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Research on Technogene/Anthropocene in Brazil
Pesquisas sobre o Tecnógeno/Antropoceno no Brasil

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Abstract

This research aims to present a bibliographical review of the research related to the Technogene / Anthropocene in Brazil. The methodology consisted of bibliographic search in academic Google and in university library sites. The research was categorized according to environment and the geomorphological process: alluvial deposits and accelerated erosion; mining; dam siltation; urban and coastal environments. Of more than 200 publications pertinent to the theme, twenty-nine were selected to be synthesized. The research highlighted the heterogeneity of the knowledge that has already been produced on the Technogene / Anthropocene in Brazil. They corroborate the idea of humans as geological agents, but each study situates the geologic agency of humans in an environment with intrinsic geographic characteristics that provide the technogenic variations in the surface and sub-surface.

Keywords: Technogene; Anthropocene; Research in Brazil.

Resumo

Esta pesquisa tem como objetivo apresentar uma revisão bibliográfica das pesquisas relacionadas ao Tecnógeno/Antropoceno no Brasil. A metodologia consistiu em busca bibliográfica no Google acadêmico e em sítios de bibliotecas universitárias. A tipologia das pesquisas encontradas permitiu sua subdivisão em ambiente e processo geomorfológico ocorrente: deposições aluviais e erosão acelerada; garimpo-mineração; assoreamento de barragens; ambientes urbanos e litorâneos. De mais de 200 publicações pertinentes ao tema, selecionou-se vinte e nove publicações para serem estudadas e exemplificadas. As pesquisas destacaram a heterogeneidade do conhecimento que já foi produzido sobre o Tecnógeno/ Antropoceno no Brasil. Todas corroboram a informação do homem como agente geológico, mas cada qual está num ambiente com características geográficas intrínsecas, que proporcionam as variações tecnogênicas na superfície e sub-superfície.

Palavras-chave: Tecnógeno; Antropoceno; pesquisas no Brasil.

1. Introduction

The relationships between human and nature in the Quaternary are apparent in studies of the Technogene and the technogenic deposits. This approach was established mainly by Chemekov (1983) and Ter-Stepanian (1988) and was developed in Brazil since the 1990s, especially with the 1st Brazilian Meeting of the Technogene in 2005 (Korb 2006), publication of the book Man and the Geological Environment by Peloggia (1998) and Chapter 17 of the Quaternary of Brazil - Technogene: records of the geological action of man, organized by (Oliveira *et al.*, 2005) and recent publications of Abequa- Quaternary Brazilian Association of Quaternary Studies of the Journal of Quaternary and Environmental Geosciences (QEG), which in 2014 vol. 5 n ° 1 and 2 dedicated a thematic volume to the Technogene.

The Technogene brings different approaches to Geology, Geomorphology and Geography by promoting theoretical conceptions for the understanding of the environments transformed by the human practices modifying the current landscapes (Korb & Suertegaray, 2014).

The Technogene was proposed by Ter-Stepanian in 1988 within the framework of the IAEG - International Association of Engineering Geology. Ter-Stepanian (1988) and Peloggia (1998) designate the Holocene as a transitional period for the Technogene. The modifications made by humans of geological nature occurred from the beginning of agricultural and pastoral production - the so-called Neolithic Revolution (9 or 10 thousand years ago) and progressively intensified in industrialized regions. The beginning of this epoch is characterized by a totally Quaternary situation and its end by a totally technogenic situation which, according to the author, would be completed in the next millennium, characterizing a much faster change than that of previous geological periods (Korb 2006).

In this context, the term Technogene is used to refer to the current geological-geomorphological situation, in which human geological action gains significant prominence as regards the processes of external

dynamics, in relation to the Holocene (Oliveira *et al.* 2005).

According to Oliveira and Peloggia (2014), Crutzen & Stoermer (2000) and Crutzen (2000) proposed the term Anthropocene to describe the current geological time in which human activities have become "significant geological forces" through changes in land use, deforestation, burning of fossil fuels and other "increasing impacts on the environment at all scales."

For Crutzen (2000), it is possible to consider the beginning of the Anthropocene in the late 1700s, which was evidenced by research in polar ice samples, in which the elevation of the global concentration rates of carbon dioxide and methane was identified. In fact, the main parameter proposed, according to this point of view, was to define that the Anthropocene was consolidated with the increase of the concentration of atmospheric carbon dioxide, thus relating to the industrial age in which the action of humans became global (Oliveira & Peloggia 2014).

Zalasiewicz *et al.* (2008) proposed the consideration of the Anthropocene as a formal epoch, beginning during the Industrial Revolution and having undergone sufficient changes (biotic, sedimentary and chemical) to leave a global stratigraphic signature distinct from the Holocene or even the Pleistocene. The proposal is based on human influence on climate, environment, sedimentation, temperature, biotic and oceanic changes (Oliveira & Peloggia 2014).

Ellis *et al.* (2016) argue that defining the Anthropocene requires a wide range of scientists, social scientists, and other scholar. They argue against the use of a single geological marker or "spike" to designate the start of the Anthropocene.

The decisive argument for the start of a new geological epoch into the Quaternary will likely consider the capacity of human intervention in the environment and ability to alter the course of many exogenous and some endogenous processes. Some of these processes have intensities that may, in some cases, far outweigh the equivalent natural processes (Peloggia 1998).

Human action in the environment produces diverse effects. The technogenic deposits constitute material testimonies of this action on the physiognomy and physiology of the landscape in both urban and rural areas. They are sedimentary accumulations formed from the accumulation of materials reworked by the direct or indirect action of humans. It is possible to find artefacts manufactured by modern humans, such as, for example, fragments of plastic, glass, nails, among others, in these sedimentary accumulations. In addition, the appropriation of the landscape by society transforms the forms of topographic relief, with social actors becoming agents of landscape improvement in some cases, and agents of landscape degradation in other cases (Peloggia *et al.* 2014).

In urbanized environments, where the genesis of these deposits is faster and more expressive, it is associated with the form of appropriation and occupation of the geomorphological units and the model of urbanization in force (Silva *et al.* 2014). Historically, according to these authors, Brazilian cities were built in flat areas, near the coast and the water courses, the latter used for water supply. With social development and the establishment of distinct socioeconomic strata, the way in which social groups relate to and take ownership of the natural elements, among them the topographic relief, has changed and intensified. In the case of Brazil, the spatial and demographic growth of cities as a result of changes in the social, economic and political structure that took place in the 1960s resulted in the adoption of a model of urbanization sometimes indifferent to the vulnerabilities of the physical environment.

In several Brazilian municipalities, the occupation of environmentally vulnerable areas, associated with the inexistence or precariousness of public policies aimed at the installation or improvements in urban infrastructure and services (microdrainage system, streets, sanitation, collection and treatment of urban solid waste) and the cultural habits of the population, such as burning, the disposal of domestic solid waste and rubble in vacant lots and in the valley bottoms, contributed to socio-environmental degradation.

Given this socio-environmental context, the magnitude of anthropic changes, in geological terms, justifies the proposition that man is an active agent in both direct and indirect surface processes (Felds 1958). Thus, it is a sufficient condition for geological processes to be subject to the Technogene constraints, justifying the adoption of a Technogenic approach regarding the dynamics of surface processes (Silva *et al.* 2014).

The development of techniques and the complexity of society have broadened society's capacity to intervene in the dynamics of nature, attributing to it the role of geological-geomorphological agent. The magnitude and intensity of human action on the dynamics of nature vary in time and space depending on socio-environmental arrangements and technological development.

Particularities of the historical occupation of Brazilian territory, as well as the various forms of degradation engendered by the anthropic agents on the natural environment, given by the economic cycles of each region, have resulted in several geological-geomorphological processes that need to be analyzed. What comprises research on the Technogene in Brazil? What are the main themes studied? Although there have been similar surveys such as Oliveira (2005) as well as Machado (2013), this research aims to highlight and systematize the main research related to the Technogene through the processes and environments, that is, organizing them through the Anthropic actions both directly and indirectly in Brazil. It should be noted that this research serves as a reference for future studies and is not intended to exhaust the possibility of existing research, but to gather and analyze the main case studies found in the available bibliography.

2. Methodology

The methodology consisted of a bibliographic search in Google academic and university library sites. The survey looked at 246 records on Google scholar, however, many records were repeated, and sometimes did not include thesis, dissertations, and journal articles and annals unavailable on the internet. Although theoretical analyses are relevant to the topic and studies that cite the Technogenic deposits, even though they are not specifically related to the Technogene, have been published, we excluded these because we are concerned with the case studies in the scientific literature.

The choice of research, as well as their relevance, was organized chronologically and according to the environment and process. In some cases some works may be part of multiple categories.

3. Results

Research on the Technogene in Brazil according to Oliveira *et al.* (2005) in ABEQUA's Quaternary in Brazil, began to develop in the 1990s. Such studies addressed geological topics with humans as a geological agent. According to the authors, researchers considered the transformations of the environment from their natural state to other states altered by anthropic actions, represented by agriculture, urbanization, mining and diverse infrastructure such as roads, dams and reservoirs, ports, etc.

According to França Junior (2016) research on the Technogene in Brazil related to the transformations of landscapes is recent compared to the Euro-Asian research. Korb (2006) identified that this research is related to the expansion and decline of coffee agriculture (interior of São Paulo, Minas Gerais, Rio de Janeiro and Northern Paraná), mining (Bahia, Minas Gerais), and urbanization (São Paulo, Southern Brazil). According to the author, the first attempt to synthesize studies on the Brazilian Technogenic in a temporal perspective was presented by Lisboa (2004) in her Master's dissertation. Later, Oliveira *et al.* (2005) in the book "The Quaternary of Brazil" (Souza *et al.*, 2005) highlighted the research presented in the form of academic thesis. Afterwards, Korb (2006), in his Master's dissertation, presented the State of the Art of the Technogene in Brazil and França Junior (2016) organized them according to environment and process.

For the purposes of the present study, research on the Technogene was organized in typologies of process and environment, such as alluvial/colluvial depositions and accelerated erosion; mining; dam siltation; and urban and coastal environments.

As can be seen in figure 1 and table 1, studies on alluvial/colluvial deposition and accelerated erosion were developed in the states of Paraná (PR), São Paulo (SP) and Rio de Janeiro (RJ). On mining, Bahia (BA) and Minas Gerais (MG) states are well represented. Studies on sedimentation were carried out in the states of Rio Grande do Sul- (RS), São Paulo (SP) and Bahia (BA). Urban environments in the State of Goiás (GO), (SP), (PR) and (RS) received attention. Coastal research on the Technogene focuses on (RS) and Santa Catarina (SC) states.

The understanding of humans as a geological-geomorphological agent, the replacement of a natural environment by an increasingly artificial one, and the environmental consequences resulting from these substitutions are specific and relevant characteristics of the Brazilian Technogene.

As discussed by Korb (2006), and confirmed in the present research, the authors mentioned below consider the characteristics of the environment prior to direct intervention and those altered by the Technogenic action when analyzing environmental transformations and their consequences,. The temporal scale of analysis varies between geological and geo-historical time, depending on the processes of human occupation and transformation of nature. In addition, studies are associated in different ways to the levels of the transforming action of man on the landscape, defined by Peloggia & Oliveira (2005) as Geotechnogenesis.

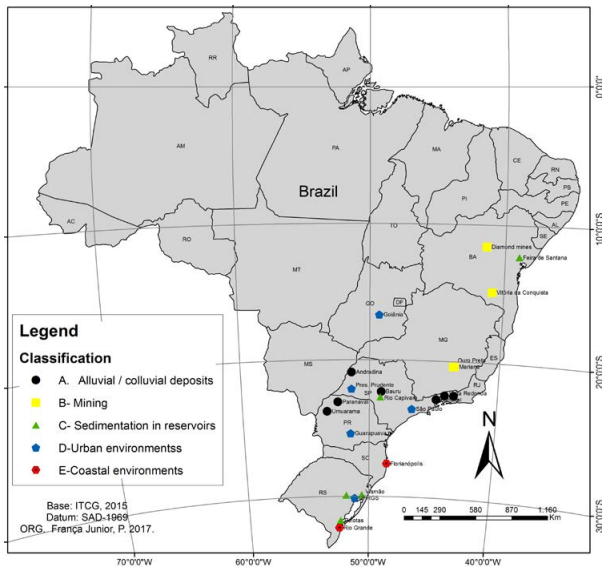

Figure 1: Location of the studies developed in Brazil under a thematic of the Technogene

Table 1: Categories of identified studies, state location and numbers of highlighted research.

Process / environment	UF	Number of searches
A. Alluvial / colluvial deposits and accelerated erosion	PR, SP, RJ	10
B. Mining	MG, BA	04
C. Sedimentation in reservoirs	RS, SP, BA	05
D. Urban environments	SP, GO, RS, PR	08
E. Coastal environments	RS, SC	02
TOTAL GENERAL		29

Organization: Authors, 2017.

A. Alluvial / Colluvial Deposition and Accelerated Erosion

The research on alluvial deposits and accelerated erosion can be understood in the work of Oliveira *et al.* (1992) and Oliveira and Queiroz Neto (1994), who investigated the Technogenic processes involving the mobilization of surface materials and consequent accumulation in the plains of flood and floodplain of the Western Paulista Plateau (Planalto Ocidental Paulista). In the first work the authors focus on Andradina and Bauru-SP. Both studies identified the erosive processes resulting in the formation of Technogenic deposits.

Moura *et al.* (1992) analyzed the Technogenic influence in the Middle Paraíba do Sul Valley. They indicated successive phases of 'instability' and 'stability' in the landscape as related to significant paleohydrologic, paleoclimatic, and neotectonic changes. The authors associate the most recent phase of land occupation history of the Valley with technogenic actions.

For Moura *et al.* (1992) the most recent river deposits, preserved in low fluvial terraces, presented physical and chemical characteristics suggestive of an evolutionary phase under humid climatic conditions. The dates of these deposits indicated very recent ages, approximately 240 years before present (A.P), paleohydrological variations and recent adjustments in the fluvial dynamics implying a technogenic influence. Moreover, on hillslopes, colluvial deposits rich in organic matter corresponds to the last phase of topographic readjustment due to the removal of the forest cover in the historical scale, defined by the authors as technogenic deposits.

Dantas (1995) analyzed the spatiotemporal variations of sediment storage (natural and anthropogenic) in the Bananal river basin (SP / RJ), middle Paraíba do Sul valley, and adjacent areas. Through stratigraphic profiles and radiocarbon dating, the author identified two periods of Holocene erosion and sedimentation.

The first period, which occurred between 10,000 and 8,000 AP, was associated with high intensity concentrated rainfall conditions. The second, 200 years AP, evidenced technogenic processes based on the removal of vegetation cover and its replacement, which altered the dynamics of the hydrological processes of slopes. Based on these processes, the author measured the magnitude of the environmental changes in the sediment storage through the calculation of sedimentation rates, estimating deposition at 97,000m³ / year for the Piracema River basin (Bananal subbasin) during the coffee cycle. In contrast, for the Pleistocene-Holocene transition period, the author found sedimentation rates that indicated the deposition of 38,000m³ / year occurred mainly in the central part of the drainage headwaters.

The recognition of more precise indicators on the environmental changes associated with the repercussions of technogenic interference of occupation and land use occurred in the region of Bananal (RJ) in the last hundreds of years was carried out by Ribeiro *et al.* (1996). Through the conceptual approach of Oliveira (1994), they carried out a pedological characterization of technogenic colluvial deposits. They recognized that the genesis of this deposit is associated with the transformations in the appropriation of space: removal of original vegetation cover, expansion and decline of coffee cultivation.

Technogenic colluvial deposits were recognized from stratigraphic and pedological profiles in qualitatively representative locations in terms of their occurrence and preservation. Through the stratigraphic discontinuity presented by the deposits, which evidenced clearly erosive contacts with texturally coarse layers, alignments of rocky granules and charcoal fragments, and the low pedogenetic development of the technogenic depositional units, Ribeiro *et al.* (1996) identified the detritic and allochthonous nature of the materials as the main characteristics of the technogenic deposits.

The research of Muratori (1997) described the genesis of edaphic micro-deserts in the neolandscape of the Northwest of Paraná (Paranavai). According to the author, the intensification of human activity, starting in the 1940s with removal of forest cover and intense agricultural occupation through the coffee expansion of the state of São Paulo, accelerated processes modifying the landscape in the Northwest region of Paraná. These changes created new conditions of environmental imbalance and caused the exhaustion of soils triggering accelerated erosive processes, the formation of technogenic deposits related to pre-desertification, in the form of edaphic micro-deserts.

Brannstrom and Oliveira (2000) confirmed the claims made by Oliveira and Queiroz Neto (1994), reinforcing the argument that the Western Paulista Plateau has extensive areas of technogenic deposits originating from early twentieth-century land uses. Brannstrom and Oliveira (2000) separated physical processes and occurrences of these deposits according to soil texture and slope characteristics and land-use change processes. Deforestation, intended to clear land for coffee and cotton between the early 1920s and the 1960s, created post-settlement alluvium (PSA, roughly equivalent to technogenic deposits) in small (<50 km2) catchments. Materials in the PSA included leather, plastic, and glass, but radiocarbon dating provided additional evidence as to the twentieth-century origin of the PSA. PSA was incised after the 1960s during urbanization processes, which encouraged vertical erosion into the PSA, exposing paleosol horizons and cultural artifacts within the PSA. In some areas of the Western Paulista Plateau, the onset of soy-wheat double cropping, introduced in the mid-1970s without soil conservation techniques, encouraged intense soil erosion that created vast alluvial fans covered in Typha angustifolia. Brannstrom and Oliveira (2000) also report that stream channel width more than doubled between 1920 and 1997 in a 550 km² catchment, based on comparisons between a survey found in a legal

archive and re-mapping attempts. Sedimentation, resulting from a highly destructive period of cotton production in the Western Paulista Plateau (Brannstrom 2010), had lasting alterations of stream morphology.

Layers in these deposits were characterized and interpreted from the analysis of the human artifacts present in the stratigraphic column, a result of a technogenic dynamics associated with deforestation and land uses by agricultural activities. Subsequent to coffee cultivation, urbanization triggered erosive processes from concentrated surface flows, transporting tons of sediment. These sediments covered the old floodplains and formed a 1 to 3 m sediment layer, classified and described as induced technogenic deposits. Thus, the induced technogenic deposits, are testimony of the phases of occupation of the Western Paulista Plateau.

Mello *et al.* (2005) presented the identification and mapping of the main transformations in the Brandão River basin drainage network, in the city of Volta Redonda (RJ), located in the Middle valley Paraíba do Sul River. The authors sought to establish morphological and behavior of fluvial channels, from the individualization (titling) of crowded and vacant areas, erosive and depositional features in fluvial segments and their relations with processes and interventions in the contributing areas.

These authors considered the natural dynamics of the evolutionary processes of the drainage network of the middle course of the Paraiba do Sul Valley and the processes triggered by human intervention in the region. From this intervention, besides the effects of deforestation, the cultivation of coffee and the introduction of dairy farming, the interventions that emerged from the construction of the Presidente Dutra Highway (BR-116) and Companhia Siderúrgica Nacional in Volta Redonda-RJ, in the 1940s. These latter interventions produced urban-industrial growth in the cities located in this road axis, which represented significant vectors of the transformations that occurred along the tributary River valleys of Paraíba do Sul. Nine major types of fluvial channels were recognized in different erosive and depositional morphological features (and are related to the geological - geomorphological domains): silted, erosive, clad, forested, incised, non - incised, rectified, waterproofed and rocky channels.

The researchers França Junior (2010) and França Junior and Souza (2014) point out that the sedimentation of soils originating from slopes occurred, that is, edaphic sediments mentioned by Muratori (1997) that were transported to the valley bottoms through accelerated erosion pulses. Alluvial sediment layers with distinct technogenic deposits were formed in the alluvial plains of the Pinhalzinho II stream in Umuarama-PR (Northwest Paraná state). The author highlighted the river changes caused by the silting of the channel during 1970 to 2009, emphasizing lateral erosion, meandering, silting, formation of “marshes” and widening of the channel width. The author points out that the erosive processes in the drainage headwaters associated with the increase in the runoff caused by urbanization promoted the displacement of tons of sediments to points where the channel does not have sufficient flow to transport and is deposited, forming the layers of technogenic deposits in the floodplains.

B- Mining

Souza and Zuquette (2001) studied the influence of anthropic action on the genesis and classification of the unconsolidated materials created by the exploration of minerals (gold, pyrite, bauxite and sulphides) whose activity is inactive and by the tailings of active mining of imperial topaz, ornamental rocks and building materials (quartzite, dolomite, dolomite itabirite) in the city of Ouro Preto-MG. The authors included the technogenic deposits in mapping these materials. In addition, they moved beyond the time scale of the mining cycle by including urbanization.

The authors classified the materials by means of geotechnical mapping in a scale of 1:10.000, in which one of the steps was the elaboration of a map of unconsolidated materials. The mapped materials also underwent laboratory analysis, in which the samples were collected by geomorphological criteria. The authors classified the materials according to their genesis: residual (saprolite and evolved) and reworked (colluvium, talus and alluvium).

However, the well-defined textures and structures of the deposits involved the inclusion of a new class encompassing materials associated with the technogenesis, which relate to mining tailings, non-compacted landfills and debris deposits. Uncompacted landfills consist of several types of materials, usually from adjacent rocks, and the rubble is composed in a heterogeneous way, with artifacts from construction resulting from urbanization near the site.

The recognition of influence results from work by Souza and Zuquette (2001) of the anthropic (or technogenic) action on the genesis and classification of the unconsolidated materials created by the exploitation of minerals (gold, pyrite, bauxite and sulfides) whose activity is inactive and the tailings waste of imperial topaz, ornamental rocks and construction materials (quartzite, dolomite, dolomite itabirite) in the city of Ouro Preto (MG).

Another study of technogenic interventions triggered by mining, Nolasco (2002), developed an interdisciplinary methodological research, which proposed classification using terms recognized by *garimpeiros* (artisanal miners). Her thesis was based on the diamond mines in Bahia state, which has been the scene of the anthropic geological action since colonization started 160 years ago. This mining activity, according to the author, was carried out predominantly by means of manual and traditional techniques until mechanized dredging in the period 1986-1996. It remained until recently as a major activity, with diamond mining concentrated mainly on river courses and slopes.

The erosive/depositional processes of mining activity, which for more than a century modified the landforms of the Diamantina landscape, triggered morphological changes in the valleys, transforming them from V-valleys wich similar morphology to U-valleys by means of the parallel retreat of the slopes, and consequent deepening of the secondary rivers.

Nolasco (2002) developed a classification of the sedimentary gold mining system: "race" tailings (residues of the initial processing in sites of the traditional *garimpo*); "hoses" (waste from the sterile capping of dredge mining); mounds (deposits in of fragments of rock abandoned in the *garimpo* (gold panning, ore mining), generally arranged as close to the working region, varying from blocks to stones); "race" fill deposits (sites prepared to wash the material removed from pits), holes resulting from the removal of sand and gravel turned into washing channels and sieves, a second stage of the mining; water channels (larger structures and adduction that transfer water over long distances, facilitating the process of mining in areas with water shortages). Nolasco and Macedo (2005) proposed identification keys to erosive scars and technogenic deposits in diamond mining based on these findings.

The morphodynamic and genetic characterization of the technogenic deposits observed along the Serra do Periperi Municipal Park (BA), performed by Estevam *et al.* (2005), referenced the Morphodynamic Method of Tricart (1977). The authors related the fragility of the physical environment to the formation of the technogenic deposits originated from the sand mining.

In order to analyze the landscape transformations by the exploration of gold in the eighteenth century in the Mariana Passage District, Mariana (MG), Sobreira (2005) analyzed and maps a portion of the Serra de Ouro Preto, a site in which large clearings on the hillside were made for open-pit mining.

This work presented an interesting proposal to the methodological approach in the analysis of the technogenic transformations. In addition to characterizing the clearings, it quantified the volumes of mobilized materials of the slopes.

In 2016 this region suffered one of the greatest environmental impacts caused in Brazil by waste deposits, the "Mariana-MG Disaster," which killed 20 people and made 1,300 people homeless after failure of a dam holding mining tailings.

C. Reservoir Sedimentation

Oliveira (1994), one of the pioneers in the work on the Technogene in Brazil, represented an example of application in the technogenic approach with respect to the analysis of the sediment production in watersheds and the occurrence of sedimentation deposits in reservoirs correlated to the history of land use. The author applied the method adopted by the Sedimentation Engineering Manual of the American Society of Civil Engineers (Vanoni 1977), used in sediment production determinations, based on prospecting by probing in deposits in valleys. By means of the occurrence of technogenic deposits in these sectors of small basins (20 to 30 Km²) in the Capivara dam, tributary of the Paranapanema River in São Paulo state. The author determined rates of 2.900m³/km² /year of sedimentation for basins with urban land use in the period from 1935 to 1962 and of 600m³/km²/year of sedimentation in basins with agricultural use between the years of 1967 and 1991. The sediments included plastics, rubber, and glass.

Viana *et al.* (2000) investigated the influences and consequences of the technogenic action on the hydromorphological aspects of the dam at IPH / UFRGS (Instituto de pesquisas hidráulicas/ Universidade Federal do Rio Grande do Sul) in Porto Alegre. By analyzing processes in the reservoir and the occupied area upstream of the reservoir, the authors collected samples of surficial sediment to characterize the deposits and analyze the process of accelerated sedimentation and eutrophication in recent years. According to the authors, the accelerated appropriation of the slopes of the Santana hill allowed the alteration of the erosion and deposition dynamics in the lake with consequent modification in its hydrodynamics. The intense occupation and the deforestation of the slopes have caused a continuous erosion, resulting in sediment being carried towards the bodies of water. Deposition in the reservoir caused its progressive silting.

Rossato (2000) used a technogenic approach to analyze the acceleration of geomorphological time by activities and human occupation associated with silting processes in the case of the Lomba do Sabão reservoir in Viamão, RS. Through the mapping of the vegetation cover, characterization of the deposits as to its structure and genesis, the author quantified the silted area and explained the morphogenesis of the recognized deposits. This reservoir underwent significant technogenic action between 1972 and 2000. Actions and positive changes, such as the increase of the forest area, in part through the classification of the Saint Hilaire Park as a permanent preservation area, and negative changes such as the considerable increase in the areas under siltation.

Neto *et al.* (2005) analyzed the technogenic changes in the dynamics of the set of ponds in Feira de Santana - BA, triggered by occupation and also mineral extraction of clays. The abundance of water in this region has become the main attraction for the semi-arid interior communities that have the local economy concentrated on livestock and commerce.

This phenomenon and regional migration enabled the rapid expansion of the urban network, which triggered changes in the dynamics of nearby lagoons. These water bodies were mainly affected by landfill for residential and commercial occupation, domestic effluents, construction of small reservoirs, segmentation and blockage of drainage channels by the construction of roads. The lagoons located in rural areas began to undergo transformations by replacing natural vegetation with pastures, road construction and extraction of clay, sand and rock used in construction.

Korb (2006) surveyed the reservoir of the Santa Bárbara dam in Pelotas, Rio Grande do Sul state, Brazil, with the objective of analyzing the influence of human action on the formation and constitution of deposits derived from siltation. To verify the changes, the author conducted multitemporal mapping (1988 and 2002) to verify the spatial and temporal changes in land use. She also analyzed sediment cores in the laboratory in order to describe in detail the geological evidence in silting areas. The following were described: staining; textural parameters; concentration of organic matter; identification of human artifacts; concentration of heavy metals (Pb, Cu, Cr, Zn). The morphological parameters of the samples were analyzed, and, from this, the author delimited phases of smaller and greater anthropization of the reservoir. As for heavy metals, a Class 1 geoaccumulation index was obtained, demonstrating that the reservoir was moderately polluted. All these parameters permitted classification using the Peloggia (1998) methodology in sediment-induced sedimentary technogenic of alluvial and urban and rural environments.

D. Urban environments

Peloggia (1996), one of the precursors of this research, developed a theoretical advance in the Technogene approach when analyzing the formation of technogenic deposits of slopes and morphosedimentary transformations in the floodplains of the city of São Paulo-SP. He characterized the urban Technogene as result of a new phase in the production of nature. The author took as reference the methodological propositions of Ab' Saber (1969) for the studies of the Quaternary that made the analytical path of the Technogenic possible.

Human action, according Peloggia (1996), is the central point of the Technogene, which had consequences that can be viewed in three levels: in the modification of the relief and physiographic alterations; changes in the physiology of the landscape; the creation of correlative surface deposits. Based on the geological and geomorphological history of the lands on which the city of São Paulo was built and expanded, the author applied the levels of approach to human action that are associated with the most serious geological risk situations. These situations of risk are related not to natural forcing, but to the peculiarities of precarious urban occupation on the floodplains, dissected slopes and on the embankments and remobilized covers - the technogenic deposits.

Cunha (2000) analyzed the impacts of urban occupation on the floodplain of the Anicuns stream in Goiânia-GO. The author points out that the occupation modified the sediment production and altered the physiography of the fluvial course so that in a short period of time, 1975-1992, profound modifications occurred in its profile. Meandering at a rate of 4.2 to 6.8m / year evidenced technogenic action and influence in the river dynamics.

This work recognized the presence of technogenic and induced deposits, the latter, in the form of improvised dumps. According to the author, the induced deposits have a volume of 2,906,000m³ and the built ones total 2,480,000m³, both having an average thickness of 7m.

Bertê's (2001) highlighted the technogenic transformations of the urban environment. He sought to investigate the presence of technogenic deposits in the form of urban landfills (landfills and sanitary landfills) in the city of Porto Alegre (RS). In an attempt to recognize environmental dynamics of these deposits in more detail, the author selected the Sanitary Landfill of the North Zone as site of analysis of this new element of the urban landscape.

In addition to the identification of sedimentation deposits, doctoral thesis of Fugimoto's (2001) correlated some technogenic features to the taxonomic classification of Ross (1992). In the the subasin of the Dilúvio Stream, metropolitan region of Porto Alegre (RS), the author distinguished forms in fluvio-technogenic and fluvial-lacustrine plains related to the urban growth process Porto Alegre (RS), mainly since the construction of the Mãe d'Água dam of the IPH / UFRGS.

Figueira (2007) developed his research in the city of São Paulo, analyzing the technogenic processes in the form of technogenic systems (ST- S*istemas tecnogênicos*) in historical evolution. In the first ST, channel and reservoir systems were described from the drainage of wide floodplains, the straightening of the rivers and later the occupation of these areas by innumerable infrastructure works, with avenues and streets. The second ST is related to the need of raw materials for the construction industry, which resulted in mining, marked by the intense demand for gravel and sand alluvium; the latter was replaced by mantle washing of alteration of granitic-gneiss rocks. The third ST of waste is complex, consisting of different materials, old dumps, current landfills and sedimentation deposits accumulated in the swimming pools, which are relocated to landfills and reduce the vegetation of these places. The last ST is that of mass movements, which develop over inert deposits and can harm the population that lives in these places. The research, addressing the processes and technogenic products in a systemic way, identified the dynamics, interaction and evolution from one system to another, demonstrating a new way of understanding the environmental and urban problems of a city like São Paulo-SP.

Mirandola (2008) demonstrated the related problems of the technogenic deposits in risk areas. The author reported that excavations on the slopes and the generation of new deposits or the modification of the surface water dynamics have provoked Technogenic changes, which directly or indirectly intensify geological processes such as landslides. This constant and effective action increases the outbreak of these processes, which can reach a large number of dwellings and cause economic and social damage. The author applied geological risk charts that quantitatively classify the areas that present a risk of landslide,

facilitating the diagnosis and characterization of the problem and indicating appropriate interventions to control and manage risks.

The author discussed aspects related to the addition of a new proposal for the classification of the Technogene, including the mapping of features, deposits and technogenic vectors; the analysis of superficial runoff axes and the definition of the Technogene; and the conventional method of creating risk maps. The author used the Parque Real favela in São Paulo city to develop the risk map, which improved the slip risk analysis, increasing the detail in the field observations and making it possible to identify new sectors, which have degrees of higher risk than those observed by the usual method.

Silva (2012) studied the presence of technogenic deposits in urban and peri-urban areas of the city of Presidente Prudente-SP, where formations were observed in several places. In general, technogenic deposits occur in areas of slopes close to the water courses, as well as in erosive features and, especially, in the interior of alluvial plains, since these received material transported from upstream. These formations present characteristics of the processes of local use and occupation.

França Junior (2016), using the methodology of Price *et al.* (2011) and Peloggia *et al.* (2014), described the technogenic plots and, through Peloggia (1999) proposal, integrated classification of the technogenic deposits observed in the urban environment of Guarapuava, Paraná. The author emphasized that the effects of recent urbanization provided the formation of several environments: land used for leisure with induced technogenic deposits in river banks and reservoirs; built in grounding sheets and insulated bulkheads; the degradation of lands formed by the dismantling of environments by means of the removal of material, such as quarries, landfill cutting and railway construction.

E. Coastal Environments

Telles (1999) carried out an analysis of the formation of technogenic deposits built on the coastline in the form of landfills. The author discusses the geomorphological evolution of the Pontal of Rio Grande - RS in the boundary of geological time (time that flows) and historical time from the human occupation (time that is made) (Suertegaray and Nunes 2015). In the evolutionary description of the time that flows, the geomorphological site of Rio Grande originated with the transgressive and regressive events of the sea level that occurred during the Quaternary, which allowed the formation of depositional systems of the lagoon-barrier type. In this process, the migration of the lagoon channels occurred, which allowed the settlement of bundles of coastal strands. These strands were reworked by the lagoon flow, currents of coastal drift and wind action, highlighting, thus, a set of features classified by Godolphin (1976) as beach, wind, lagoon, fluvial and emerald features.

In order to emerge from these lands, it took 400,000 years of exogenous processes to act, forming thick sheets of sand, active and passive dunes, quarry (hard-rock) occupied by lagoons, and lagoon terraces at different levels of evolution. This support was incorporated into the territory in the eighteenth century, starting, from then on, a series of technological modifications that aimed to adapt it to the needs required by the occupation.

Historical time (human time) has developed in the context of the strategic-military settlement of the Portuguese crown on the lands of southern Brazil. The author describes that, in the initial phase of occupation (XVIII century), the geomorphological changes occurred in the form of removal of sand from the dunes to the marshy banks with introduction of exotic plant species, serving as windbreaks and sands.

In the 1800s, the need to improve access to the port of Rio Grande-RS unleashed a series of works that gradually modified the environment with the construction of the jetties and the dredging of the canals. The material originated from the dredging began to be thrown on the ponds, swamps, thus expanding the areas of land emerged. The advance of urbanization linked to the construction of a new port and the establishment of new industries triggered the acceleration of geomorphological processes, as dunes were terraced, bathed and landed lagoons, channeled streams, establishing a new spatial configuration.

Lisboa (2004) identified a change in the coastline as a function of technogenic landfills in the district of Florianópolis-SC. Through a historical survey of the appropriation of space and consequent transfiguration of the landscape, the author identified landfills made in the last 30 years, relating them to the public policies of spatial organization and elaborated sketches of the coastline in different years.

4. Final Remarks

This research highlighted the heterogeneity of the knowledge that has been produced on the subject of the Technogene in Brazil. Use of the term Technogene predominates over the use of Anthropocene.

All scientists whose work is cited here corroborate humans as a geological agent in environments with intrinsic geographic characteristics, which provide the technogenic variations on the surface and sub-surface. It should be noted that the effects of humans as geological agents are related to the appropriation of land for widely varied purposes, implementing economic activities to the detriment of environments and producing reworked technogenic landscapes with different degrees of vulnerability to their current occupants.

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