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Review Article

Theoretical concepts about alluvial fans and debris cones: case studies of an Alluvial Fan in São Desidério (Bahia, Brazil) and a Debris Cone at Mount Somma, near the Vesuvius Volcano (Naples, Italy)

Concepções teóricas sobre leques aluviais e cones de dejecção: estudos de caso de Leque Aluvial em São Desidério (Bahia, Brasil) e de Cone de Dejecção no Monte Somma, próximo ao Vulcão Vesúvio (Nápoles, Itália)

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Abstract: Analyzing the last 24 years of the Brazilian Journal of Geomorphology and the National Symposiums of Geomorphology (SINAGEO), it is evident that there is a lack of studies on alluvial fans in Brazil and in Portuguese literature. The situation is even more unclear concerning debris cones. This paper aims to provide a concise and comprehensive bibliographic review of alluvial fans and debris cones in Portuguese and to the Brazilian geomorphological science. These features are crucial for understanding and studying the relationship between form and process, paleoenvironmental reconstruction, sensitivity to climate variations, risks associated with mass movements on slopes, and more effective territorial planning by human actions. Additionally, the paper seeks to clarify the main theoretical and conceptual distinctions between alluvial fans and debris cones, proposing a new classification based on two particularly illustrative case studies. Do alluvial fans and debris cones represent the same or different depositional forms in the landscape? To this end, the methodology includes a detailed theoretical and conceptual review of the topic, a survey of relevant data about the subject in the main means of the Brazilian geomorphological community dissemination, a proposal of a new classification to differentiate these forms, and the mapping, characterization, comparison and analysis of two specific study areas: an Alluvial Fan identified in São Desidério (Bahia, Brazil) and a Debris Cone identified in Mount Somma, the ancient crater of the current Vesuvius Volcano (Naples, Italy).

Keywords: Piedmont areas; Alluvial transport; Slope processes; Colluvial deposits.

Resumo: Analisando os últimos 24 anos da Revista Brasileira de Geomorfologia e dos Simpósios Nacionais de Geomorfologia (SINAGEO), é evidente a ausência de estudos a respeito de leques aluviais no Brasil e na literatura em língua portuguesa. Ao se tratar de cones de dejecção o tema se torna ainda mais nebuloso. Nesse sentido, este artigo busca fornecer breve e assertiva revisão bibliográfica a respeito dos leques aluviais e cones de dejecção em língua portuguesa e para a ciência geomorfológica brasileira, tendo em vista que estas feições possuem suma importância no entendimento e estudo: da relação entre forma e processo, da reconstituição paleoambiental, da sensibilidade à variações climáticas, dos riscos envolvendo movimentos de massa em encostas, e de um ordenamento territorial mais efetivo por parte das ações humanas. Além disso, o trabalho pretende esclarecer as principais distinções teóricas e conceituais entre leques aluviais e cones de dejecção, propondo uma nova classificação à luz de dois estudos de caso bastante evidentes. Afinal, leques aluviais e cones de dejecção representam formas deposicionais iguais ou diferentes na paisagem? Para tal, a metodologia baseia-se em detalhada revisão teórica e conceitual sobre o tema; levantamento de dados nos principais meios de divulgação da comunidade geomorfológica brasileira; proposição de uma nova classificação para diferenciar essas formas; e mapeamento, caracterização, comparação e análise de duas áreas de estudo específicas: Leque Aluvial identificado em São Desidério (Bahia, Brasil) e Cone de Dejecção identificado no Monte Somma, cratera pretérita do atual Vulcão Vesúvio (Nápoles, Itália).

Palavras-chave: Áreas de piemonte; Transporte aluvial; Processos na vertente; Depósitos coluviais.

1. Introduction

The absence of conceptual, theoretical, and methodological development concerning alluvial fans in the Brazilian scientific literature and Portuguese-language is notable. These forms have been extensively studied in the western United States, a region of arid and semi-arid climate, particularly in California, during the latter half of the twentieth century. This region is known for its large coalescent alluvial fan systems (DENNY, 1967), with significant studies focused on Owens Valley and Death Valley (BULL, 1963; DENNY, 1965; SOHN et al., 2007; D'ARCY et al., 2015; D'ARCY, WHITTAKER and RODA-BOLUDA, 2016). Additionally, there are also important studies on the Okavango Fan in Botswana (STANISTREET and MCCARTHY, 1993; MCCARTHY et al., 1997; RINGROSE et al., 2008) and on the Kosi Fan in India (WELLS and DORR, 1987; CHAKRABORTY et al., 2010; SINGH, NAIK and GAURAV, 2022).

When it comes to the international scope, recent works, such as that of Vetra and Clarke (2018), warn that few studies and articles have been dedicated to examining these important landforms from geological, geomorphological, and sedimentological perspectives. If this is the situation internationally, the Brazilian context is even further behind.

Studies of alluvial fans in Brazil are still not very expressive, with most of them beginning only in the twenty-first century. Notable works include the dissertations and theses, such as those by Pontelli (1998; 2005; 2009) and Back (2015) in Santa Catarina, as well as studies by Assine (2003; 2005), Zani (2008), Pupim (2014) and Pupim et al. (2017) on the Taquari River megafan in the Pantanal and those by Rosseti et al. (2012; 2017; 2018) and Zani (2013) on amazon megafans. In addition, the publications by Suguio et al. (1985) and Vilas Boas et al. (1985) in Bahia should also be taken into account, and more recently the works by Lopes et al. (2022; 2023) in the Quadrilátero Ferrífero/MG.

Despite their relevance, the number of publications listed above may obscure the reality of the study of these forms in Brazil. Most of these studies have focused on distributary systems of megafans or fluvial fans located in the Pantanal (ASSINE, 2003; ASSINE et al., 2015; ZANI 2008; PUPIM, 2014), in the Bolivian Chaco (LATRUBESSE et al., 2012), or in the amazon wetlands (ROSSETTI, ZANI and CREMON, 2014). While these contributions are important, they still do not address the lack of basic studies related to alluvial fans in Brazilian literature and Portuguese-language.

From the point of view of basic science, that is, the advancement of knowledge, the importance of developing conceptual and methodological studies on alluvial fans in Brazil lies mainly around the significance that such landforms hold for geomorphological understanding. They serve as highly instructive examples, demonstrating the complex relationship between form and process through their genesis and development—fundamental concepts in geomorphology (PENTEADO, 1980; CASSETI, 2005; PONTELLI, 2009). Furthermore, alluvial fans play a crucial role in the connectivity between mountain systems and adjacent valleys, acting as sediment storage areas (HARVEY, 1978). Additionally, recent studies have identified these forms on the surfaces of other planets (JEROLMACK et al., 2004; KRAAL et al., 2008), further emphasizing the importance of their study.

From the perspective of applied science, which seeks short-term results and is focused on societal needs, a deeper understanding of alluvial fan environments is essential as a subsidy for territorial planning, public policy development, and land use and occupation strategies. The occurrence of these landforms may be associated with risk areas, prone to debris flows events and mass movements of varied natures, which can have significant social impacts on urban infrastructure and the most vulnerable populations. (HARVEY, 1984; HUBERT and FILIPOV, 1989; DUARTE, 2001; MERCANTE and SANTOS, 2009; SANTANGELO et al., 2011; WELSH and DAVIES, 2011; D'ARCY, RODA-BOLUDA and WHITTAKER, 2017; KANJI, MASSAD and GRAMANI, 2017; and DIAS et al., 2022)

In this sense, we note that the deficiency in the study of alluvial fans in the Brazilian scientific literature stems from three main factors: (1) the need to overcome the still common conception that these landforms are only found in arid and semi-arid environments, with few studies and in-depth projects in tropical and humid climate regions; (2) the focus of national research on this topic has been limited to the study of megafans in South America; and (3) due to the lack of references in Portuguese-language and the difficulty of access to international classical works on this subject, which can also lead to confusion and theoretical-conceptual uncertainty regarding the distinctions between the alluvial fans and the so-called debris cones.

Thus, this paper has two main objectives, which are linked to the other: firstly, to develop and provide a basic bibliographic review of alluvial fans in Portuguese for geographers, geomorphologists, geologists and anyone else who may be interested, so that future research projects have a more accessible theoretical basis. And secondly, based on this review, to propose, through a new classification and theoretical advances, a clearer and more effective conceptual differentiation, in terms of form and process, between alluvial fans and debris cones.

Therefore, in order to make this study more robust from an argumentative perspective, we aim to demonstrate the absence of studies on the subject in the country. This was done through data collection and review of publications in the annals of the National Symposium of Geomorphology (SINAGEO) and the Brazilian Journal of Geomorphology over the last 24 years. Additionally, to assist in the classification and distinction between alluvial fans and debris cones, we will characterize two specific case studies: the occurrence of an alluvial fan adjacent to the São Desidério River (city of São Desidério/BA) and the occurrence of a debris cone in Monte Somma, an ancient crater of the current Vesuvius Volcano (Naples, Italy).

2. Materials and Methods

We conduct the methodological procedures in a few stages, referring to each aspect contemplated in the review on the proposed theme. The first stage refers to the collection of data and publications on the theme of alluvial fans and debris cones over the last 24 years (2000-2023); this period was chosen taking into account the creation of the Brazilian Journal of Geomorphology, which took place in the year 2000. Thus, we carried out a review in the volumes published in the Brazilian Journal of Geomorphology and in the Annals of SINAGEO in this period, considering both as the main means of disseminating works from the Union of Brazilian Geomorphology (UBG). As a search parameter, we considered all occurrences of the terms "fan(s)", "alluvial fan(s)" and "debris cone(s)" in the title of the works.

Still on this first stage, it should be noted that, for the search carried out in the Brazilian Journal of Geomorphology, the parameters had to be expanded due to the insufficiency of results, therefore, studies in which the terms "fan(s)", "alluvial fan(s)" and "debris cone(s)" appeared in the abstract of the published articles were also considered in the survey. For the SINAGEO annals, the same cannot be done due to the number of published works and the fact that not all of them have an abstract. It is also noteworthy that we do not consider the appearances of the term "fan(s)" in the abstracts that are not related to the depositional form of alluvial fans.

The next stage consisted of an extensive survey and review of data and bibliography on alluvial fans and debris cones worldwide, in order to identify which authors and which lines of research consider only the existence of fans, only the existence of cones, the existence of both and with the same meaning, or the existence of both but with different meanings. To this end, we started the search by consulting the main national and international geological and geomorphological dictionaries and later turned to books, theses, articles and papers. Not all the works and authors that have focused on the subject could be verified, as there are countless possibilities and paths, but we contemplated the main ones.

After a brief review, in the third stage the paper proposed, based on the bibliography previously raised and adding pertinent works, to defend the point of view that alluvial fans and debris cones are related but different forms in the landscape. In this sense, we established some parameters of distinction for these geomorphological features, in order to make this work a possible reference for further studies that require a more solid theoretical framework in Portuguese. The parameters defined were: (1) Form's declivity (slope); (2) Stages of Form's Complexity; (3) Genesis process; and (4) Textural characteristic of the deposits. After these parameters characterization, we prepared a summary table that proposes to systematize a comparative classification between the two features.

The fourth and final stage refers to the identification and exemplification of these forms on the surface. Using what was discussed and placed in the previous topics in the form of a theoretical review and parameters to distinguish fans and cones, we brought two examples of how these forms can manifest themselves differently in the landscape. On the occasion of two fieldworks carried out in recent years, we identified an Alluvial Fan adjacent to the São Desidério River, in the city of São Desidério, west of Bahia, and a Debris Cone on Mount Somma, an abandoned crater of the current Vesuvius Volcano (Naples, Italy).

The choice of this last example as a case study outside Brazil was due to the absence of debris cones identified and characterized in the country, which we will justify in the next topic referring to the survey of Brazilian scientific productions on these forms, as well as by the photographs and measurements made by the authors in the fieldwork in Italy, which resulted interesting and opportune material for dissemination. In addition to photographs and field measurements, such case studies are also presented in the form of maps, topographic profiles and diagram blocks produced in GIS environment (ArcGIS Pro), from IBGE (2022), ESRI (2023) database and digital elevation models from DEM Copernicus (ESA) and Tarquini et al. (2023).

3. Results and Discussions

3.1. Survey of Brazilian geomorphology productions with the theme of alluvial fans and debris cones over the last 24 years (2000-2023)

Most of the work carried out by Brazilian researchers regarding alluvial fans is restricted to master's dissertations and doctoral theses (PONTELLI, 1998; 2005; PUPIM, 2014; OLIVEIRA, 2014 and ZANI, 2008; 2013). Without disregarding the important advances mentioned by these studies, the theoretical and methodological framework on alluvial fans in the Portuguese language is still insufficient, especially in terms of academic articles in indexed journals and in papers presented at national events of the geomorphological community.

In an attempt to highlight the absence of these works, we carried out a search for the terms "Fan(s)" or "Alluvial Fan(s)" in the titles and abstracts of the papers/articles published in the Brazilian Journal of Geomorphology and in the abstracts and complete works published in the annals of the Brazilian Symposium on Geomorphology over the last 24 years, considering that these are the two main means of dissemination of Brazilian geomorphological science in the context of the UBG. The initial idea was to search for these terms only in the title of the papers, but the absence of results meant that the search was also expanded to the abstracts of the articles. This information in itself is already a result that demonstrates the lack of production and publication of studies on this theme.

It is noteworthy that we considered all volumes published by the Brazilian Journal of Geomorphology in the proposed period, including articles and technical notes, as well as the annals of all the thematic axes of the editions of the SINAGEO. In chronological order, the editions of SINAGEO considered in the period of the last 24 years were: III in Campinas (SP), IV in São Luís (MA), V in Santa Maria (RS), VI in Goiânia (GO), VII in Belo Horizonte (MG), VIII in Recife (PE), IX in Rio de Janeiro (RJ), X in Manaus (AM), XI in Maringá (PR), XII in Cariri (CE), XIII in Juiz de Fora (MG) and XIV in Corumbá (MS). These results are shown in the graph in **Figure 1**.

Regarding the data obtained from the Brazilian Journal of Geomorphology, it was not possible to make a table that would better represent the results found, as these were inexpressive. In the period from 2000 to 2023, the journal published 70 issues distributed among 24 volumes, adding up to a total of 783 articles/technical notes that we visited. Among these, the term "alluvial fan(s)" appears only twice in the title of works, in Lopes, Castro and Lana (2022) and Lopes et al. (2023). We also searched for those titles of works in which only the term "fan(s)" appeared in the title. As a result, we found only three more works: the term *"leques de arrombamento"* appears in Da Silva et al. (2008); the term "megafan(s)" appears in Zani et al. (2009) and in Kuerten and Stevaux (2021).

Based on these results, we expanded the survey to the studies that contained the term "fan(s)" or "alluvial fan(s)" in their abstracts. The results were greater, but still not satisfactory, as the term appears in nine studies (ASSINE et al., 2005; LADEIRA and DOS SANTOS, 2005; SINHA, LATRUBESSE and STEVAUX, 2005; SANTOS et al., 2008; SUERTEGARAY, 2012; SOUZA JUNIOR et al., 2013; MORAIS and ROCHA, 2016; NASCIMENTO, SALGADO and GOMES, 2019; NUNES et al., 2019), except for those already mentioned above. In addition to these, Menezes et al. (2007) write about "*leques de dejecção*" and Figueiredo, da Rocha and Fernandez (2018) about "*leques de transposição*", both in their respective abstracts.

Regarding the annals of SINAGEO, there were also no significant data on the occurrence of works with the theme of alluvial fans, but we prepare a graph (**Figure 1**) so that the visual contrast demonstrates, in other terms, the absence of Brazilian research in this line, already enunciated in the survey carried out in the Brazilian Journal of Geomorphology. Due to the number of works and the fact that not all of them have an abstract, here we have only considered the occurrence of the term "fan(s)" or "alluvial fan(s)" in their title:

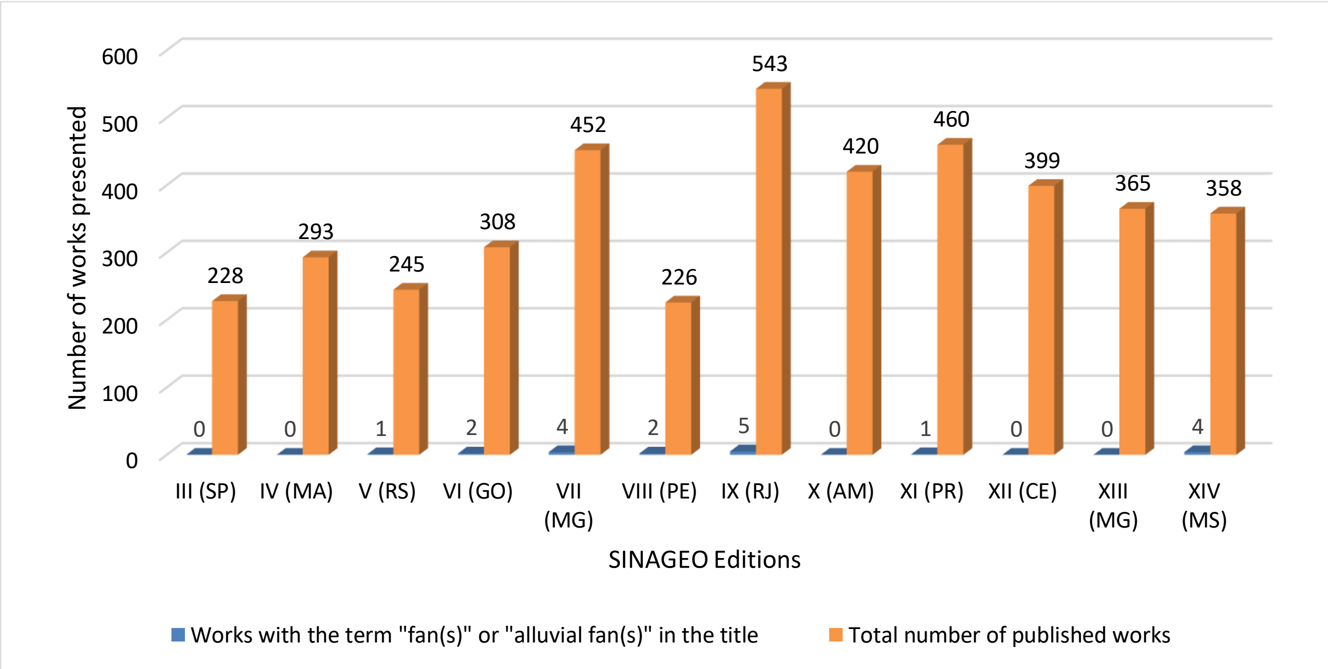


Figure 1. Occurrence survey of the term "fan(s)" or "alluvial fan(s)" in works published in the editions of the SINAGEO (National Symposium of Geomorphology) over the last 24 years (2000 – 2023). Source: UGB (2023)

Thus, there is a clear lack of geomorphological research related to alluvial fans in Brazil. It is also noteworthy that for the last five editions of the symposium, only five papers were published on this theme, four of them only in the last edition (XIV).

Regarding the V SINAGEO (RS), we have found the work of Bacani et al. (2004); in the VI SINAGEO (GO), the works of Pontelli and Paisani (2006) and of Mercante et al. (2006); in the VII SINAGEO (MG), the works of Pontelli (2008), Mercante (2008), Zani (2008) and Trindade et al. (2008); in the VIII SINAGEO (PE), of Mercante, Santos and Garnés (2010) and Souza Filho and Cremon (2010); in the IX SINAGEO (RJ), of Cremon, Rosseti and Zani (2012), Pupim, Zaparoli and Assine (2012), Morais et al. (2012), Andrades Filho and Zani (2012) and Zaparoli, Stevaux and Riedel (2012); in the XI SINAGEO (PR), the work of Melo et al. (2016); and finally, to the last event (XIV SINAGEO – MS), we have found the works of Breda et al. (2023), Mescolotti, Montebello and Assine (2023), Prebianca and Perez Filho (2023) and Souza, Valdati and Gomes (2023).

We expected that more works involving the theme of alluvial fans would be found in all editions of SINAGEO visited, but especially in the last edition (XIV SINAGEO in Corumbá/MS), in view of the host city's geographical proximity of the event with the Taquari River's megafan (Megafan of the Pantanal), however, there are only four publications in this line in the annals of this edition.

The term "Debris Cone(s)" or "Dejection Cone(s)" was not found in any of the 783 articles' titles visited in the Brazilian Journal of Geomorphology. There is only one occurrence in the articles' summary of Fonseca Filho, Varajão and Castro (2019). In the annals of all the editions of SINAGEO visited, there is only one appearance of this term, in the title of the work of Mascarello and Camargo Filho (2016).

It is mainly based on the findings made in this survey that this paper aims to encourage a gradual increase in the studies of these geomorphological features in Brazil, offering a concise and relevant bibliographic review on this theme and in Portuguese, as well as clarifying and proposing advances in the conceptual distinctions between alluvial fans and debris cones, forms that can be considered different, but related. In addition, the case studies that we present here will demonstrate the spatial occurrence of such forms, providing clearer paths to identify and map them.

3.2. Brief literature review on the definitions of alluvial fans and debris cones

In general terms, alluvial fans can be understood as depositional bodies positioned at the foot of escarpments and slopes in mountainous regions or in areas with a marked topographic difference between uplands and lower plains, having a semi-conical shape similar to an open fan and characterizing a transitional environment where the flow from the apex in the uplands spreads and deconfines due to the abrupt change in the hydraulic geometry of the channel, which causes the alluvial material to be deposited in a radial format in the lower Piedmont areas. (BULL, 1964; 1977; HARVEY, 1978; BLAIR and MCPHERSON, 1994a)

On the other hand, debris cones can be defined as deposits of debris in a semi-conical shape, composed of poorly sorted material, that occur at the foot of steep slopes. They are primarily transported through mass movements, falling/sliding rocks and torrents, which deposit the material due to the deconfinement and loss of transport capacity. It is widely accepted among most authors who work with this feature to distinguish it from alluvial fans based on the steeper slope of the form. (BRAZIER, WHITTINGTON and BALLANTYNE, 1988; SUGUIO, 1998; IBGE, 2009)

After presenting the general definitions for these deposits, the starting point is the research in some of the main geological and geomorphological dictionaries published in Brazil and in other countries, with the objective of reflecting the theme in more than one school or line of thought. Thus, in the Brazilian context, we have the definitions found in the "*Dicionário de Geologia Sedimentar e áreas afins*" (SUGUIO, 1998), where, in this author's classification, alluvial fans and debris cones are different but related forms, and the main difference is in the lower slope of the first compared to the seconds. Following the same line, the "*Manual Técnico de Geomorfologia*" (IBGE, 2009) also distinguishes these forms, but based on process and material, with the debris cones being formed by torrents and consisting of detrital material, and the alluvial fans with more varied material in areas of deconfinement of flows.

However, the "*Novo dicionário geológico-geomorfológico*" of Guerra and Guerra (2008), even separating "*cones de dejecção*" (dejection cones) from "*leques de aluvião*" (alluvium fans), presents that both are synonyms. Therefore, there is no distinction between these forms, in which, according to these authors, are detrital deposits associated with torrents in Piedmont areas.

Referring to international literature, such as in the United States, two of the main geological dictionaries (AGI, 1962 and ALLABY, 2008) despite present two different terms (Alluvial Fan and Alluvial Cone), indicate that both are synonyms for the same form, the one with the shape of a fan or semi-cone formed where torrents and flows slow down, deconfine and deposit the loaded material. On the other hand, the "Alphabetical Glossary of Geomorphology" (GOUDIE, 2014) points out that the main difference between Alluvial Cones and Alluvial Fans lies in the fact that the first have a higher slope than the seconds, and that they are also formed by short torrential events. Parallel, the "Dictionary of Physical Geography" (WHITTOW, 2000) presents that, Alluvial Cones are a type of Alluvial Fans, but with a higher angle of slope, coarser material and generated through rapid torrents.

Fairbridge (1997) organizes a geomorphological encyclopedia with more than 400 articles, of which, Rapp and Fairbridge (1968) and Bull (1968) discuss the subject of alluvial fans and debris cones. The first authors state that the two forms are often treated as synonyms, however, they consider that cones are steeper than fans. The second author also corroborates this statement, pointing out that talus cones are often more inclined than talus fans.

Schneuwly-Bollschweiler, Stoffel and Rudolf-Miklau (2012) organized a compilation of chapters that explore possible dating methods in processes that give rise to fans and cones. The parameter used by these authors to differentiate the two forms is also in the slope, with the fans being considered flatter deposits, while the cones are steeper.

Based on works by French authors, we can mention the republication of the São Pedro-SP city's Geomorphological Map, by Coutard et al. (2020), which was originally published by Queiroz Neto and Journaux (1978). Both editions of this map identify and characterize, among other forms, the occurrence of debris cones at the foot of the *cuestiform* relief of São Pedro-SP. The authors highlight the occurrence of coalescing torrential cones in the amphitheaters of the *Cuesta* (accommodation area at its foot), consisting of coarse material of basalt fragments and silicified sandstone (COUTARD et al., 2020).

In fact, the characteristic that unites alluvial fans and debris cones in synonyms of the same form, is in their semi-conical deposition at the foot of higher areas, acting on the connectivity and sediment stock between the mountain system and the adjacent valley (HARVEY, 1978). As a result of this similarity, many classic authors on the topic, such as Bull (1977), Schumm (1977) and Stanistreet and Mc Carthy (1993) use alluvial fan or alluvial cone to designate deposits where a feeder channel radiates downslope from its source area (drainage basin). Even so, Bull (1977) recognizes that some authors use the term Debris Cone (*Cone de Detritos*) or Alluvial Cone (*Cone Aluvial*) to refer to small steep talus deposits located at the foot of hills, with a slope greater than 30°.

It is Christofoletti (1981) who brings the nomenclature "Alluvial Cone" to Brazilian literature, and it is important to highlight that this author does not separate fans and cones, he only prefers to use the term Alluvial Cone to refer to these depositional forms, with a definition very similar to that of Bull (1977). Other authors use only the term Debris Cone and its variations in their works, such as Church, Stock and Ryder (1979), Iso et al. (1980) and Brazier, Whittington and Ballantyne (1988). The latter clearly demarcates the difference between Debris Cone and Alluvial Fan.

Finally, Adrian M. Harvey can be considered a researcher who is concerned with the scalar notion of time and space in his publications, which follow the reasoning of form and process differentiation between, in the author's words: alluvial fans and debris cones. (HARVEY, 1978; 2010; 2012a; 2012b)

It is necessary to be careful with the translations of these terms between the Portuguese and English languages, especially. Based on the publications surveyed, we have observed that, in general, Alluvial Fan is synonymous with Alluvial Cone or Colluvial Cone, the latter being less common nomenclature. While the most accurate translation in the English language for *Cone de Dejecção* is Debris Cone.

Whittow (2000) informs that in the USA, Alluvial Cones are restricted to arid and semi-arid regions, but that in Europe it is more common to use the term Cone of Dejection for deposits originating from torrential flows from mountainous regions. We have also noted that the origin of the word "Dejection" comes from the French school, and it is necessary to pay special attention to the choice of the adjective that follows after the terms fan and cone, since alluvial, colluvial and dejection can refer to different materials, processes and contexts.

3.3. Parameters to distinguish alluvial fans and debris cones

From the literature review presented, we understand that many authors still consider alluvial fans and debris cones as the same geomorphological feature, mainly due to the fact that both forms must have the shape of a cone segment. However, in most publications, we have noted that the preference is for the use of the designation alluvial fans, because this form has more notoriety in geomorphological studies than the debris cones, especially in the Brazilian literature and accessible to national researchers.

In this sense, we believe that the root of this preference lies in the fact that the definition of Debris Cone is still confusing, and this form is recurrently associated as a synonym for Alluvial Fan, as demonstrated in the previous review. In addition, taking into account the presented absence of studies on this theme in our territory (Brazil), many researchers do not have access to this debate or even know the existence of debris cones, which makes the scenario of distinction or similarity between these features even more confusing. Therefore, considering that this conceptual impasse has not been resolved in the Portuguese pertinent literature yet, we propose below, through some parameters, a clearer and more definitive differentiation and classification to these forms.

3.3.1. Form’s declivity (slope)

As it is a theoretical review of a geomorphological nature, it is essential to have as a starting point the study of the shape of the forms in question. To this end, we observe the notes of Rapp and Fairbridge (1968), when they consider that the debris cones must have a steeper slope (5° to 10°, and can reach up to 25°), while the alluvial fans would be configured as forms of a smoother slope (less than 1° to 5°). (SUGUIO, 1998)

According to Harvey (2012b), in these depositional systems the morphological gradient is a property of paramount importance in the identification of deposition processes and styles. This author also brings an example of a Debris Cone at the foot of the Bowderdale Valley, Howgill Fells, England, where it is possible to verify a steep slope of the form. Stanistreet and McCarthy (1993) also take into account the degree of form slope in their proposal to classify the different types of subaerial fans.

In the same way, Bull (1977) associates alluvial or debris cones as depositional forms with slopes always greater than 30°. Brazier, Whittington and Ballantyne (1988) state that the highest gradient of the cone can be estimated between 12° and 25°. Blair and McPherson (1994a; 1994b) position what they call of talus cone steeper and closer to the slope, as can be seen in Figure 2 below.

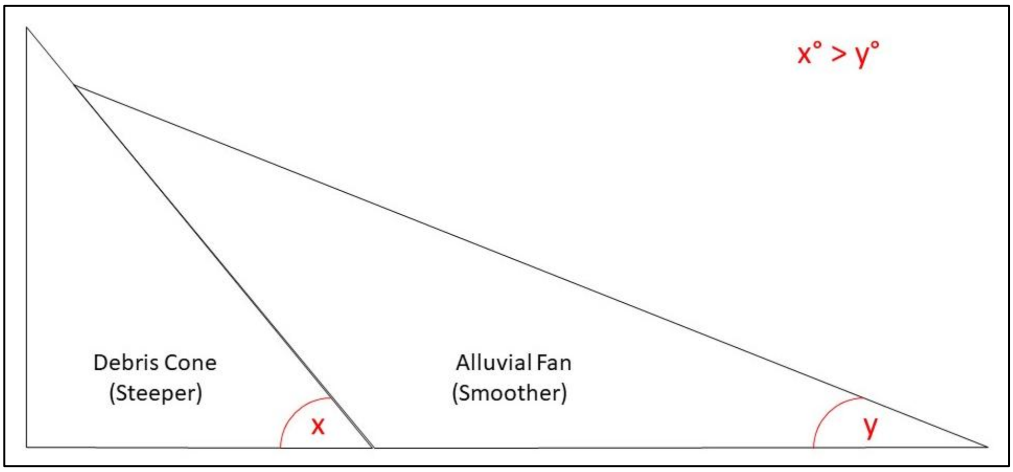


Figure 2. Example of the difference in slope between debris cones and alluvial fans. The scale and measurements of the figure are variable depending on the author.

It is worth noting that the precise values of the x and y angles in the previous figure vary from author to author: as previously stated, Rapp and Fairbridge (1968) and Suguio (1998) point out that the values of x (Debris Cone) should vary between 5° and 10°, and can reach up to 25°, and the values of y (Alluvial Fan) from less than 1° to 5°. Blair and McPherson (1994a; 1994b), when discussing the different stages of evolution of these forms, state that these values can vary between 1.5° and 25°, and that the most typical fans have a slope between 2° and 12°. The so-called talus cones, in their initial stages, exhibit values between 12° and 25°, as stated by Brazier, Whittington and Ballantyne (1988).

The fact is that, regardless of the bibliography used, it is possible to state that the general trend indicates that the debris cones are forms of greater slope, that is, steeper than the alluvial fans, which in turn tend to manifest smoother reliefs. This difference in inclination is the main factor used by most authors to refer to these forms. (GOUDIE, 2014; MACHADO and PINTO, 2017)

3.3.2. Stages of Form’s Complexity

According to Denny (1967), Blair and McPherson (1994a; 1994b) and Harvey (1978; 2010), we can hypothesize about the evolution of the complexity of these forms in the landscape. In this approach, the Debris Cone would be a stage in the development of an Alluvial Fan, its first phase, for example. In this way, the cones develop at the foot of the escarpment, and the constant dissection of the same from alluvial processes and debris flows will develop the shape and rework the sediments, until an Alluvial Fan is formed.

Thus, Blair and McPherson (1994a) place the so-called "talus cones" as a precursor stage for the formation of alluvial fans. Harvey (1978; 2012a), when writing about the connectivity characteristics of alluvial fans and debris cones to the fluvial systems of the accommodation basin, also differentiated these forms based on their spatial and temporal scales, with the cones having smaller temporo-spatial scales, and the fans having larger scales.

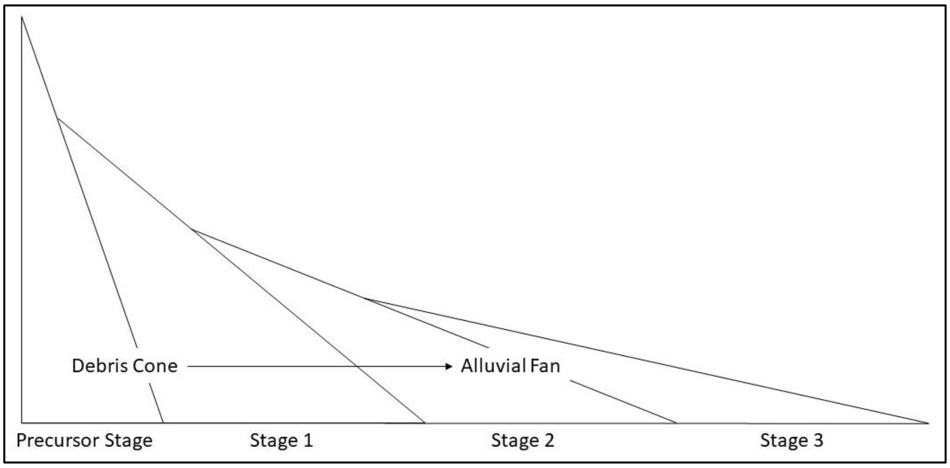


Figure 3. Examples of different stages of shape complexity from a Debris Cone to an Alluvial Fan. Adapted from Blair and McPherson (1994a). The scale varies depending on the author.

Based on this point of view, it is essential to note that the Debris Cones represent younger phases of the increase in relief complexity, while the Alluvial Fans represent more mature phases. For comparison, looking at the erosion cycle for arid regions (DAVIS, 1905), this perspective becomes even clearer, because over the evolution of the erosion cycle, the cones tend to disappear, giving way to fans in the landscape.

Denny (1965; 1967) uses the term Debris Cone when referring to the development of alluvial fans in the piedmont areas of Death Valley, California. This author discusses the state of dynamic equilibrium between deposition and dissection of alluvial fans and how this state can influence their development from the apex at the head of the escarpment to the floodplain downstream. To this end, he elaborates a hypothetical and ideal scheme of development of these forms from the entrenchment of the head of the fan, dissection, and consequent deposition of new lobes. This scheme can be adapted in order to also demonstrate how the debris cones can be dissected by the changes in the characteristics of the flows acting in the area, modifying the complexity of the shape, so that furrows and ravines appear, for example, remobilizing the sediments and creating new segments with characteristics of alluvial fans. The adaptation of Denny's scheme (1967) is below.

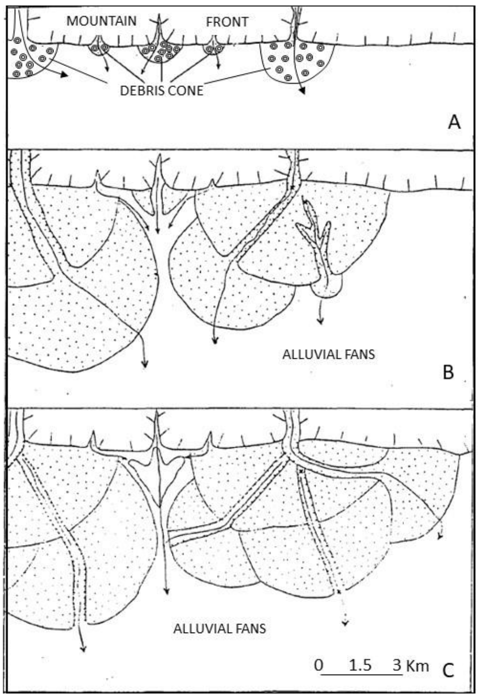


Figure 4. Evolutionary scheme from debris cones to alluvial fans. (A) Debris cones at precursor stage and stage 1; (B) Alluvial fans at stage 2; (C) Alluvial fans at stage 3. Adapted from Denny (1967).

3.3.3. Genesis process

The third parameter of differentiation between the forms studied refers to their genesis. It is assertive to say that the processes of mass movement related to water and the force of gravity are the main responsible for the formation of both alluvial fans and debris cones. It is worth noting that due to the systemic character of geomorphology, the processes involved in the elaboration of these forms must vary due to several factors, such as the existence, size and lithology of the drainage basin in the uplands of the system, slope, accommodation space, vegetation, variations in the base level and climate, among others.

In general, the main processes of deposition of alluvial fans are related to the conjunction of tectonic characteristics, which ensure the spatial configuration for connectivity between the mountain system and the adjacent valley/plain, and the climatic characteristics, which in turn, through the generation of river flows or debris flows, mobilize the sedimentary material from the drainage basin that will be deposited in the form of an alluvial fan. This can be summarized mainly in the following processes: debris flows, sheetfloods and braided pattern channel incision. (HARVEY, 1978, 2012b; HOGG, 1982; BLAIR and MCPHERSON, 1994a)

In turn, the main processes involved in the deposition of debris cones are related to mass movements caused much more by the force of gravity than by the action of water. It is because of this that the occurrence of debris cones does not depend on the existence of an adjacent drainage basin in the mountainous area, while the deposition of alluvial fans is necessarily linked to this feeder basin. Thus, talus deposits, rock avalanches, rockslides, falling blocks and even debris flows are the primary processes responsible for the elaboration of debris cones. (BLAIR and MCPHERSON, 1994a)

By looking at the debris flows more closely, it is also possible to classify them into different categories and occurrences, depending on the type of material transported, water/sediment ratio, nature of movement and among other factors (COUSSOT and MEUNIER, 1996). Each author classifies and differentiates these genetic processes of alluvial fans and debris cones in a way, which can be observed mainly in Hogg (1982), Blair and McPherson (1994a; 1994b), Harvey (1978; 2012b) and Schneuwly-Bollschweiler, Stoffel and Rudolf-Miklau (2012).

In this sense, it is common for most authors to separate the so-called cohesive debris flows and the frictional or granular debris flows. Synthesizing the classification of these authors, the first type of flow is related to the high cohesion and viscosity between the sediments, having a muddy character. While the second type of flow moves predominantly due to the rapid shock between the grains and the lower cohesion between them. (LOWE, 1979; POSTMA, 1986; HARVEY, 2012b)

Based on the classification of these authors for the debris flows, and differentiating alluvial fans and debris cones from the bibliography already presented, it is possible to point out that the frictional or granular debris flows must be associated with the formation of the cones, since the deposit correlative to this movement will present greater slope and lower textural selection. On the other hand, cohesive debris flows must be more related to the formation of alluvial fans, as they are more plastic and, therefore, their resulting deposits will have less slope and less coarse material than cones.

Following the same line, Schneuwly-Bollschweiler, Stoffel and Rudolf-Miklau (2012) point out that the process of cone formation is linked to rapid mass movements, involving rock avalanches and torrential flows. This conception is also shared by other authors, such as Coutard et al. (2020), when they refer to these forms as torrential cones, in addition to Rossato et al. (2008) and IBGE (2009), who list torrents as the main process that forms debris cones at periodic times of increased precipitation in which the channel acquires great energy power through floods.

Hooke (1965) demonstrates that fluvial processes involving a greater volume and flow of water are responsible for generating less steep forms, while episodic events with a lower volume and flow of water, and of coarser material, generate forms of greater slope, which corroborates the arguments raised in the first parameter.

Two of the main papers related to the processes involved in the alluvial fan environment are those of Blair and McPherson (1994a; 1994b). These authors differentiate the primary processes between those resulting from Bedrock Cliff Failure and those resulting from Colluvial Slope Failure.

The first context includes rock falls and rock slides as well as materials from torrents and avalanches, that is, what predominates in the elaboration of these forms are gravitational flows of sediments. From the bedrock, these sedimentary processes lead to the precursor and initial stage of elaboration of these features, closer to debris cones. However, in relation to the second context of colluvial slope failure, from the emergence of new processes in this system, such as debris flows, fluid and sediment-laden gravity flows, sheetfloods, incised-channel flows and establishment of the drainage network, there is the development of alluvial fans, more advanced stages of complexity of these forms and with a greater radial extension and lower slope (HOGG, 1982; BLAIR and MCPHERSON, 1994a). The figure below details these processes and their respective stages of development.

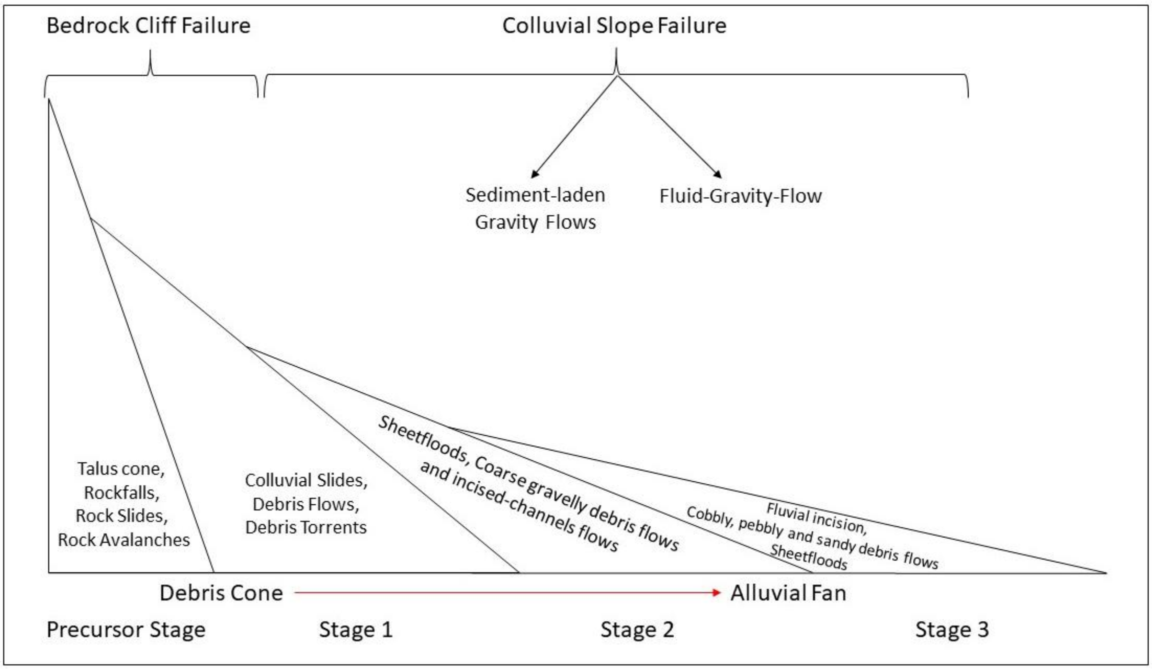


Figure 5. Examples of the different processes that can generate debris cones and alluvial fans. Adapted from Blair and McPherson (1994a). The scale and processes are variable depending on the author.

3.3.4. Textural characteristic of the deposits

In the literature, there is no and nor is possible to establish a specific textural pattern for the deposits of alluvial fans and another for debris cones, since numerous variables, both autogenic and allogenic, can influence the facies characteristics of these forms, such as the depositional environment, the bedrock of the area and the drainage basin, the climatic pattern, the declivity of the slope, the different predominant processes and among others (HARVEY, 1978; HEWARD, 1978; BLAIR and MCPHERSON, 1994a; ASSINE, 2008; VETRA and CLARKE, 2018). In this sense, Christofoletti (1981) recognizes that these forms are composed of detrital sediments that can present large particle size variation.

However, it is possible to reach some approximations through the systemic effort in which we constructed this article by comparing the differentiation parameters of the previous topics that are responsible for the elaboration and characterization of each form.

Considering that the processes related to the formation of the debris cones are mainly associated with torrential events and gravitational flows of blocks and fragments of rock, in a context of high slope towards the accommodation area, we can infer that this form is largely composed of poorly selected and coarse sediments, detrital and absent of any stratification and consolidation (HOOKE, 1965; CHRISTOFOLETTI, 1981; ROSSATO et al., 2008; IBGE, 2009). In addition, the cones have sediments in chaotic distribution and low rounding (SUGUIO, 1998).

On the other hand, alluvial fans tend to have a well-selected and less angular texture, especially in their more advanced stages of formation (MCGOWEN and GROAT, 1971; STANISTREET and MCCARTHY, 1993). Several studies also point to the formation of soils under the surface cover of alluvial fans (RITTER et al., 1995; WHITE and WALDEN, 1997; HARVEY, 2012a; SHOSHTA and KUMAR, 2023), demonstrating a greater capacity for weathering development of its constituent material, which would not be possible to occur in debris cones.

In short, from what has been exposed, it is also possible to establish a parameter of textural differentiation of the deposits between these forms. In accordance with the fact that the debris cones do not have a drainage basin in the uplands that feeds them, as well as their main processes are linked to gravitational flows of sediments, frictional or granular debris flows, torrents and falling blocks (talus deposits), that is, they have their genesis linked to gravity and with little or no influence of water (depending on the environment), the granulometric/textural pattern of your deposits should exhibit a Fining Upward Sequence.

In contrast, alluvial fans should present a Coarsening Upward Sequence, since their primary processes exhibit higher contents of water in the water/sediment ratio, such as fluid-gravity-flows, cohesive debris flows, sheetfloods, and braided channel incisions, because they are directly related to an adjacent feeder drainage basin. The following figure illustrates this situation.

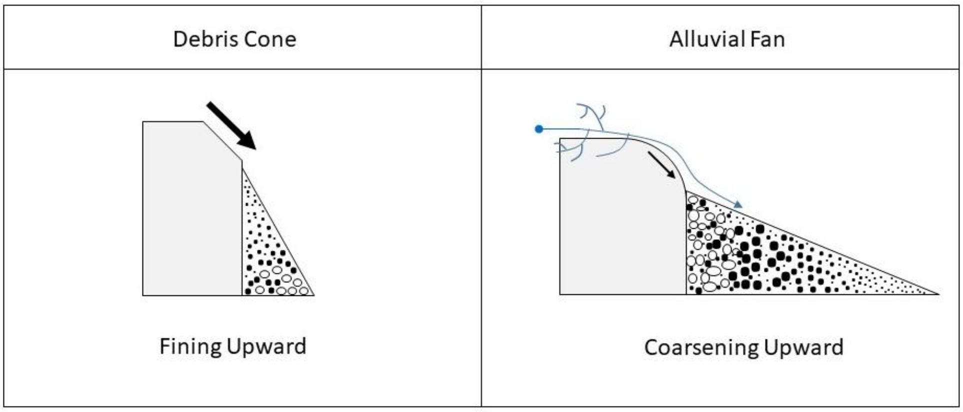


Figure 6. Example of the textural differences in deposits between debris cones and alluvial fans. Elaborated by: Authors. The measurements of the figure and the scale are illustrative and relative.

3.3.5. Summary table and new proposal to classify/differentiate alluvial fans and debris cones

Establishing a classification for the different alluvial fans that have already been studied and mapped on the planet has not been an easy task. More than 100 years after the work of Drew (1873, apud Blair and McPherson, 1994a), considered a pioneer in the geological studies of alluvial fans, the most robust attempts to classify these depositional environments have emerged, with particular emphasis on the paper of Stanistreet and McCarthy (1993). They proposed a classification of subaerial fans divided into: (1) those dominated by debris flows (such as the coalescing alluvial fan systems studied in Death Valley – California); (2) those dominated by braided rivers (such as the Kosi River fan – India); and (3) as and endmember of the classification, those dominated by low sinuosity/meandering rivers (such as the Okavango–Botswana River fan). The latter two are classified by the authors as "river fans".

However, this classification was contested by Blair and McPherson (1994a), leading to a significant debate about the environment of alluvial fans at the end of the twentieth century. These authors state that the model proposed by Stanistreet and McCarthy (1993) is generalized and cannot serve as a basis for all types of alluvial fans. Additionally, the authors highlight the problems in the literature when relating the unique depositional environments of alluvial fans with fluvial depositional environments of braided and low sinuosity patterns.

Subsequently, the paper of Blair and McPherson (1994a) was contested by McCarthy and Cadle (1995) and again responded to by Blair and McPherson (1995). Without entering into the debate about the validity of such models, much has already been discussed in the geological and geomorphological literature about what can happen in the environments of alluvial fans and piedmont when the temporo-spatial scale advances/increases (HARVEY, 1978), ranging from alluvial fans to the so-called megafans or river fans, such as the Pantanal megafan in Brazil (ASSINE, 2008). At the same time, the difference between alluvial fans and river fans remains a subject of debate today (HARVEY, 2010; MOSCARIELLO, 2017; VETRA and CLARKE, 2018).

However, very little has been explored on the other side, that is, when retreating/reducing the scale of time and space in these alluvial fan environments, what form can we find and how can we classify it in relation to fans? It is especially this gap that the classification developed in the following table intends to fill, based on the main points and parameters discussed in this work and taking into account the interrelationship between these attributes.

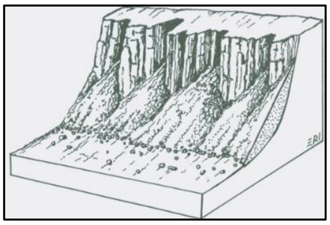
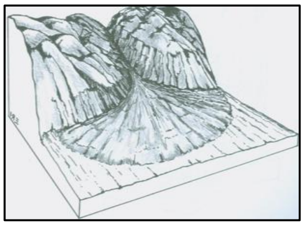
	Debris Cone	Alluvial Fan
Form/Shape	Cone segment	Open fan/semi-conical
Size/Extension	Tens of meters	Hundreds of meters to a few kilometers
Slope/Declivity*	Steeper (12° - 25°)*	Smoother (1,5° - 12°)*
Feeder drainage basin	**X**	✓
Predominant primary processes	- Sediment-laden gravity flows; -Frictional or granular debris flows; - Rockfalls; Rock slides; - Rock avalanches; -Debris torrents;	- Fluid gravity flows; - Cohesive debris flows; - Sheetfloods - Incised-channel floods;
Predominant textural sequence	Fining Upward	Coarsening Upward
Temporo-spatial scale	**-** ⟶	**+**
Illustration (From Rossato et al., 2008)		

Table 1. Proposal to classify debris cones and alluvial fans based on the parameters and bibliography that we have been discussed throughout this article. Elaborated by: Authors.

* The classification of slope varies from author to author, as is the case of Rapp and Fairbridge (1968), Suguio (1998), Brazier, Whittington and Ballantyne (1988), Blair and McPherson (1994a; 1994b) and Bull (1977), for more details see section 3.3.1.

Based on the parameters analyzed and the classification proposal above, we suggest that Debris Cones and Alluvial Fans should be observed as related forms in the landscape, but at different stages of evolution and under the influence of different processes. That is, the cones represent the initial deposition phase of these forms, with steeper slopes, smaller spatial extension, large amount of blocks and talus in their composition. They also have coarser granulometry and fining upward sequences, in addition are dominated by processes more associated with pluvial, torrential and gravity action.

On the other hand, the fans represent a more advanced stage of the development of these forms, and this advancement is mainly characterized by more complex erosive processes that involve not only the forces of precipitation and gravity, but also the action of alluvial transport through a large amount of water, the presence of channels, and the feeder drainage basin. This should result in forms with lower slopes, larger spatial extents, and more diverse granulometry with coarsening upward sequences, including finer materials, and often constituting different depositional lobes.

In order to clarify the discussion raised in the previous topics, we will present two study areas below that illustrate the different parameters of differentiation between these forms (slope, shape, extension, processes and textural pattern): an Alluvial Fan identified in the west of Bahia State (Brazil) and a Debris Cone on Mount Somma, part of the Somma-Vesuvius volcanic complex in the province of Naples (Italy).

3.4. Case Studies

3.4.1. Example of an alluvial fan adjacent to the São Desidério River, western Bahia (Brazil)

The west of Bahia State (Brazilian Northeast), a region inserted in the western edge of the São Francisco craton, is marked by the altimetric contrast between plateaus and areas of low topographies of the São Franciscana depression, where sedimentary deposits occur, especially those of fluvial and colluvial origin (ALVES et al., 2009). As previously discussed, this geomorphological context is ideal for the formation of alluvial fans, which have a strong presence in this region. Among them, we highlight an Alluvial Fan adjacent to the right bank of the São Desidério River, near the city of the same name, as shown in **Figure 7** below.

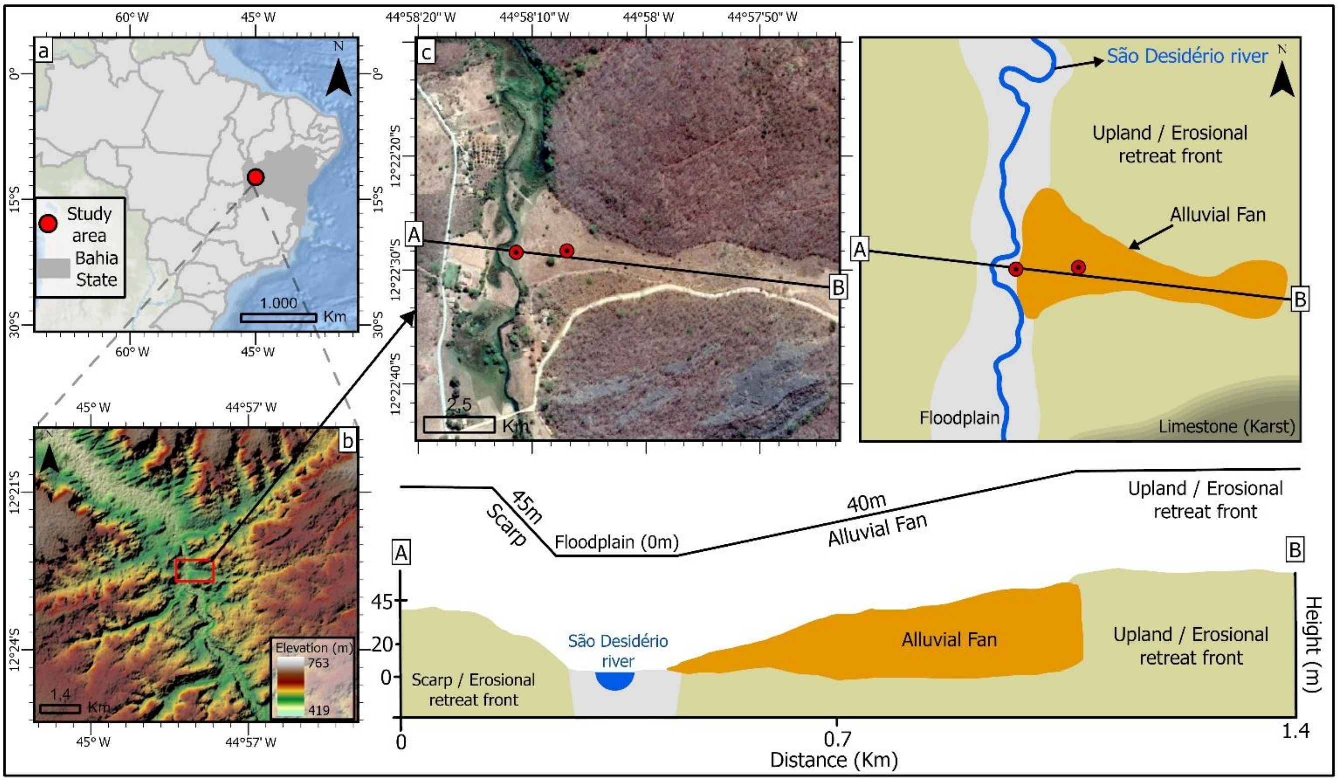


Figure 7. a) Map of the location of the study area in Western Bahia State (Brazilian Northeast). b) Hypsometric map highlighting the study area. c) Location of the Alluvial Fan adjacent to the São Desidério River (São Desidério/BA), characterization of the features in the area and its respective AB Topographic Profile. Elaborated by: Authors. Source: IBGE (2022); Copernicus DEM (2022); GCS SIRGAS 2000.

Passo et al. (2010) divides the city of São Desidério into eight geomorphological units: *Chapadão*, Escarpments, Erosional Retreat Fronts, Interplanaltic Plains, Intraplanaltic Plains, *Mesas*, Ramps and *Veredas*. The study area corresponding to the Alluvial Fan is located in the Erosional Retreat Front. The geological configuration of the region exerts a very significant morphostructural control in the landforms, highlighting the Urucuia Formation, the São Desidério Formation, the Bambuí Group and a sediment accumulation zone corresponding to the São Francisco Depression, encompassing the entire lacustrine system of the region and composed of neugenic and quaternary sandy-clayey materials from the highest units in relation to its surroundings (JACOMINE et al., 1976; BATISTELLA et al., 2002; SANTOS and CASTRO, 2016).

In a more detailed scale adjusted to the Alluvial Fan, according to Godinho and Pereira (2013) and Ana (2018), it is observed the outcrop of rocks from the Bambuí Group, composed of a set of carbonate rocks and subdivided by Egydio-Silva et al. (1989), among other formations, in the São Desidério Formation, consisting of bluish-gray metalimestones, with a fine texture and foliate structure. Godinho and Pereira (2013) also point out that rock exposures from the São Desidério Formation are recorded at the south of the city, on the walls near the east bank of the São Desidério River, exactly where the Alluvial Fan is.

We brought this example in order to elucidate and better illustrate the theoretical discussion held previously, and it was extracted from a fieldwork conducted in the area. It is possible to observe exactly all the attributes that characterize this form in question as an Alluvial Fan: based on the figure below and the topographic profile placed in the previous figure, it is clear that this specific feature has a low slope and a wide radius of extension, so that its height does not exceed 40 meters, in addition to the favorable environment to specific processes elaborate this deposition in an open fan format. Such notes can be seen in the block diagram and fieldwork photograph below (**Figure 8**).

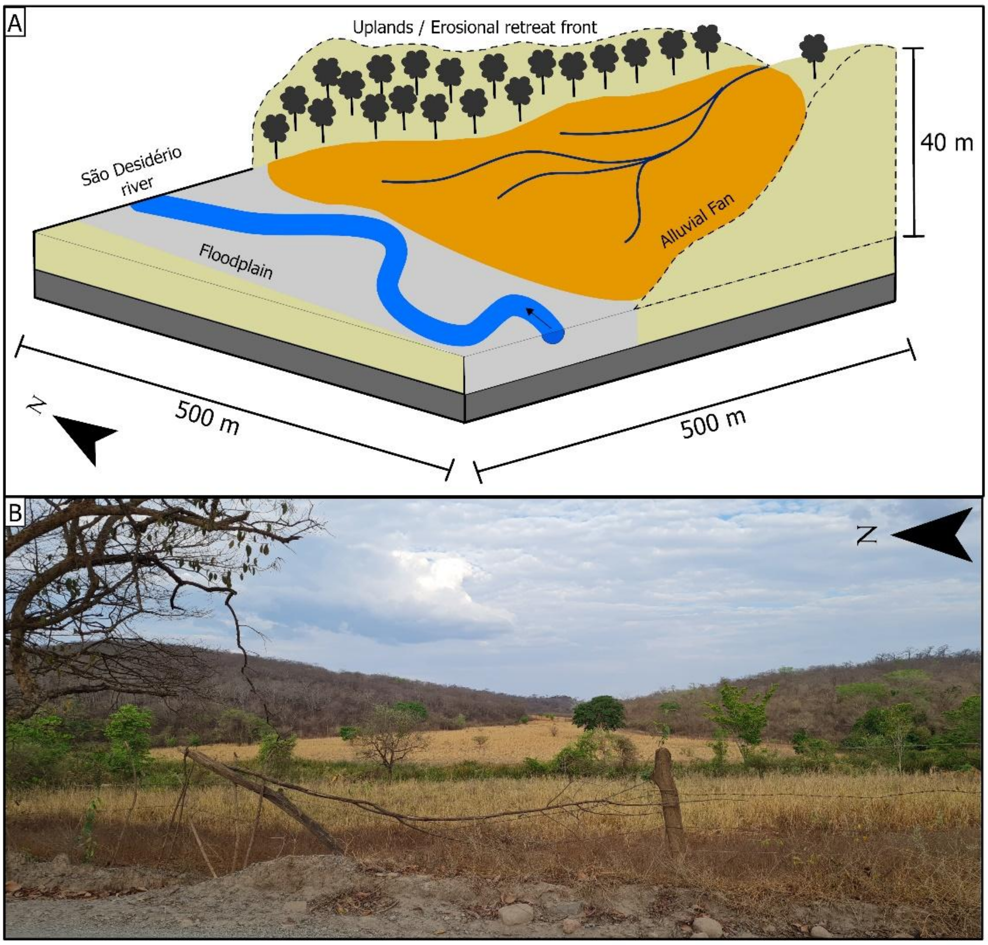


Figure 8. (A) Block Diagram of the Alluvial Fan in question. (B) Frontal fieldwork photograph towards the Alluvial Fan. Elaborated by: Authors. Note: The dashed lines in figure A do not represent faults.

3.4.2. Example of a Debris Cone at Mount Somma, near the Vesuvius Volcano (Naples-Italy)

There are few studies that identify and characterize debris cones in the Brazilian geomorphological literature and in the national territory, citing for example the studies by Mascarello and Camargo Filho (2016), Machado and Pinto (2017) and Coutard et al. (2020). Far beyond the already stated problem in defining these forms in Brazilian literature, this is due, as pointed out in the previous item, to the young state in which these forms manifest themselves in the landscape, being eroded or reworked, giving way to alluvial fans, again emphasizing their small temporal and spatial scale of formation.

As a result of these facts, we were not able to point out and bring to this work a specific Debris Cone form in the Brazilian territory, especially with fieldwork verification. However, in fieldwork carried out close to the Vesuvius Volcano (Naples, Italy), we verified the occurrence of numerous debris cones deposited at the foot of its old crater, already abandoned and known as Monte Somma, in the context of abrupt elevation difference and coarse material, as can be seen in **Figure 9** below.

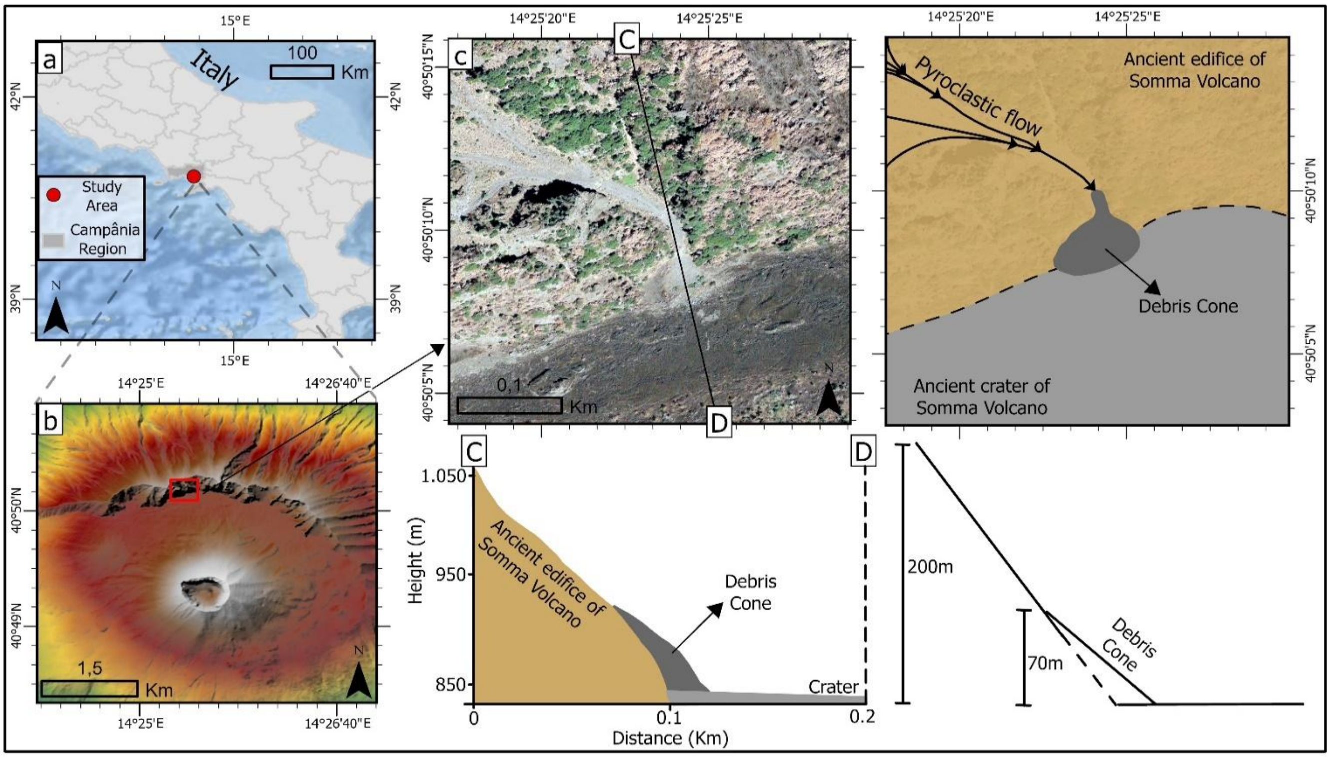


Figure 9. a) Location map of the study area in Napoli (Italy). b) Hypsometric map highlighting the study area (Mount Somma and Vesuvius Volcano). c) Location of the Debris Cone, characterization of the features in the area and its respective Topographic Profile CD. Elaborated by: Authors. Source: Copernicus DEM (2022) and Google Earth Pro; GCS SIRGAS 2000.

Observations: There may be vertical exaggeration in the CD profile. The dashed lines in the figure do not represent faults.

The so-called Somma-Vesuvius volcanic complex is considered a dormant stratovolcano and the beginning of its activities dates back between 0.3 and 0.5 million years ago (SANTACROCE et al., 2008). Mount Somma, the area highlighted in this case study, because at its foot that we identified the debris cones, is part of the ancient caldera of this volcanic complex, which today is restricted only to the main cone of Vesuvius, and has very abrupt elevation difference in its northern portion (GURIOLI et al., 2010). Historical studies show that flows of pyroclastic material dominated its eruptions and are deposited in the northern portion of Mount Somma, with thicknesses of up to 70 meters (VENTURA and VILARDO, 2006; LINDE et al., 2017), as can be seen in the previous CD Topographic Profile and in **Figure 10** below.

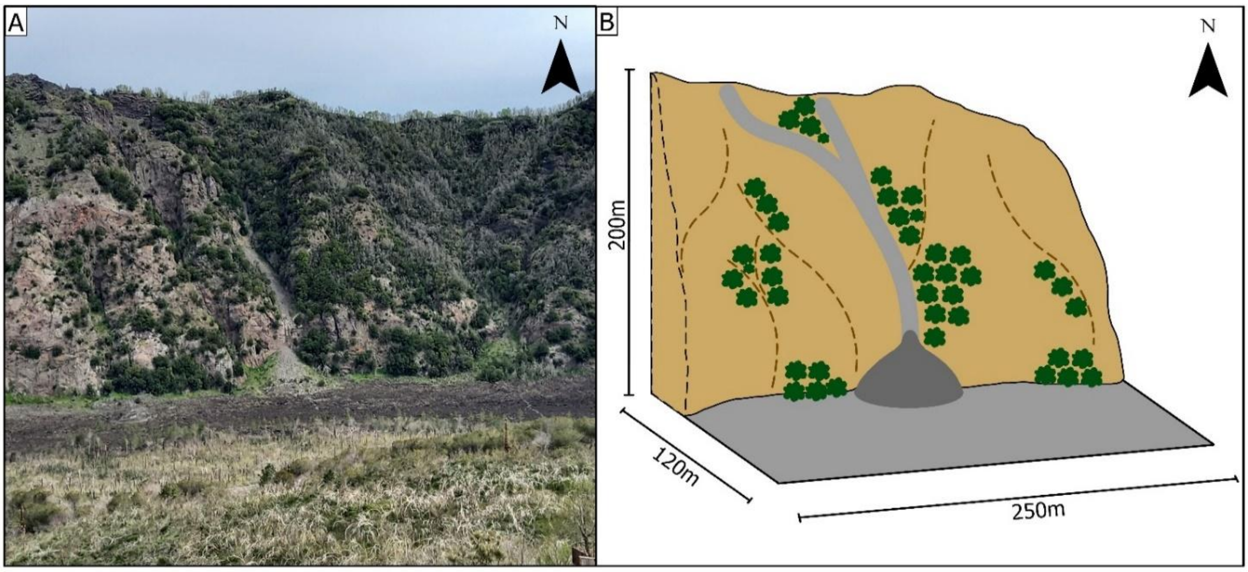


Figure 10. (A) Frontal fieldwork photography towards the Debris Cone. (B) Block Diagram of the Debris Cone. Elaborated by: Authors. Note: The dashed lines in figure B do not represent faults.

In this case, the reworking of the pyroclastic material deposited in the area, by torrent events, debris flows and rocks and rock fragments slides, driven more by the action of gravity than by the action of water, causes the debris cones deposition. As evidenced in the previous figures and in agreement with the discussion brought during the paper, this form has a high slope and a small radial extension, with an altimetric variation of up to 70 meters in this case, as opposed to the Alluvial Fan of São Desidério, which has a maximum height of 40 meters. In addition to be located in a context of high topographic unevenness and with an adequate accommodation area for the material deposition. The work of Zanchetta, Sulpizio and Di Vito (2004) identifies alluvial fans and talus deposits of Pleistocene and Holocene formed from pyroclastic materials in this region and brings more light to the discussion.

4. Conclusions

This paper aimed to analyze and fill bibliographic gaps in Brazilian geomorphology regarding alluvial fans and debris cones, with the goal of providing basic material in Portuguese and produced in Brazil for future research related to this topic. In addition to propose a new classification to differentiate these two landforms.

We highlighted the notable absence of these studies and works within the Brazilian geomorphological community based on our survey of data and publications from the Brazilian Journal of Geomorphology and the annals of SINAGEO over the past 24 years. There is a clear need for new projects and research lines that address the theme of alluvial fans and debris cones in Brazil, particularly the first one, which are found in the coastal and continental landscapes of the national territory.

The brief bibliographic review conducted on the forms in question includes only a selection of the main articles, books, book chapters, papers presented at events, and geological and geomorphological dictionaries that discuss the subject. While it is not possible to cover all existing literature, we believe that the most important and general definitions have been addressed. With this in mind, future works can further explore the literature based on what has been produced in this study.

It is important to recognize that the attempted conceptual separation between alluvial fans and debris cones may be considered relative and imprecise, as is the case with any model-based classification. In fact, this concern arises when trying to understand the parameters discussed in the course of this article in an isolated and detached manner.

However, it is necessary to observe the systemic nature of this approach, considering the declivity (slope), the genesis processes, the stages of development and the textural characteristic of the deposited material as related and dependent parameters. By examining these variables in a systemic manner when interpreting the landscape, the identification and distinction between alluvial fans and debris cones becomes less relative and more robust.

At the same time, it is worth noting that these forms can manifest across various terrestrial landscapes, primarily because they result from different combinations of factors. Nevertheless, the established parameters can serve as a starting point for future research, as they contemplate the more general aspects that differentiate the two features, moving beyond interpretations that consider these landforms as merely synonymous or not. Thus, while these propositions do not completely eliminate the similarities between the forms, it is possible that a Debris Cone evolves into an Alluvial Fan, as has been demonstrated, thereby characterizing the evolution of the landscape.

In addition, we must recognize that all research and construction of a scientific project in any field often involve making conceptual and bibliographic choices, relying on certain authors while not on others. The same applies to this discussion: some works and authors consider alluvial fans and debris cones as synonymous, while others highlight the differences between these forms. In this paper, we sought to present both perspectives, but with a greater focus on and discussion of the bibliographies that distinguish between these features.

The case studies we provided to exemplify and illustrate how alluvial fans and debris cones manifest themselves in the landscape clearly support the differences established in the discussion of this article. The parameters of declivity (slope), stage of development and genesis processes are evident and can be observed and in the examples presented. However, the textural characteristic of the material could not be addressed, as laboratory analyses of sediment samples from these landforms were not performed. These analyses are presented as future possibilities to advance in the sedimentological discussions suggested here with new projects and perspectives. Thus, we encourage new researchers to apply the models proposed here in different areas of study to confirm, complement and/or disagree what has been proposed.

Finally, from the literature review conducted in national and international geological and geomorphological dictionaries, we noted that the tradition of the French geographical school, and European geography in general, lies in using the term Debris Cone/Dejection Cone and their variations to designate these depositional environments. On the other hand, the Anglo-Saxon geographical tradition tends to use the term Alluvial Fan to refer to these forms. We will not explore or discuss the reasons for these different approaches here, but this remains a final question to guide future discussions.

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