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Geologic Highway Map of Rio de Janeiro State: a product to stimulate geotourism and broadcast Rio de Janeiro's geodiversity

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Abstract

Geologic Highway Maps are used in several countries to, inform and entertain travelers who drive along main highways. They bring, in a language style accessible to the general public, information about the observable nature along roads, showing local and regional geodiversity on a map, in geological sections and at specially chosen stops. The remarkable geodiversity of the Rio de Janeiro state is considered to be the result of a complex geological and geomorphological evolutionary history, resulting in several geotouristic attractions. Although there are many important initiatives for dissemination of Rio de Janeiro's geodiversity, such as the Caminhos Geológicos Project, the Rio de Janeiro state still remains with a wide geotouristic potential yet to be explored. In this sense, this work presents the Geologic Highway Map of the Rio de Janeiro State (GHMRJ), in its final stage of design, as a product to propagate geodiversity and encourage geotourism. GHMRJ is an unprecedented initiative in Brazil, and a new way of publicizing geotourism bringing geoconservation of Rio de Janeiro's geodiversity into the spotlight.

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1. Introduction

Geologic Highway Maps are used in several countries to disseminate, inform and entertain travelers who drive along main highways (Kamilli and Richard 1998, Colorado Geological Survey 2003, Wilks 2005, Matthews 2009). They bring, in a language style accessible to the general public, information about the observable nature along roads, showing local and regional geodiversity on a map, in geological sections and at specially chosen stops.

Diverse concepts of geodiversity, from the most classic to the most current, address the variety of the abiotic environment that constitutes the natural diversity of terrestrial landscapes (Mansur 2018, Gray 2004, Gray 2013), considering the geological characteristics together with the hydrological, geomorphological and pedological ones in the set that makes up geodiversity.

The richness and exuberance of nature in Rio de Janeiro State, and the recent publication of the Geological and Mineral Resources Map on a 1: 400,000 scale by the Geological Survey of Brazil (Heilbron et al. 2016), motivated the team of the Tectonic Studies Laboratory of the Research Group in Geotectonic (LET-TEKTOS) of the Rio de Janeiro State University to prepare a Geologic Highway Map of the state. This map fills a gap in this type of scientific diffusion in the country and takes advantage of the tourism potential of Rio de Janeiro.

The difficult choice of highways, many of them traverse spectacular scenic landscapes, as well as stopping points, which demand places for secure and safe parking for travelers, was based on criteria of geological and geomorphological diversity and the extension of the roads, prioritizing those that cross a large part of the state. The Map was designed to be easy to use, with information on the front and back, and with a list of geosites and geological stations of interest, as well as the delimitation of the Costões and Lagunas Geopark Project and State Conservation Units.

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We hope that the Geologic Highway Map of the of Rio de Janeiro State will be a means of disseminating geosciences and stimulating environmental preservation.

2. General Aspects on the Design of Rio de Janeiro State's Geologic Highway Map

In the final stage of design, GHMRJ aims to stimulate geotourism and publicize Rio de Janeiro's geodiversity, highlighting the relevant aspects of such geodiversity around the state's highways.

GHMRJ is the result of the vast database acquired by the Geotectonic Research Group - TEKTOS, from UERJ, for design of the Geological and Mineral Resources Map of the Rio de Janeiro State (Heilbron et al. 2016). Its target audience is composed of tourists, students and other people interested in geosciences who wish to broaden their knowledge of Rio de Janeiro's geodiversity. In this sense, the use of simple and accessible language for different audiences was one of the major aspects taken into account when designing the map.

In addition to the TEKTOS Group database, data from other institutions were used; for example, Brazil's Ministry of the Environment (MMA), Brazil's National Department of Transport Infrastructure (DNIT) and the Mineral Resources Department of Rio de Janeiro State (DRM-RJ). The final publication foresees a Front and Back layout (60 cm x 120 cm) divided into thematic sections; this way, when folded, the GHMRJ is 15 cm x 15 cm in size, which is compatible with pocket publications. It is noteworthy that all maps presented in the publication used the geodesic reference SIRGAS 2000.

3. Front Face: Geology of the Rio de Janeiro State

The front face of GHMRJ has six thematic sections (Figure 2): (1) geological map and geological road profiles; (2) geotectonic evolution; (3) publication cover; (4) tectonic map; (5) mineral resources map; and (6) credits and general information about the publication.

The geological map presented in GHMRJ (Figure 3) is a simplification on a 1:600,000 scale of the Geological and Mineral Resources Map of the Rio de Janeiro State (Heilbron et al. 2016). In terms of simplification, some lithostratigraphic units were grouped, resulting in 21 classes of complexes and groups. The structures were simplified and grouped according to the main characteristics; they were represented on the map only as shear zones, faults, fracture zones and mylonitic zones.

The geological map also presents road vector data (DNIT 2013) with recent updates in the road network, and the geological sections of the main highways in the state: (a) BR-101 (Rodovia Rio-Santos), (b) BR-040 (Washington Luís Highway), (c) BR-116 (Via Dutra), (d) RJ-116 (Presidente João Goulart Highway), (e) RJ-124 (Via Lagos), (f) RJ-106 (Amaral Peixoto Highway) and (g) BR-356.

The tectonic map (Figure 4), represented on a scale of 1: 3,500,000, is also a simplification and update from the Geological and Mineral Resources Map of the Rio de Janeiro

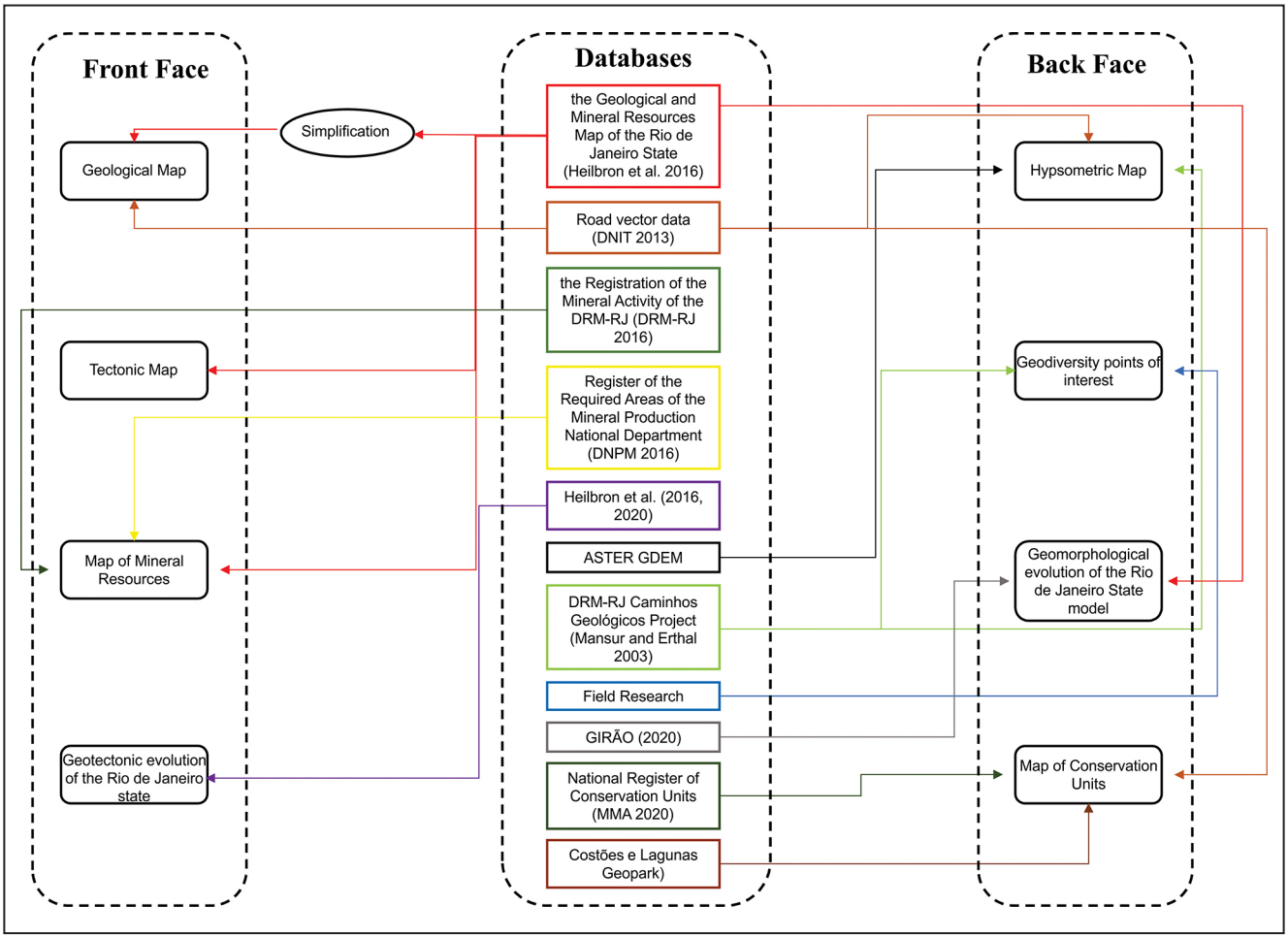

FIGURE 1. Flowchart with the database and products developed for the Geological highway map of the Rio de Janeiro State.

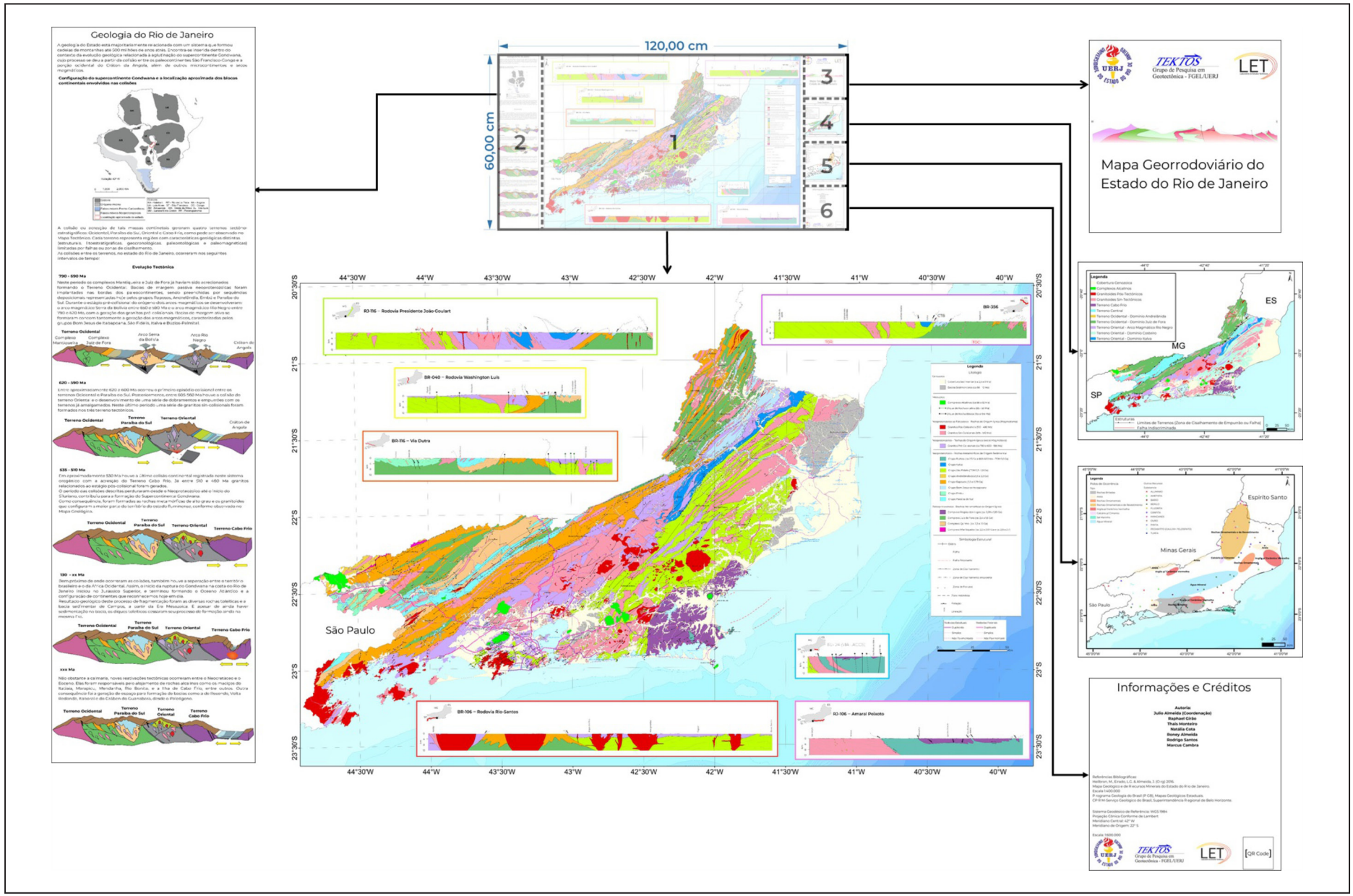

FIGURE 2. Front face of the Geologic Highway Map of Rio de Janeiro State.

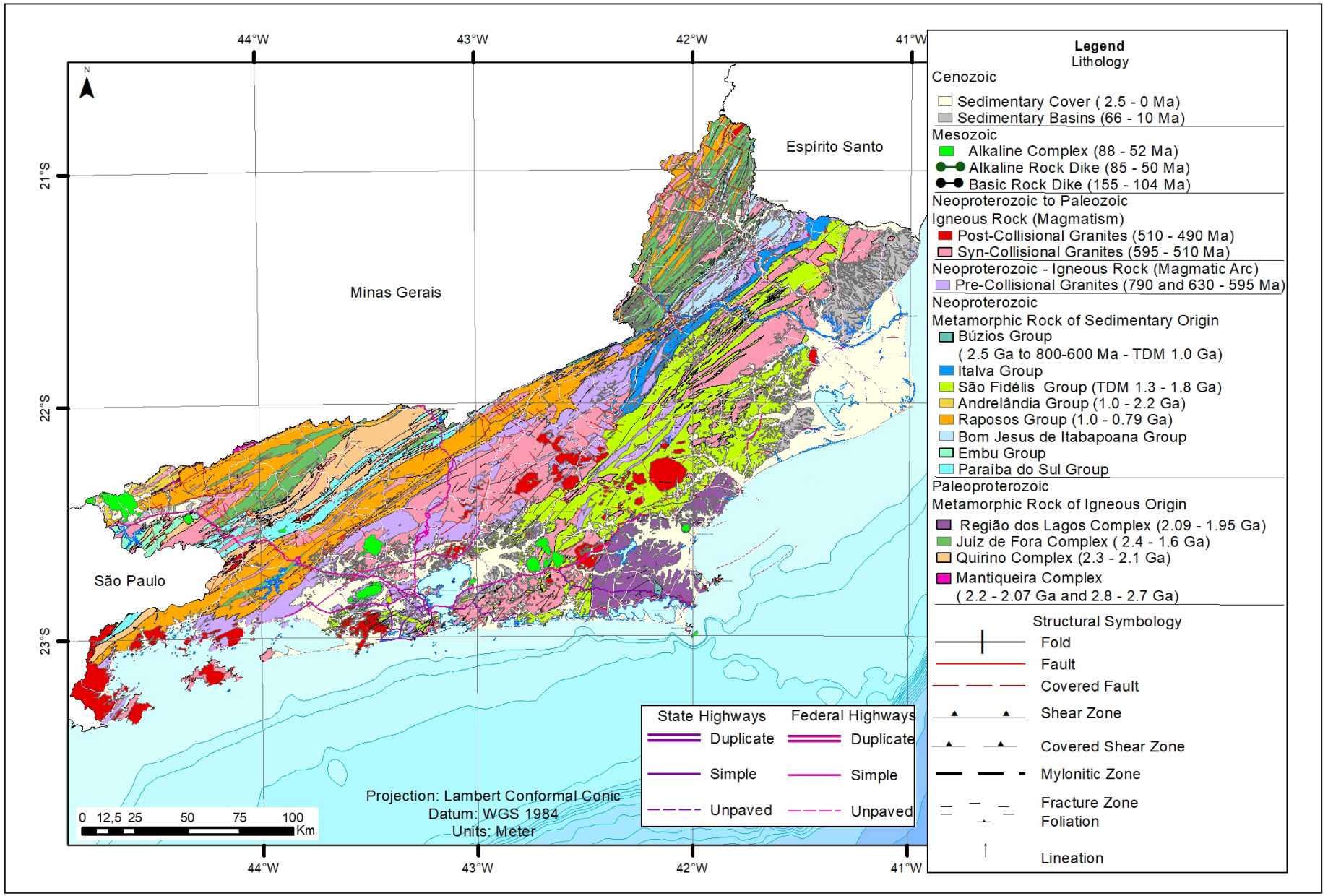

FIGURE 3. Geological Map of Rio de Janeiro.

State (Heilbron et al. 2016). This map shows the tectono-stratigraphic terranes that make up the Ribeira Orogenic Belt, the granites of the sin and post tectonic magmatic events, the intrusive alkaline rocks, and the Cenozoic sedimentary cover.

The map of mineral resources was prepared on a scale of 1: 3,500,000 (Figure 5) from the compilation of three data sources: the Geological and Mineral Resources Map of the Rio de Janeiro State (Heilbron et al. 2016), the Registration of the Mineral Activity of the DRM-RJ (DRM-RJ 2016) and the Register of the Required Areas of the Mineral Production National Department (DNPM 2016). Based on these data, areas were identified where the main mineral resources are exploited, such as mineral water, ornamental rocks, sand and clay. The map also shows the most significant mineral occurrences for the state of Rio de Janeiro.

The geotectonic evolution of the Rio de Janeiro State is presented in stages over geological time accompanied by schematic models (Figure 6), based on Heilbron et al. (2016, 2020), which integrates data collected from geological surveys for more than thirty years.

4. Back Face: Geomorphology, Geodiversity points of interest; Conservation Units

The back face of GHMRJ has four thematic sections (Figure 7): (1) hypsometric map; (2) geodiversity points of interest; (3) geomorphological evolution; and (4) map of conservation units.

The hypsometric map was created on a 1:800,000 scale using the digital elevation model (DEM) ASTER GDEM, which has a spatial resolution of 1 arc-second and is associated with the geoid model EGM96. Road vector data (DNIT 2013) were also used, updated with the recent changes in the road network and the stations of geological interest of the DRM-RJ Caminhos Geológicos Project (Mansur and Erthal 2003).

By showing the different colors of the altimetric classes, the map offers the perception of the geomorphological compartmentation of the state that is criss-crossed by the state and federal highways, representative of the relief units of mountains, hills and plains. Figure 8 shows a simplified version of the hypsometric map present in GHMRJ.

Field research was carried out to select the points of interest for geodiversity on the major highways in the state: BR-101, BR-040, BR-116, RJ-116, RJ-124, RJ-106 and BR-356. The stations of geological interest of the DRM-RJ Caminhos Geológicos Project (Mansur and Erthal 2003) were used as an initial basis and, in field research, the points of interest were selected considering the following criteria: scientific value, educational value, touristic value, access facilities for visitors and minimum structure for visitors to stay in the place safely. Some points of interest not belonging to the DRM-RJ Caminhos Geológicos Project (Mansur and Erthal 2003) were also included because, during field research, they were found to be of great relevance.

Figure 9 shows an example of one of these points. In addition to the photo and a description of aspects of its geodiversity, there is also information about its location and how to stop at such location.

The geomorphological evolution of the Rio de Janeiro State deals with the geological and geomorphological events that gave rise to the current Rio de Janeiro relief (Figure 10). Three-dimensional models illustrate four

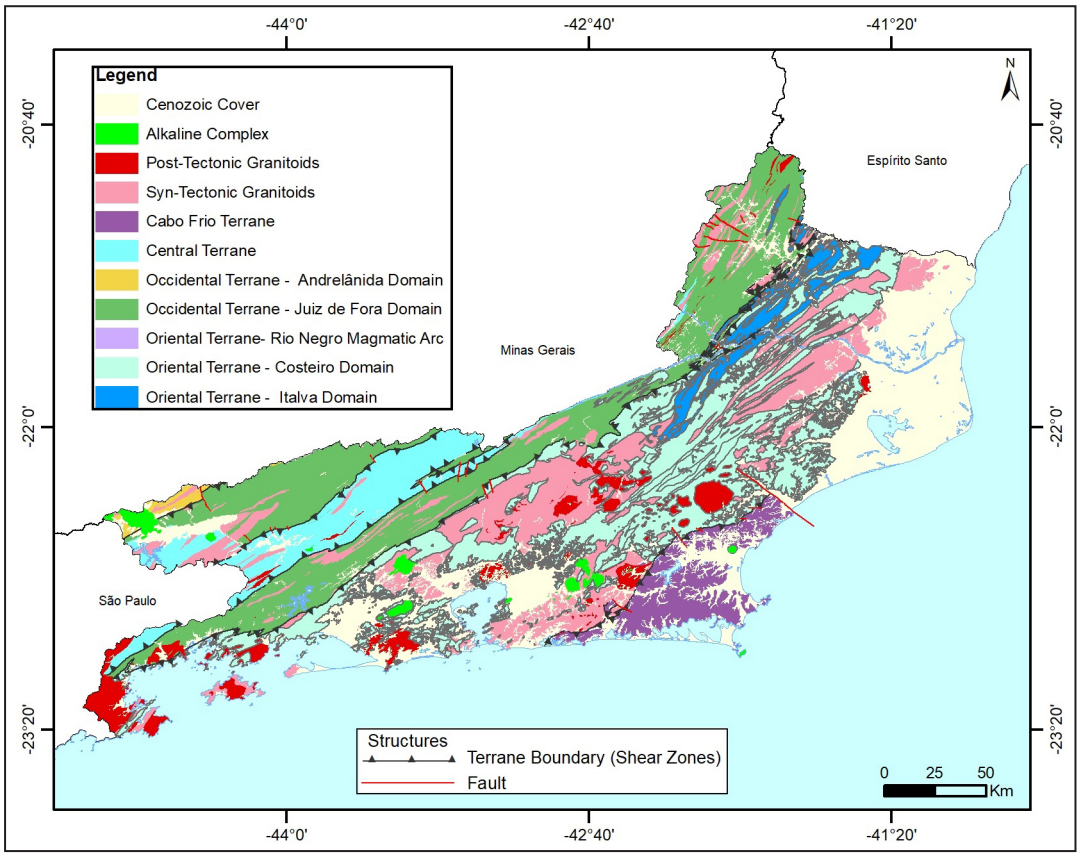

FIGURE 4. Tectonic map of Rio de Janeiro.

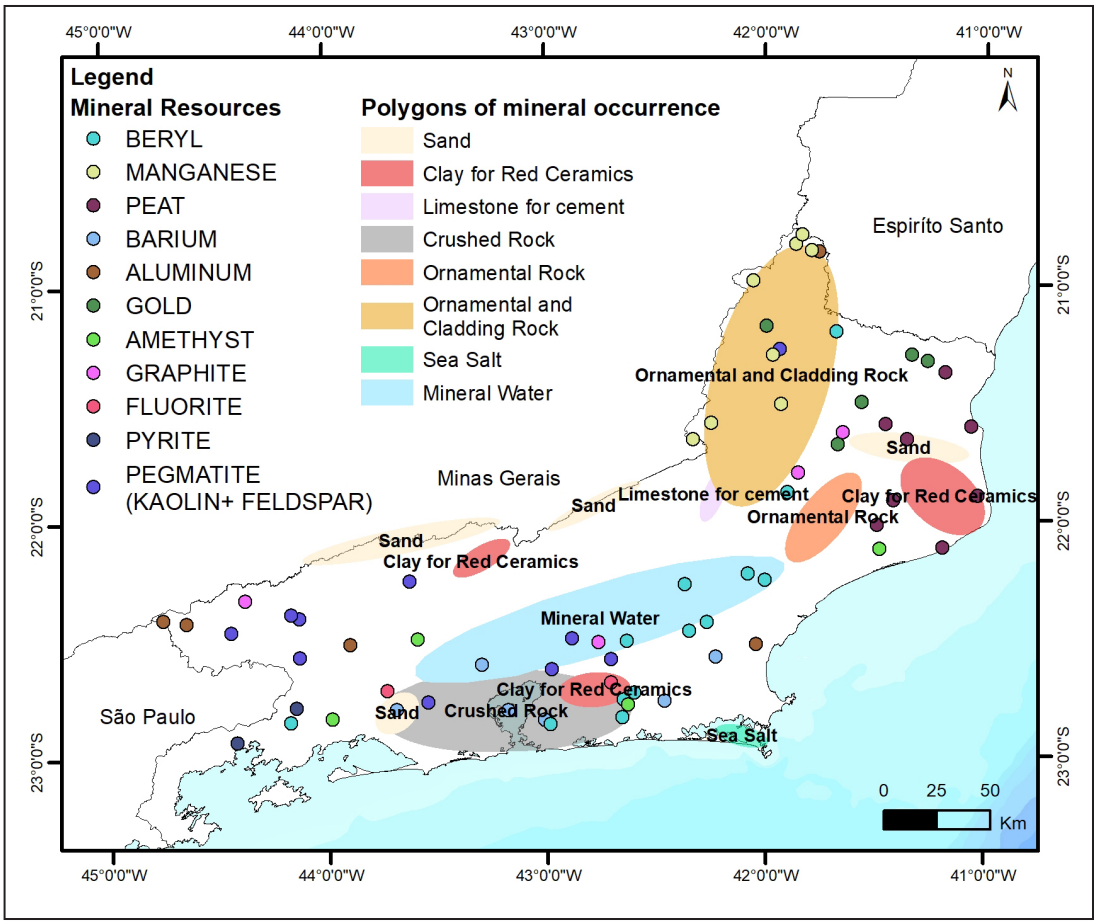

FIGURE 5. Map of Mineral Resources of the State of Rio de Janeiro.

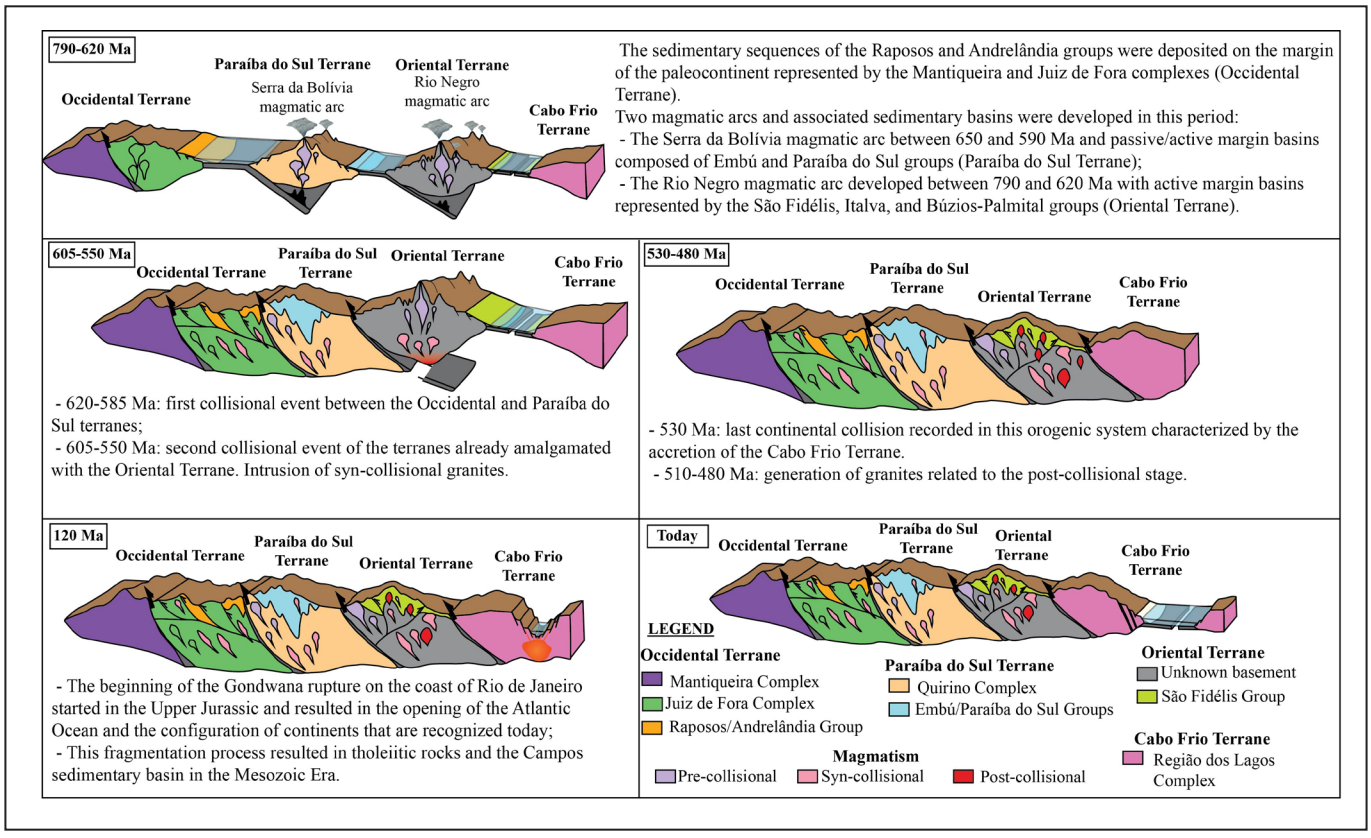

FIGURE 6. Geotectonic evolution of the Rio de Janeiro state..

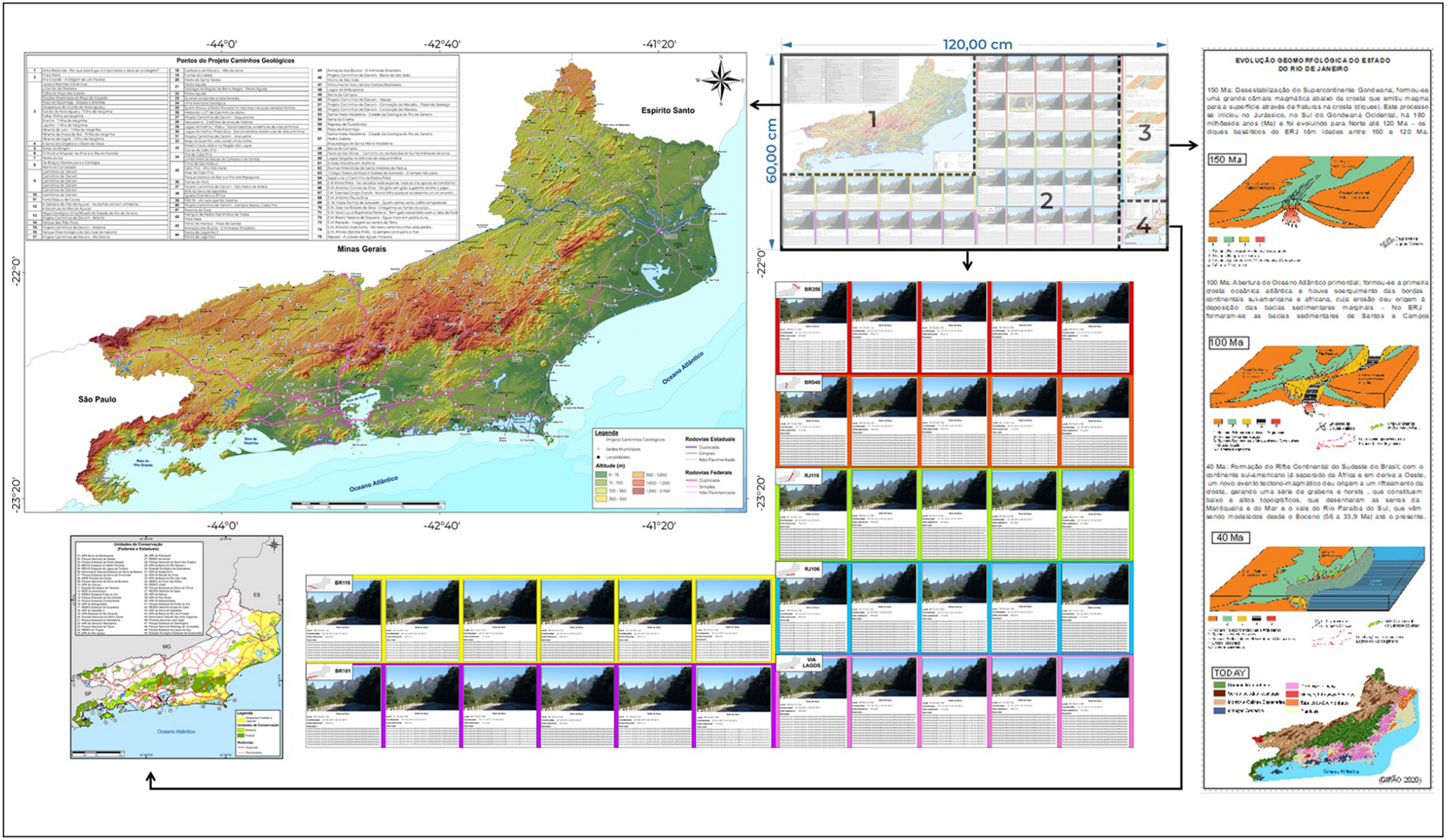

FIGURE 7. Back face of Geologic Highway Map of Rio de Janeiro State.

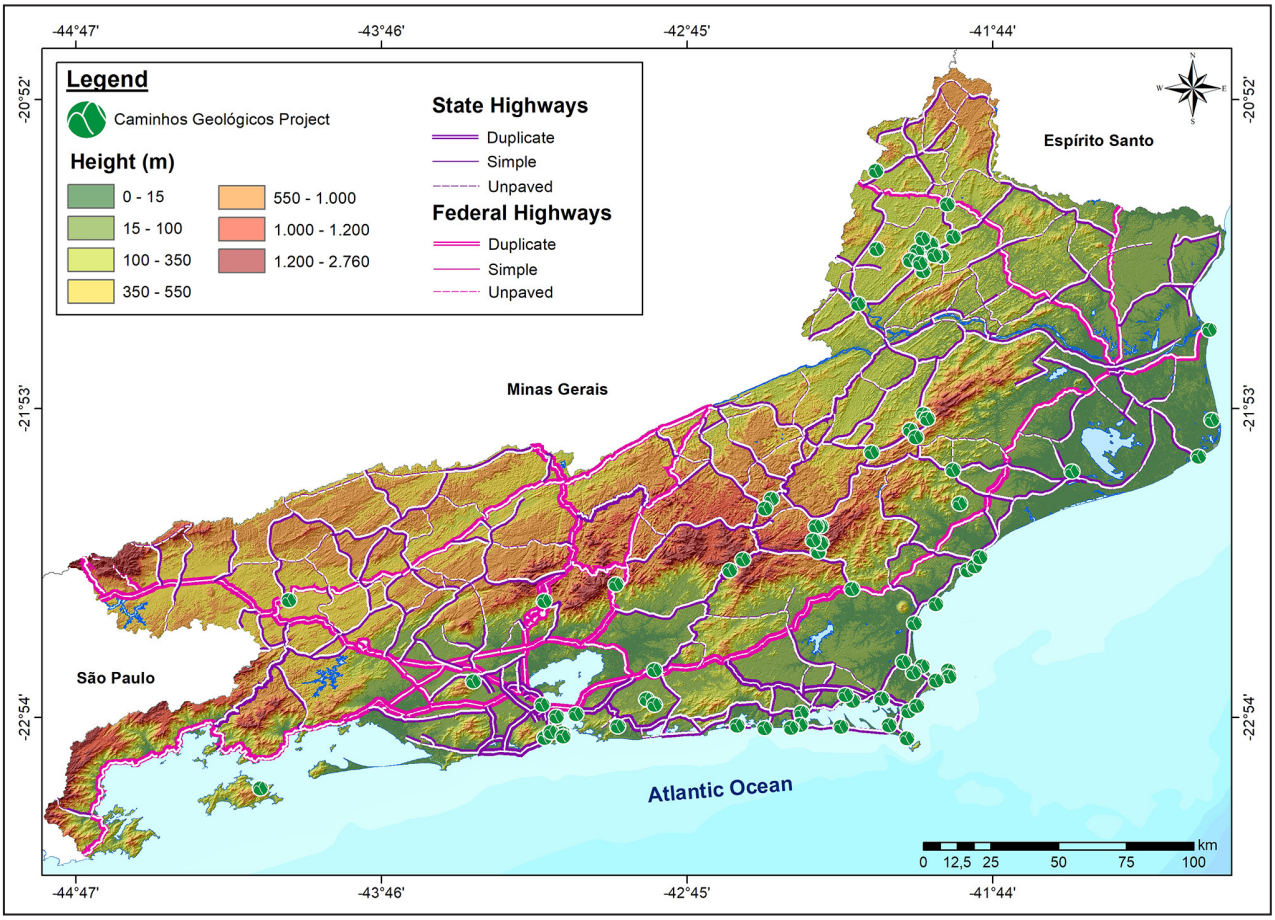

FIGURE 8. Hypsometric Map of Rio de Janeiro.

FIGURE 9. Example of geodiversity points of interest.
Caieira São Joaquim.
Site: BR-356 highway. Coordinates: 21°24'09"S; 41°41'24"W.
Where to park: Highway shoulder.
Description: "Caieiras" are ovens for the production of lime (lime kiln). In 1940, A.R. Lamego mentioned the existence of fourteen of these ovens in the Muriaé River valley, close to Fazenda São Joaquim (São Joaquim farm), where thick layers of marble emerge. The furnace shown in the photo was dug into the side of the hill and its walls were raised with blocks of local gneiss. Filled with crushed limestone ($CaCO_3$), the burning took five days and eight more days for cooling (Lamego 1940). The product removed was lime (CaO), used in the local construction and in the sugar mills of the Baixada Campista region. Currently, limestone is no longer calcined, being ground and used in the cement industry.

stages of the relief evolution of the region, where the state of Rio de Janeiro is located today, and which also configured the Brazilian southeastern continental margin, the contours of the current Brazilian coast, as well as marginal sedimentary basins, rich in mineral and energy resources and the Atlantic Ocean itself. The models also show how the drainage network has evolved, especially the Paraíba do Sul River and its tributaries, in addition to the contours of the highlands of the Mar and Mantiqueira ridges and coastal plains and lagoons.

The map of conservation units (Figure 11) was designed on a 1: 3,500,000 scale using vector data from state and federal conservation units, collected from the National Register of Conservation Units (Brasil 2020), and from state and federal highways. (DNIT 2013). It has been updated with the recent changes in the road network. In addition, the limits of the proposal of the Costões and Lagunas Geopark were included (Mansur et al. 2012).

5. Final Remarks

In its proposition, GHMRJ presents updated information on the geology of Rio de Janeiro offered for optimal use of the enormous geotouristic potential of the state. Users of the GHMRJ, when traveling along the main highways in the state of Rio de Janeiro, will be able to take advantage of knowledge of the geodiversity of Rio de Janeiro. In places with greater geotouristic potential, carefully selected points of interest contain information about their geological, geomorphological, hydrological, and mineral resource aspects.

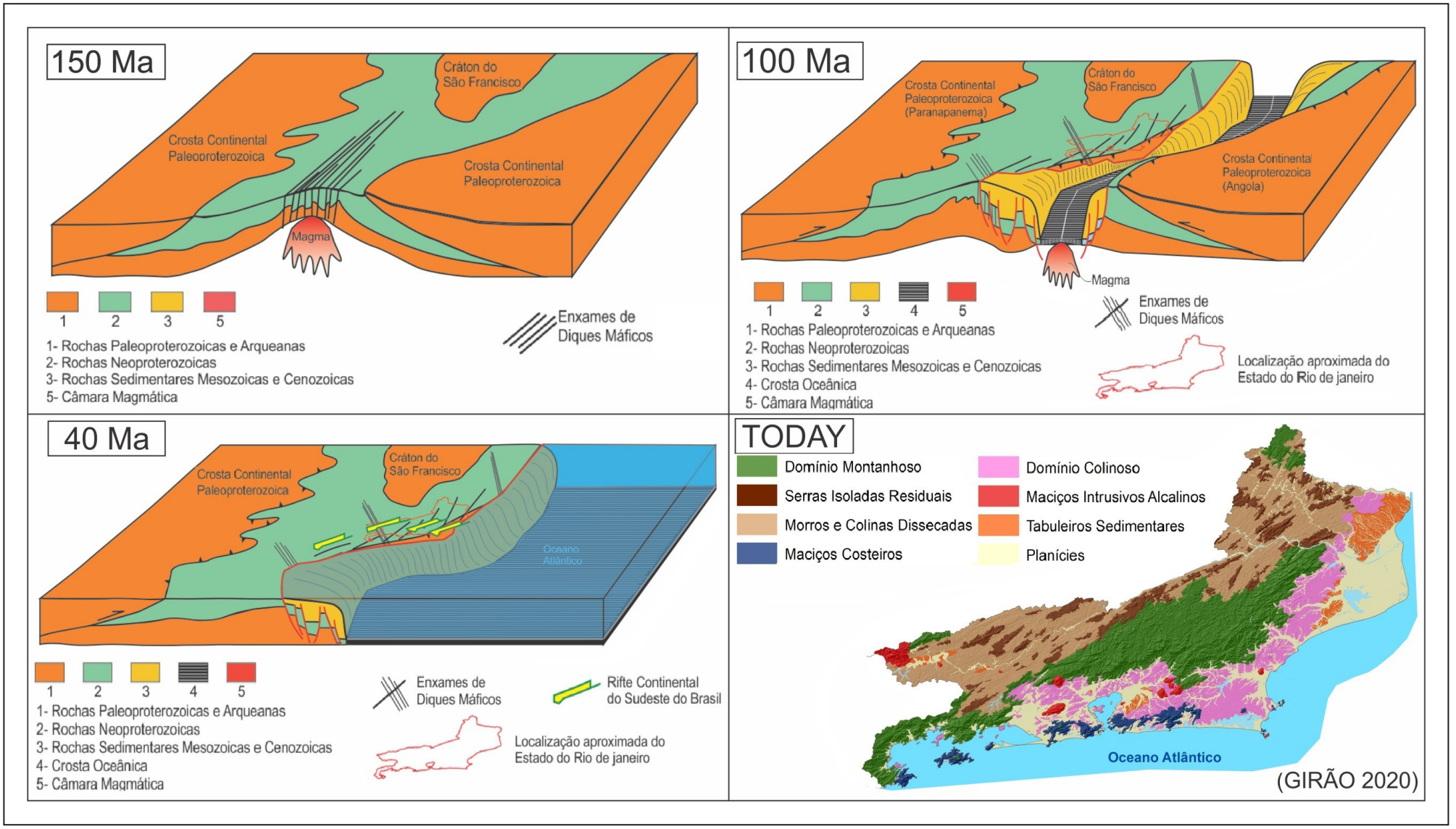

FIGURE 10. Geomorphological evolution of the Rio de Janeiro State model.

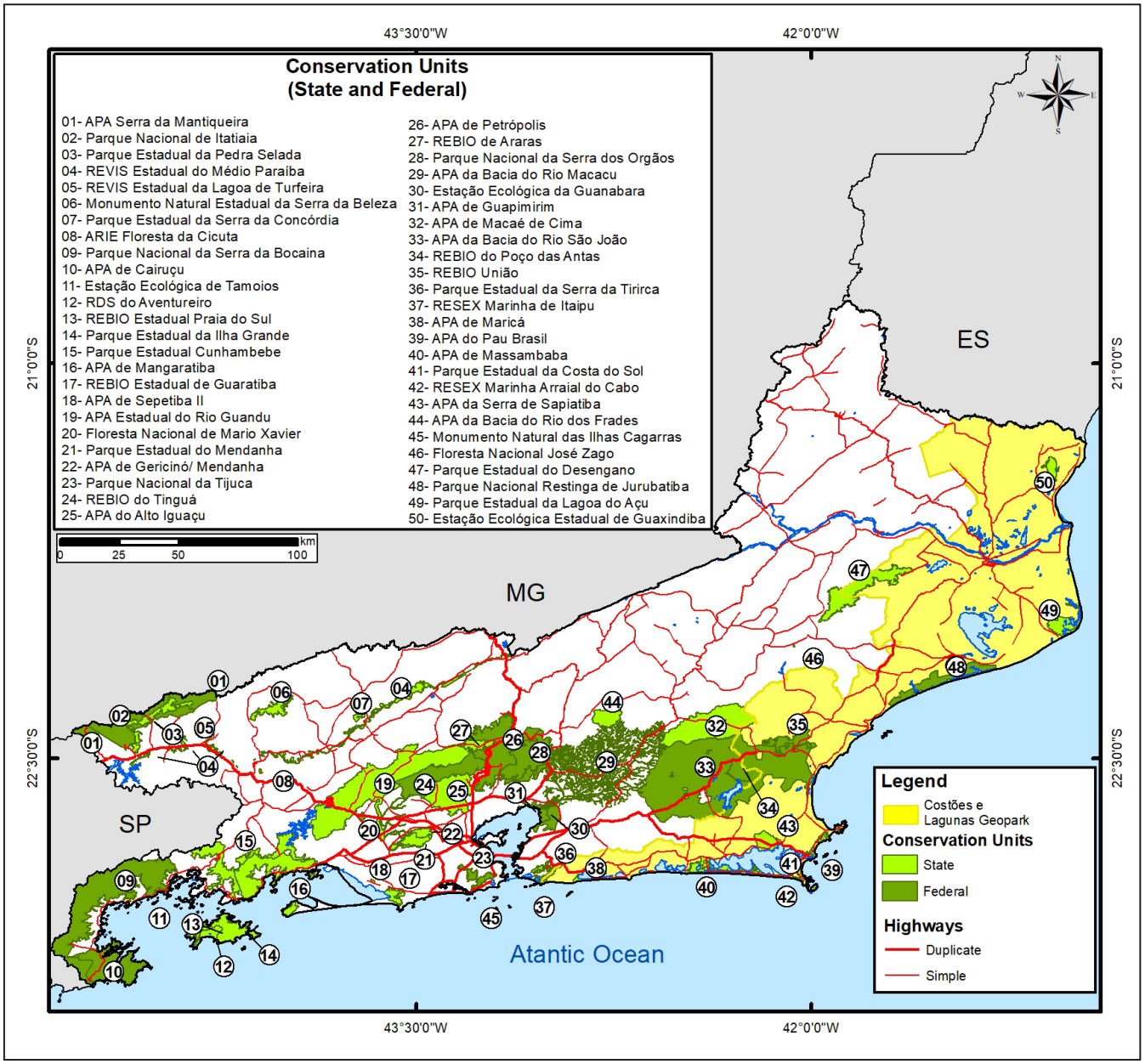

FIGURE 11. Map of Conservation Units of Rio de Janeiro

GHMRJ is an unprecedented initiative in Brazil. It can be adopted as a means of propagating geodiversity and encouraging geo tourism. It can be considered as new way of publicizing geotourism, bringing geoconservation of Rio de Janeiro's geodiversity into the spotlight. Moreover, it can be adopted in conservation and environmental preservation projects.

Acknowledgements

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References

Brasil. 2020. Ministério do Meio Ambiente. Cadastro Nacional de Unidades de Conservação. Brasília – DF. Available on line at: http://mapas.mma.gov.br/i3geo/datadownload.htm / (accessed on 05 April 2021).

Colorado Geological Survey (ed.) 2003. Colorado Geologic Highway Map. GTR MAPPING, Colorado.

DNIT. 2013. Mapa Multimodal. Rio de Janeiro. Brasília – DF. Available on line at: https://www.gov.br/dnit/pt-br/assuntos/planejamento-e-pesquisa/dnit-geo/mapas-multimodais / (accessed on 05 April 2021).

DRM-RJ. 2016. Cadastro da Atividade Mineral.

DNPM. 2016. Cadastro Mineiro das Áreas Requeridas. Available on line at: https://www.gov.br/anm/pt-br/assuntos/acesso-a-sistemas/cadastro-mineiro-1 / (accessed on 05 April 2021).

Girão R. S. 2020. Mapeamento geomorfológico do estado do Rio de Janeiro por modelagem do conhecimento. PhD Thesis, Instituto de Geografia, Universidade Federa Fluminense.

Gray M. 2004. Geodiversity: valuing and conserving abiotic nature. Chichester, Wiley-Blackwell, 434 p.

Gray M. 2013. Geodiversity: valuing and conserving abiotic nature. Londres, John Wiley & Sons.

Heilbron M., Eirado L.G., Almeida J. (ed.). 2016. Mapa geológico e de recursos minerais do estado do Rio de Janeiro. Escala 1:400.000. Belo Horizonte, CPRM-Serviço Geológico do Brasil. Available on line at: http://rigeo.cprm.gov.br/jspui/handle/doc/18458 / (accessed on 05 April 2021).

Heilbron M., Silva L.G.E., Almeida J.C.H., Tupinamba M., Peixoto C., Valeriano C.M., Lobato M., Rodrigues S.W.O., Ragatky C.D., Silva M.A., Monteiro T., Freitas N.C., Miguens D., Girão R. 2020. Proterozoic

to Ordovician geology and tectonic evolution of Rio de Janeiro State, SE-Brazil: insights on the central Ribeira Orogen from the new 1:400,000 scale geologic map. Brazilian Journal of Geology, 50, 1-25. DOI: 10.1590/2317-4889202020190099

Kamilli R.J., Richard S.M. (ed.) 1998. Geologic highway map of Arizona. Arizona Geological Society and Arizona Geological Survey. Tucson, Arizona.

Lamego A.R. 1940. Mármores do Muriaé. Rio de Janeiro, Departamento Nacional da Produção Mineral, Boletim Serviço Geológico e Mineralógico, 97, 1-47.

Mansur K.L. 2018. Patrimônio geológico, geoturismo e geoconservação: uma abordagem da geodiversidade pela vertente geológica. In: Guerra A. J. T., Jorge M. C. O. geoturismo, geodiversidade e geoconservação: abordagens geográficas e geológicas. Oficina de Textos, São Paulo, SP.

Mansur K.L., Erthal, F.L.C. 2003. Preservação do patrimônio natural – desdobramentos do projeto caminhos geológicos – RJ. In: Simpósio de Geologia do Sudeste, 8, Águas de São Pedro, SP, p. 235.

Mansur K.L., Guedes E., Alves M.G., Nascimento V., Pressi L.F., Costa Jr. N., Pessanha A., Nascimento L.H., Vasconcelos G. 2012. Geoparque Costões e Lagunas do Estado do Rio de Janeiro (RJ): proposta. In: Schobbenhaus C., Silva C. R. (org.). Geoparques do Brasil: propostas. Rio de Janeiro, CPRM, p. 687-745. v. 1. Available on line at: http://rigeo.cprm.gov.br/jspui/handle/doc/1209 / (accessed on 05 April 2021).

Matthews V. (ed.). 2009. Tourist guide to colorado geology. Colorado Geological Survey, Colorado.

Wilks M.E. (ed.). 2005. New Mexico Geologic Highway Map. New Mexico Geological Society and New Mexico Bureau of Geology and Mineral Resources, New Mexico.