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Tsunamis Struck Coasts of Triassic Oceans and Seas: Brief Summary of the Literary Evidence

Dmitry A. Ruban

Department of Organization and Technologies of Service Activities, ITSCI, Southern Federal University, 23-ja Linija Street 43, Rostov-on-Don 344019, Russia; ruban-d@mail.ru

Abstract: Studying palaeotsunamis is important to the comprehensive understanding of these events and their role in the geological evolution of the coasts of oceans and seas. The present work aims at summarizing the published information on Triassic tsunamis to document their spatiotemporal distribution and the related knowledge gaps and biases. A bibliographical survey was undertaken to collect the literature sources, and their content was examined to extract the principal information about palaeotsunamis. The certainty of the literary evidence for particular localities and regions is addressed by checking the consistency of the published interpretations. It is found that tsunamis were discussed commonly in different parts of the world for the Permian–Triassic transition and the end-Triassic. However, the certainty of the literary evidence is questionable in both cases. Some interpretations of palaeotsunamis were disputed, and storm versus tsunami interpretations were offered in several cases. A few tsunamis were also reported from the Olenekian–Carnian interval but with the same quality of literary evidence. Taking into account the frequency of tsunamis in the historical times and the Holocene, as well as the presence of their possible triggers in the Triassic, it is proposed that the analyzed literary evidence is significantly incomplete, and, thus, our knowledge about Triassic tsunamis is imperfect. Further research should aim at studying them in a bigger number of localities, paying attention to the Olenekian–Norian interval and trying to relate them to different triggers.

Keywords: bibliographical survey; knowledge biases; Mesozoic; natural catastrophe; palaeotsunami

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1. Introduction

Tsunamis are not only devastative events of outstanding magnitude and different nature but also factors of geological evolution, which affect coastal landforms, depositional systems, and habitats [1–19]. Although there have been significant advances in their understanding after the two catastrophes that occurred at the beginning of the 21st century [20–24], there is much to be studied yet in regard to their spatiotemporal regularities, causes and mechanisms, and effects.

Indeed, the geological records of tsunamis can facilitate a comprehensive understanding of this phenomenon in general. Palaeotsunamis have been studied actively, with significant attention to their sedimentological and palaeoecological evidence [25–30]. The oldest tsunami was interpreted for the Archaean [31]. However, the preservation potential of tsunamis and/or the scientists' ability to identify them and interpret them correctly is limited. That is why the knowledge of pre-Quaternary tsunamis remains scarce. However, it is available and not too limited, and the related studies have experienced growth. Taking into account that this knowledge is scattered through the geological literature and the related notions sometimes appear "marginally", it appears very reasonable to synthesize it regularly and with attention to particular intervals of geological time.

The Triassic Period, which lasted ~50.5 Ma [32], was marked by palaeoenvironmental changes (for instance, fluctuations of the thermal regime [33,34] and global sea-level changes [35,36]), which were superimposed by a series of extraordinary events such as the Permian/Triassic (P/T) [37–39] and Triassic/Jurassic (T/J) [40–42] catastrophes and lesser crises [43–47]. Taking into account these changes, it appears intriguing to investigate Triassic tsunamis, irrespective of whether they were related to the noted events or not. Some high-resolution studies of Triassic sequences in search of the evidence of these above-mentioned catastrophes might have led to finding tsunamis. A brief check of the available literature (see review below) implies that the related lines of evidence exist. Arguments pro et contra palaeotsunami interpretations were expressed. However, it appears that the knowledge of Triassic tsunamis is not only heterogeneous but also fragmented and controversial to a certain degree.

The objective of the present work is to summarize briefly the available literary evidence of Triassic tsunamis. Attention is paid to their spatiotemporal distribution. However, even more important is the examination of the certainty of the lines of evidence because palaeotsunamis can only be interpreted (hypothesized) with more or less strong arguments. Judgments about these interpretations are out of the scope of this study, but it appears essential to check controversies and alternative explanations already stated in the published literature. The author neither favors nor criticizes the previous interpretations but tries to synthesize the information to reflect the present understanding of Triassic tsunamis, as evidenced by the entity of the related literature sources. In other words, this work offers a general and neutral view of these events—a kind of view from the outside (for instance, of any professional geologist needing to learn about palaeotsunamis of this age and caring about the consistency of this information). The present synthesis has been stimulated by the examination of the regional geological record of the hypothetic, earliest Induan tsunami in the Western Caucasus; nonetheless, bringing together the dispersed published information from different stratigraphical levels of the Triassic and different parts of the world is the central task, solution of which may be helpful for further developments, both of regional and global scale.

2. Materials and Methods

The present study follows the Triassic time scale established by the International Commission on Stratigraphy [32]. The period consisted of three epochs and seven stages, and its subdivision is highly disproportional because the Late Triassic was longer than the Early and Middle Triassic taken together, and the Norian Stage lasted more than two Triassic epochs (Figure 1). The Triassic world was organized rather simply, with one supercontinent, namely Pangaea, surrounded by the Panthalassa Ocean; the Palaeo- and Neo-Tethys oceans intruded into the interiors of Pangaea and formed a giant "tongue" [48–50]. The climate was warm, with global average temperatures above 20 °C [33,34]. A thermal maximum with extreme temperatures took place in the Early Triassic [51–53]. The global sea level was relatively low, and it fluctuated generally near or above the present level [35,36]. Palaeoenvironmental and palaeoecological perturbations stressed the world during a significant part of the Triassic (Figure 1).

The material of the present study is the entity of literature sources, chiefly articles mentioning Triassic tsunamis and published in international journals. In order to collect these sources, a bibliographical survey was undertaken. The principal part of the information was obtained with the major bibliographical database "Scopus", which boasts extensive coverage of sources and outstanding richness [54–56]. However, various additions were made via search with the bibliographical databases of particular publishers such as "Elsevier" and "Springer". Direct search on the Internet was also helpful. The sources mentioning Triassic tsunamis in their titles, abstracts, keywords, and full text were collected this way. After "filtering" (deletion of duplicating or irrelevant works), the set of the literature includes 39 publications, which is not so small taking into account the consideration of the highly-specific subject and the poor preservation of palaeotsunamis in pre-Quaternary geological records. This set seems to be representative because the used bibliographical databases include all leading and numerous national/local journals, including those published in languages other than English (indeed, missing a few papers published is possible, but such biases are principally unavoidable; anyway, the set is treated as not fully comprehensive, but only representative).

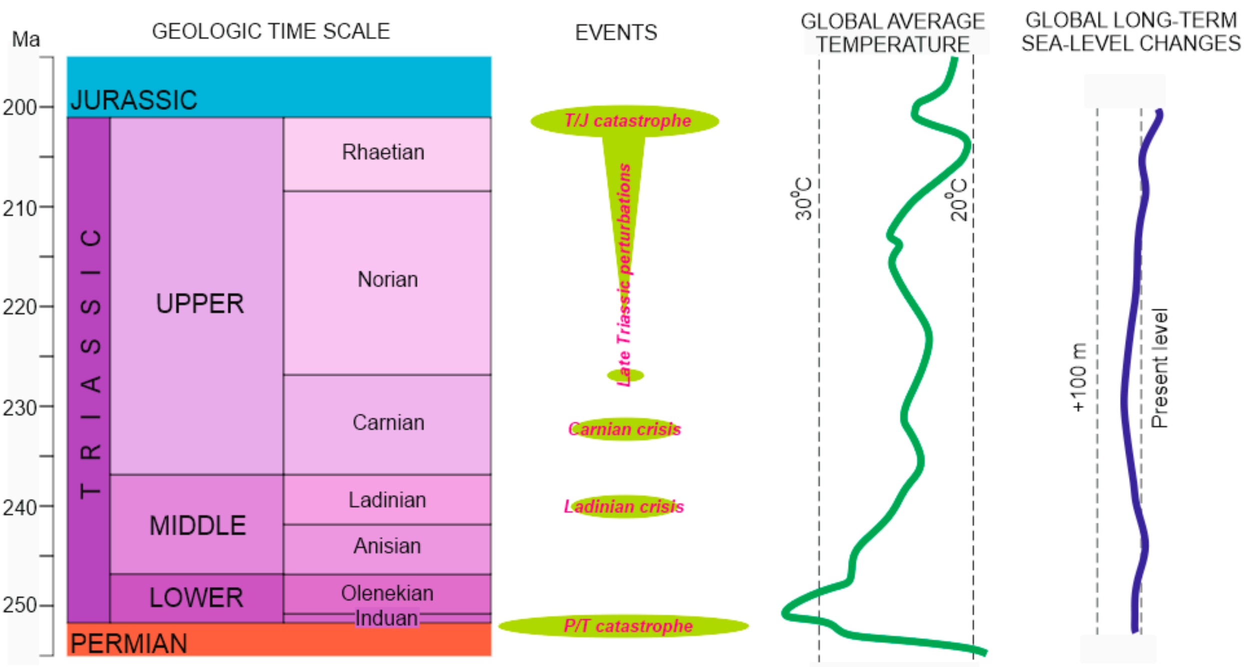

Figure 1. Selected patterns of the Triassic history of the Earth (geologic time scale follows [32], events according to Ruban [45], global average temperature is modified from [34], and global long-term sea-level changes are modified from [35]). One should note the well-developed but disproportional geologic time scale, which may reflect the changed tempos of the planetary evolution. Biotic perturbations were very frequent, with two major catastrophes and several smaller crises. The Earth was warm, but the palaeotemperatures fluctuated significantly. The global sea level remained generally low, although it peaked in the first half of the Late Triassic.

Essentially, the present analysis is a kind of bibliographical survey aimed at a concise, systematic description of the matter. The content of the collected literature sources was analyzed to extract the basic information about Triassic tsunamis. In several cases, the same section or group of sections is addressed in several works. To reduce the heterogeneity of the information, the sections are attributed to the localities, which can be either small or rather large, but presumably, each of them represents the same event or series of events. These localities are specified for only descriptive purposes, and thus, differences in their size do not matter. For each locality, the evidence of tsunami is summarized to reveal its certainty resulting from the consistency of the interpretations from the related works. For instance, some works hypothesize palaeotsunami, others imply the presence of either tsunami or storm, and there are situations when the authors argue for the absence of palaeotsunami. Such interpretations are based on sedimentological and somewhere palaeoecological and geochemical observations. The age of palaeotsunamis is further considered. When possible, it is established at the stage level. It should be noted that many works focus on the Permian–Triassic or Triassic–Jurassic transitions. Naturally, these transitions go beyond the Triassic's limits, and older and younger tsunamis should also be considered because they are directly related to the Triassic geological history, with two outstanding catastrophes that marked its beginning and end. If mentioned in the analyzed literature sources, the possible triggers of palaeotsunamis are outlined. Finally, the temporal (not necessarily causal) correspondence to the global events (Figure 1) can be traced.

The certainty of evidence can be established as follows: it is very high when palaeotsunami is hypothesized without an alternative, it is high when the majority of the works propose palaeotsunami, but some specialists propose alternative interpretations, it is medium when palaeotsunami is hypothesized together with some other factors or some specialists question it, and it is low when the evidence is too weak, or palaeotsunami is one of many possible explanations. Finally, arguments against palaeotsunamis are specified for some localities. Indeed, this procedure is somewhat subjective, but it appears to be useful for the general judgments of the certainty of evidence. Moreover, it should be stressed that this certainty is always only relative because even the strongest and currently undisputed evidence allows only to hypothesize palaeotsunami, not to prove it. In this work, the quality of the evidence from each particular work is not checked because this would require detailed field studies in all considered localities and also because such a critical assessment of the previous literature would require avoiding the neutrality of judgments and choosing any particular methodological framework.

Then, the information is again generalized and grouped by major spatial domains and principal time slices. Domains are outlined provisionally and include closely situated localities (also those localities, the relations discussed in the literature sources) with comparable palaeogeographical settings (for instance, it appears reasonable to consider all West European localities together). The literature has paid significant attention to the Permian–Triassic transition and the end-Triassic interval (Rhaetian and Triassic–Jurassic transition), and the rest information characterizes the Olenekian–Carnian interval. These slices reflect the different temporal "density" of the available lines of evidence, i.e., the former depends on the concentration of the latter. The interpretations of the certainty of evidence are generalized for all major domains in each time slice.

3. Results

The literary evidence of Triassic tsunamis implies that the contemporary knowledge of them is far from being ideal. On the one hand, some palaeotsunamis are disputed or face alternative explanations (Table 1). Commonly, they are interpreted for beds with unusual sedimentary, palaeoecological, and geochemical characteristics, the origin of which can also be attributed to storms or seismicity. A typical example is found in the earliest Induan sandstones bearing boulders and megaclasts (Figure 2) reported from the Western Caucasus [57]. On the other hand, too little attention has been paid to the Ladinian–Norian interval (Table 1), which constitutes more than half of the Triassic history (Figure 1). It is also necessary to note the concentration of research in particular localities, such as the British Isles or Kashmir (Table 1). Nonetheless, the already published information generally proves tsunamis as a rather characteristic phenomenon of the Triassic or, at least, its particular intervals.

Table 1. The literary evidence for judgments of Triassic tsunamis.

Locality	Source and Evidence	Certainty of Evidence	Age	Possible Trigger	Events
Carnic Alps (Austria)	[58]: tsunami (storm not excluded)	High	Permian–Triassic transition	-	P/T catastrophe
Germanic Basin (Germany and Poland)	[59]: tsunami (storm not excluded)	High	Anisian	Earthquake	-
	[60]: tsunami (storm not excluded)				
	[61]: tsunami				
	[62]: tsunami				
	[63]: tsunami				
	[64]: tsunami				
	[65]: tsunami				
	[66]: tsunami (mass movements not excluded)				
	[67]: tsunami	Very high	Anisian–Ladinian		Ladinian crisis

Table 1. *Cont.*

Locality	Source and Evidence	Certainty of Evidence	Age	Possible Trigger	Events
Kashmir (India)	[68]: storm/tsunami	High	Permian–Triassic transition	-	P/T catastrophe
	[69]: tsunami			Remote massive volcanism	
	[70]: tsunami/seismicity			-	
	[71]: tsunami			-	
Lagonegro Basin (Italy)	[72]: tsunami in adjacent area	Unclear	Norian–Rhaetian	Bolide impact	Late Triassic perturbations
Northern Ireland (UK)	[73]: not tsunami	Medium	Rhaetian	-	Late Triassic perturbations
	[74]: not tsunami			-	
	[75]: tsunami			Earthquake, bolide impact?	
	[76]: tsunami				
Massif Central (France)	[77]: tsunami	Very high	Triassic–Jurassic transition	Bolide impact	T/J catastrophe
Mino Terrane (Japan)	[78]: tsunami among other possible processes	Low	Anisian–Carnian	-	Ladinian and Carnian crises
Northwestern Peninsular Malaysia (Malaysia)	[79]: tsunami/seismicity	Medium	Middle Triassic	-	Ladinian crisis
Ordos Basin (China)	[80]: not tsunami	Absence	Ladinian–Carnian	-	Ladinian and Carnian crises
	[81]: not tsunami			-	
Parana Basin (Brazil)	[82]: tsunami	Very high	Permian–Triassic transition	Bolide impact, earthquake	P/T catastrophe
	[83]: tsunami				
Paris Basin (France)	[84]: tsunami	Very high	Rhaetian	Bolide impact	Late Triassic perturbations
Sichuan Basin (China)	[85]: storm/tsunami	Medium	Triassic–Jurassic transition	-	T/J catastrophe
South Iberia (Spain)	[86]: storm/tsunami	Medium	Middle–Late Triassic (Ladinian–Carnian?)	-	Ladinian and Carnian crises
Southern and Southwestern England (UK)	[87]: not tsunami	Medium	Rhaetian	-	Late Triassic perturbations
	[74]: not tsunami			-	
	[75]: tsunami			Earthquake, bolide impact?	
	[76]: tsunami				
Spiti (India)	[88]: tsunami in adjacent area	Unclear	Permian–Triassic transition	Earthquake, bolide impact	P/T catastrophe
Spitsbergen (Norway)	[89]: storm/tsunami	Medium	Permian–Triassic transition	Earthquake	P/T catastrophe
Tataouin Basin (Tunisia)	[90]: not tsunami	Absence	Late Triassic (Rhaetian?)	-	Late Triassic perturbations
Tatra Mountains (Poland)	[91]: not tsunami	Absence	Olenekian–Anisian	-	-
Utah (USA)	[92]: tsunami	Very high	Olenekian	-	-
Western Balkanides (Bulgaria)	[93]: not tsunami	Absence	Olenekian	-	-
Western Canada (Canada)	[94]: tsunami cannot be excluded	Low	Permian–Triassic transition	-	P/T catastrophe
Western Carpathians (Slovakia)	[95]: tsunami	Very high	Anisian	-	-
Western Caucasus (Russia)	[57]: storm/tsunami	Medium	Permian–Triassic transition	-	P/T catastrophe

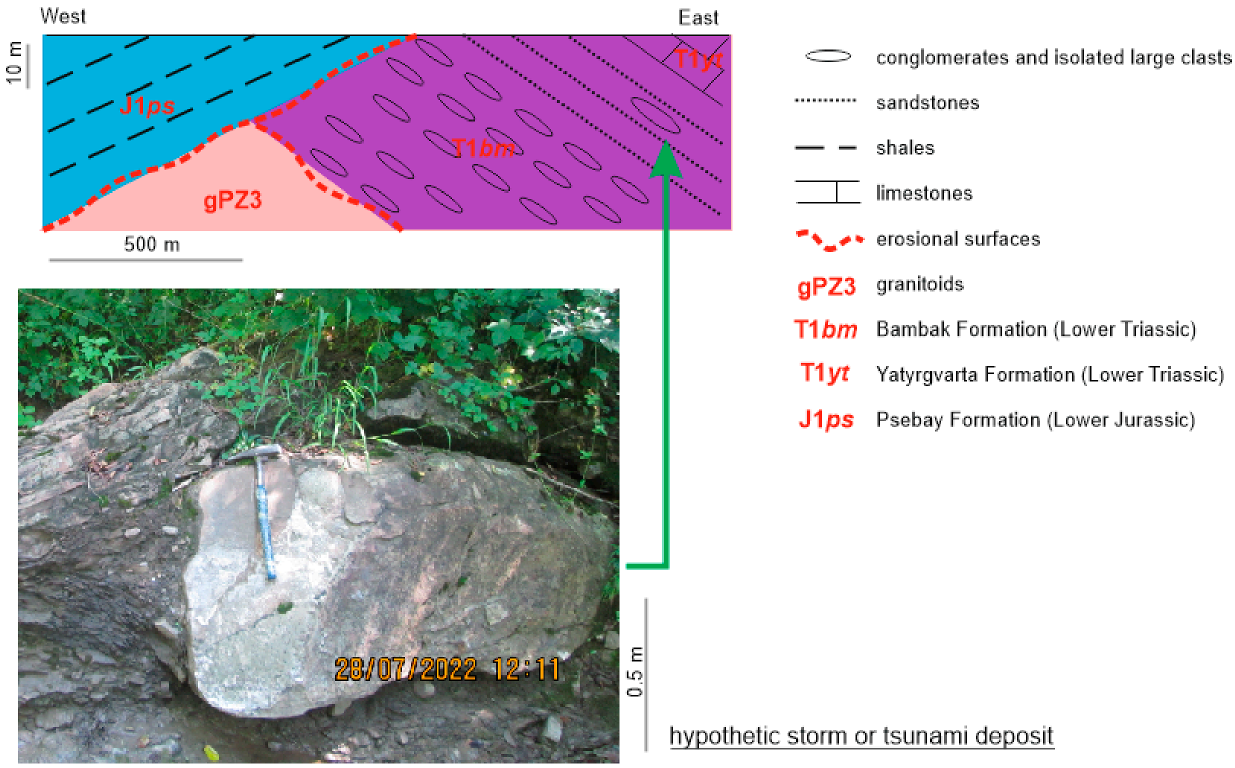

Figure 2. Lowermost Induan strata (Bambak Formation) of the Western Caucasus: simplified cross-section (above) and image of characteristic megaclast in sandstone bed (below) (the image is a part of the larger photograph from [57], and it is re-published with permission of MDPI).

Tsunamis at the Permian–Triassic transition have been reported from several localities, from which the most studied is the Guryul Ravine in Kashmir (Table 1). However, the Parana Basin of Brazil is the only place where the evidence of palaeotsunami seems to be the most certain. For the other localities, alternative interpretations were proposed, with storms as the most common (Table 1). Nonetheless, it is notable that the available lines of literary evidence come from different parts of the world (Figure 3a), which means tsunamis could be a global phenomenon during the Permian–Triassic transition. Before the 2010s, researchers stated the absence of any tsunami deposits linked to the P/T catastrophe [96,97]. However, new information has been obtained from several localities (Table 1), and it appears to be promising to link this phenomenon to the P/T catastrophe, although one should note the questionable correlation of the described events. In Kashmir, they occurred near the beginning of the Permian–Triassic transition [68,69], but the hypothetic palaeotsunami took place near its end in the Western Caucasus [57]. Moreover, one should note that different specialists indicated different triggers of the palaeotsunamis hypothesized for the Permian–Triassic transition, in which a bolide impact could cause massive remote volcanism and earthquakes (Table 1). In the latter case, they were not necessarily related to planetary mechanisms.

Olenekian tsunamis were discussed for three localities (Table 1). Surprisingly, their absence was argued in two places, and thus, only their presence in western North America was hypothesized with certainty. More publications focused on the possible Anisian tsunamis, but the majority of them deal with the Germanic Basin (Table 1). The certainty of evidence from this major Central European palaeogeographical domain is high because many works offered interpretations of the only earthquake-triggered palaeotsunamis, although alternative explanations of the observed features (first of all, storms) cannot be totally excluded. Ladinian–Norian tsunamis were mentioned from only a few localities (Table 1). The certainty of this evidence is usually limited. On the one hand, alternative interpretations were given for some localities. On the other hand, one should note arguments against palaeotsunamis, which are especially strong in the case of the Ordos Basin [80,81]. Generally, Olenekian–Norian tsunamis were reported rarely, and the entire literary evidence of these events seems to be rather uncertain (Figure 3b). Although a few possible events corresponded to the Ladinian and Carnian crises, this correspondence may be only occasional. Moreover, the triggers of the proposed palaeotsunamis were not indicated in the literature, except for the Anisian events in the Germanic Basin, where they were attributed to seismicity (Table 1).

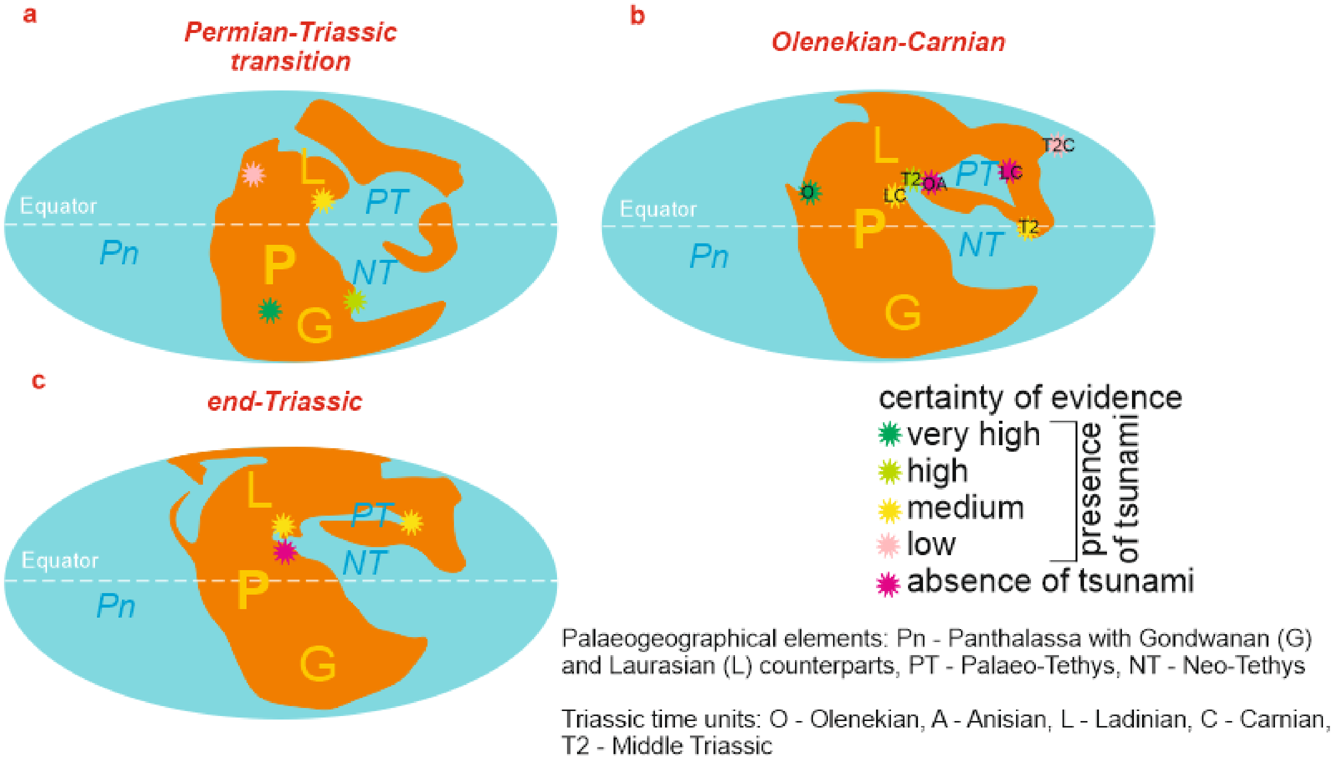

Figure 3. Global distribution and certainty of evidence of palaeotsunamis from the three time slices of the Triassic Period (configurations of continental blocks are strongly simplified from [48]).

End-Triassic tsunamis were reported in rather numerous works, although from a limited number of regions; the best studied are the localities of the British Isles (Table 1). In the French localities, the evidence seems to be very certain, but apparently, the same palaeotsunamis are disputed in the localities of Northern Ireland and Southern and Southwestern England (Table 1). The number of works arguing for palaeotsunami and disproving it seems to be comparable, which decreases the certainty of the evidence. In the other localities, either alternative (storm) interpretations were offered, or it was argued against palaeotsunami. Principally, the available literary evidence seems to be less certain and less geographically representative (Figure 3c) than in the case of the Permian–Triassic transition (Figure 3a). Indeed, it appears to be intriguing to relate the hypothesized end-Triassic tsunamis to the T/J catastrophe or its prelude that started yet in the Norian (Figure 1). Some works argued bolide impact as a possible trigger of palaeotsunamis [72,75–77,84], although seismicity, either related to this impact or not, cannot be excluded. Such a bolide impact could be linked to the end-Triassic sequence of catastrophic events. However, the arguments against palaeotsunamis make the related scenarios questionable, if possible. Much depends on the interpretations of soft-sediment deformations [76,87], and some scenarios can be only highly-hypothetic and based on the more or less logically organized sets of assumptions.

4. Discussion

Taking into account the state of the literary evidence summarized above (see also Table 1 and Figure 3), it appears that the quantity and the certainty of the available knowledge of Triassic tsunamis remain restricted. Nonetheless, it has been established that tsunamis could be linked to planetary-scale catastrophes (such as those marked the Permian–Triassic transition and the end-Triassic) and local/regional events (such as major earthquakes). The literary evidence of the hypothetic tsunamis associated with (but not necessarily linked to) the P/T catastrophe demonstrates rather high certainty. The biggest problem is that, in many cases, it is impossible to be sure that tsunami took place or that this was a tsunami and not a storm (Table 1). This appears to be a general methodological problem that cannot be avoided presently. First, it is evident that sedimentary records of palaeotsunamis can often be challenged and interpreted differently [73,74,80,91,93], whereas arguing for palaeotsunami requires difficult, state-of-the-art approaches [98–100], which do not necessarily work in the "Deep Past". Second, making clear distinctions between storm (also hurricane) and tsunami deposits on the basis of simple criteria is very difficult (if possible), at least in contemporary geology [101–109]. The very high certainty of the interpretations is established chiefly for those localities, which were addressed in only one to two works. When a given locality attracted the attention of several research teams, arguments pro et contra were commonly expressed. For some localities, which have been studied for a long time, it is also possible to observe interesting shifts: for instance, storm versus tsunami was initially interpreted, but the tsunami was further emphasized (apparently, this might have occurred even without the accumulation of more convincing evidence).

To realize the incompleteness of the literary evidence of Triassic tsunamis, it is necessary to hypothesize the true frequency of these events. In historical times, numerous tsunamis were recorded, and there were several major events of this kind even during the past century [1,5,8,21,24,109–113]. The Holocene records of tsunamis, including those archaeological, are known to be very rich [114–121]. Taking into account the longevity of the Triassic Period of ~50.5 Ma [32], one can hypothesize a huge amount of tsunami events, many times larger than those few possible events discussed in the literature (Table 1).

To prove the assumption of the outstanding incompleteness of the knowledge, it is necessary to check the presence of the principal triggers of tsunamis in the Triassic. The global plate tectonic reconstruction [50] shows a significant extension of active tectonic zones in this period; particularly, subduction zones stretched along the Panthalassic margins of Pangaea and the northern Tethyan (northwestern Neo-Tethyan and northeastern Palaeo-Tethyan) margin was also active, with well-shaped subduction zones. If so, seismicity could be significant on the global scale, as well as the probability of earthquake-triggered tsunamis. Moreover, such tectonic events as the emplacement of large igneous provinces contributed to global seismicity [122]. Triassic volcanism of different natures was reported from different regions and time slices [123–128], and thus, it could be responsible for some (if not many) tsunamis. Considering the extension of shelfal versus deep-marine palaeoenvironments [48], wide distribution of submarine slides and other mass wasting processes can be supposed for the Triassic, and such events have been reported from different localities [78,129–131]. Therefore, many palaeotsunamis of this origin are expected. Finally, several bolide impacts have been argued for the Triassic [46,132–135]. Apparently, such extraordinary events were able to cause tsunamis, and not only at the time of the P/T and T/J catastrophes, for which such a trigger has already been considered (Table 1).

Taking into account the above-mentioned information, it appears that our knowledge (at least, the literary evidence) of Triassic tsunamis (Table 1) is too insufficient (one can even proclaim it as close to zero). This can be explained by the very low preservation potential of tsunamis [136–140], unclear criteria for their identification (see above), and concentration of the researchers' attention on the P/T and J/T catastrophes (Table 1), whereas many "ordinary" palaeotsunamis with regional/local triggers are not looked for. The Germanic Basin (Table 1) example demonstrates how information regarding palaeotsunamis not linked to planetary-scale catastrophes can be studied. Three biases in the knowledge of Triassic tsunamis can be outlined as follows. First, too few events from too few localities were reported. Second, the Olenekian–Norian (especially Ladinian–Norian) tsunamis are known less than those from the Permian–Triassic transition and the end-Triassic. Third, palaeotsunamis with different triggers were not recorded adequately, and their causal relationships to the Triassic events other than the P/T and T/J catastrophes are unclear. One can hypothesize that these may be biases of not only the previous research but also of this study; in other words, they can be caused by the limited literature availability and/or reporting of some research in languages other than English. Although missing sources cannot be excluded, it appears that hypotheses of Triassic tsunamis are internationally important by definition, and, thus, the majority of the related research was published in the journals covered by the bibliographical database "Scopus", which is employed for the purposes of this study. Importantly, this database also offers extensive coverage of numerous national and even local journals, including those published in languages other than English.

An interesting perspective in the studies of Triassic tsunamis is their relation to geological heritage (geoheritage). Indeed, their rarity in the geological records and the impressions of ancient natural catastrophes make their localities ideal candidates to geoheritage sites (geosites). At least two geosites of this kind have already been proposed (Table 2). They both represent the hypothetic tsunamis corresponding to the P/T catastrophe. It is known that geoheritage recognition itself facilitates research activities and promotes unique geological objects among the international scientific community [141–145]. If so, establishing geosites on the basis of the localities representing Triassic tsunamis may be very helpful in decreasing the above-mentioned uncertainties and filling various gaps in the knowledge.

Table 2. Examples of geoheritage related to possible Triassic tsunamis.

Geosite	Location	Lithology	Age	Source
Guryul Ravine	Vicinity of Srinagar city, Kashmir, northwestern India	Bioclastic limestones from the transition between the Zewan and Khunamuh formations	Permian–Triassic transition	[69]: description [71]: description and formal geosite proposition
Sakhray Canyon	Gosh river valley, Mountainous Adygeya, southwestern Russia	Coarse siliciclastics of the Bambak Formation, with large boulders and megaclasts	Permian–Triassic transition	[57]: description and formal geosite proposition

5. Conclusions

The present brief summary of the literary evidence of Triassic tsunamis emphasizes the urgency of research intensification on this promising theme. The main findings are as follows.

(1) Triassic tsunamis were reported from different regions of the world and different time slices, and some of them corresponded hypothetically to the P/T and T/J catastrophes.
(2) The amount of literary evidence remains very little, and its quality (certainty) is often restricted: particularly, some palaeotsunamis were disputed, or the related geological features can be interpreted alternatively (for instance, as signatures of severe storms).
(3) The incompleteness of the knowledge of Triassic tsunamis is significant, especially taking into account the activity of their possible triggers in this period.

Generally, the present study indicates various gaps and biases in the knowledge of Triassic tsunamis. Although some of them have objective sources (for instance, difficulties in making distinctions between tsunami and storm deposits or low preservation potential of tsunamis), many others can be explained by the state and the imperatives of contemporary geosciences research. For instance, overemphasis on the P/T and T/J catastrophes can be linked to better funding of the related research, as well as better opportunities to publish its outcomes. Presumably, geologists deal with potential tsunamis in some (if not many) cases, but they are unable to recognize them because of low awareness and the absence of related skills. Some researchers would be disinterested in launching projects aimed at palaeotsunamis to avoid involvement in "too hypothetic" and "too unserious" studies. Apparently, the very "atmosphere" of the geosciences research should be changed to make Triassic and other pre-Quaternary tsunamis studied really adequately. A limitation of this work is that it deals with the only published information. Checking the opinions of researchers and evaluating the readiness of the international research community to increase attention to highly-hypothetic subjects need further analyses.

Revealing gaps and biases in this knowledge allows for highlighting perspectives for further research. Particularly, special investigations are necessary to identify palaeotsunamis related to different triggers, with special attention to the Olenekian–Norian interval. Studies of the possible relations of palaeotsunamis to the mechanisms of biotic crises other than the P/T and T/J catastrophes seem to be very promising. The present work does not offer a critical re-examination of the published lines of evidence, but future studies can try to achieve this—at least for some major regions. It also appears that reconsidering the already available literary evidence, even considering the degree of its completeness and certainty, can facilitate the development of advanced methodology for identifying tsunamis in the pre-Quaternary sedimentary records.

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