), sometimes occurring in thick beds (>2 m) (Lotze, 1929; Gabaldón et al., 1991; Liñán et al., 2004). The apparent contradiction between the current elevation of the source materials in this area (around 900–1000 m) and the elevation of the resulting deposits in the Sierra Pelarda (up to 1500 m) can be resolved by taking into account the tectonic structure of the region, particularly that resulting from its subsequent evolution. On the one hand, the Neogene Calatayud Basin and its Paleozoic basement are bounded to the east by the NNW–SSE Cucalón–Pancrudo fault segment, whose Pliocene–Quaternary (post-SEF3; 3.5 Ma) has been estimated in the Lagueruela sector (west of the Sierra Pelarda) at about 300 m (Peiro, 2023; Peiro et al., 2024). This jump would likely exceed 500 m if considered the Neogene evolution of the basin as a whole (Fig. 15B, C). Reconstruction of this Neogene–Quaternary normal fault displacement would place the Paleozoic basement of the Calatayud Basin at a height similar to or greater than that of the conglomerates of the C1 group located at the highest point of the Sierra Pelarda, currently within the uplifted block of that normal fault. On the other hand, this fault segment results from the reverse faulting of an imbricated system of thrust faults with a similar orientation—perhaps with a more Iberian trend (NW–SE)—which are recognized in the vicinity of the town of Lagueruela and to the northeast and east of the town of Collados (southwest of the Sierra Pelarda). It is interpreted that the source area for the siliceous C1 conglomerates of the Sierra Pelarda would be the upper block of this thrust system, whose erosional undercutting led to the deposition of this assemblage. This new paleogeographic proposal for the upper part of the Montalbán T2 tecto-sedimentary unit would explain the facies change described here and recognized by Pailhé (1984), with alluvial facies lying relatively farther to the east—that is, toward areas farther from the thrust system.

- **Conclusions:** The siliceous conglomerates that form the main body of the Sierra Pelarda, characterized by their abundance of rounded blocks derived from Paleozoic and Triassic quartzites and sandstones, belong to a thick section of the Paleogene series of the Montalbán Basin, approximately 800–900 m thick and attributable primarily to the Middle–Upper Eocene (UTS T2 of the Montalbán Basin). Its source area was the upper block of a system of thrust faults activated during Alpine compression and subsequently inverted during Neogene extension, giving rise to a segment of the Cucalón–Pan Crudo fault zone. Currently, the materials from this source area are covered by the Neogene fill of the Calatayud Basin. Starting from these original conglomerates (assembly C1), the boulders and blocks containing the remaining alluvial materials in the mountain range and its surroundings were recycled from them during their erosive dismantling beginning in the Oligocene. Although these materials show a notable convergence of facies resulting from their common origin (Pelarda facies), constitute a polygenic and heterochronous complex comprising three lithological groups: C2, Middle Miocene–Lower Pliocene conglomerates and sandstones; C3, uncemented and unstratified alluvial gravels from the early Upper Pliocene; C4, alluvial and colluvial gravels from the Upper Pliocene–Quaternary. The overall morphotectonic-sedimentary evolution of the Sierra Pelarda comprises three stages: (1) Paleogene Stage. The original siliceous conglomerates, originating from a Paleozoic source area to the west, are deposited. During and after their

sedimentation, these conglomerates are folded and overthrust by lower Paleozoic units. (2) Miocene–Pliocene stage. The Calatayud Basin subsides within a context of compression-extension transition. The relief of the mountain range is shaped; its highest point remains as residual relief, while several stepped level surfaces develop in its surroundings: SEF2, SEF3, and SEF4. Erosion of the Paleogene conglomerates causes their siliceous clasts to be incorporated into the sediments of the C2 complex and subsequently into the C3 cover associated with SEF3. (3) Pliocene–Quaternary Stage. The Cucalón-Pancrudo fault zone is reactivated, completing the negative inversion of the contractive structures. The vertical jump reaches 280–300 m (net jump of 305–325 m). During the Quaternary, the drainage network continues to cut into the uplifted block, and alluvial sedimentation occurs in fans and on slopes. The spatial extent of the deposits of rounded siliceous blocks and the objective difficulties in observing them initially led some authors to interpret that the entire upper part of the Sierra Pelarda was formed by a large Pliocene–Quaternary alluvial unit, with a thickness of nearly 200 m—an idea that was incorporated into the IGME’s mapping. The model proposed here corroborates the alternative model defended in the works of Moissenet, Adrover, and Pailhé, which had remained on the sidelines of the debate for the past four decades.

2. Observations Our 2019 article

Regarding their genesis, the deposits of the Pelarda Formation have been attributed to fluvial processes (Carls and Monninger, 1974; Adrover et al., 1982; Smit, 2000 (written communication)), to alluvial processes (Lendínez et al., 1989; Pérez, 1989; Aurell et al., 1993; Aurell, 1994; Cortés et al., 2002; Díaz-Martínez et al., 2002a, 2002b, 2002c; Díaz-Martínez, 2005), and to processes linked to an impact (Ernstson and Claudin, 1990; Ernstson and Fiebag, 1992; Rampino et al., 1997a and b; Claudin et al., 2001; Ernstson et al., 2002; Ernstson et al., 2003; Claudin and Ernstson, 2003; Ernstson, 2004; Claudin et al., 2019).

The proposed age for the assemblage of materials constituting this Formation has ranged from the Paleogene (Carls and Monninger, 1974; Adrover et al., 1982; Ernstson and Claudin, 1990; Ernstson and Fiebag, 1992; Ernstson et al., 2002; Ernstson et al., 2003; Claudin and Ernstson, 2003) and the Quaternary (ITGE, 1989; ITGE, 1991; Aurell et al., 1993; Aurell, 1994; Smit, 2000 (written comment), Cortés et al., 2002; Díaz-Martínez et al., 2002a, 2002b, 2002c; Díaz-Martínez, 2005). The same authors (Cortés et al., 2002) who attribute a Quaternary age (Pliocene or Pleistocene) to it, consider it a “raña”¹-type deposit, generated by a local alluvial fan (adjacent to now-denuded Paleozoic landforms), although Díaz-Martínez (2005) curiously considers it to still be under study. While in our first and extensive article on this Formation (Ernstson and Claudin, 1990) we merely added a few observations to the work carried out by Carls and Monninger (1974), *the present study (Claudin & Ernstson, 2018) aims to provide a more detailed review and analysis of it.*

Geologically, the Pelarda Formation is “surrounded” by Paleozoic, Mesozoic, Lower Eocene–Oligocene, Lower–Middle Miocene, and Quaternary materials, according to existing maps (ITGE, 1991 (Fig. 1); ITGE, 1989; IGME, 1977) and our own field data.

¹ A glacia composed of quartzite pebbles with a clay matrix, developed on Paleozoic strata under a periglacial or arid climate.

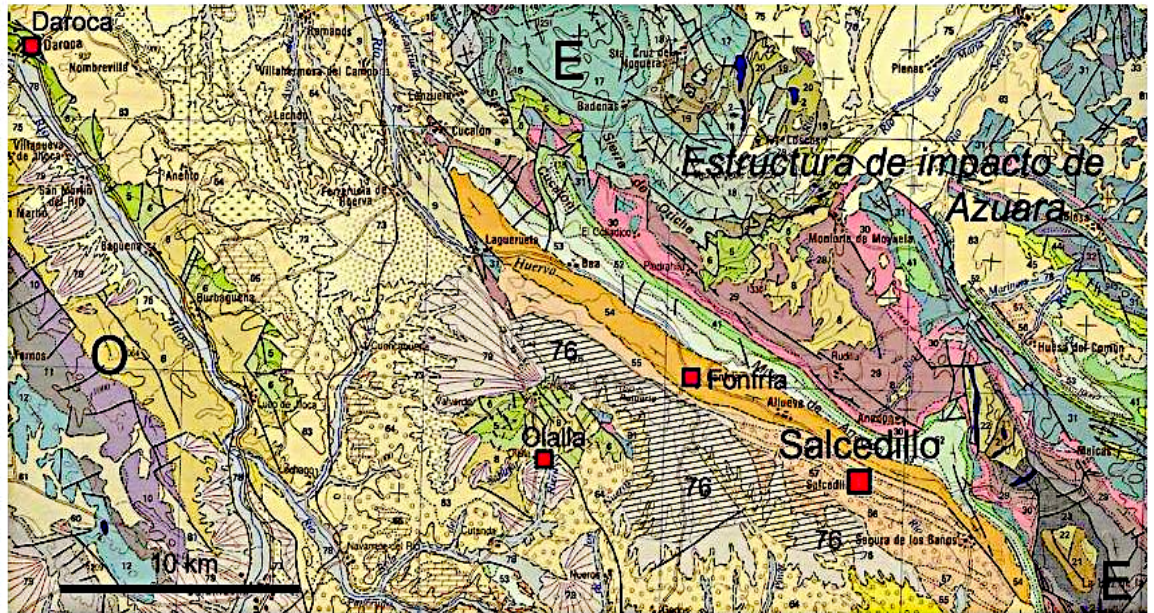


Fig. 1. The Pelarda Formation on the incorrect 1:200,000-scale map by the ITGE (1991). On this map, the Formation (number 76) corresponds to a Quaternary-age deposit (a “raña”) that does appear in the Salcedillo area (outlined in red).

- The methods used to study the Pelarda Formation consisted of:
 - The construction of stratigraphic columns where outcrops permitted it, and their correlation.
 - Collecting and analyzing more than 150 clasts from the diamictic levels, whose roundness and sphericity were determined according to the visual criteria of Powers (1953) and Krumbein and Sloss (1955).
 - Petrographic characterization, as well as the analysis of 35 thin sections of the collected clasts
 - The collection and petrographic analysis, including 25 thin sections, of sandstones from both the intercalations between diamictites and isolated levels.
 - The analysis of the identified sedimentary structures and facies.
 - Analysis of paleocurrents, where the outcrop has allowed it.
 - The search for fossils in layers likely to contain them, in order to perform dating.
- To construct the stratigraphic column—in this case, the type section of the Pelarda Formation—we followed a trail leading southwest from Salcedillo that cuts across the Pelarda Formation approximately perpendicular to its dip (Fig. 2).



Fig. 2. The route of the trail leading from Salcedillo in a southwesterly direction, shown in red, provides a view of a complete section of the Pelarda Formation.

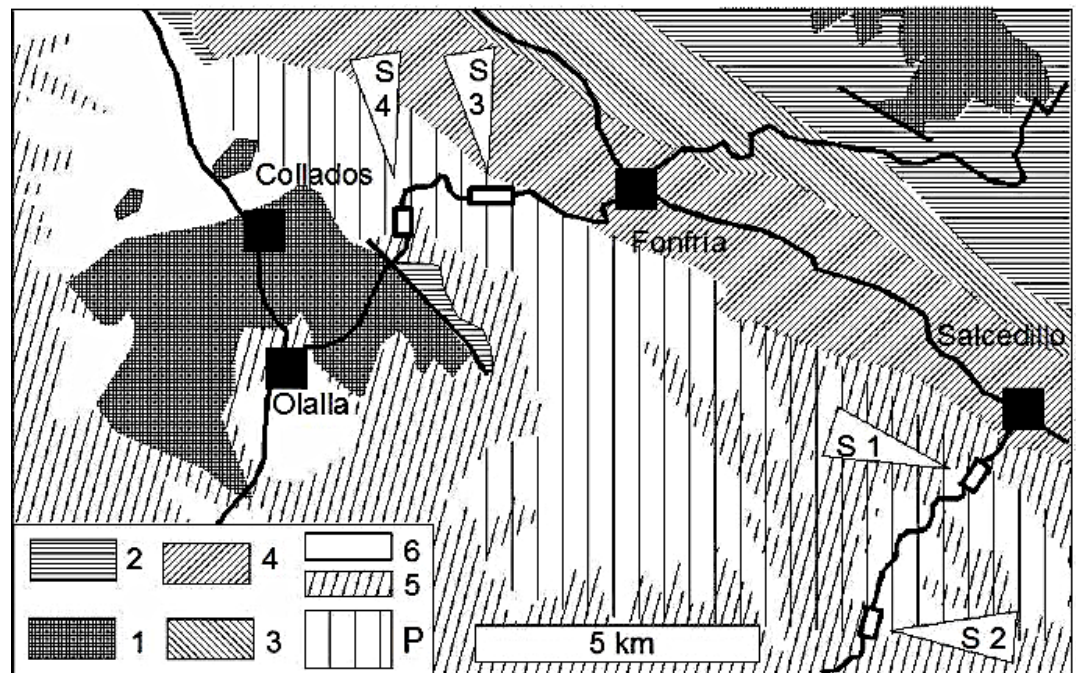


Fig. 3. Simplified geological map of the study area showing the locations where cross-sections could be established. S1 and S2 correspond to the section cut along the road (in red) leading from Salcedillo toward the southwest, which allowed for the establishment of the type column for the Pelarda Formation. 1 = Paleozoic; 2 = Triassic; 3 = Cretaceous; 4 = Eocene–Lower Oligocene; 5 = Miocene; 6 = Quaternary; P = Pelarda Formation. Pelarda

- The type section of the Pelarda Formation (see Fig. 4), corresponding to set C1 in Simón et al. 2026, consists of three parts that correspond to those we were able to identify in 1990 along the road connecting Fonfría with Olalla (whose cutting or roadside ditch intersects the strata in a section parallel to their dip, providing very incomplete information about the Formation compared to the Salcedillo section).

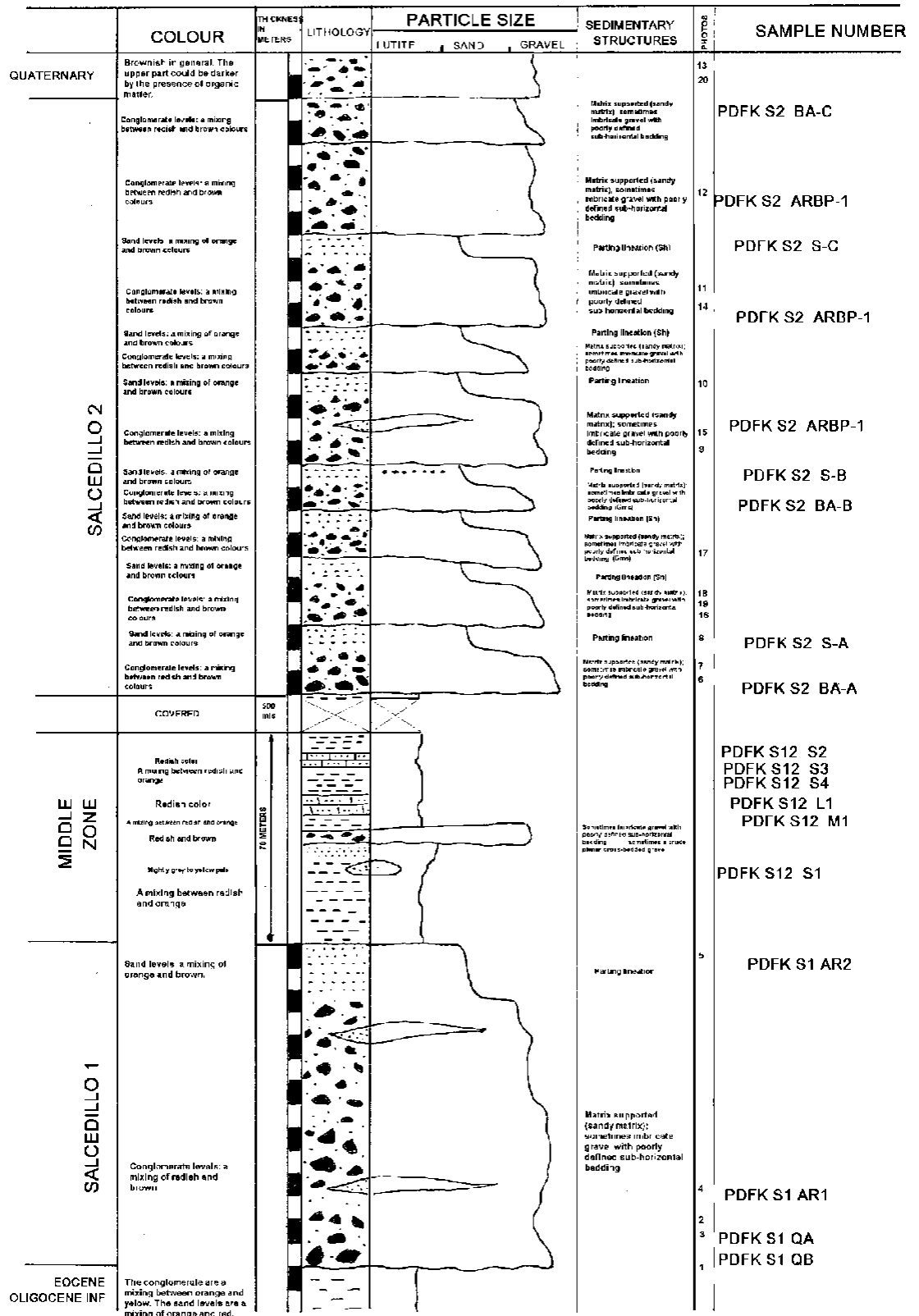


Fig. 4. Stratigraphic column, the type section of the Pelarda Formation, compiled from data observed along the path marked in red in Fig. 2. S1 corresponds to the lower level, followed by the middle zone, and S2 is the upper zone of what we identified in 1990 in a less detailed manner and without being able to discern as much detail. S1 has a thickness (measured with a Jacobs rod

) of about 14 m. The middle zone has a measured thickness of about 70 meters. The S2 zone has a thickness of about 26 m. Between the middle zone and S2, there is a 500-meter-long covered area where we were unable to make any observations of the materials. Topographically, the S1 zone begins at an elevation of 1,204 m, and S2 at an elevation of 1,244 m.

- **Salcedillo 1 (lower section of the stratigraphic column)**

S1 begins at UTM coordinates 30667751 E / 4536032 N (elevation 1204 m) and corresponds to a first conglomeratic series of the Pelarda facies. The contact with the underlying Upper Eocene–Lower Oligocene materials is apparently concordant, although erosive (Fig. 5)

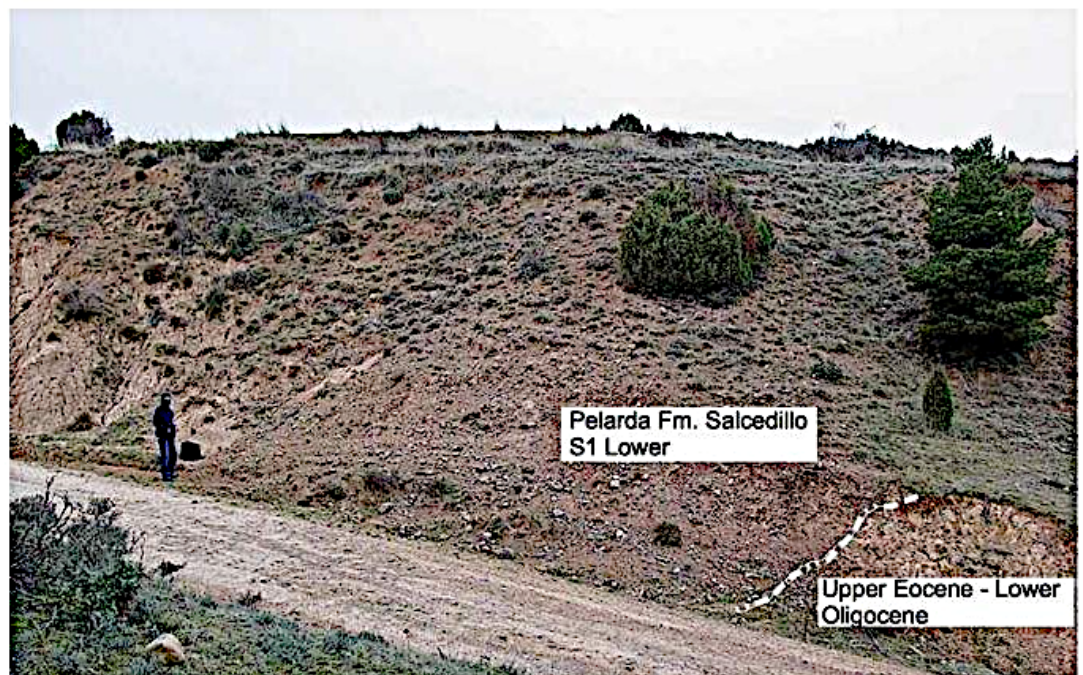


Fig. 5. Erosive contact between S1 (lower part of the Pelarda Formation) and the Upper Eocene–Lower Oligocene (according to ITGE, 1991), consisting of conglomeratic layers with a lenticular morphology, less than 1.5 m thick, and scattered among sands.

It consists of a diamictite layer approximately 12 m thick, with intercalations of sandstones and a 2-m-thick sandstone layer toward the top of the sequence. The sequence shows a slight tendency toward fining upward, although there are marked variations in grain size within the diamictite layer. The diamictite layer is (Fig. 6):

- a. Polygenetic (clasts of Bámbola and Armoricana quartzite, phyllites, schists, and slates). The morphology of the clasts ranges from subangular to subrounded, generally exhibiting low to intermediate sphericity.
- b. Heterometric: clast sizes can range from 1 to 35–40 cm.
- c. Matrix-supported: although there may be a few areas where a clast-supported texture is present, the deposit as a whole contains a significant amount of sandy matrix (ranging from fine to coarse sand, compositionally similar to that of the sandy levels).



Fig. 6. Appearance of a section of the Salcedillo 1 diamictic level. Note the marked heterometry of the clasts, the polygenic nature of the deposit, as well as the morphology of the components, the significant presence of sandy matrix, and a weak parallel arrangement of some clasts.

Macroscopic surface features of the clasts include: open parallel fractures, irregular fractures with complex bifurcations, and striations (Fig. 7). Microscopic features include the presence of planar features (both PFs and PDFs; Figs. 18a, 18b, and 18c).



Fig. 7. Armorican quartzite clast with irregular fractures exhibiting complex bifurcations.

The color of this layer is intermediate between the reddish and yellowish-orange hues of the underlying lutitic materials (Upper Eocene–Oligocene), so a certain contribution of these materials to the matrix (within the finer fraction) cannot be ruled out. In general, a certain stratification can be observed, defined by the parallel arrangement of the elongated clasts (Fig. 28), although there are areas where this stratification is chaotic. The general dip of the materials is 140/36 SW.

Among the materials of the diamictitic layer, intercalations of unconsolidated sandstones can be found. Compositionally, they correspond to heterometric litharenites (Folk, 1968) (grain size ranges from fine to coarse sand), composed of quartz grains, schists, quartzites, and slates. Morphologically, the grains range from angular to subangular (quartz grains are the most angular, while metamorphic grains tend to be subangular), exhibiting moderate sphericity.

The unconsolidated sandstone layer located in the upper zone (Fig. 8) corresponds to a heterometric (grain size ranging from fine to coarse sand) and polygenetic (grains of quartz, schist, quartzite, and slate) litharenite (Folk, 1968). Morphologically, the grains range from angular (quartz grains) to subangular (metamorphic rock grains), exhibiting low to medium sphericity. The notable sedimentary structure of this layer is the presence of planar lamination (parting lineation).



Fig. 8. Litarenite level located at the top of Salcedillo 1. The contact between this level and the sandy intermediate zone is diffuse, so its possible inclusion in that zone cannot be ruled out.

- ***Intermediate lutitic-sandy section:***

Between Salcedillo 1 and 2 lies a thick lutitic-sandy section approximately 70 m thick (Fig. 9). It consists primarily of limolites containing heterometric grains of quartz, quartzite (Bambola and Armorican), and metamorphic rocks (slates and schists). The morphology of the quartz grains is angular or very angular, while that of the rest is subangular. The

sandy levels correspond compositionally to heterometric litharenites (Folk, 1968), with the same components as the siltstones but of larger size. Their morphology is similar to that of the lutite layers. Among the lutites and sands, a lenticular conglomerate layer (Fig. 10) can be observed at the base and near Salcedillo-1, with a maximum thickness of 2 m and low-angle cross-bedding. Within it, we find heterometric clasts of Bambolar and Armorican quartzite, as well as metamorphic rocks, embedded in a sandy matrix. The maximum size of the clasts does not exceed 40 cm. The contact between this level and the underlying sandstones is clearly erosional.



Fig. 9. Appearance of the intermediate level (lithic–sandy section). The lenticular-shaped stratum at the top of the photograph corresponds to a carbonate level (not limestone) present among the litharenites.



Fig. 10. Appearance of the conglomeratic level in the middle zone. The contact with the sandy section (shown in white), which is clearly erosive, has been highlighted. The dip of this level is 140/35 SE. The paleocurrents, where they could be measured, indicate a N–NE flow direction.

In addition to this conglomeratic layer, there are two layers—one near this layer and another near the contact with Salcedillo-2—that appear calcareous and have reddish hues (Fig. 9). Field examination of these levels confirms that they consist of the same very fine-grained limolites and litharenites described thus far, but embedded in a highly carbonate-rich matrix (a fact corroborated by microscopic preparations) and containing “passes” or zones of accumulation of larger clasts. The rock mass exhibits a distinct ochre-like appearance, and it is possible to observe “channels” that are perpendicular, oblique, and parallel to the stratification. In a hand specimen, the sections reveal the presence of oxidized zones (limonitized zones—formerly metamorphic rock clasts—that are yellowish in color) and reddish zones (accumulations of very fine silt-to-sand-sized material, wine-red in color), which correspond to “passes” or zones of sand and conglomerate accumulation. As we move laterally along the deposit, we can observe two additional “carbonate” levels intercalated among the very fine-grained shales and litharenites of this intermediate zone. As with the two levels found along the path, it is possible to observe “passes” or zones of accumulation of larger clasts. All of them have a short lateral extent, a thickness always less than 1.5 m, and surfaces apparently affected by karst processes.

- Salcedillo 2 (upper section of the stratigraphic column)

A series approximately 26 m thick, consisting of alternating diamictic-sandy layers (about 9 in total; see Fig. 4), each with a grain size that decreases toward the

top (fining upwards), which overlies the materials of the sandy section (Fig. 11) and is covered (underlies) by a Quaternary (?) layer approximately 5 m thick (Fig. 12).



Fig. 11. The initial diamictic level of the Salcedillo 2 Series lies in erosive contact with the fine- to medium-grained litharenites in the middle part of the outcrop. An accumulation of large clasts can be seen near the contact.



Fig. 12. The Quaternary (?), with a horizontal or subhorizontal dip ($< 5^\circ$), overlies the Pelarda Formation in discordant contact. Its thickness never exceeds 8 m. Its brownish color also makes it easily identifiable.

Each level generally consists of a basal diamictite portion, within which sandy intercalations may (or may not) be observed, and a sandy upper portion (Fig. 13).

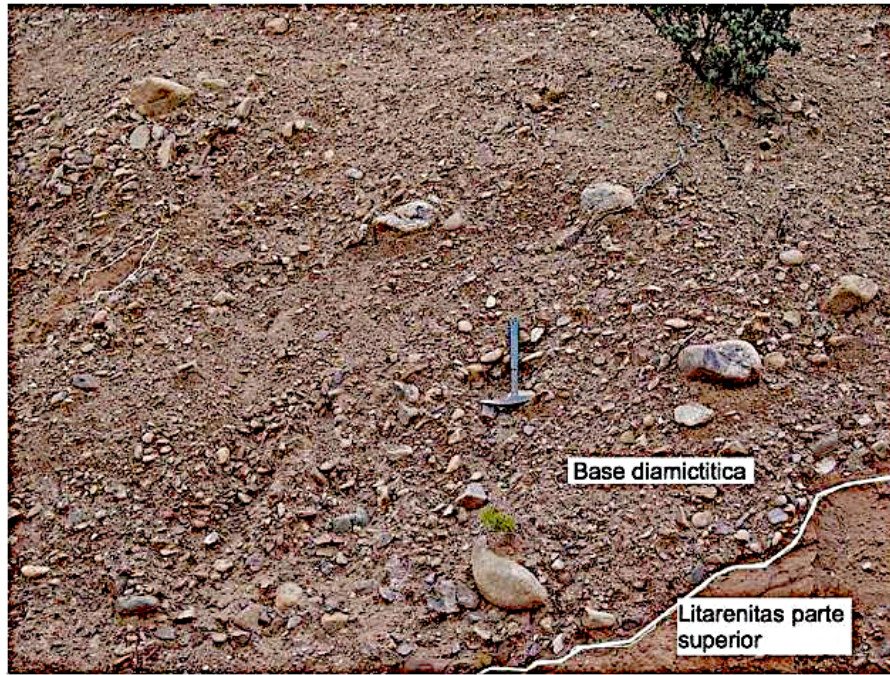


Fig. 13. The basal diamictitic part of one of the levels in the series, as well as its erosional contact with the upper part of the preceding level. A small, lenticular sandy intercalation within the diamictitic level has also been highlighted. A certain tendency toward horizontal stratification of the clasts can be observed, although the arrangement is often chaotic.

The *diamictite portion* is:

- a. Polygenetic (clasts of Bambolar and Armorican quartzite, phyllites, schists, red quartz sandstones of the Buntsandstein or Permian, quartz sandstones, and slates). The morphology of the clasts ranges from subangular to subrounded, generally exhibiting low to intermediate sphericity (Fig. 14).
- b. Heterometric: Clast sizes can range from 1 to 60 cm.
- c. Matrix-supported: although there may be a few areas where a clast-supported texture is present, the unit as a whole contains a significant amount of sandy matrix (ranging from fine to coarse sand, compositionally similar to that of the sandy levels) (Fig. 14)



Fig. 14. Polygenetic, heterometric, and matrix-supported appearance of the diamictic portion. Clasts with irregular fractures and complex bifurcations can be observed (center of the photo).

The color of this part tends to be reddish, perhaps due to the contribution of material from the reddish quartzarenite clasts of the Bunts found in the deposit. The clasts may exhibit rotational fractures (Fig. 15), surface striations (Fig. 16), irregular fractures with complex bifurcations (Fig. 14), and occasionally intense polishing (Fig. 17). Measurements of the striations on the clasts have shown that their azimuth agrees with that previously published by Ernstson & Claudin (1990) (peaking in the SW–NE direction). Under the microscope, thin sections prepared from Bambolar and Armoricana quartzite clasts exhibit features of impact metamorphism (both PFs and PDFs; Figs. 18a, 18b, and 18c).



Fig. 15. Rotational fractures present in a Bambola quartzite clast.



Fig. 16. Phyllite clast with marked striations on its surface. The azimuth measurements of these striations agree with the data previously published by Ernstson & Claudin (1990).



Fig. 17. Bambola quartzite clast showing intense polishing on part of its surface as well as striations (whose azimuth agrees with that previously published by Ernstson & Claudin (1990)).

In general, a certain stratification can be observed, defined by the parallel arrangement of the elongated clasts; however, there are areas where this stratification is chaotic. The general dip of the materials, where it can be measured, ranges from 135/38 SW to 145/33 SW. The direction of the paleocurrents indicates a source from the N-NE. *sandstone interbeds* can be found among the diamictic materials. Compositionally, they correspond to heterometric litharenites (grain size ranges from fine to coarse sand), composed of quartz grains, schist, quartzite, and slate. Morphologically, the grains range from angular to subangular (quartz grains are the most angular, while metamorphic grains tend to be subangular to angular), exhibiting low sphericity. In terms of sedimentary structure, they exhibit planar lamination (parting lineation). No magnetic particles are observed under a binocular magnifying glass or when exposed to a magnet.

The *sandy upper part*, where sampling was conducted, corresponds compositionally to a heterometric lithosandstone (ranging from fine to coarse sand), containing grains of quartzite, schist, phyllite, slate, and quartz. Morphologically, these grains range from angular (mostly quartz) to subangular to angular (the metamorphic ones), exhibiting low sphericity. No magnetic particles were found in any of the analyzed samples. A notable sedimentary structure is the presence of planar lamination (parting lineation).

As can be seen in the stratigraphic column, not all levels have a sandy upper part. In fact, this part is absent in the last two levels, as it was likely eroded or never deposited.

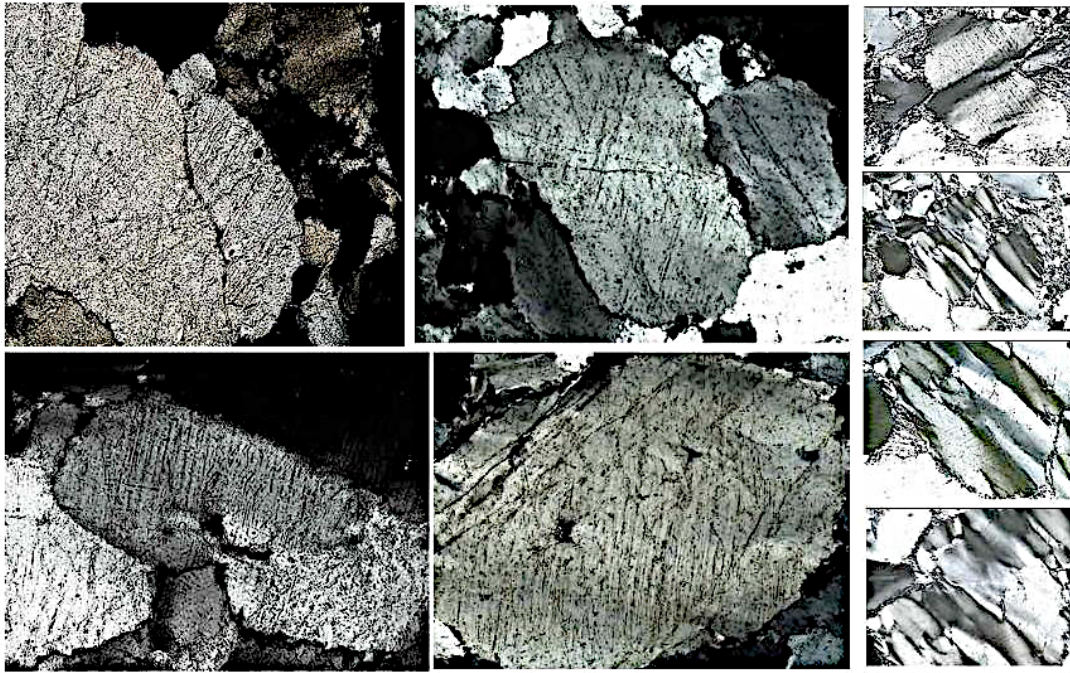


Fig. 18a. Different aspects of PDFs in shocked quartz from quartzites at various locations within the Pelarda Formation. In many cases, there are several PDF systems that intersect with one another. Right: A shock effect is also observed in quartz grains from the Pelarda Formation: kink bands (accordion-like folds) with PDFs following the bands. Crossed polarizers; the images are each 200–300 μm wide.



Fig. 18b. Multiple sets of PDFs in a quartz grain from a Bámbole quartzite clast (sample PDFKS2 BA-B from Fig. 3).

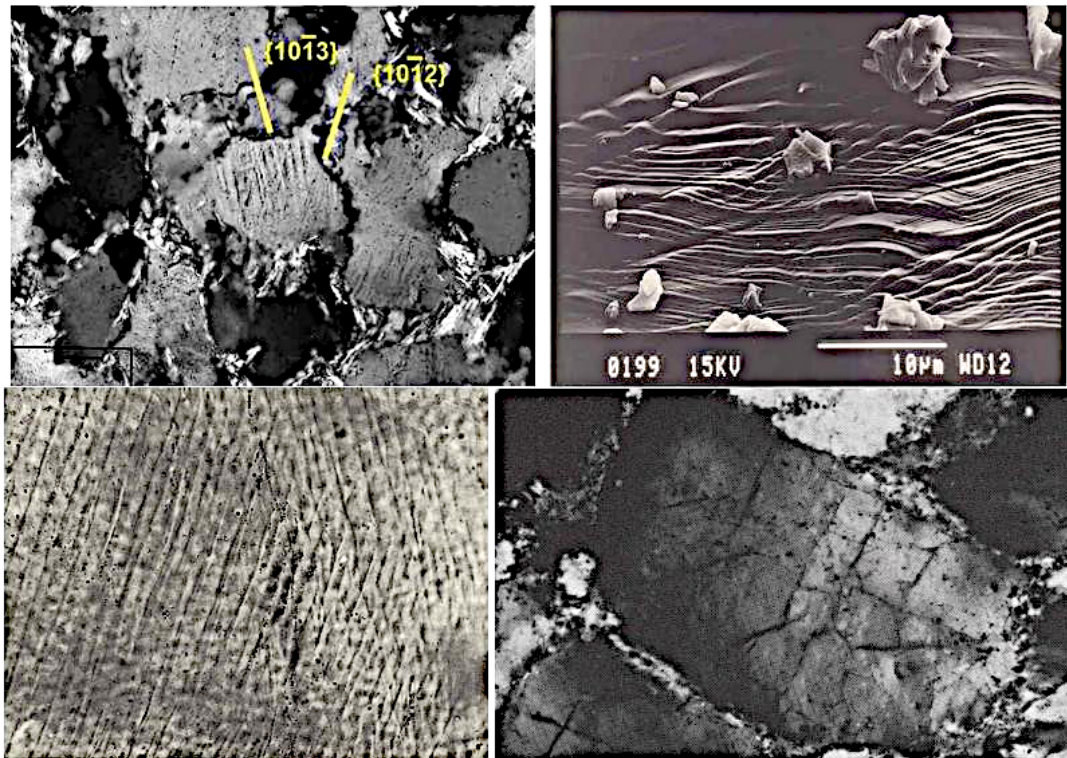


Fig. 18 c. Intersecting systems of planar deformation features (PDFs and PFs) in quartzites of the Pelarda Formation from previous studies (Ernstson & Claudin 1990, Ernstson et al. 2002). Top left photo: Polarizing microscope, crossed polarizers (image width 200 μm); right: scanning electron microscope, the spacing between PDFs is in some cases less than 1 μm . Bottom left image: Two intersecting PDF systems in the foreground (image width 220 μm); bottom right image: multiple planar fracture systems (image width 440 μm).

Upon examination under a universal stage, these planar deformation features exhibit the same crystallographic orientations as those used in our 1990 study (Fig. 20).

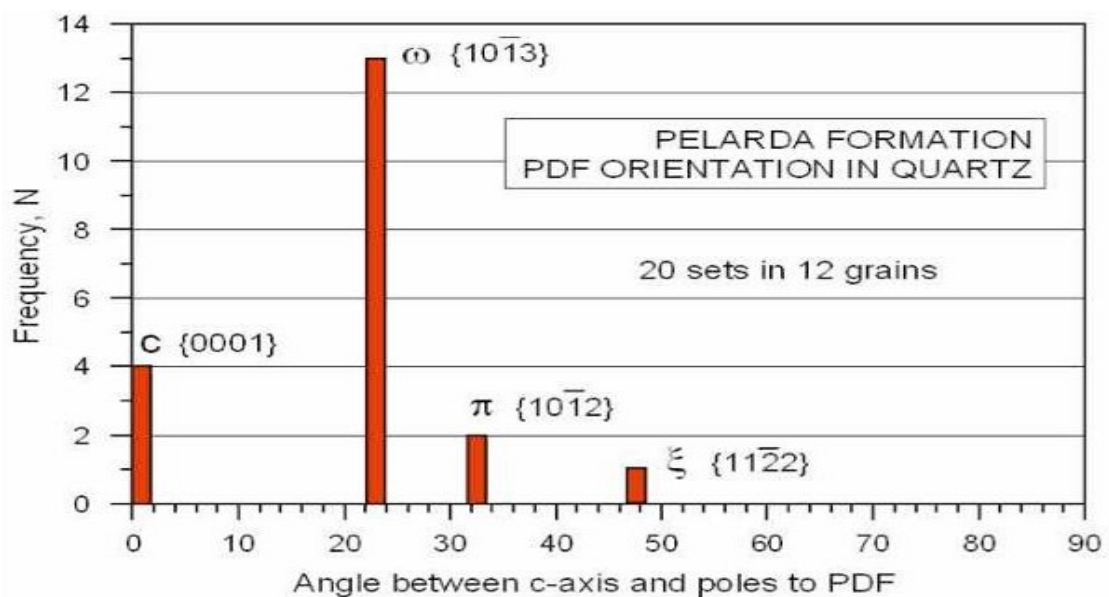


Fig. 18 d. Frequency diagram of the crystallographic orientation of planar deformation features (PDFs) in quartz from the Pelarda Formation. Data from Therriault (2000)

A notable feature of this section is the presence of tectonic deformations, specifically extensional faults that affect certain sections (sandy or conglomeratic parts), but without affecting the entirety of the underlying or overlying sections (Fig. 19).



Fig. 19. A extensional fault affecting the sandy section located directly in front of W. Monninger and the lower part of the diamictic section of the next level, which, however, shows an arrangement of the overlying clasts that clearly “fossilizes” the fault.

Field observations suggest that the mechanism is syn-depositional, corresponding to a rapid sequence of erosion, sedimentation, faulting, and flow within a “limited unit.” This could be represented as shown in (Fig. 20)

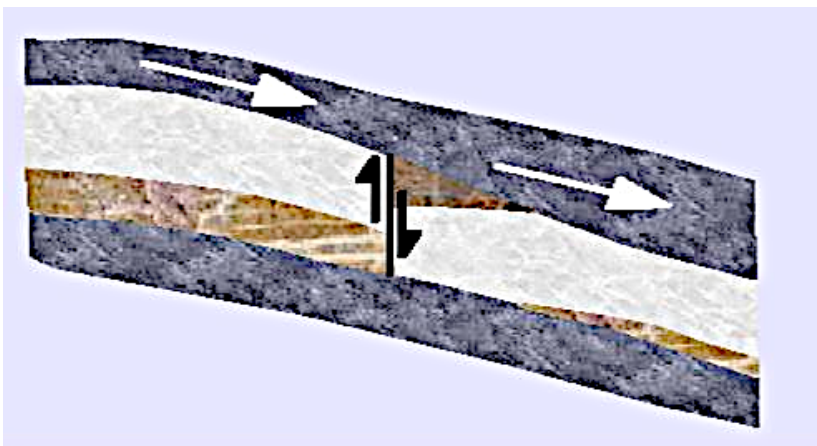


Fig. 20. Schematic representation of the syn-depositional mechanism shown in Fig. 19.

Continuing along the road leading from the village of Salcedillo to the outcrops, at coordinates 30665781 E / 4533873 N (elevation 1283 m), we reach the materials that make up the upper part of the Pelarda Formation in this area. At this point, there is

any section that would allow us to see the appearance of the materials; therefore, we can only observe their lithology due to the plowing of the fields by local farmers. It is evident that these are materials belonging to the Pelarda Formation, since the Miocene in this area consists exclusively of breccias of Paleozoic clasts and lutites (IGME, 1977; ITGE, 1989 and 1991; author's own field observations). Among the “waste materials”—basically clasts that interfere with plowing due to their size (Fig. 21)—we can observe clasts of Eocene-Oligocene conglomerates, as well as clasts of Bámbola quartzite, Armorican quartzite, Buntsandstein, and Jurassic limestones.



Fig. 21. Among the “waste materials”—basically clasts that are too large to be incorporated into the field plowing—we can observe, next to the GPS locator, a clast of Eocene-Oligocene conglomerates (Fig. 22), as well as clasts of Bámbola quartzite, Armorican quartzite, Buntsandstein, and Jurassic limestones.



Fig. 22. Detail of the Upper Eocene–Oligocene conglomerate clast found among the waste materials in Fig. 21. Comparison with the Upper Eocene–Oligocene conglomerates (Fig. 22) reveals compositional similarities.

- **Olalla–Fonfría Road** (S 3 and S 4 in Fig. 3):

The outcrops—located along the road connecting Fonfría and Olalla, which have made it possible to construct a stratigraphic section—are limited to zone S 4 in Fig. 3. There is a simple explanation for this situation. Figure 23 shows an approximate “theoretical” projection of the layers that make up the materials of the Pelarda Formation. While this projection is clearly not very valid for materials of this nature (since their direction and dip can theoretically vary due to their depositional characteristics), it does allow us to highlight two interesting points. The first of these concerns the massive, diamictitic appearance of the Pelarda Formation along the road between Fonfría, the Pelarda Pass, and the first 2 km of the descent toward Olalla (point S3 in Fig. 23; see Fig. 24). This appearance is due to the fact that the layers are being intersected in a direction parallel to their strike.

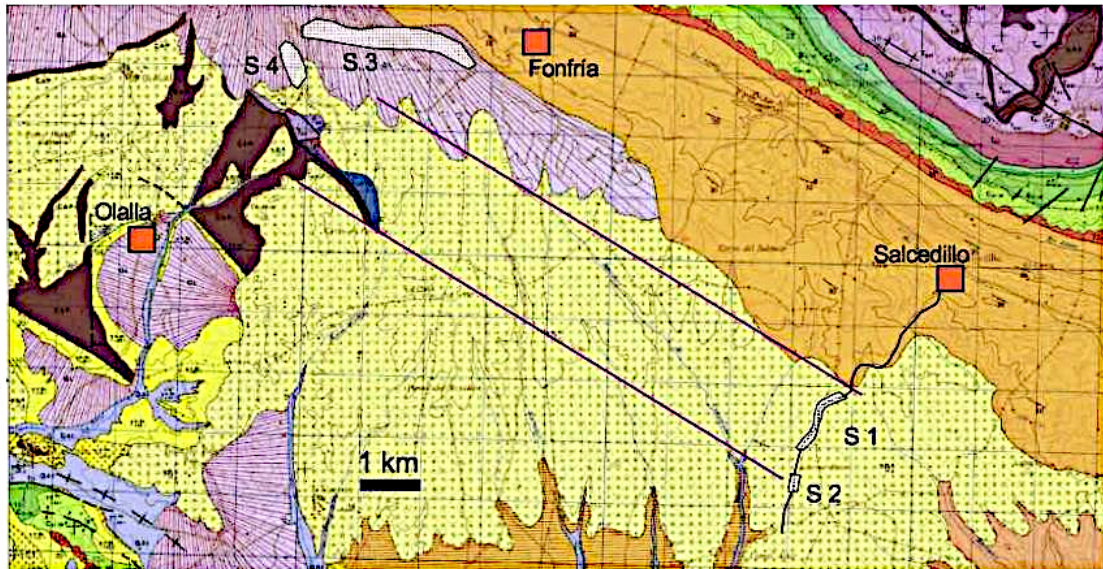


Fig. 23. Location of zones S3 and S4 on the geological map—which is obviously erroneous—at a scale of 1:50,000 (sheet no. 492 of Segura de los Baños), prepared by the IGME in 1977. The purple lines represent the lateral “theoretical continuity” of the materials of the Pelarda Formation, taking into account an average strike of 140° (the result of averaging the strikes measured at Salcedillo 1 and 2 and the lutite-sand section).



Fig. 24. Massive and diamictic appearance of the Pelarda Formation at the outcrop corresponding to point 3 in Fig. 23 (S3 in Fig. 3). A megaclast from the Buntsandstein, approximately 9 m long, is intercalated among the materials. It should be noted that the reddish coloration of the Pelarda Formation matrix is due to the contribution of Buntsandstein material.

As the road approaches the perpendicular to that direction, the depositional characteristics more closely resemble those observed at Salcedillo (Figs. 25, 26, and 3).

Regarding the second point: As we travel from Fonfría toward Olalla, we can observe the formation from its base to its top.



Fig. 25. Appearance of the Pelarda Formation in the outcrops of Zone 4 (see Fig. 23). A sandy zone (ar) (with diamictite interbeds) is intercalated within a diamictite section (dia). The dip of the materials in this zone is 26° toward the SW. cu = Quaternary. 42

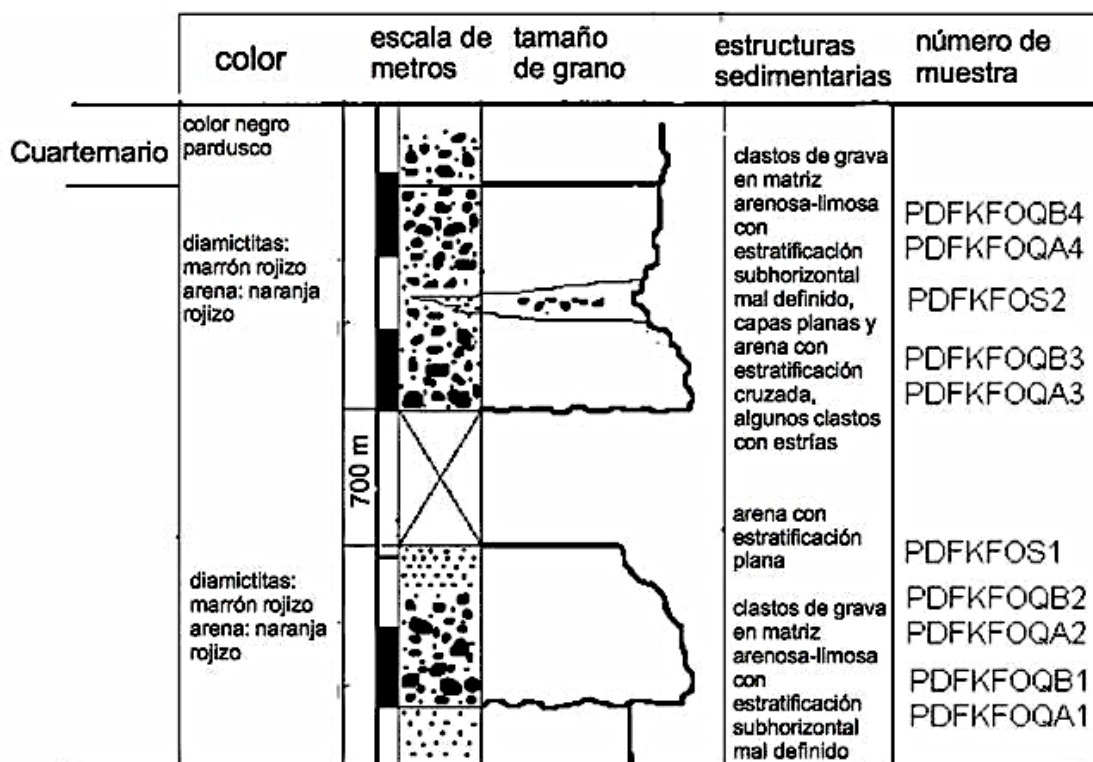


Fig. 26. Stratigraphic column corresponding to two outcrops located in Zone S 4 (Fig. 23) and separated by a distance of 700 m. There is a similarity between the levels observed here and those at Salcedillo. Any correlation between the two zones is impossible due to the absence of any index beds. In the thickness column, each interval represents 1 m. Note that in each case, the sequence is always granodecreasing, beginning with a diamictic base consisting of gravel-sized clasts and blocks supported by a sandy matrix, and ending with a sandy (litharenitic) zone in which planar stratification can be observed most of the time.

Specifically, moving toward the top of the Formation, in section S 4 of Fig. 23, we find Bámbola quartzite blocks larger than 1 m with striations on their surface. Similarly, opposite the Pelarda sanctuary, we find a Buntsandstein outcrop amidst the materials of the Pelarda Formation (Figs. 27 and 28). This outcrop, mapped by Monninger (1973), reveals Buntsandstein clasts with rotational fractures and impact marks (Fig. 29).

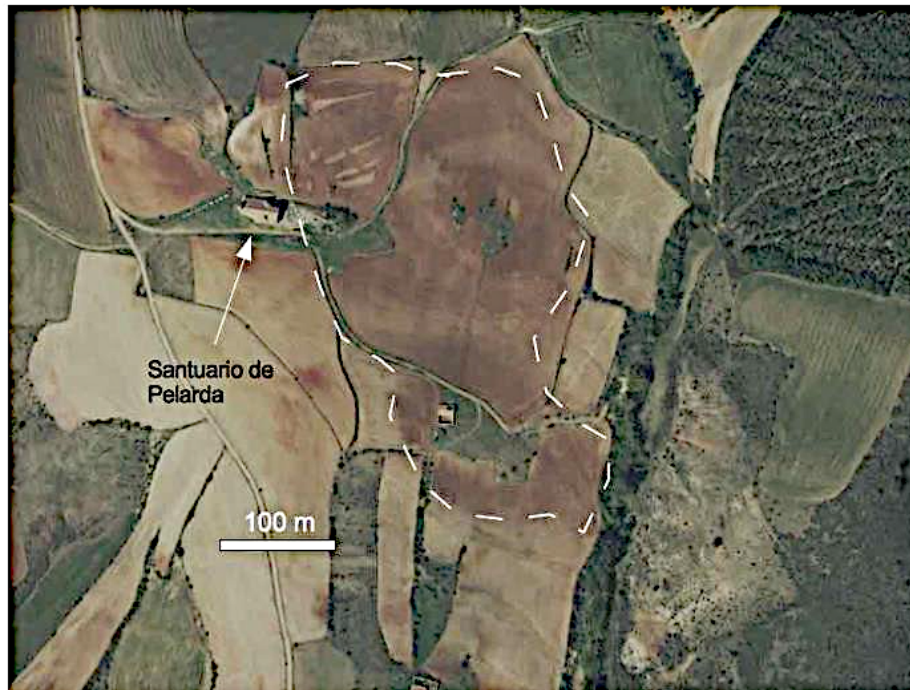


Fig. 27. The Buntsandstein block in the center of the Pelarda Formation can be recognized by its characteristic color and, therefore, can also be mapped in the aerial photograph. According to Monninger (1973), the Buntsandstein block is inverted. Aerial photograph: Apple Maps.



Fig. 28. Outcrop of the inverted Buntsandstein megablock that was likely transported by the Pelarda Formation. This area extends over 300 meters.



Fig. 29. Buntsandstein clast with marked rotational fractures.

As in Salcedillo, the clasts in the diamictitic sections exhibit rotational fractures, surface striations, open parallel fractures, and irregular fractures with complex bifurcations. All these characteristics, previously described by Ernstson C. Claudin (1990), are indicative of intense confining pressure at the time of deposition.

The Pelarda Formation ends, a few meters before the outcrop of the overlying basal suevitic breccia, in a breccia section. This unit was described and mapped by Monninger (1973), who termed it a “rim breccia” and divided it into two parts, designated P and M. P is a breccia composed of Paleozoic components of clay-silt composition, transitioning to quartzite clasts embedded in a quartz-arenite matrix, which predominate toward the road (section S4 of our study). The Armorican quartzite clasts may exhibit rotational fractures (Fig. 31), although no striations have been observed on their surface, possibly due to the granular surface of the quartzite. M is a breccia consisting of limestone blocks that can exceed 1 m in size and have a texture similar to that of P.



Fig. 30. Appearance of the section of Armorican quartzite breccias located on the uppermost part of the Pelarda Formation, already near the outcrop of the basal breccia.

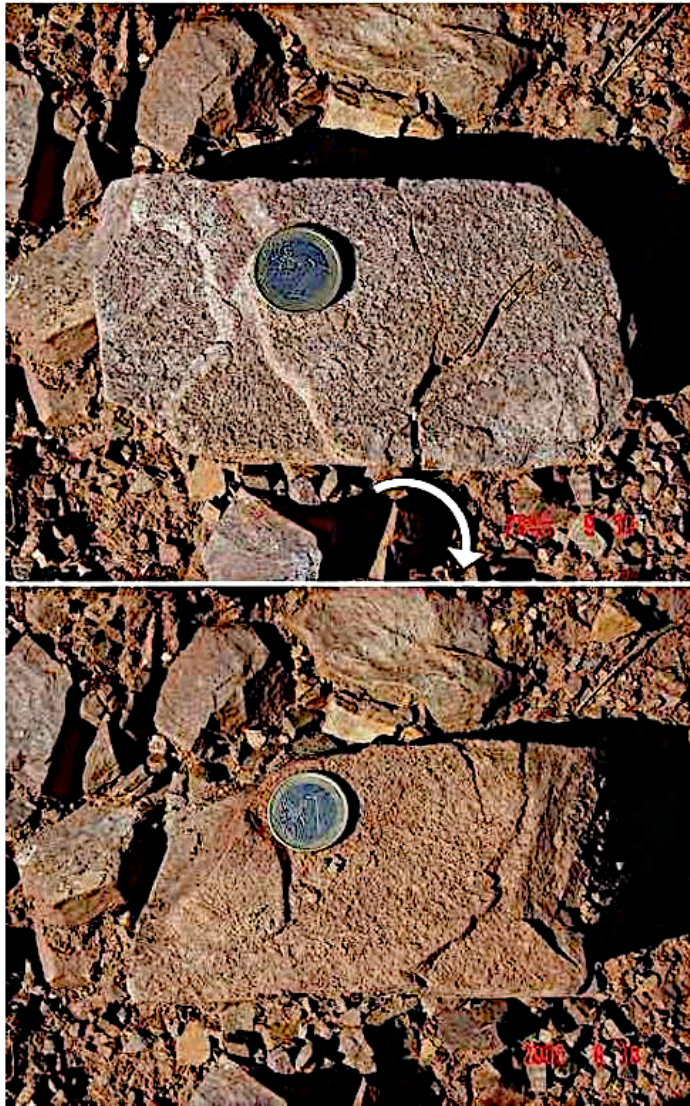


Fig. 31. Rotational fracture in a quartzite clast from the breccia level beneath which the Pelarda Formation ends. There is no fracturing on the rear side.

3. Discussion—response to the article by Simón et al. (2026):

- *“The poor quality of the outcrops makes their mapping and stratigraphic and structural characterization difficult.”* This statement is not entirely accurate. A complete characterization of the Pelarda Formation can be performed, and its type column (type sequence; Fig. 4) can be defined along the road leading out of Salcedillo (see Fig. 2). The levels can also be sampled to perform a petrographic, granulometric, and textural characterization of them. At the same time, within the area covered by our study (Claudin-Ernstson, 2019), it is possible to observe the relationships between the type sequence—that is, between the Pelarda Formation et al. and the various Paleozoic, Mesozoic, and Cenozoic materials in the area. What is NOT possible is to establish stratigraphic correlations with other areas given

the inability (to date) to identify other routes that would allow for the construction of similarly detailed stratigraphic columns.

- *“Cortés Gracia and Casas Sainz (1SSc) apply the same model proposed by Moissenet (1S80) to the Sierra Pelarda conglomerates: Cenozoic continental materials overlain by the Triassic and Paleozoic strata of Olalla-Collados. Aurell et al. (2022) do the same, considering the “Pelarda conglomerates” to be a continuation of the basal series of the Montalbán Basin.”* Well, it must be that we were unaware of this, since the cited article by Gracia and Sainz (1996) makes no mention of the Pelarda Formation, and in Cortés and Martínez (1999), its origin and age are assigned based on the work of Ferreiro et al. (1991)—that is, Pliocene–Quaternary and formed by mudflows. Furthermore, during the field trip of the 6th ESF-IMPACT Workshop (“Impact Markers in the Stratigraphic Record,” held in Granada in 2001) conducted in Azuara, Cortés Gracia insisted time and again (along with Aurell, Sanz Rubio, and Díaz Martínez) that the Pelarda Formation was a Quaternary-age clay layer. He reiterated this point in a subsequent article (Cortés et al., 2002). Regarding the article by Aurell et al. (2022), the only mention of the Pelarda Formation appears in the bibliography, where citing the article by Adrover et al. (1982), which they use in their paper to describe a set of charoophytes found in Segura de los Baños and studied by Adrover et al. (1982)—which currently serves as the reference followed by the authors of this article under reply. It seems more like a well-intentioned attempt to exonerate the aforementioned authors for their error and stubbornness in maintaining—rather than correcting—the age and genesis of this Formation over the years.
- *“The third interpretation for the uppermost quartzite conglomerates, clearly distinct from the previous ones, is based on the work of Ernstson et al. (1S85), who argued for the existence of a Paleogene meteorite impact in the transition zone between the Iberian Mountain Range and the Ebro Basin. Aurell et al. (1SS3) demonstrate the inconsistency of that interpretation, presenting solid arguments based on knowledge of stratigraphy and regional tectonics: the structure of the Azuara area is determined simply by arched folds and thrusts overlain by the discordant Miocene of the Ebro Basin; breccias and megabreccias attributed to the impact are, in reality, brecciated limestones from the Lower Jurassic (Cortes de Tajuña Formation) or Cenozoic conglomerates deformed on a small scale by Alpine compression; the “ejecta” from Sierra Pelarda is a conglomerate of rounded pebbles typical of fluvial or alluvial environments. Therefore, of the three hypotheses regarding the area, this one is not considered.”* We remain consistent with our position regarding the circularity of Azuara: initially, it was denied, and later it was attributed to folds and overthrusts arched by normal tectonics. None of the impact hypothesis proponents has ever claimed that the Cortes de Tajuña Formation was produced during the impact. What has been said, however, is that in the Belchite area—on a section of the crater wall where this formation was found—it had been affected by the impact, resulting in megabreccas (the original breccias were impacted and brecciated again, forming megabreccas). This has been repeated several times,

but Aurell and Co. keep repeating their same old refrain to dominate the narrative. As for the breccias, what can one say? It is outrageous to claim that both the breccias and the megabreccias we have mentioned correspond to brecciated limestones of the Cortes de Tajuña Formation. To give an example, at the contact zone between the Pelarda Formation and the Muschelkalk (Fig. 32), a breccia dyke can be observed, formed by fragments of the Muschelkalk embedded in a lapillitic matrix (Figs. 33 and 34). As can be seen, these are not Lower Jurassic breccias... We could provide many more examples like this one.



Fig. 32. The Pelarda Formation overlies Paleozoic materials (upper right of the photograph) and Mesozoic materials (Muschelkalk limestones intruded by the lapilli dyke; see Figs. 33 and 34). It lies beneath the basal breccia (30656447 E / 4539152 N; elevation 1306 m), which in turn overlies the Paleozoic, the Muschelkalk, and the Armorican quartzite breccias at this point.

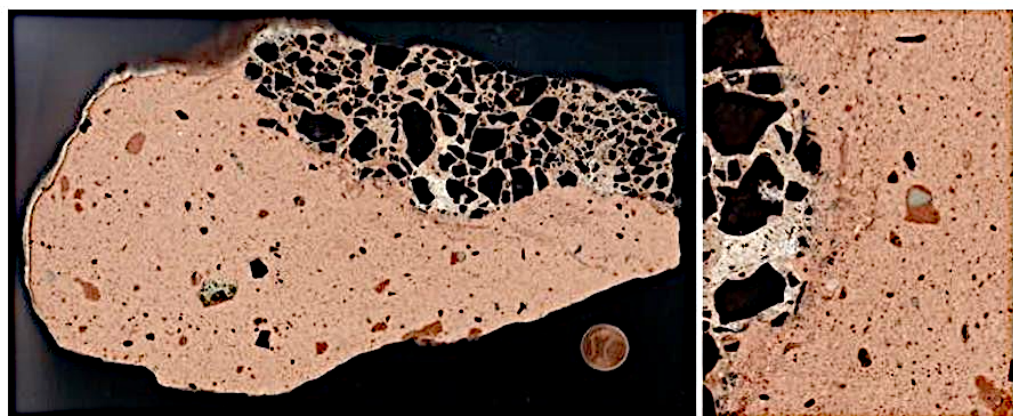


Fig. 33. Polished section of the lapilli-rich breccia dyke intruding into the Muschelkalk strata. Fragments of

Muschelkalk (dark color) embedded in an orange-colored accretionary lapilli matrix. (coin diameter: 16 mm)

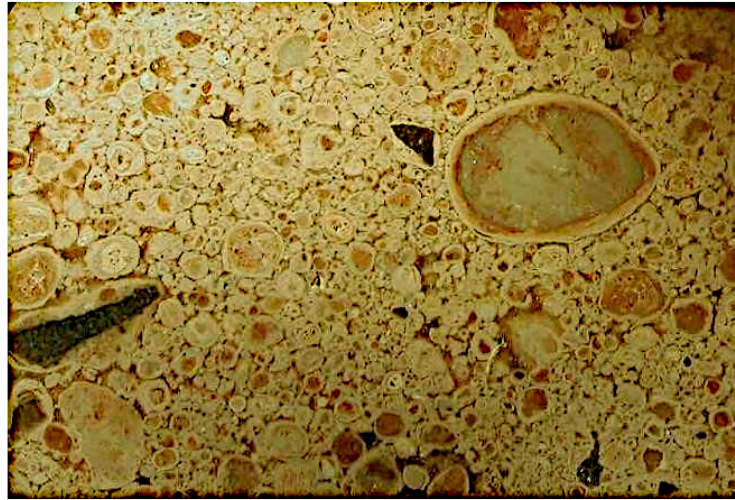


Fig. 34. Polished section of lapilli rock with angular fragments of limestone (dark in color) and quartzite (reddish-gray in color), surrounded by of silica and carbonate.

As for the Cenozoic conglomerates deformed on a small scale by Alpine compression, a picture is worth a thousand words (Figs. 35, 36, and 37)



Fig. 35. A rotational fracture in a limestone clast from the breccia level located in immediate contact between the Paleozoic and materials dated as Miocene by the IGME (1977) and the ITGE (1991) in the area (at coordinates 30655445E / 4536964 N (next to the river in the direction of Fonfría-Olalla, already near Olalla)).



Fig. 36. A Bundsanstein clast (not from the Mesozoic) illustrating the gentle deformations that, according to Aurell, are caused by Alpine deformation in the materials of the Azuara area. Despite the intense deformation, the clast remains cohesive, although it clearly cannot be transported by currents that do not involve intense confining pressure. Curiously, the deformations observed in the materials of the Pelarda Formation are not observable in other materials in the area. Coincidence?



Fig. 37. Intensely fractured bámbola quartzite clast. The irregular fractures observed are incompatible with transport, which would have broken up the sample, and indicate in situ fracturing under high confining pressure.

The claim that the Pelarda Formation *is a conglomerate of rounded pebbles typical of fluvial or alluvial environments* is refuted by our observations in the Salcedillo area. They are neither conglomerates (they are rather diamictites), nor are they typical of fluvial or

alluvial environments, given the characteristics observed in their components (both macroscopic and microscopic). The sequence observed in Salcedillo (see Fig. 4) illustrates a sequence formed by alternating, granulometrically decreasing units, always consisting of a diamictic base of Bámbola and Armoricana quartzite, phyllites, schists, and slates—generally supported by the matrix—which transitions toward a top consisting of sands (litharenites) that typically exhibit planar stratification. Within each diamictic section, there may be lenses of litharenites or limolites. When observing the vertical development of the sequence—not only along the road leading out of Salcedillo—it can be seen that the series is granulocreciente toward the top (in the upper part, Bámbola clasts over 1 m in diameter and megablocks of Buntsandstein can be found among the materials). It should also be noted that while the materials at the base of the series are primarily Paleozoic—albeit with a significant contribution of Buntsandstein within the matrix—which gives it that characteristic reddish color—toward the top the predominant materials—at least in the Salcedillo section—are Cenozoic (with clasts of Eocene materials). In other words, this represents an inversion of the “inverted mountain” pattern typical of the dismantling of a preexisting relief, in which the younger materials are deposited first... If we add to this the petrographic characteristics of the rocks, which exhibit features of shock metamorphism (PDFs and PFs) in all the units mentioned throughout the series, then this does not seem very typical of fluvial and alluvial environments.

- *“The published evidence regarding this unit is not very explicit: no detailed maps, panoramic photos, or borehole photos are provided to support it; only a few photographs and descriptions of the materials, along with general considerations regarding their relationship to erosion surfaces and tectonic structures.”... The fact that Simón et al. (2026) chose not to discuss the impact hypothesis in their paper is obviously a personal choice—justifiable or not—but in any case, what is not valid is failing to cross-check the most recent published information on the subject. Information in which they could have seen the Salcedillo section and the relationships between the Pelarda Formation and the various materials in the area, and which would have prevented them from making clearly erroneous statements of this kind (in addition to the occasional test pit...).*
- *“In previous publications, the materials of La Pelarda were described as conglomerates consisting of rounded pebbles and blocks up to 1 m in diameter, predominantly of siliceous composition (quartzites and sandstones of Paleozoic and Triassic origin). The authors acknowledge that although this is the appearance of the deposit in some places, field surveys on the slopes, foothills, and highest points of the mountain range (based on excavations in certain deeply incised ravines or, alternatively, exploratory test pits dug using a backhoe) have shown that the situation is more complex”... As we have already noted, in our 2019 article this is already reflected along the survey route conducted in Salcedillo, which enabled the compilation of the type stratigraphic column for the Pelarda Formation. In other words, while there are areas where the deposit is not*

is easily recognizable, in the Salcedillo area the deposit is recognizable and therefore amenable to study.

- *“In this study, four lithological assemblages have been distinguished that contain the characteristic rounded siliceous pebbles of the Pelarda facies but clearly differ in their lithological and textural features, as well as in their arrangement and age. They show no stratigraphic continuity and have been designated as groups C1 through C4. From oldest to youngest, they correspond to: a stratified and inclined conglomerate series (C1); subhorizontal stratified conglomerates and sandstones (C2); uncemented, unstructured, and unstratified gravels at medium and high elevations in the mountain range (C3); and uncemented, unstructured, and unstratified gravels in the western foothills of the mountain range (C4).”* ... Group C1 is the one that corresponds to our column compiled in the Salcedillo area. Needless to say, the degree of precision in our study is higher than that provided by Simón et al. (2026), given that observational conditions are better along the Salcedillo route (Fig. 2). Nevertheless, there is one point we would like to highlight: why have Simón et al. (2026) not conducted petrographic analyses of the clasts present in these levels? This would be interesting for comparing our observations with those of F. Langenhorst, whose claims regarding structures present in specimens from Poyo del Cid (far, very far from the impact structure) were used to argue that there is no impact metamorphism in the clasts from La Pelarda or in other clasts from the area. These claims were quickly—and without verification—were adopted by non-impactists to uphold their narrative. As for the other assemblages, C2, C3, and C4, we have only—in the studied area—identified some discordant materials within C1 assemblage, which we have assumed to belong to the Quaternary (Fig. 12). It is curious that, given the difficult conditions for observation and lateral continuity acknowledged by the authors of this study (Simón et al. (2026)), they assign ages and spatial relationships to these C2, C3, and C4 assemblages.
- *“Formation C1 constitutes the majority of the Pelarda Formation. Its layers exhibit inclined stratification trending NW-SE to WNW-ESE and a dip ranging from 25° to 40°S on the northern slope, which tends to decrease to 18–20°S at the summit of the Sierra Pelarda and on its southern slope. Taking into account the dip and the width of the outcrop along the mountain range (greater than 2 km), the thickness of this entire sequence of conglomerates with intercalations of sandstones and shales is estimated at 800–500 m. The Pliocene erosion surfaces SEF2 and SEF3 have affected C1.”* ... Indeed, C1, which is easily visible in the Salcedillo area, allows for the identification and representation of most of the characteristics of the Pelarda Formation. Regarding its total thickness (including the three zones in the column in Fig. 3), we believe a figure of around 400 m is more accurate.

Evidently, following the deposition of C1, this unit underwent post-Oligocene erosion events.

- *“The source area of the siliceous pebbles that make up the thick conglomerate deposit of Sierra Pelarda assigned to C1 would be located to the west of the mountain range (Fig. 15A). The alluvial fans originating from this siliceous source area would converge, toward the central-eastern part of the Montalbán Basin (south and southeast of Segura de los Baños), with the predominantly carbonate alluvial fans of northern origin described by Pérez (1985). The source of the siliceous materials from Sierra Pelarda (group C1) is currently located in the Paleozoic basement of the Neogene Calatayud Basin. This substrate consists of Cambrian units (e.g., the Bámbola, Daroca, and Embid Formations) and, to a lesser extent, Ordovician units dominated by siliceous rocks (quartz arenites/quartzite sandstones and conglomerates), sometimes occurring in thick beds (>2 m) (Lotze, 1985; Gabaldón et al., 1991; Liñán et al., 2004).” ... The clasts present in the Pelarda Formation show features of impact metamorphism (PDFs and PFs; Figs. 18a, 18b, 18c) and surface striations. These features are not observed in the samples collected during two campaigns (one in 1990 and another in 1995) along the road connecting Mainar and Codos (samples from F. Bámbola), between Huermeda and Embid (samples from the Bámbola Formation) and samples collected at a pass located at an altitude of 1,250 m between Atea and Used (samples of Armorican quartzite). In all these cases, none of these samples exhibits the features observed in clasts of the same lithology and age from the Pelarda Formation.*
Pelarda Formation.
The source area of the materials, based on the paleocurrents and the azimuth of the striations, was located to the N-NE. The subrounded-subangular morphology of the clasts present in both the conglomerate levels and those of litharenites and lutites (coarse-grained limolites) argues against a sedimentary genesis linked to an alluvial fan adjacent to nearby landforms. In this case, given the depositional characteristics (which, if this hypothesis is considered, are consistent with low transport efficiency (Colombo, 1989)), one would expect greater angularity in the clasts, given the short distance from the fan (which in principle would be similar to Type II fans as defined by the ITGE (1991)). The origin via fluvial systems whose currents originated in the Codos area—a hypothesis used to explain the presence of Bámbola quartzite clasts in the Formation’s materials (Adrover, 1982; Carls, 2005 (personal communication))—contradicts the observed paleocurrents as well as the depositional characteristics already mentioned. The absence of Mesozoic limestone clasts in the lower levels, and the degree of roundness of the clasts present in the deposit, lead us to conclude that these are inherited characteristics. As we have previously discussed in other studies (Ernstson and Claudin, 1990; Ernstson et al., 2002), the materials likely originated from molasse—deposited in the interior of what is now the Azuara structure—that was affected by the impact and subsequently ejected and “redeposited.” The impact would have resulted in the superimposition of mesoscopic and microscopic impact features onto the clasts’ inherited characteristics. It would also help explain the presence of

large blocks of Bámbola quartzite, Buntsandstein megaclasts/megablocks throughout the Formation, and Paleogene clasts incorporated within the deposit.

- *“The apparent contradiction between the current elevation of the materials in this source area (around 500–1000 m) and the elevation of the deposits derived from it in the Sierra Pelarda (up to 1500 m) can be resolved by taking into account the tectonic structure of the region, especially that resulting from its subsequent evolution. On the one hand, the Neogene Calatayud Basin and its Paleozoic substrate are bounded to the east by the NNW-SSE Cucalón-Pancrudo fault segment, whose Pliocene-Quaternary (post-SEF3; 3.5 Ma) has been estimated in the Lagueruela sector (west of the Sierra Pelarda) at approximately 300 m (Peiro, 2023; Peiro et al., 2024). This jump would likely exceed 500 m if the Neogene evolution of the basin is considered as a whole (Fig. 15B, C). Reconstruction of this Neogene–Quaternary normal fault would place the Paleozoic basement of the Calatayud Basin at an elevation similar to or higher than that of the conglomerates of the C1 complex located at the highest point of the Sierra Pelarda, which currently lies within the uplifted block of that normal fault. On the other hand, this fault segment results from the reverse faulting of an imbricated system of thrust faults with a similar orientation—perhaps with a more Iberian trend (NW–SE)—that are recognized in the vicinity of the town of Lagueruela and to the northeast and east of the town of Collados (southwest of the Sierra Pelarda). It is interpreted that the source area for the siliceous C1 conglomerates of the Sierra Pelarda would be the upper block of this thrust system, whose erosional undercutting led to the deposition of this assemblage. This new paleogeographic proposal for the upper part of the Montalbán T2 tectosedimentary unit would explain the facies change described here and recognized by Pailhé (1984), with alluvial facies relatively more distal to the east—that is, toward areas farther from the thrust system.”*...In order to propose that the materials comprising the Pelarda deposit originated from the Paleozoic substrate of the Calatayud Basin, Simón et al. (2026) need to put forward a new proposal—as they acknowledge—in which, naturally, a whole series of faults are used to raise and lower blocks in order to justify the origin of the materials in that area within the Calatayud zone. In our view, as explained in our 1990 and 2019 articles, and in the previous point of this reply, the materials would originate from molasse—deposited in the interior of what is now the Azuara structure—affected by the impact and subsequently ejected and “redeposited.” The impact would result in the superimposition of mesoscopic and microscopic impact features onto the clasts’ inherent characteristics. It would also explain the presence of large blocks of Bámbola quartzite, Buntsandstein megaclasts/megablocks throughout the Formation, and Paleogene clasts incorporated within the deposit. Furthermore, it would be consistent with the paleocurrents and the azimuth of the striations, which indicate that the source area was located to the N-NE.

- “Conclusions: The siliceous conglomerates that form the main body of the Sierra Pelarda, characterized by their abundance of rounded blocks derived from Paleozoic and Triassic quartzites and sandstones, belong to a thick section of the Paleogene series of the Montalbán Basin, approximately 800–500 m thick and attributable primarily to the Middle–Upper Eocene (UTS T2 of the Montalbán Basin). Their source area was the upper block of a system of thrust faults activated during Alpine compression and subsequently inverted during Neogene extension, giving rise to a segment of the Cucalón–Pan Crudo fault zone. Currently, the materials from that source area are covered by the Neogene fill of the Calatayud Basin. Starting from those original conglomerates (assembly C1), the boulders and blocks containing the remaining alluvial materials in the mountain range and its surroundings were recycled from them during their erosive dismantling beginning in the Oligocene. Although these materials show a notable convergence of facies resulting from their common origin (Pelarda facies), they comprise a polygenic and heterochronous complex consisting of three lithological groups: C2, Middle Miocene–Lower Pliocene conglomerates and sandstones; C3, uncemented and unstratified alluvial gravels from the early Upper Pliocene; C4, alluvial and colluvial gravels and silts from the Upper Pliocene–Quaternary. The overall morphotectonic–sedimentary evolution of the Sierra Pelarda comprises three stages: (1) Paleogene stage. The original siliceous conglomerates, originating from a Paleozoic source area to the west, are deposited. During and after their sedimentation, these conglomerates are folded and overthrust by lower Paleozoic units. (2) Miocene–Pliocene Stage. The Calatayud Basin subsides within a context of compression–extension transition. The relief of the mountain range is shaped; its highest point remains as residual relief, while several stepped level surfaces develop in its surroundings: SEF2, SEF3, and SEF4. Erosion of the Paleogene conglomerates causes their siliceous clasts to be incorporated into the sediments of the C2 unit and subsequently into the C3 cover associated with SEF3. (3) Pliocene–Quaternary Stage. The Cucalón–Pancrudo fault zone reactivates, completing the negative inversion of the contractive structures. The vertical jump reaches 280–300 m (net jump of 305–325 m). During the Quaternary, the drainage network continued to cut into the uplifted block, and alluvial sedimentation continued in fans and on slopes. The spatial extent of the rounded siliceous block deposits and the objective difficulties in observing them initially led some authors to interpret that the entire upper part of the Sierra Pelarda was formed by a large Pliocene–Quaternary alluvial unit, with a thickness of nearly 200 m—an idea that was incorporated into the IGME’s cartography. The model proposed here corroborates the alternative model advocated in the works of Moissenet, Adrover, and Pailhé, which had remained on the sidelines of the debate for the past four decades.” All the characteristics observed in the Salcedillo area, as well as along the road between Fonfria and Olalla and on the trails that cross the Sierra de Pelarda, allow us to conclude that this is a deposit associated with gravity flows (Lowe, 1979 and 1982; Colombo, 1989). The diamictitic sections present in the deposit exhibit characteristics*

correlatable to debris flows, in which the matrix (sandy in this case) has provided sufficient cohesion to support the clasts, allowing them to be transported en masse. This transport would have prevented, in most cases, the collision between them. Thus, the clasts could have been preserved with significant plastic deformations (rotational fractures, parallel fractures, fractures with complex bifurcations) observed in the diamictitic sections of Salcedillo and in sections 3 and 4 between Fonfria and Olalla. It would also explain the tendency of many of the observed clasts to be oriented parallel to the base. However, there are areas that show that this tendency toward a laminar (non-Newtonian) regime is not always maintained, and that, as is typical in this type of deposit, there is an evolution over time from laminar and turbulent behavior (Enos, 1977; Nemec and Steel, 1984; Wilson, 1980; Colombo, 1989; Colombo and Martí, 1989). This would be the case for the bases of the diamictitic sections, which are clearly erosional and incorporate fragments of the underlying materials, as well as the megablocks incorporated into the deposit that can be observed in the upper part of the deposit (near the Sanctuary) and on the road connecting Fonfria and Olalla (section 3 of Fig. 53). If we add to this data the presence of a certain tendency toward internal stratification, we are dealing with very dense flows with a high concentration of particles. This high concentration would favor a massive (rather than tractive) behavior despite the turbulence. The sandy sections intercalated between the diamictitic sections would indicate that transport did not occur in a single stage, but rather that there were several massive episodes. In turn, the sandy sections at the top would confirm this circumstance, meaning we would have a set of “flows” (flow units) that would be superimposed on one another. This circumstance is particularly evident in the Salcedillo 2 sequence.

The large sandy-litic section located between Salcedillo 1 and Salcedillo 2, consisting of massive lithosandstones or those with occasional parallel lamination and unconsolidated, also indicates high-energy transport conditions as well as a loss of the “channelized” character of the “currents.” In this zone,

the only diamictitic deposit with structures clearly indicative of a non-laminar regime and associated with tractive currents (fluidal flow). The levels of very fine-grained litharenites—cemented siltstones with a slightly lenticular morphology, of small thickness and grain size, without associated fossils, and scattered within the large sandy-litic section—could correspond to zones of carbonate fluid accumulation embedded within this section during their transport. The karstification observed in these zones occurred after their formation, when these levels were exposed to weathering. Classifying them as hard-ground levels associated with lacustrine activity seems unlikely based on field observations, since neither fossils nor associated lateral alteration zones have been observed in the sandy section in which they are embedded. The grayish, pseudo-channel-like structures, oriented in various directions, which occasionally cut through these materials, do not appear to correspond to rhizocreations.

In thin sections, they appear as accumulations of subidiomorphic-xenomorphic calcite crystals, with no zoning apparent in the sections perpendicular to the direction of the pseudochannel. Based on these data, we propose an origin linked to the escape of gases from the fluid that transported them within the lutitic-sandy section. Furthermore, it is worth noted that within the deposit's materials: a. Impact features can be observed, which may be macroscopic (plastic deformations in the clasts, spallation structures) and microscopic (planar structures); b. There is a particular "syn-depositional faulting¹⁰"; c. There are intercalated megaclasts and megablocks. Taking into account all the sampled and analyzed areas, in addition to Salcedillo, the overall sequence is granulogranular, with clasts larger than one meter and large megablocks in the upper part of the deposit. The sequence terminates beneath breccias composed of metamorphic components. These observations suggest a genesis linked to successive "flows" (floods/flow units) originating from the "ejecta curtain" generated during the impact that gave rise to the Azuara structure. These flows would have consisted of streams of semi-fluidized, high-density material moving primarily in a laminar flow (Schultz and Gault, 1979; Melosh, 1989; Mackaman, Lofland et al., 2014). The particle-to-fluid ratio would have been high (high concentration) favoring laminar behavior despite the turbulence. The fluid, considering the lapilli dikes found beneath the deposit, may have occasionally been water vapor (produced in large quantities during the impact), although the overall massiveness of the deposit suggests that the predominant fluid was water (produced by the condensation of the vapor). Vapor-liquid phase transitions, as well as sudden fluid losses within the transported mass, must have influenced the deposition of the ejecta. In this regard, the presence of striations whose azimuth predominantly points in a NE-SW direction—generated by friction with the matrix—suggests that the sudden halt (likely due to the loss of buoyancy caused by the fluid) of the various units was responsible for this phenomenon. The presence of the peculiar within some units may also have been linked to the same phenomenon. The sequence—consisting of a basal conglomerate layer overlying upper litharenites—appears to reflect a tendency toward pulsations within the ejecta, and, despite obvious differences, is similar to that observed in volcanic pyroclastic flows and in the deposits of some craters on Mars (Schultz and Gault, 1979; Melosh, 1989). Following the same line of analogy, the materials of the Pelarda Formation may have been deposited by flow units whose morphology was similar to that of pyroclastic flows: a large droplet moving across the preexisting surface, within which several distinct parts can be identified, each giving rise to a characteristic deposit. As with pyroclastic flows, and depending on variations in flow velocity (sometimes influenced by topography) and the particle-to-fluid ratio, a whole range of transitions can be observed, giving rise to different depositional facies. In the case of massive deposits, these facies can range from debris flows to highly concentrated aqueous flows (hyperconcentrated

flood flows) (Colombo and Martí, 1989). So much for the analogies. Since the time of Oberbeck (1975), an important model has been available for explaining ejecta deposition: that of ballistic sedimentation. We (Ernstson and Claudin, 1990) previously proposed this model to explain the genesis of the Pelarda Formation, since the mesoscopic characteristics (as well as the depositional characteristics) of the clasts—indicative of intense confinement pressure confinement—do not consistent with deposition linked to “base surges” (i.e., pyroclastic flows with a certain degree of turbulence) (Chao, 1977). From the velocity distribution within ejecta (Melosh, 1989; French, 1998), we can deduce that the materials of the Pelarda Formation would have been among the first to be deposited because they originated from the surface levels (and near the impact site) of the target. The Armorican quartzite clastic breccias, which have an angular to very angular morphology and clear signs of plastic deformation, and which lie at the top of the Formation, correspond to materials originating from the crater rim area. In this case, their deposition would have occurred later, as they are farther from the initial impactor-target contact zone. Their angularity is likely due to the absence of reworking, since their placement probably occurred in a manner similar to that of the Pelarda Formation. Classifying these materials as belonging to this Formation—even though they were formed during the same impact process—seems illogical to us, since, according to the stratigraphic definition of a Formation, its materials differ from adjacent ones by the predominance of a certain lithology or combination of lithologies (or by possessing unifying or notable lithological features).

Taking this into account, the typical Pelarda facies would be that observed in the Salcedillo type section (stratotype) (including Salcedillo 1, the intermediate section, Salcedillo 2, and Salcedillo 3). There would therefore be lithological continuity throughout the entire formation, consisting primarily of clasts of slate, phyllite, schist, and Buntsandstein quartz sandstone, Armoricana quartzites, and Bámbola quartzites, which exhibit both mesoscopic and microscopic impact features.

- “The spatial extent of the deposits of rounded siliceous blocks and the objective difficulties in observing them initially led some authors to interpret that the entire upper part of the Sierra Pelarda was formed by a large Pliocene-Quaternary alluvial unit, with a thickness of nearly 200 m—an idea that was incorporated into the IGME’s mapping. The model proposed here corroborates the alternative model defended in the works of Moissenet, Adrover, and Pailhé, which had remained on the sidelines of the debate for the past four decades.”*

... I insist that those “some authors” are the very same ones who are now trying to propose a new model to salvage their narrative in light of the evidence contradicting the genesis and evolution they had previously proposed. For decades, they defended a Quaternary age and a genesis linked to scour marks (ITGE, 1989; ITGE, 1991; Aurell et al., 1993; Aurell, 1994; Smit, 2000 (written comment), Cortés et al., 2002; Díaz-Martínez et al., 2002a, 2002b, 2002c; Díaz-Martínez, 2005), ignoring any other evidence. Curiously, despite the difficulties

objective difficulties in observation and dating, the materials from the Pelarda Formation type series that lie on top of the Upper Eocene–Lower Oligocene (according to IGME, 1977; ITGE, 1989; ITGE, 1991) belong to the Middle–Upper Eocene and correlate with UTS 2 from Montalbán....

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