Terræ Didatica

ARTIGO 10.20396/td.v18i00.8670612

Geobike Project: riding on the rocks and motivating alternative fieldwork actions in Geosciences

Projeto Geobike: pedalando sobre rochas e motivando ações alternativas para trabalhos de campo em Geociências

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Abstract: The Geobike Project is an initiative that aims to take advantage of the geological potential of a given region, using bicycle as a mobility instrument to stimulate and disseminate Geosciences for students and professionals of the academic area and for enthusiasts in Earth Sciences, as well. The initial proposal of this study is the municipality of Campinas, São Paulo State. Despite the intense urban occupation, Campinas still has extensive rural areas with very different landscapes, where igneous, metamorphic, and sedimentary rocks outcrop. This setting is propitious to the practice of alternative fieldwork and the diffusion of geoscientific knowledge, at the complementary academic level or at the university extension level, with the possibility of the outcrops being used by students of elementary school and high school levels. Therefore, the Geobike Project can be associated with Geotourism and Geoeducation, encompassing all educational levels.

Resumo: O Projeto Geobike é uma iniciativa que objetiva aproveitar o potencial geológico de uma determinada região, utilizando a bicicleta como meio de transporte com o propósito de estimular e divulgar as Geociências tanto para os estudantes e profissionais da área acadêmica quanto para entusiastas das Ciências da Terra. A proposta inicial possui como área de estudo o município de Campinas, Estado de São Paulo, que, mesmo com a intensa ocupação urbana ainda dispõe de extensas áreas rurais com paisagens bem distintas, onde afloram rochas ígneas, metamórficas e sedimentares. Trata-se de cenário propício para a prática de trabalhos de campo alternativos, além da difusão do conhecimento geocientífico tanto em nível complementar acadêmico quanto voltado à extensão universitária, com a possibilidade de os afloramentos serem utilizados por alunos de escolas do ensino fundamental e médio. O Projeto Geobike pode, portanto, estar associado ao Geoturismo e à Geoeducação, englobando todos os níveis de escolaridade.

Citation/Citação: Amaral, W. S., Farhat Junior, M. Z., & Sanchez, J. P. (2022). Geobike Project: riding on the rocks and motivating alternative fieldwork actions in Geosciences. *Terræ Didatica*, 18(Publ. Contínua), 1-13, e022035. doi: 10.20396/td.v18i00.8670612.

Keywords: Cyclotourism, Geoeducation, Geodiversity, Geoconservation, Campinas.

Palavras-chave: Cicloturismo, Geoeducação, Geodiversidade, Geoconservação, Campinas.

Manuscript/Manuscrito:

Received/Recebido: 02/08/2022

Revised/Corrigido: 03/10/2022

Accepted/Aceito: 01/11/2022

Introduction

Since its invention in Europe at the end of the 19th century, the bicycle has continually been an important means of transport in the most diverse locations around the world. It is the main mode of transport in some countries, either because of socioeconomic vulnerability or topographical and cultural aspects allied to environmentally responsible public policies for urban mobility, as in Amsterdam in the Netherlands. With the worsening and greater visibility given to the environmental crisis – created by the emission of greenhouse gases in the Earth's atmosphere – the bicycle has become a crucial ally in combating the burning of fossil fuels. No less notorious is the dissemination of bicycling for leisure, recreation, and competitive sport, as well as for its health benefits.

According to Ribeiro (2005), the bicycle is suitable for covering small and medium distances, meeting the daily needs of access to work, public facilities, and running errands. Using bicycles as an alternative means of transport contributes to the democratization of public roads, as it helps reduce traffic jams, environmental impacts resulting from using motor vehicles, and energy consumption. It also contributes to improving health, raises awareness about collective interests, and promotes a new quality of urban life, providing more intimate contact with both urban and rural ways and landscapes.

The recent use of the bicycle that has gained much notoriety is for cycle tourism, which, according to Lamont (2009), is a non-competitive sport and leisure practice. An increasing contingent of individuals has sought to reconcile leisure with healthy and sustainable activities, thus promoting well-being and interaction with the environment and local communities.

For Lumsdon (2000), the use of the bicycle for tourism differs from other non-competitive activities, as it allows traveling greater distances, reducing the travel time between different attractions and allowing interaction and contemplation of the environment along the way. In this way, the practice of cycle tourism enables greater interaction with the environment, exploring it more sustainably and intimately, generating a feeling of belonging to the environment, which is fundamental for the awareness of geoconservation.

The use of electric bicycles – which have been increasingly accessible in the market – unravels the issue of accessibility for the elderly or riders with disabilities for the practice of cycle tourism because, while pedaling, the electric motor potentiates the force applied by the user; moreover, the engine can also propel the bicycle effortlessly, like a motorcycle.

Cycle tourism – based on a previously structured itinerary that focus not only on the built historical-cultural heritage but also the geological heritage, including outcrops of exceptional scientific value – meets the expectations of both the laypeople, who seek significant and formative experiences, and the experts, who have already experienced the scientific investigative methods. Cyclotourism encourages a new and significant perspective, making close contact with the environment possible.

Fieldwork in undergraduate Geology courses is a mandatory and necessary curricular activity. It allows direct and practical observation of how rocks, soils, minerals, structures, fossils, and geomorphological features occur in nature. The objective is to provide insights into the complexity of natural phenomena via observation, description, and systematic characterization of the physical environment.

Thinking, planning, and executing a field trip is not always a trivial task. For various reasons, several obstacles make fieldwork in undergraduate courses difficult: logistics, costs, and security –to mention a few. Carrying out fieldwork as extracurricular or complementary activities is almost impossible due to most Brazilian universities' budget constraints; therefore, only curricular activities are prioritized. In this sense, the GeoBike Project (Amaral, 2019) is proposed as a feasible alternative to make field trips less complex using bicycles. The GeoBike Project is directed to smaller groups of students or Earth Sciences enthusiasts, thus characterizing it as an extension activity.

Our study area is the Campinas Municipality, which has a vocation for scientific and educational practices in Earth Sciences, as it is an interesting scenario from the geological-geomorphological point of view, thanks to its location at the contact between the Paraná Sedimentary Basin and the Precambrian basement, with a variety of outcrops including magmatic, sedimentary and metamorphic rocks.

Although the study area is characterized as an intensely urbanized megalopolis, it is still possible to explore the geological potential of the municipality, thanks to the excellent exposure to fresh and weathered rocks for educational activities or research. In this context, we conceived the GeoBike Project as a combination of the practice of physical activities with the dissemination of geoscientific knowledge – both dealt with at a complementary academic level – and as university extension, which can be qualified as elementary and secondary education.

Brief geological context of the Campinas Municipality

In a regional geological context, the Campinas Municipality is located at the contact of the Brasília Sul Orogen and the Paraná Sedimentary Basin (Figure 1). This region consists of a variety of igneous, metamorphic, and sedimentary rocks distributed in four lithological domains along the NE-SW direction (Amaral et al., 2019).

The first domain, where sedimentary rocks of the Itararé Subgroup predominate, is located in the westernmost portion of the municipality. The Itararé Subgroup is a Permian-Carboniferous lithostratigraphic unit of the Tubarão Supergroup of the Paraná Basin (Zalan et al. 1990, Milani et al. 2007). Very fine-grained to conglomeratic sandstones, rhythmites (which may contain glacial erratics), tillites/diamictites, and pelitic rocks, such as siltstones and claystones, crop out in the unit (Arab et al. 2009) (Fig. 2A). Bryophyte and spore fossils belonging to the Carboniferous megaflora are identified in the pelitic rocks (Perinotto & Lino et al., 2007, Ricardi-Branco et al., 2016) (Fig. 2B). Early Cretaceous diabase sills/dikes and tholeiitic

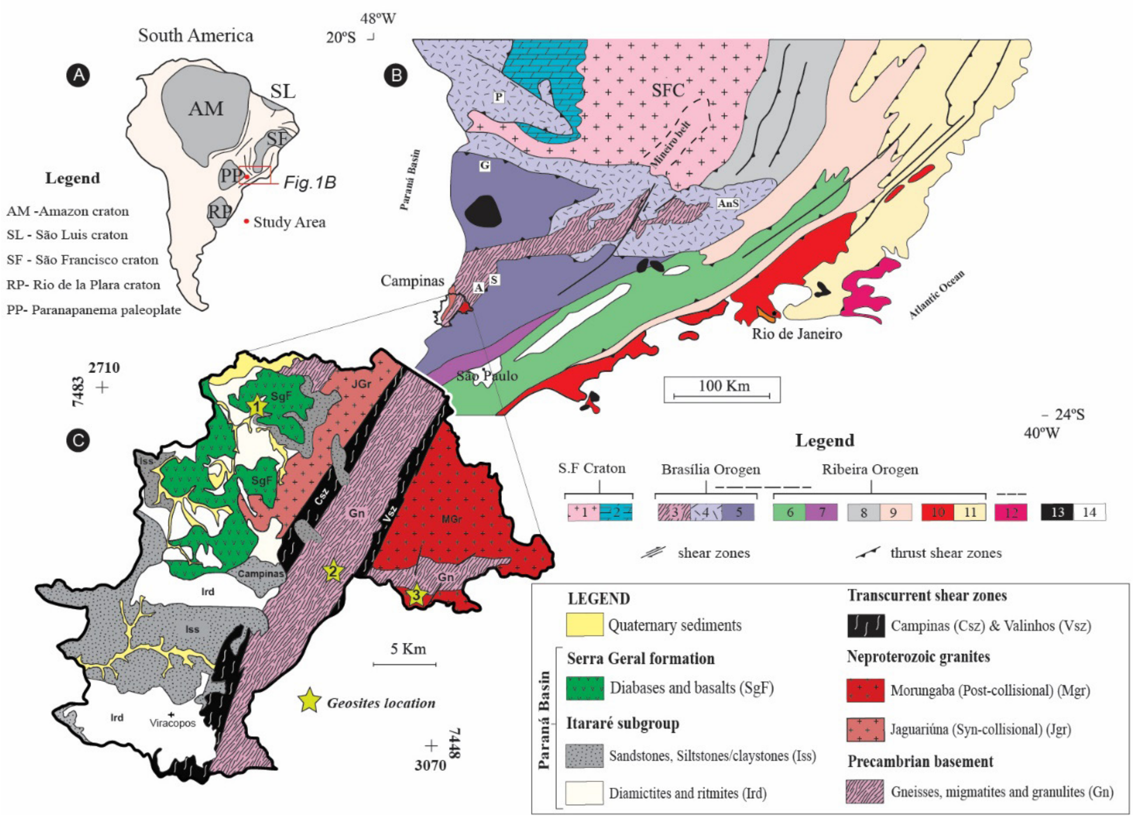

Figure 1. (A) Location of the study area in the context of the tectonic subdivision of the South American Platform. (B) Simplified tectonic map of the region, modified from Trouw et al. (2013). The study area representation is highlighted in black. (1) San Francisco Craton; (2) Metasedimentary cover (Bambuí Group); (3) Southern basement of the Brasília Orogen (Amparo/Serra Negra Complex, Pouso Alegre Complex, Itapira Complex); *Brasília Orogen*: (4) Andrelândia Nappes System; (5) Socorro-Guaxupé nappe; (6) Embú and Paraíba do Sul terrains; (7) Apiaí Terrane; *Ribeira Orogen*: (8) Eastern Domain; (9) Juiz de Fora domain; (10) Rio Negro arc; (11) Eastern Terrane; (12) Cabo Frio Terrane; (13) Cretaceous to Cenozoic alkaline intrusions; (14) Cenozoic covers. (C) Simplified Geological Map of the Campinas municipality with the location of the respective routes/geosites: 1- Barão Geraldo; 2- Ecological Park; 3-Joaquim Egídio (modified from Fernandes et al. 1993, Amaral et al. 2019).

basalt flows of the Serra Geral Formation (Almeida et al. 1981) respectively intrude and overlie the Itararé Subgroup in the study area.

The second domain, located in the central portion of the municipality, is characterized by porphyritic igneous rocks of the Cryogenian-Ediacaran Jaguariúna Suite (Fernandes et al. 1993). The predominant lithologies in this suite are syn-orogenic foliated granites, with a predominance of hornblende-biotite granite-gneisses and biotite equigranular gneissic granite (Figure 2C-D). Oliveira & Silva (2016) obtained a zircon U-Pb age of *ca.* 631 Ma for sheared porphyritic granitoids, which agrees with the ages of regional calc-alkaline type I granites from the Socorro and Guaxupé nappes (Perrota et al. 2005, Toledo et al. 2018).

The third domain dominates the entire east-central portion of the municipality. It corresponds to the Paleoproterozoic basement, composed of medium- and high-grade metamorphic rocks (biotite gneisses, hornblende-biotite gneisses, garnet-biotite gneisses, migmatites, and mafic granulites) – (Figure 2E). Amaral et al. (2019) obtained a zircon U-Pb age of 2134±6 Ma for the hornblende-biotite gneisses that occur in the southern region of the study area. In the same region, sheared gneisses identified meter-sized mafic granulite bodies as lenses. The ages for these granulites were 2156±6 Ma for the protolith and 608±6 Ma for the metamorphism (Figure 2F).

The fourth domain occurs in the easternmost portion of the Sousas and Joaquim Egídio districts, where the Morungaba Granitic Suite crops out (Wernick, 1972). This suite belongs to the Socorro nappe and is characterized by equigranular, isotropic, post-collisional granites of granitic, monzonitic, alkali- and leuco-granitic composition (Figure 2G). Vlach (1985), applying the (U-Th)-

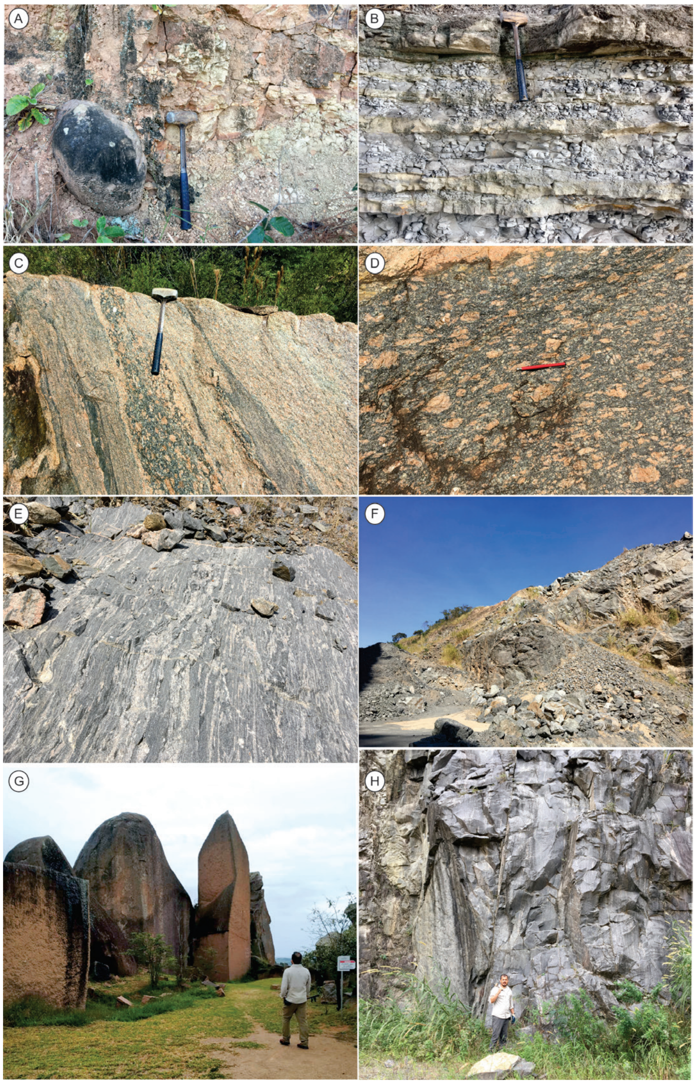

Figure 2. Some aspects of the main lithological associations in the Campinas region: A) Granite boulders also preserved in the diamictites located in the first route; B) Outcrop located on Bandeirantes highway, where pelitic rocks with vegetal fossiliferous content are preserved; C) Outcrop of the diversity of types in the Jaguariúna suite; D) Detail of the hornblende-biotite porphyritic granite of the Jaguariúna suite; E) Biotite gneisses from the Paleoproterozoic basement of the Campinas municipality; F) Metric lens of Neoproterozoic mafic granulite, located in Pedreira Basalto 6 in the southern portion of the municipality; G) Region of the Pico das Cabras where outcrop boulders of the granitic composition of decametric dimensions and varied shapes; H) Outcrop of protomylonites with sub-vertical foliation in the Campinas shear zone.

-Pb method to monazite and whole-rock Rb/Sr dating, obtained ages between 582 and 619 Ma for the equigranular and porphyritic granites. Oliveira & Silva (2016) obtained a zircon U-Pb age of 555 Ma for the predominant isotropic pink granites.

Two NE-SW-trending shear zones crosscut the study area, predominantly ductile and dextral. The Valinhos Shear Zone separates the Morungaba Granitic Suite from the Paleoproterozoic basement, and the Campinas Shear Zone (Figure 2H) – separates the Jaguariúna Suite to the north and the Paraná Basin to the south from the basement (Amaral et al. 2018).

Materials and Methods

The main focus of this project is the incentive to carry out fieldwork focused on geodiversity with the use of bicycles as an instrument: in addition to being an accessible and non-polluting means of transport, it facilitates the circulation and access to points of geological and historical-cultural interest without any difficulties. Handicapped elderly can participate in the project using electric bicycles. It is worth pointing out that people with reduced mobility can also carry out the activities, as inclusion is one of the premises of the GeoBike Project. Most visitation points aid people who have access needs.

The use of smartphones is essential, as they allow recordings along the routes and at points of interest. It involves plotting points on the map, using the compass with great precision, viewing images, annotating information, and good-quality photography. There is a wide range of useful applications for field practices, which are available free of charge in app stores, e.g., Wikiloc, for recording the route, and Avenza maps, for georeferenced plotting of points, in addition to viewing planimetric maps and geology in PDF format.

The diversity of geological and geomorphological features in the study area allowed the project to be thematically structured, encouraging the exploration of the environments of formation of sedimentary, volcanic, metamorphic, and igneous rocks along three main routes. In spite of being illustrative, the GeoBike routes are also interpretative, providing the participants with situations for reflection, discussion, and awareness regarding the preservation of geosites. Several other thematic possibilities are available in the Campinas Municipality and other areas of interest for geology, cycletourism, and geodiversity.

For the effectiveness of the activity, prior geological knowledge of the area to be visited is necessary, as well as the identification of didactic outcrops, logistics and safety planning, stops for refreshment, assessment of meteorological conditions, and the topography of trails and access roads. In this study, three GeoBike routes are proposed. An inventory of geosites on each route was performed to quantify their scientific, educational and touristic relevance. The degradation risk of each route was also estimated, adopting the methodology proposed by Brilha (2016) and the parameters presented by Garcia et al. (2018).

Results

GeoBike route 1: Phanerozoic sedimentary and volcanic rocks of the Paraná Basin

GeoBike Route 1 explores the northern region of the study area. It is located in the Barão Geraldo district, where the Permian-Carboniferous sedimentary rocks of the Itararé Subgroup crop out and are intruded by Jurassic-Cretaceous volcanic rocks correlated with Serra Geral volcanism (Figure 1). The starting point is the Institute of Geosciences of the State University of Campinas – IG UNICAMP. The route is *ca*. 20 km long, interspersed between flat regions, gentle slopes, inclines, and side roads in rural areas (Figure 3A). Depending on the group's physical conditions, the number and age of the participants, and the type of bicycle (electric or conventional), the route can be completed in a maximum of two hours, including moments for explanations about the outcrops and breaks for photos and snacks.

The first point is located to the north of IG-UNICAMP, towards the rural district of Guará and crossing the Anhumas stream, where it is possible to see the transitional contact between sedimentary rock blocks and granite boulders of the Jaguariúna suite on the banks of the stream. Continuing for about 3 km, the participants can see siltstones and claystones cropping out in slabs and roadblocks (Figure 3B), containing clasts of different compositions and sizes, from pebbles to boulders, supported by fine- to very fine-grained matrices. Clasts with angular to rounded, striated, and faceted surfaces are also observed.

At this point, the genesis of these rocks is discussed, as several questions are formulated, mainly about a possible glacial origin for these diamictites, on the basis that faceted pebbles are observed (Figure 3C). Circa 60 km far from Campinas, varvites and *roches moutonnées* occur in the municipalities of Salto and Itu, attesting glacier activities during the Paleozoic in that region (Almeida, 1948).

The next point is located in an open pit used for construction waste disposal, where fine- to medium-grained sandstones and siltstones with parallel plane stratification occur (Figure 3D). Dark, millimeter-thick manganese oxide venules are common among strata and in fractures. These rocks' genesis, grain distribution, and sedimentary and structural features are didactically approached.

The gradual expansion of closed condominiums along the vicinal road indicates the advance of urban occupation, as opposed to an Atlantic Forest fragment known as Mata, do Quilombo, and rural sugarcane farms. At this point, there is a break for lunch. The geological map of the Campinas Municipality is exposed with a brief discussion of the aspects observed in the outcrops (Figure 3E).

The final stop of this route includes intermediate rocks (diabase) that occur as slabs along the Rio das Pedras stream. At the scale of the outcrop, it is possible to explain the genesis, age, and structures of these rocks, how they occur in nature, the area covered by the Campinas geological map, their economic use, in addition to the weathering that originates the well-developed latosols known as "terra roxa", essential for the 19th-century coffee cycle. It is possible to identify certain properties in hand specimens, such as density, color, fineness, mineral composition, and weathering degrees (Figure 3F).

GeoBike route 2: metamorphic rocks and their structures

One of the best places to observe the occurrence of metamorphic rocks is the Ecological Park, located in the east-central region of Campinas, in an area of 110 hectares. A coffee farm named Mato Dentro constitutes an important historical and cultural heritage of the municipality, thanks to its relevant preserved and restored architecture. Native species of the Brazilian flora can also be appreciated in the Ecological Park, in addition to the already mentioned outcrops of metamorphic and igneous rocks. Hiking and mountain-biking trails of intermediate difficulty are distributed

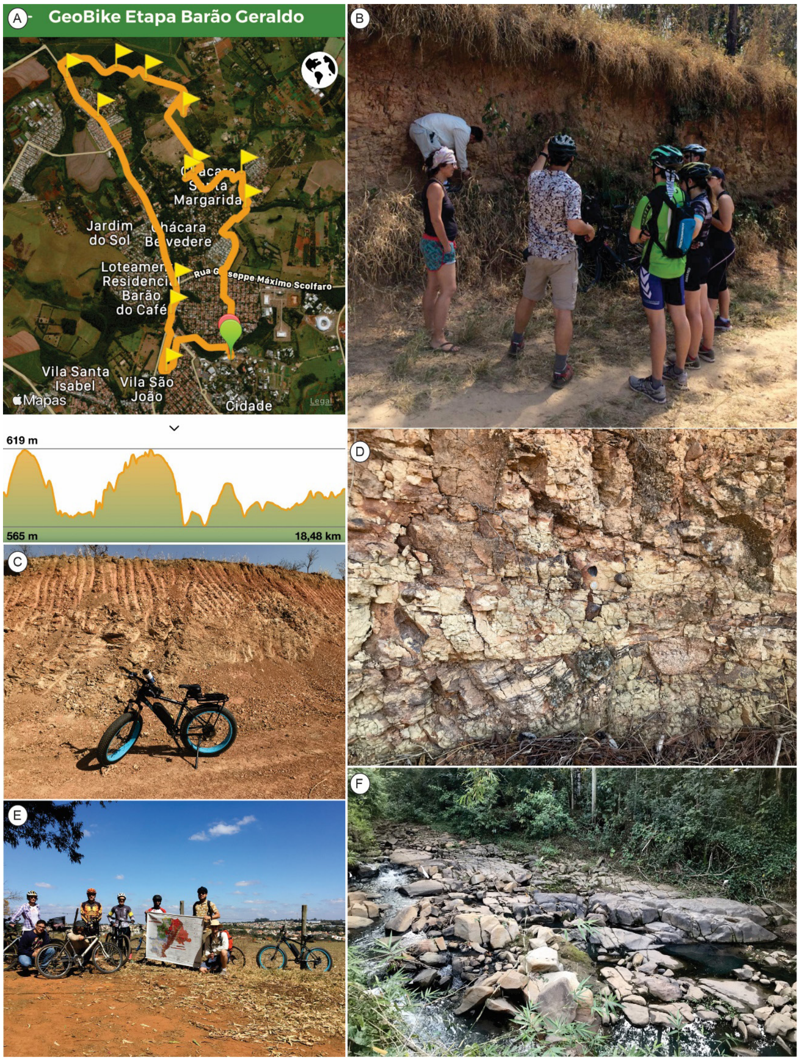

Figure 3. Images of the first route of the Geobike Project in the northern region of the Barão Geraldo district in Campinas: A) The 18.5 km route suggested in this stage of the project, carried out using the smartphone and the Wickloc application. Yellow flags locate points of interest; B) Well-preserved outcrop of diamictites in the Guará neighborhood; C) Sedimentary bedding with clasts of varying sizes randomly dispersed in a silt-sandy matrix; D) Outcrop of fine sandstone with flat parallel bedding; E) Viewpoint for discussion of the activity; F) Bed and banks of the Rio das Pedras stream, where several diabase outcrops occur.

in the park, which is widely signposted and well preserved. The infrastructure is excellent, with parking, police, and fire brigades. It is possible to gather large groups (an average of 15 cyclists) without worrying about traffic. As it is easy to access and a well-located area, cyclists can go to the park at their convenience and, from a meeting point, start the activity together with the organizers.

The route is approximately 7.5 km long, with a maximum decline of 127 m and difficulty varying from easy to intermediate (Figure 4A). In all, 20 points are visited, and all trails have signposts provided by the park, which inform the difficulty level and the correct path to follow. There are dozens of outcrops along the route, with the predominance of metamorphic and igneous rocks. Shapes and sizes vary from 2 to 3 m-long slabs to rock exposures of more than 100 m^2.

The rock structures are evident and well preserved in most outcrops. The first outcrops expose sub-vertical mylonitic gneisses resulting from the activation of the Campinas and Valinhos shear zones (Figure 4B). The varying mylonitic deformation and the decreasing foliation angle can be observed along the path, in general trending NE and dipping NW (Figure 4C). By observing how biotite and quartz stretch, we can identify their lineation. An N-NE-trending oblique lineation is sometimes observed in gneisses and mylonites (Figure 4D). Protomylonitic and augen-like textures are also observed at some points (Figure 4E). Gneissic banding is the most representative feature of metamorphic rocks. Minerals present in the felsic (quartz, feldspar, and plagioclase) and mafic (biotite, hornblende, garnet) bands are easily recognized.

Metamorphosed plutonic and subvolcanic mafic rocks, such as garnet amphibolites, mafic granulites, meta-gabbros, and diabase dikes, occur in the highest point of the park. The contact relationship with the host rocks is in concordance with the regional foliation. Metamafic rocks occur as in-situ decameter- to meter-sized lenses or as blocks and boulders on the ground (Figure 4F). Reddish soil and denser vegetation indicate the occurrence of metamafic rock lenses.

Figure 4. Illustrations of the second route of the Geobike Project in the Ecological Park: A) 7.5 km circuit suggested in the second stage of the project, using the smartphone and the Wickloc application as tools; B) Outcrop with sub-vertical mylonitic foliation; C) Outcrop of biotite gneiss with medium angle foliation to the northwest; D) Mineral stretch lineation very well defined by biotite; E) Augen gneiss with protomylonitic texture; F) Outcrop of high-grade metamafic rocks that occur as lenses enclosed within paragneisses.; G) Plutonic granitic rocks like boulders of metric dimensions.

In the last stretches of the route, the participants easily recognize the occurrence of isotropic granites of the Morungaba Granitic Suite, which are intrusive in the Paleoproterozoic basement rocks. The igneous rocks are blocks and boulders that can reach 2 m in diameter (Figure 4G). The color and texture of the soil change again, becoming lighter and sandy. That can be didactically discussed with the participants, stimulating their perception of such variations and relating them to the topography and lithotypes.

A closing activity takes place at the end of the route, which takes between 2 and 3 hours, depending on the participants' disposition. If Geosciences students are the target audience, the basic geological techniques for fieldwork will be emphasized; if enthusiasts of Geosciences and laypeople are the target audience, the closing activity will emphasize the dissemination of the Geosciences, the recognition of rock types and minerals, and the geological history of the Campinas region, in order to stimulate, disseminate and encourage the study of the Geosciences as an extension activity offered by UNICAMP.

GeoBike route 3: magmatic rocks and shear zones

The longest route (approximately 27 km) with a high difficulty level is recommended for more experienced groups and better physical fitness (Figure 5A). The average duration, including stops and discussions, varies between 3 and 4 hours, depending on the composition and characteristics of the group. The starting point of the route is 25 km far from IG-UNICAMP, in the Sousas and Joaquim Egídio districts.

The route is located in the largest Conservation Unit of the Campinas Municipality – the Campinas Environmental Protection Area (APA Campinas). The APA Campinas is home to numerous forest fragments, such as rupestrian vegetation and Atlantic Forest. Several species of Brazilian fauna live in the APA, including endangered species, such as the maned wolf and the puma.

Regarding the relief, the Campinas Municipality is located between two large geomorphological compartments: the Peripheral Depression to the west and the Atlantic Plateau to the east. The latter, where the activity takes place, is made up of hills with slopes ranging from moderate to steep. Several rocky outcrops exist in the region, but meter-sized granitoid boulders predominate in the landscape (Figure 5B).

The granitoids belong to the Morungaba Granitic Suite (Wernick, 1972, Vlach, 1993), including medium- to coarse-grained alkali-feldspar granite (Figure 5C), biotite syenogranites (Figure 5D), and medium-grained monzogranites (Figure 5E). The granitoids are easily identified in the field by their predominant color: pink, gray, and white.

Right at the beginning of the Bocaina trail, there is a narrow band of quartzites (Figure 4F) in tectonic contact with sheared gneisses, which probably corresponds to remnants of the Itapira Group metasedimentary sequence (Ebert, 1968). The main outcrop of the Bocaina Range is well exposed and preserved, making sample collecting possible. In addition to other structures, grain size and foliation can be easily identified and recorded.

A sudden change to the Morungaba Granitic Suite's granitic rocks occurs after the first stop. The suite crops out along the entire path as blocks and boulders of varying sizes. The soil becomes lighter in color and sandy, indicating the presence of granitic rocks.

At this point, discussing magma mixing and presenting new minerals recognizable in hand specimens should be interesting. Close to the Salto Grande Hydroelectric Power Plant, more specifically at the back of a small abandoned chapel, intermediate rocks occur in a narrow, NNW-trending area in diffuse contact with monzonites (Figure 5G). These are grayish medium-grained rocks containing plagioclase phenocrysts, amphibole, and clinopyroxene, characteristic of subvolcanic rocks of alkaline nature.

A 7 km-long ride uphill begins, ending at the José Bonifácio Coutinho Nogueira Highway (SP-081) intersection. After passing the hydroelectric power plant, the side road becomes increasingly rough with the occurrence of boulders on the way, preventing the traffic of vehicles. It is the most critical part of the route, where extra attention is needed to avoid accidents. Then, the route follows the Atibaia River for about 2 km, being possible to make stops to rest.

The last 3 km of the route are dominated by metamorphic rocks associated with low- to moderate-angle shear zones. Kinematic indicators

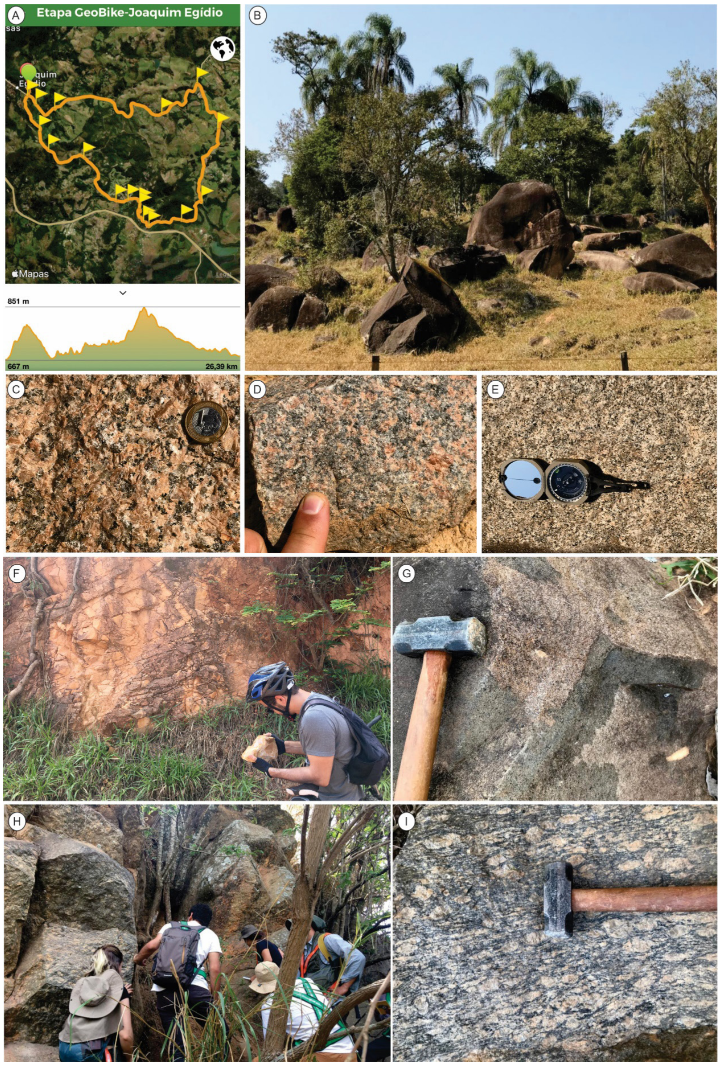

Figure 5. Images of the third route of the Geobike Project in the region of the Joaquim Egídio district: A) 26.39 km-long Route, suggested at this stage of the project, carried out using the smartphone and the Wickloc application; B) Typical forms of occurrence of the granitic rocks of the Morungaba Suite; C) Detail of coarse-grained alkali-feldspar granite, the main lithotype that emerges along the path; D) Detail of coarse-grained grayish-granite biotite; E) Detail of the medium-grained, whitish-colored monzogranite; F) Outcrop of quartzite in contact with basement gneisses; G) Contact relationship between monzonite and subvolcanic rock; H) Preserved outcrop of augen gneisses with low dip angle foliation to SW; I) Detail of the protomylonitic gneiss with stretched K-feldspar porphyroclasts.

are observed in mylonites, and well-preserved outcrops expose fresh rocks, making the measurement of various structures, such as foliation and lineation, and the three-dimensional kinematic analysis of the outcrop (Figure 5H). At this final point, protomylonitic augen-gneisses with bluish quartz and stretched potassium feldspar porphyroclasts occur (Figure 5I).

Discussion

The GeoBike Project stimulates the use and educational potential of fieldwork in neighboring areas for teaching Geosciences at all stages and education modalities. The Campinas Municipality, in particular, has an exceptional geological diversity, encompassing all three types of rocks, allowing a progressive acquisition of knowledge via field activities at different levels, according to the types of lithological associations and the discussion about the different geological environments in an integrated way.

For each GeoBike route, an inventory of geosites or places of geological interest was carried out (Figure 6). The graphs were generated adopting the quantitative method for inventorying geosites proposed by Brilha (2016). Quantification ensured that the outcrops have scientific, didactic, and touristic value. The selected outcrops can be used to explain certain geological contexts and create a constructive and progressive understanding of the study area. The potential for touristic and educational use is practically the same for all routes – this is very important for the dissemination of the Geosciences, as there is the possibility of easy access and potential for the discussion of geological and geoscientific concepts among different audiences at all the inventory points, qualifying the routes, both for touristic and educational use either by students or people interested in Geosciences.

The Ecological Park and the Joaquim Egídio district – respectively, geosites of GeoBike Routes 2 and 3 – are located in conservation areas, and consequently, degradation risk is minimal, as current regulations already protect these sites. The diamictite outcrop in the Barão Geraldo district (GeoBike Route 1) is clearly of the greatest scientific value and highly prone to degradation. The most frequent questions asked by the participants are: "What are diamictites? How important are these rocks? What are tillites?". These are important questions to understand the meaning of outcrops of high scientific and didactic value. Even among Geology students, these terms still raise doubts.

Diamictite (Flint et al. 1960) refers to a rock of sedimentary origin constituted by clasts and fragments of pre-existing rocks of different sizes and shapes dispersed in a muddy or silty-clayey matrix. It is a term with no direct genetic connotation. Several high-energy, gravity-driven processes can originate a diamictite. Tillites, in turn, are diamictites formed by the action of glaciers.

An expressive part of the Campinas area is composed of rocks belonging to the Itararé Subgroup (Fernandes et al. 1993), which comprises a succession of terrestrial and marine environments developed during the Permian-Carboniferous glacial period in the Paraná Basin. However, due to the intense urbanization, very few outcrops attest to glacier activity occurring in the study area. As mentioned before, in the municipalities of Salto and Itu, important glaciation records are observed, such as streak marks on *roches moutonnées* and glacial erratics in varvite sequences (Washburne 1930, Almeida, 1948). These outcrops are protected and conserved within municipal parks.

The advance and retreat of glaciers in the Permian-Carboniferous are very impressive but difficult to be explained to laypeople. However, when the evidence is engraved on the rock, the narrative becomes clearer and better understood, especially when establishing relationships with other locations. For a Geosciences student, this is an opportunity to observe features that require prior knowledge of their characteristics, such as structures, mineral composition, and lithological diversity, making it possible to understand the formation of rocks.

Some actions are needed to contain the accelerated degradation of an outcrop, either located in a rural area or along a side road, due to the growth of vegetation and roots and erosion resulting from rainfall. The cleaning of outcrops can be done manually from time to time. Signaling, using informative didactic panels, can also be a measure to promote awareness among residents about the importance of the geosite. These simple measures can help maintain the outcrop in good condition for constant visits. Sampling and hammering are not recommended.

Excepting *Mata do Quilombo*, the other geosites of GeoBike Route 1 are complementary in the context of the Permian-Carboniferous and Jurassic-Cretaceous evolution of the Paraná Basin.

Several blocks and slabs of subvolcanic rocks along the Rhodia road and in the waterways near UNICAMP – pieces of evidence of volcanism that took place during the Gondwana supercontinent fragmentation can be shown to participants. The story of fissure magmatism and the separation of the South American and African continents, with the concomitant growth of the Atlantic Ocean, can arouse the curiosity and enthusiasm of the participants for global tectonics.

The notion and dimension of geological time is an important exercise in order to guide discussions (Frodeman, 2010, Cervato & Frodeman, 2012, 2012b). The Geological Time Scale raises many questions that cannot easily be answered. For example, clasts of basalts or other volcanic rocks of the Phanerozoic have not yet been found in the diamictite outcrop. A viable explanation is that the diamictites are older than the Cretaceous Serra Geral basaltic rocks. Other pieces of evidence that associate the genesis of diamictites with older geological processes can be offered, such as their contemporaneity with Permian glaciations. All these perceptions must be formulated by the participants at the end of the activities, making knowledge acquisition a unique experience for each.

The points of greatest scientific value are located in the Ecological Park (GeoBike Route 2) and the Joaquim Egídio district (GeoBike Route 3). Degradation risk in these two sites is minimal, taking into account that these sites are located in preservation areas and that the magmatic and metamorphic rocks have been little affected by weathering.

GeoBike Route 2 – Ecological Park – is the most complete regarding lithological diversity and safety. We will propose the creation of a geopark in this area of the Campinas Municipality. Identifying high-grade metamorphic rocks in the interior and in the surroundings of the Ecological Park is of great scientific value to understanding the tectonic evolution of the Campinas Municipality region. Geology students can profit from the highly didactic outcrops (Figure 6), involving topics related to Geological Mapping, Structural Geology, and Igneous, Sedimentary, and Metamorphic Petrology, plus other basic disciplines of the undergraduate Geology course. Very well-preserved outcrops with various structures, textures, and mineral compositions will certainly encourage geological studies, such as describing and collecting structural information in a practical and didactic way.

For Geosciences enthusiasts and laypeople, what is the importance of high-grade metamorphic rocks? Why are the rocks that occur in the Ecological Park particularly important? What is it like to translate and elucidate these questions in a less technical language and make them understandable to these participants? At first, it is important to make clear that the presence of granulites and possible retrograde eclogites is quite rare. These rocks generally occur at tectonic plate boundaries. Using the Campinas Municipality geological map, we can strengthen such evidence, since there are records of collisions or parts of a possible suture zone between the Paranapanema and São Francisco paleoplates – GeoBike Route 3 (Figure 1C). We take the Andes and the Himalayas as examples of "modern" settings where these rocks are being formed.

This exercise facilitates understanding and arouses the curiosity of geobikers even more with the formulation of further questions such as: "But where are the mountains? The volcanoes? Was there an ocean here? How did these rocks come to the surface?". Furthermore, again the question of time is crucial. Unpublished data from Amaral et al. (in prep.) reveal that the genesis of these Paleoproterozoic rocks and the Neoproterozoic metamorphism took place in the context of the Columbia supercontinent (2.2 – 1.8 Ga) and that the resulting rocks were once again metamorphosed during the Gondwana amalgamation (ca. 610 Ma). Understanding is facilitated by using maps and schematic drawings that aid geological interpretation.

Following GeoBike Route 3, the activity becomes increasingly exciting when participants observe the presence of structures in the rocks resulting from shearing. The presence of granites related to the end of the Gondwana amalgamation concludes the Precambrian geological history of the Campinas Municipality. The elaboration of a roadmap facilitates understanding the tectonic evolution of the study area in a didactic and simplified way.

It is interesting to note that in GeoBike Route 3 – Joaquim Egídio district, the first and last geosites have the greatest scientific and educational value, giving a perspective of the geological evolution of the study area (Figure 6). Despite the emphasis here on magmatic rocks, there are several geosites with interesting geological structures on this route. The participants of this activity are not necessarily the same that carried out other activities. Therefore, there is no problem repeating the regional geological/geotectonic contextualization. It is a distinct geomorphological area of the Campinas Municipality, where the landscape is dominated by "seas of hills" (*Mares de Morros*), reaching altitudes of more than 1000 m. The area is predominantly constituted by granitic rocks and secondarily by rocks formed by regional and dynamic metamorphism. Due to the difficulties and long duration of this part of GeoBike Route 3, we carried out only one activity before the pandemic, with the participation of three students from the last semesters of the Geology course at UNICAMP.

During the preparation of this route, important outcrops were discovered for educational use and of relevant scientific value, including quartzites, subvolcanic rocks, and mylonites (Figure 6). The dynamics of the activity on this occasion served as training for this group in fieldwork. It was a technical activity, with discussions on structural geology, geological mapping, global tectonics, and geochronological dating. Oriented mylonite samples were collected, and structural data were collected using the compass of the smartphones, thus allowing descriptive, kinematic, and dynamic analyses to be performed. Depending on the interests of the further participants of this route, a more didactic and inclusive activity can be planned, with simplified descriptions of the outcrops and the various natural landscapes, plus considerations of the historical heritage provided by this Atlantic Plateau scenario in Campinas.

Conclusion

With the quantification of the geological and educational relevance of the geosites along each route of the GeoBike Project, it was possible to define the best target audience for each route and even the most appropriate language to be used. All GeoBike routes include geosites that can be used in all education stages, from basic to higher education. The emphasis, however, is on the applicability of the GeoBike Project in higher education, where advances in acquiring regional geological knowledge can be achieved. Moreover, such field activities will aid the training of undergraduate and graduate Geoscience's students.

The GeoBike routes proposed here are alternative fieldwork formats, allowing different approaches regarding learning processes by combining sport, tourism, and leisure activities with the acquisition of local/regional geological knowledge – in other words, activities of new and significant didactic approaches. The routes proposed here are largely inclusive – in addition to learning, moments of leisure associated with healthy practices are promoted in scenarios that allow the appreciation of the natural and historical-cultural heritage of the Campinas Municipality.

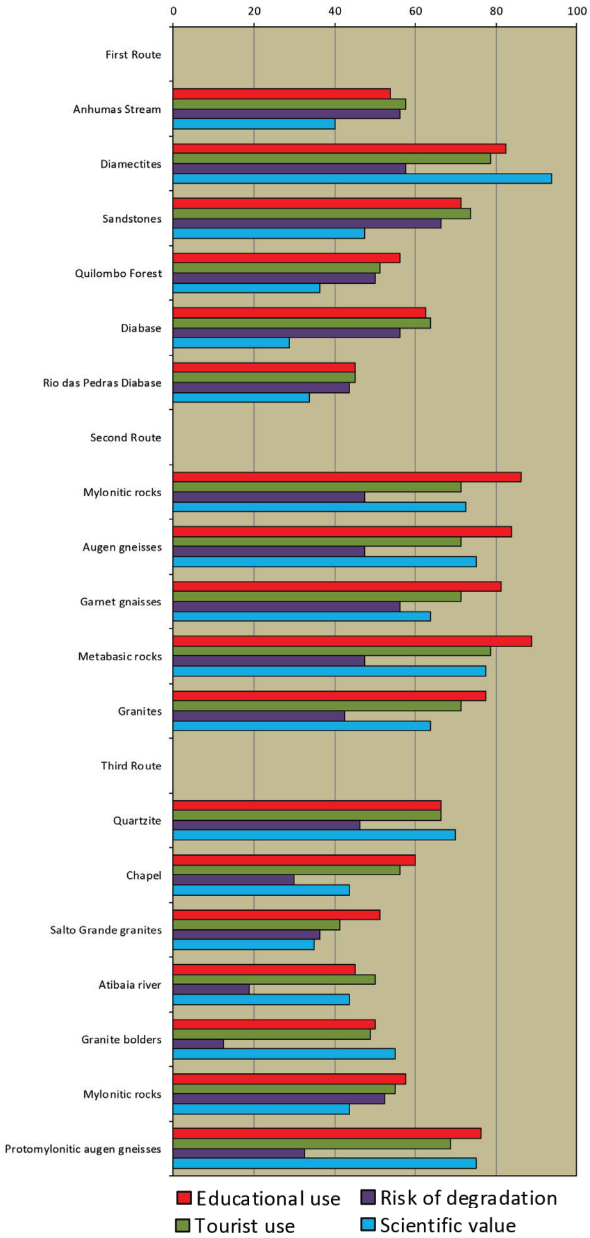

Figure 6. Graph of the quantification of geosites or places of geological interest. For each of the three stages (Barão Geraldo, Ecological Park, and Joaquim Egídio), seven geosites were selected for quantification (educational, tourist use, risk of degradation, and scientific value) according to parameters by Brilha (2016). Each geosite was named according to its main features or landmarks that can be consulted in the results.

Acknowledgements

The authors are grateful for the editorial care of Celso Dal Ré Carneiro and the constructive comments of the reviewers Hernani Chaves and Luana Rangel. WSA also acknowledges the Conselho Nacional de Desenvolvimento Científico e Tecnológico (CNPq) for research grant (Process. 305263/2020-0). For more information about the GeoBike Project, visit us at @projetogeobike

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