






Geodiversity as part of Heritage Rivers: The Example of São Francisco, River of National Unity - Along the Stretch its River Source to the Casca d'Anta Waterfall

A Geodiversidade como Elemento dos Rios Patrimônio: O Exemplo do São Francisco, Rio da Unidade Nacional – da Nascente até a Cachoeira Casca d'Anta

Carmélia Kerolly Ramos de Oliveira¹ , Paulo de Tarso Amorim Castro¹ , Úrsula de Azevedo Ruchkys² , Diamantino Insua Pereira³  & Michael Vinicius de Sordi⁴ 

¹Universidade Federal de Ouro Preto, Programa de Pós-Graduação em Evolução Crustal e Recursos Naturais, Departamento de Geologia - Escola de Minas, Ouro Preto, MG, Brasil.

²Universidade Federal de Minas Gerais, Instituto de Geociências, Departamento de Cartografia, Programa de Pós-Graduação em Análise e Modelagem de Sistemas Ambientais, Belo Horizonte, MG, Brasil.

³Universidade do Minho, Instituto de Ciências da Terra, Braga, Portugal.

⁴Universidade Estadual do Oeste do Paraná, Departamento de Geografia, Francisco Beltrão, Paraná, PR, Brasil
E-mails: carmeliageo2008@gmail.com; ptcarso@gmail.com; tularuchkys@yahoo.com.br; insuad@dct.uminho.pt; michael.sordi@gmail.com

Resumo

Os rios são partes integrantes da geodiversidade e têm proximidade especial com a sociedade. O patrimônio fluvial é caracterizado por rios incomuns com aspectos singulares de geodiversidade, valores culturais e históricos e elementos ecológicos e paisagísticos de destacada qualidade cênica. Nesse contexto, o presente estudo visou identificar o conjunto de elementos ou lugares de interesse que poderiam ser utilizados para reconhecer o patrimônio fluvial baseado em valores de geodiversidade ao longo de um trecho de 17 km entre a cabeceira do Rio São Francisco e a Cachoeira da Casca d'Anta no Parque Nacional da Serra da Canastra (estado de Minas Gerais, Brasil). Aqui, sete elementos do patrimônio fluvial foram reconhecidos: i) Conjunto paisagístico da Serra da Canastra; ii) nascente histórica do rio São Francisco; iii) Curral de Pedras; iv) Cachoeira da Casca d'Anta; v) área de nidificação do Pato Mergulhão *Mergus octosetaceus*; vi) extração de diamantes; vii) o Queijo Canastra. Os elementos do patrimônio fluvial identificados ressaltam a importância ecológica, cultural, histórica e turística/econômica do trecho fluvial analisado. Além disso, tais elementos demonstram a necessidade de melhorias nas legislações existentes e instrumentos mais efetivos para a conservação e gestão dos rios e sua conservação.

Palavras-chave: Patrimônio fluvial; Rio São Francisco; Serra da Canastra

Abstract

Rivers are key parts of geodiversity and have special proximity with society. Hence, river heritage is characterized by uncommon rivers with singular aspects of geodiversity, historical and cultural values, ecological and landscape elements of high scenic quality. In such context, the present study aimed to identify the set of elements or places of interest which could be used to recognize river heritage based on geodiversity values along a 17 km stretch between São Francisco river headwaters and the Casca d'Anta waterfall within Canastra Range National Park (Minas Gerais State - Brazil). Here, seven elements of river heritage were recognized: i) landscape set of the Canastra Range; ii) São Francisco historic headwater; iii) Curral de Pedras; Casca d'Anta waterfall; v) Nesting area of the *Mergus octosetaceus*; vi) diamond mining; vii) the Canastra cheese. The identified elements of river heritage highlight the scientific, ecological, cultural, historic and touristic/economic importance of the analyzed stretch. Moreover, such elements illustrate need for improvement of the existing legislations and more effective instruments of river management and river conservation.

Keywords: River heritage; São Francisco River; Canastra Range

1 Introduction

A territory's identity is recognized by the register of natural and human processes through time. Therefore, integrating environmental and cultural heritage defines the essence of a territory (Ferrão & Braga, 2015). Historically, progress of society has close relation to rivers, initially by fishing and agriculture viability and subsequently by favoring commercial trades and production flow. The writer Mia Couto (Couto, 2005) defines herself as born in 'fluvial ground' since we are all tied to a 'waterland', and that is the reason why many communities use rivers as conductor elements and support for growth. Good examples come from the waterside communities developed along the Egyptian Nile River, which allowed the flourishing of the Old Egyptian Empire. Also, the Mesopotamians took advantage of the benefits from the Tiger and Euphrates rivers. Asian rivers were as well, fundamental to the organization of some of the most populous countries in the world; whereas Chinese arranged social and economic life around Yellow and Yang-Tsé rivers, India development was based on Indo and Ganges rivers.

Rivers are abiotic geodiversity elements of the landscape along with soils, rocks, caves and mountains. As components of geodiversity with closer relation to society, river relevance often transcends its functional values and gain heritage meaning attached to cultural, scientific, esthetic, educational, and touristic aspects – tying them to the geoheritage concept.

Although it is possible to find numerous rivers where there is a strong connection between local hydrography, nature, and culture, within Brazilian territory such rivers are not addressed through the heritage approach. Brazilian legislations protect rivers by different legal apparatus, which, in general, approach water quality for supply and recreational water quality assessment (Rodrigues & Castro, 2008).

Nowadays whereas different areas (politics, economy, ecology, environment, philosophy, arts...) dedicate to comprehend river complexity and background public policies (Vidal & Gandara, 2015), from the juridical angle there is no holistic approach on rivers and its elements (waterfalls, tributaries, river beds, outlets and headwaters). Hence, handling rivers by the heritage approach can contribute to the promotion of its cultural assets and waterside communities through tourism also playing a role to river conservation. Equally, Ferrão & Braga (2015) highlight water as the essential element of cultural landscape – understood as the focus of human-environment interrelations (natural and cultural assets).

Within the Brazilian territory, Minas Gerais State is highlighted for its vast fluvial network. Therefore, State government decided which rivers and river stretches should

be protected by law. The protected rivers are listed on the '*Lei Sobre os Rios de Preservação Permanente*' (law 15,082 from 27/04/2004). Nonetheless, there is no specific law that establishes procedures, criteria and means to the eligibility of the rivers and river stretches to permanent protection due to natural, historical, cultural and socioeconomical characteristics.

Therefore the present paper aims to identify the set of elements and places of fluvial heritage interest, based on geodiversity values (cultural, educational, scientific) proposed by Gray (2004; 2013), besides environmental (Pereira, 2006) and touristic values (Brilha, 2005). To do so, São Francisco River was analyzed along a 17 km stretch between its river source and the Casca D'Anta waterfall in the Parque Nacional da Serra da Canastra boundaries (Figure 1). São Francisco River runs for about 2,800 km from its headwaters to its outlet (Silva, 2017).

2 Rivers and Geoheritage

Geodiversity comprises Earth abiotic aspects (geology, geomorphology, hydrology and pedology), fundamental to comprehension and management of the land. Besides, it helps to preserve geological past heritage as well as natural landscape evolving processes, which continuously shape Earth's morphology (Brilha, 2005). Natural resources are also important to economy and social progress, from the utilization and transformation of minerals and energetic assets (Brilha *et al.*, 2018). Although economic and heritage uses are conflicting at first it is essential to seek for equilibrium between uses and protection of natural resources. To do so is vital to define relevance and geodiversity elements which need conservation.

Geoheritage represents geodiversity segment quantitatively associated to different demands of conservation and protection, i.e., geoheritage is a value carrying definition to identify specific elements of diversity selected to geoconservation (Brilha, 2018). Along with other nature components, elements of geodiversity exhibit several degradation levels, hence emerging the need of conserving them. Assigning values to geodiversity aspects is important to identify and classify geoheritage elements. Values related to geodiversity are intrinsic, cultural, esthetic, functional, scientific and didactic (Gray, 2004, 2013).

Several categories of heritage can be distinguished: geomorphological (landforms), petrological (rocks), mineralogical (minerals), paleontological (fossils), among others. Rivers and fluvial features, such as waterfalls, are fundamental in the context of the geomorphological heritage. Natural heritage also embraces a set of assets or areas with remarkable historical, environmental and cultural importance, which must be preserved for the future generations (Grandgirard, 1997).

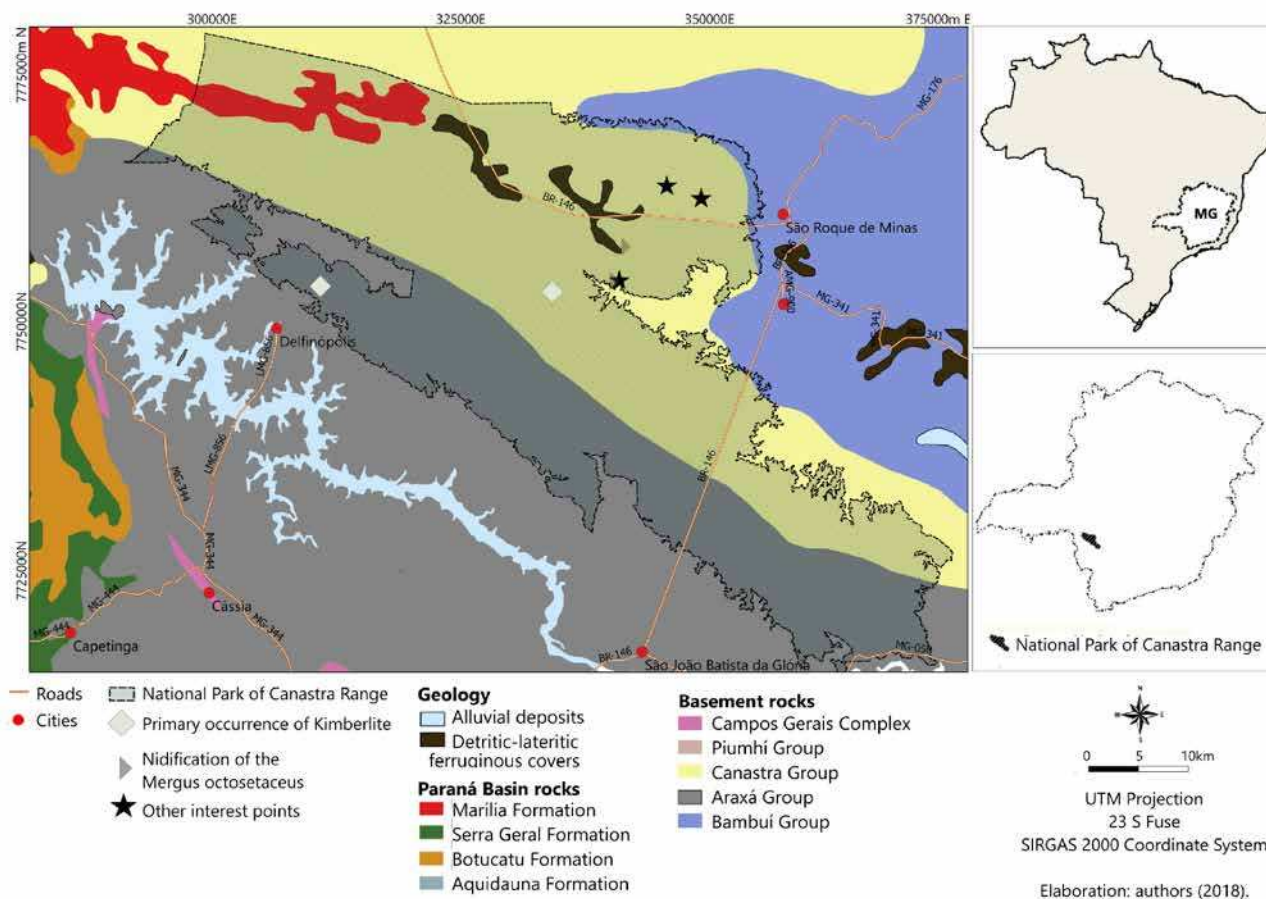


Figure 1 Geology and location of the Canastra Range National Park (CRNP) in the Minas Gerais and Brazilian context (left).

Earth’s fluvial networks account for some 1,2 billion channels and even so, there are no identical rivers. Also, rivers have different functionalities for the society. All this diversity constitutes a paramount and priceless heritage, characterized by very intricate dynamics, diversity and geomorphic, ecologic, environmental, and landscape complexity (Ollero, 2017). According to Ollero (2017) regardless functional relevance, better or worse ecological and scenic quality, channels, rills, gullies and rivers connect spaces and ecosystems and can be considered as the bigger and better green infrastructure anywhere in the planet.

Furthermore, fluvial heritage is not about common rivers, but rather rivers with singular aspects in terms of geological, geomorphological, historic and cultural values, ecology, and landscapes with high scenic quality. Fluvial heritage must consider the group of elements with different orders of values both along rivers and in their surroundings.

In this perspective there are some papers and software addressing the concept river heritage, which corroborate to identify and classify fluvial heritage, as well as the restauration and conservation of rivers and their biotic and abiotic elements (Brilha, 2005; Gray, 2013; Ahri, 2016;

Chrs, 2018). Established in 1984 the Canadian Heritage Rivers System (CHRS) is a national conservation program of Canadian rivers. The CHRS recognizes nationally rivers with good environmental quality and promote the long-term management in order to preserve natural, cultural and recreative values to the benefit and enjoyment of the population, for the present and future generations (Chrs, 2018). Other examples can be cited, like the American Heritage Rivers Initiative (AHRI) in the United States, a cooperative for conservation. In this initiative, the community engages to protect and maintain the natural environment, the economy and the local heritage. The AHRI was created by the Executive Order 13061 from 1997 and has three objectives: i) environmental and natural resources protection; ii) economy revitalization; iii) historical and cultural preservation (Ahri, 2016).

Heritage rivers are defined as rivers or river stretches which ecological conditions are maintained close to original in order to maintain complexity of the native flora and fauna (Marrero, 2016). These rivers are subject of restrictive rules regarding future interventions that may affect fluvial

systems and aquatic ecosystems. Restoration works are then based on nature ecologic and geomorphic principles.

Evaluation and classification of fluvial heritage is a transdisciplinary task, in which biotic, abiotic and cultural characteristics complement each other, allowing a holistic and integrated evaluation. Individually, rivers have a vital function although the analysis on river channels must extrapolate this concept and integrate ecological, socioeconomical, and geoconservation definitions of the aquatic environments. The term ‘River Heritage’ has the objective of bringing such integrated approach where all the elements within a fluvial segment coexist and complement each other, in such a way that protection policies are effective and complementary, never excluding.

3 Materials and Methods

Initially, in order to attain the proposed objectives a bibliographical revision on some key-definitions to the research such as geodiversity, geoconservation, geoheritage, heritage river was performed. Equally, historical maps and documents along with descriptions of naturalists were considered.

The later step consisted in a previous selection of elements and sites with their correlated geodiversity values along a 17 km section of the São Francisco River, from its headwaters to Casca d’Anta waterfall as proposed by Gray (2013). Sites of interest were selected based on (i) scientific; (ii) economic; (iii) cultural; (iv) esthetic; (v) environmental; (vi) educational; (vii) touristic values.

Fieldwork was carried to assess the conservation status, describe and photograph the sites, determine and classify fluvial heritage of the selected sites. The last step consisted in integration of literature and field data of the selected sites according the geodiversity values, present use, conservation status and acknowledgement of fluvial heritage values from the São Francisco River water source to the Casca d’Anta waterfall and its surroundings.

4 Results and Discussion

Geodiversity values (Gray, 2004) were analyzed for the following elements/sites: (Figure 2): Landscape set of the Canastra Range (Figure 3); São Francisco River headwater (Figure 4); Curral de Pedras ‘Rock Stable’ (Figure 5); Casca D’Anta waterfall (Figure 6); Nesting area

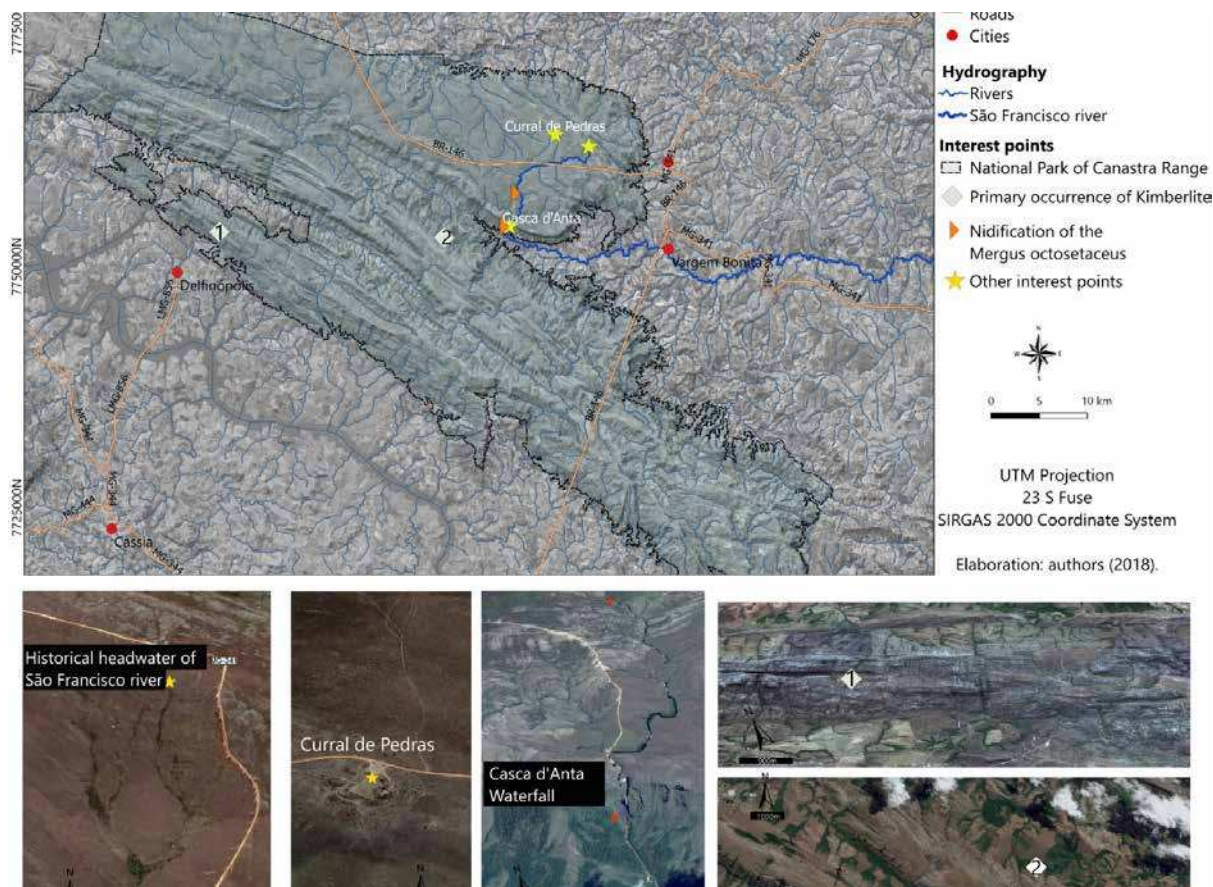


Figure 2 Elements and points with values for the geodiversity along the São Francisco river stretch between historic headwater and the Casca d’Anta waterfall.


Landscape set of the Canastra Range		
Values: scientific; esthetic; environmental; touristic	Present Uses Research, educational purposes (high school/university), tourism	Conservation Status: Good conservation despite intense touristic activity
		

Figure 3 Tableland within National Park of the Canastra Range. Picture by: Luciano J. Alvarenga.

of the *Mergus octosetaceus* (Figure 7); Diamond mining (Figure 8); Canastra cheese, a regional landmark included as an example of immaterial cultural heritage (Figure 9).

Scientific values: The Canastra range consists in a complex geological array with a set of hills and tablelands whose rocks were formed during geological events dating back to the Proterozoic (Chaves *et al.*, 2008, 2009). The area is marked by kimberlite intrusions and sedimentary deposits with diamond occurrence. Canastra range locates in a morphoclimatic transition zone between the Tropical-Atlantic half-orange shaped hills covered with tropical forests domain and Hinterland Tropical Plateaus covered with Cerrados (Brazilian savannah) and gallery forests domain (Ab’Saber, 2003). Considering morpho-structural compartmentation of the Meridional part of the São Francisco Craton and the Upper São Francisco catchment by Saadi (1991), the Canastra Range locates within marginal uplifted plateaus compartment. The author also relates Canastra summits with the South American Surface, an extensive erosion surface evolved afterwards Cretaceous sedimentation (Nazar, 2018).

The typical landscape of the Canastra range is composed by two main segments: Canastra Tableland and alternating tablelands, hillslopes and valleys. Canastra Range has a remarkable importance for the regional hydrodynamics, and it arises as a major water divide along the Brazilian plateau between the Paraná and São Francisco watersheds (Silva, 2017). At the Canastra Range, geological, geomorphological and hydrological complexity, along with the occurrence of diamond in primary rocks provide a priceless scientific value to the area.

Esthetic values: locally, scenic beauty refers to relief, rivers, waterfalls, wide grasslands, local fauna and flora. The landscape set of the Canastra Range invites to contemplation – all the magnificence, diversity and complexity of the Canastra are reported and mapped from centuries now. Saint-Hilaire, one of 19th Century main naturalists, in his expeditions to Minas Gerais (1847, 1975) describes the morphological exuberance of the Canastra Range:

“Déjà, avant d’arriver à Formiga, j’avais aperçu, à l’horizon, la Serra da Canastra. Cette montagne, qui, semblable à un immense coffre, présente, dans le lointain, sa masse imposante, paraît alors isolée, mais il n’en est réellement pas ainsi. Elle fait partie de la Serra das Vertentes, c’est-à-dire, comme on l’a vu tout à l’heure, de ce plateau élevé ou cette chaîne qui, du côté de l’ouest, borde le bassin du S. Francisco.” (Saint-hilaire 1847 p. 180).

The quartzites from the Canastra Group also play an important role to the scenic beauty of the area, on which abrupt escarpments were formed along the plateau borders with a diversified relief in its inner part. Canastra shows different landscapes, generally defined by their topographic aspects, surface materials and vegetation types (Nazar *et al.*, 2017).

Touristic value: Canastra range region has a natural predilection for tourism, due to its natural and cultural attractions. Within the Canastra Range National Park (CRNP), touristic activities are regulated, and include

trekking, river bathing and waterfalls, nature contemplation, and wildlife observation. Cities and populations near the CRNP have found alternatives for the development, which results in social and economic benefits for the region, as job creation, diversification of economic activities besides assisting the visitor’s demand of the region and the park (MMA, 2005).

Environmental value: the CRNP was created in 1972, and preservation of the São Francisco headwaters was one of the driving reasons, and that is why many of the landscapes described by Saint Hilaire remain almost untouched along the Canastra Range. The park’s area embraces the Cerrado biome with influence of the Atlantic Forest biome, and therefore is the habitat for several species like canários-da-terra (land canaries), tucanos (toucans), seriemas (*Cariama cristata*), carcarás (*Caracara plancus*) and the micos (capuchin monkeys), and rare species like the pato mergulhão (*Mergus octosetaceus*), onça parda (*Puma concolor*), tatu-canastra (*Priodontes maximus*), lobos-guará (*Chrysocyon brachyurus*), tamanduá-bandeira (*Myrmecophaga tridactyla*), veado-campeiro (*Ozotoceros bezoarticus*) which are part of the rich local fauna, besides more than 10,000 vegetal species identified on the Cerrado Biome.

Cultural value: São Francisco river valley have strong cultural and historical assets. Originally, Caetés indians named the river ‘Opará’ (river that looks like a sea, in the indigenous language). Nonetheless, Américo Vespúcio wanted to pay homage to the saint of humility

and nature and therefore, he named such natural beauty São Francisco river. Its headwaters are described by many naturalists and travelers that visited the region in the 19th century. Saint-Hilaire, one of the most iconic naturalists, made same important descriptions about the Canastra Range and the surroundings the São Francisco headwaters.

In 1975, after the park creation, a small monument was built to symbolic demarcate the São Francisco headwater, although there are several small streams that form the river. Regarding the immaterial heritage, the symbolic headwater of the São Francisco river is a place know by the local population and was used along the years for religious and cultural manifestations (MMA, 2005). São Francisco River is known as “the river of national unity”, due to its importance, extension and reconnaissance within Brazilian territory. In the 19th century, Brazil counted on the indispensable contribution of travelers, chroniclers, naturalists and engineers, which passed by and left a priceless legacy to the construction of national identity (Carvalho, 2012).

Educational Value: Canastra range is one of the most important water divides within Brazilian Territory and therefore São Francisco headwaters represents a place of interest for studies in elementary, high school, and university levels. Researches of different areas visit and study the region. Furthermore, fluvial ecosystems are complex and demand a holistic approach in order to understand and preserve river dynamics, its fauna, flora and human aspects. Integrating São Francisco headwaters within the CRNP

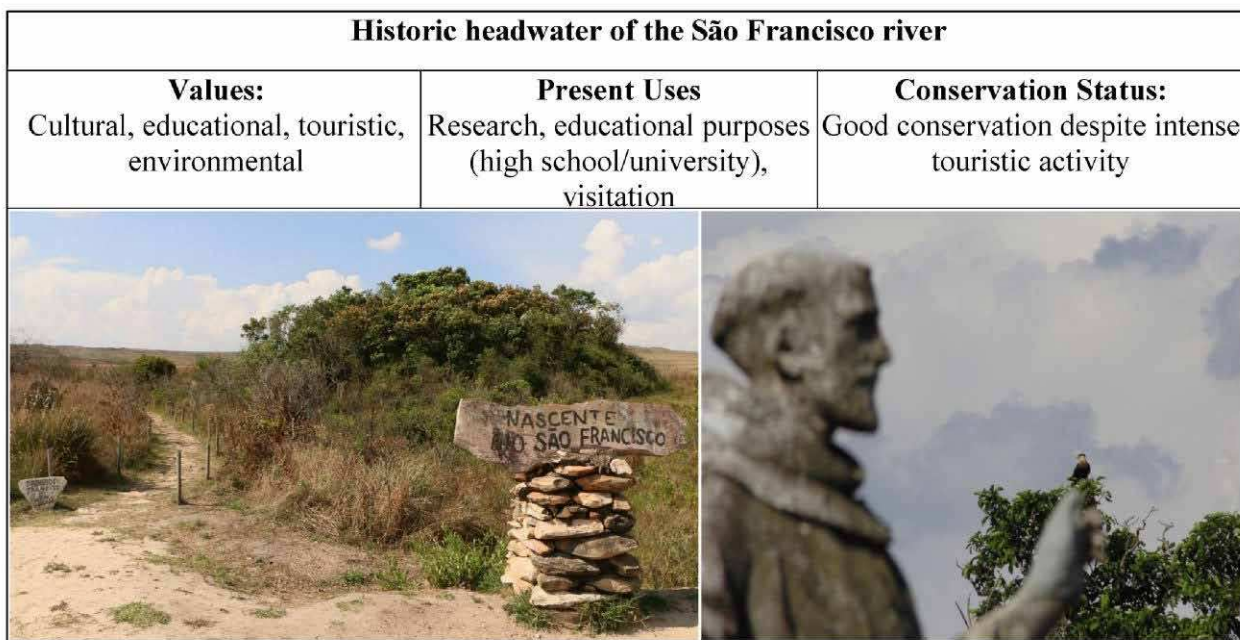


Figure 4 Historic headwater of the São Francisco river. Picture by: Luciano J. Alverenga.

limits contributes to maintain the natural aspects integrity and provides more knowledge about hydrological aspects of the region for visitors and researchers.

Touristic value: São Francisco water source creates a natural interest area for the mystery of the origin national unity river. It also contributes to give a holy connotation to the place. In a wide-open landscape, a small and lonely water flow springs and originates São Francisco River which will cross the most diversified landscapes, integrating Cerrados, Caatingas and tropical forests. Furthermore, the power of its waters generates electricity for a great part of Brazilian population (Liccardo & Mendes, 2001).

Environmental value: river headwaters are very heterogenous environmental systems products of regional and local biotic and abiotic conditions. In fact, São Francisco has many headwaters and the historical water source is one of them. Particularly, the source chosen as São Francisco’ historic water source is located on a hydromorphic grassland – a very fragile environment which demands special attention not be degraded (MMA, 2005).

Cultural value: the Curral de Pedras is a cultural expression of neighboring areas along the São Francisco riverbanks dating back to the 19th century. The structure

of the Curral represent a construction based on the dry joint “*junta seca*” method, which was locally developed to confine the cattle, troops, muleteers rest, aside from represent local geodiversity since they were built with quartzite rocks and outcrops. The Curral de Pedras is one of the few evidences of the human occupations in the region before the creation of the CRNP (MMA, 2005; Alvarenga et al., 2018).

Touristic value: the Curral de Pedras is one of the CRNP attractions accessed through the park’s main road. The rocks constitute a great and well-preserved round shaped two-ambient enclosure. The place is part of the basic itinerary departing from gate 1. This itinerary starts at the visitor’s center and pass through São Francisco historic source, the Curral de Pedras up to the higher section of the Casca d’Anta waterfall. Despite it is a very visited place and a must-stop point at the CRNP, it does not have signs or explanatory panels for the visitors.

Esthetic value: the Casca d’Anta waterfall locates along the Canastra Range borders and constitutes a scenery of paramount landscape beauty. Such exuberance and beauty were registered by Saint Hillaire 1847’ book “*Les sources du rivièrre São Francisco*”:


Curral de Pedras		
Values:	Present Uses	Conservation Status:
Cultural and touristic	Tourism, although there are no signs or explanatory panels	Good conservation despite intense touristic activity
		

Figure 5 Curral de Pedras. Picture by: Adriana Diniz.

“Depuis longtemps je savais confusément qu’il existait dans cette montagne ou dans son voisinage une cascade fort remarquable, mais personne n’avait pu me donner, à cet égard, aucun renseignement bien précis. [...] Enfin, après une marche extrêmement pénible, nous parvînmes au pied de la Cachoeira da Casca d’Anta, que nous découvriions déjà depuis long temps. [...] Nous nous enfonçâmes dans un bois, et bientôt nous commençâmes à entendre le bruit de la cascade. D’après des renseignements que l’on m’avait donnés quelques instants auparavant, je savais alors qu’elle tombait du côté méridional de la Serra da Canastra. Tout à coup j’en aperçus le sommet, et bientôt je la découvris tout entière, autant, du moins, qu’on peut la découvrir du lieu où nous étions. Ce spectacle nous arracha, à José Marianno et à moi, un cri d’admiration. A l’endroit où l’eau tombe, les rochers à pic de la montagne s’abaissent un peu à leur sommet et laissent voir une crevasse large et profonde qui, formant un zig zag, nous parut se prolonger dans les deux tiers de leur hauteur. Du point, encore très-élevé, où s’arrête la crevasse, s’épanche majestueusement une bellénappe d’eau dont le volume est plus considérable d’un côté que de l’autre. Le terrain qui s’étend incliné au-dessous de la cascade est fort inégal ; un mamelon, couvert d’un gazon verdoyant, cache la partie inférieure de la nappe d’eau, et, sur le côté droit, descend vers elle un bois d’une teinte sombre. Telle est la source du Rio de S. Francisco. [...] Je vais la peindre telle qu’elle s’offrit à mes regards, lorsque j’en fus aussi rapproché qu’il est possible. Au-dessus d’elle on voit, comme je l’ai dit, une large crevasse ; à l’endroit où elle tombe, les rochers forment une concavité peu sensible. [...] Je ne l’ai point mesurée ; mais, d’après l’estimation probablement très-approximative de M. d’Eschwege, elle aurait plus de 667 pieds anglais (203^o,23) (1). Elle ne se précipite point avec rapidité, mais elle présente une belle nappe d’eau blanche et écumeuse qui s’épanche lentement et qui semble formée par de larges flocons de neige. Ses eaux sont reçues dans un bassin demi-circulaire, bordé de pierres entassées sans ordre ; et de là, par une pente assez roide, elles s’écoulent pour former ce Rio de S. Francisco qui a près de 700 lieues de cours et reçoit une foule d’autres rivières. En tombant, les eaux de la Cachoeira da Casca d’Anta font un bruit que l’on entend d’assez loin, et en même temps elles produisent un brouillard extrêmement fin, que l’air, agité par leur chute, porte à une assez grande distance. [...] Pour sentir combien cet ensemble est ravissant, qu’on tâche

de se représenter la réunion de tout ce qui charme dans la nature; le plus beau ciel, des rochers élevés, une cascade majestueuse, les eaux les plus limpides, la verdure la plus fraîche, enfin des bois vierges qui présentent toutes les formes de la végétation des tropiques.” (Saint-Hilaire 1847, p. 180, 183, 187, 188).

Touristic Value: with 186 m high, Casca d’Anta is the São Francisco River highest waterfall and one of its main geomorphic features; it is also one of the main attractions of the CRNP. The waterfall is divided into two segments: the upstream part has calmer waters and an ideal pool to bathing. Downstream, the first section of the fall reveals a unique beauty. Downwards the waters flow through a rocky canyon to a free fall, shaping the paramount Casca d’Anta waterfall, with a huge and deep pool. At the higher segment, there is an observation deck that overview the great fall, São Francisco river riffles and the Canastra valley. Both the higher and lower section of Casca d’Anta have gates and infrastructure for tourists like signs, trails and toilets, besides a mirador with wonderful views.

Environmental value: the Casca d’Anta waterfall is described on the second volume of the Brazilian Commission of Geologic and Paleobiologic sites – SIGEP, as a site of geomorphic interest. Its importance grows bigger if the Canastra Range is understood as the cradle of the São Francisco, the river of national unity. Waterfalls are important elements of the geodiversity and therefore all waterfalls have special relevance (Oliveira *et al.*, 2017). Based on the waterfall relevance classification protocol proposed by Oliveira *et al.* (2017), Casca d’Anta is classified as a waterfall of extreme relevance. The referenced protocol evaluates the relevance of waterfalls based on criteria of environmental, esthetic, touristic, scientific and cultural orders (Table 1).

Scientific value: The CRNP presents great diversity of species, notable indices of endemism and rare species. The pato-mergulhão (*Mergus octosetaceus*) is recognized as the Brazilian waters symbol and is the unique representant of the Mergini tribe (Anatidae Family) in the Southern hemisphere, critically endangered at global scale with circa 250 individuals (Lins *et al.* 2011, Silva 2016). Between 2005 and 2015 17 nests of *Mergus octosetaceus* were found in the Canastra Range region along five different rivers (ten of these nests locate in São Francisco river whereas only three locate within the park).

Environmental value: environmental and topographic conditions of Canastra range are conducive for the *Mergus octosetaceus*, as it is one of the few Brazilian birds adapted to rivers of mountainous regions. It is a species found in low densities along crystalline bedrock rivers with riffles and waterfalls at elevations up to 1.300 m,

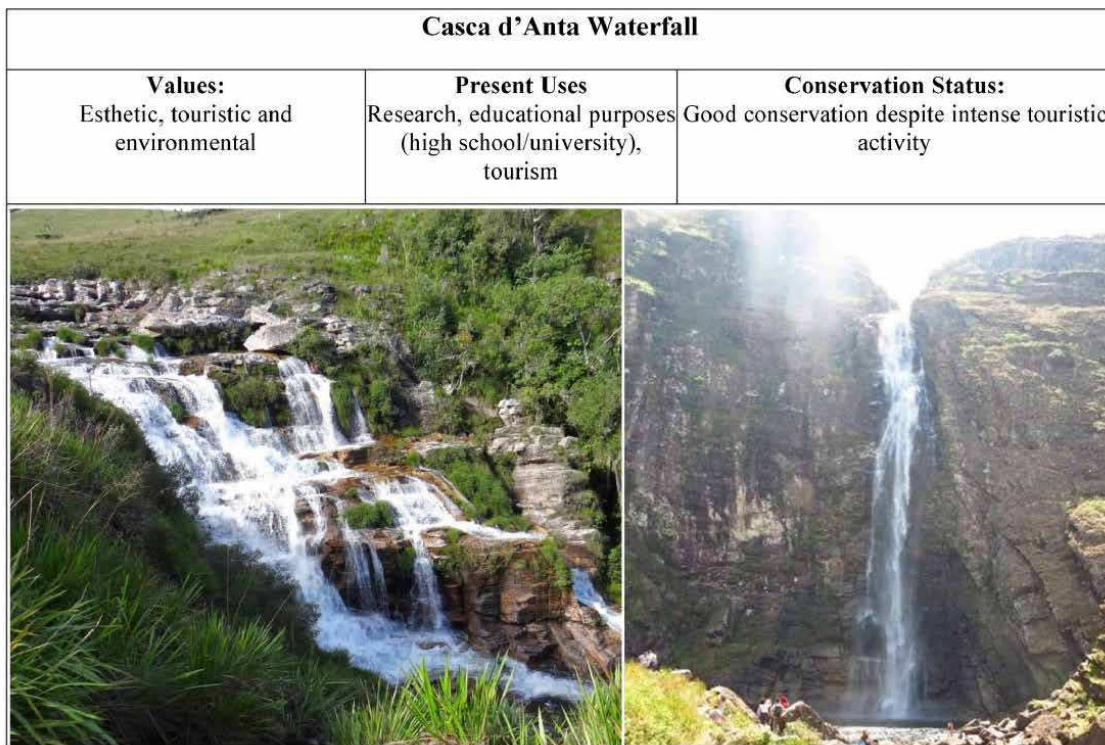


Figure 6 Higher section (left) and lower section (right) of Casca d'Anta waterfall. Picture from Blog Ademir Carosia e Daniel Duarte.

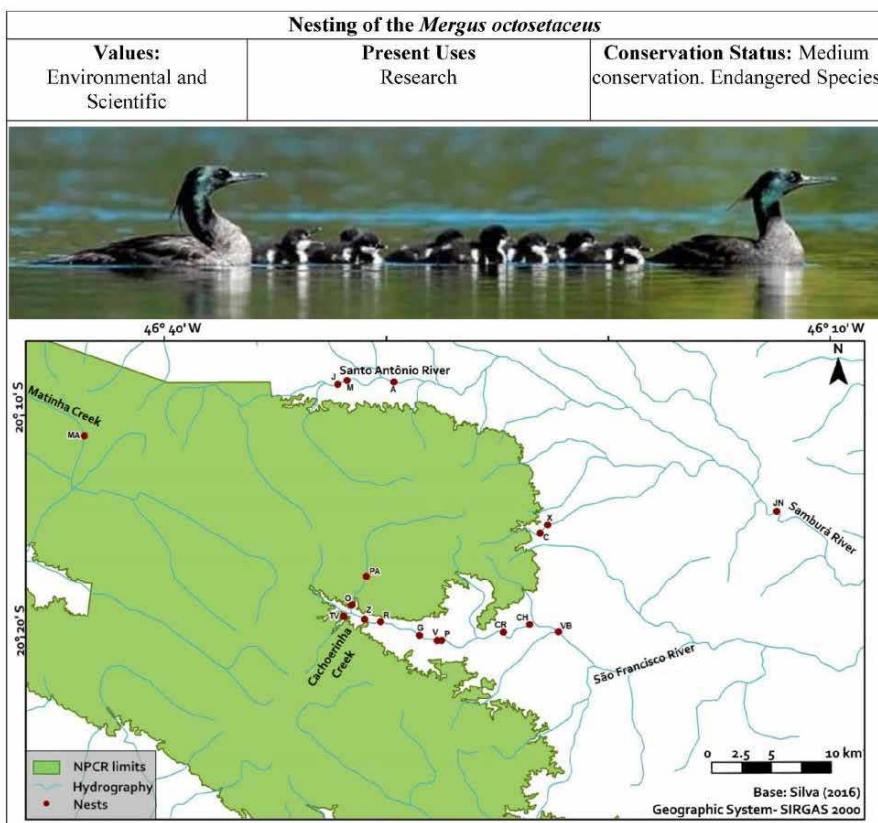


Figure 7 *Mergus octosetaceus* nest localization along the Canastra Range National Park region. Source: Silva (2016).

within areas of subtropical forests and Cerrados with gallery forests (Silva, 2016). The Canastra range stands out as a key-area for the conservation of the *Mergus octosetaceus* for it shelters the bigger and better-known population of this species, besides minimal environmental conditions for survival and species maintainability.

Scientific value: the Canastra range is one of the four diamond provinces within Minas Gerais state. The Canastra Range diamond province encompasses the south terminal area of the Brasília fold belt, surrounding western and southwestern borders of the São Francisco Craton, close to its junction to the fold belt of the Rio Grande High, which defines the Craton limits to the south and southeast (Benitez, 2009).

Kimberlitic intrusions are tectonically accommodated among the rocks of Canastra and Bambuí Groups, in close relation to the regional extension faults of NW-SE direction. Establishment of the mining competence of the Kimberlites Canastra-1 is a historic mark in the Brazilian geology as it refutes the hypothesis that kimberlites within the southwestern Minas Gerais State would be unproductive or already eroded (Benitez, 2009).

Within high São Francisco River diamond district which is almost equivalent do the “Canastra Region Diamond region” several diamond mining areas based on alluvial deposits are identified. The main areas locate along Vargem Bonita, and Samburá rivers, tributaries of São Francisco, whilst three others, along Santo Antônio River (Rio Grande watershed), Quebra Anzol, and Misericórdia are tributaries of Paranaíba river (Benitez & Chaves, 2007; Benitez, 2009).

Economic value: the area is economically relevant for it embraces the first diamond mine proven to be a primary rock font within high São Francisco River. The mines locate in the cities of São Roque de Minas (Kimberlites Canastra-1), and Delfinópolis (kimberlites Canastra-8) (Benitez, 2009). Diamond mining has always had remarkable importance along Canastra Range, and more than five thousand people worked in the area around 1940. Diamonds from Canastra Range province are one of the Brazilian’s most valuable for its octahedral rocks of elevate purity level and gemology colors known in the trade market as Canastra-type Diamond (Benitez & Chaves, 2007, Benitez, 2009).

Cultural value: Considered as Brazilian immaterial heritage by the IPHAN (National Artistic and Historic Heritage Institute) (IPHAN, 2008), the Canastra Cheese from Minas Gerais state is handmade and has an exclusive 150 years-old formula with admirers all over the globe. In his descriptions from visits to the Minas Gerais state Auguste Saint-Hilaire (1847, 1975) described the cheese

consumption and the high quality of this product, referring to it as component of the region sociability, as cuisine ingredient and as a trade product.

“[...] Aussitôt qu’on a tiré le lait, on y met de la présure, et il caille à l’instant; on donne La préférence à celle de capivara (cabiais) , lorsqu’il est possible de s’en procurer. On a des moules en bois d’environ 2 pouces de haut, dont le milieu présente un espace circulaire entièrement évidé, à peu près de la grandeur d’une assiette. Ces moules se placent sur une table étroite dont le plan est incliné. On les remplit de lait caillé, que l’on a eu soin de séparer en petits morceaux ; on presse avec la main cecaillé ainsi égrumelé : le petit-lait s’échappe, et il va tomber dans une gamelle placée au-dessous du bout de la table le moins élevé. A mesure que le caillé s’affaisse dans Le moule, on en remet de nouveau ; on recommence à presser, et l’on continue jusqu’à ce que le moule soit plein de caillé bien pressuré. On couvre de sel le dessus du fromage, et on le laisse ainsi jusqu’au soir; alors on le retourne, et on couvre l’autre côté de sel. Le lendemain, on expose le fromage à l’air dans un endroit ombragé; on a soin de le retourner de temps en temps , et il est fait avant l’espace de huit jours (Saint-Hilaire, 1847, p. 71-72).

The aspect and the flavor of each cheese is unique due to its handmade production and the natural microclimate conditions of the area which yield the ideal conditions to the development of specific bacteria and the typical landscape of the Canastra range.

Economic value: Habits, traditions, cultural manifestations and socio-economic relations have developed around the Canastra cheese. The Canastra Cheese production is one of the region main economic activities, especially on the rural area (MMA, 2005). Only seven cities (BambuÍ, Delfinópolis, Medeiros, Piumhi, São Roque de Minas, Vargem Bonita and TapiraÍ) earned the stamp for geographical indication title which gives the cheese produced in these cities the Canastra cheese authenticity stamp. Although the cheese production area does not match exactly the CRNP area, it corresponds to the park’s surroundings cities.

After the overmentioned examples, the understanding of the geodiversity elements and their values along the analyzed stretch of the São Francisco River becomes clearer. The stretch inside de PNCR is undoubtedly an important example of fluvial river heritage for it embraces different scenarios, values and functions of the same river (table 1).

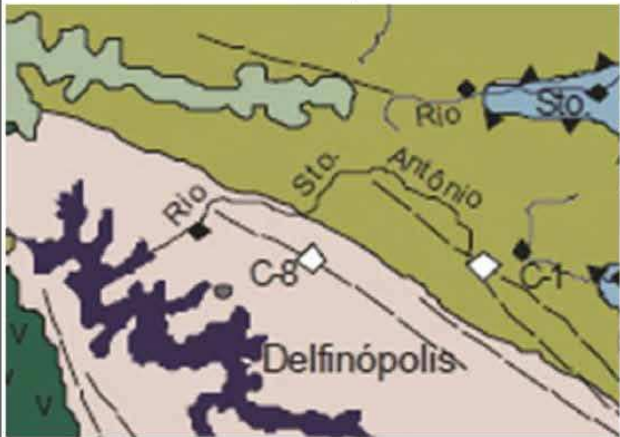

Diamond mining (Diamond formation and occurrence (kimberlite + alluvion))		
Values Scientific and economical	Present Uses No intense exploration activity	Conservation Status No activity mines, interest conflicts between park area and mining enterprises
		

Figure 8 Primary occurrence of Canastra-1 e Canastra-8 kimberlite provinces; Picture of Canastra I Mine - Samsul mineração. Source: Benitez (2009).



Canastra Cheese		
Values: Economic and Cultural	Present Use: Immaterial heritage	Conservation Status: Does not apply
		

Figure 9 Cities with production stamp; Canastra cheese. Source: EMATER (2004).

Table 1 Relation between geodiversity values tied to the fluvial heritage

Analyzed Sites	Geodiversity values	Associated elements
Landscapes set of Canastra Range	Scientific	Biotic and abiotic diversity
	Esthetic	
	Touristic	
	Environmental	
	Cultural	
São Francisco river water source	Cultural	River maintainability
	Educational	
	Touristic	
Curral de Pedras	Environmental	Troops and herd shelter
	Cultural	
	Touristic	
Casca d'Anta Waterfall	Esthetic	Canastra Range symbol/visitation
	Touristic	
<i>Mergus octosetaceus</i> nidification	Environmental	Species protection
	Scientific	
Diamond Mining	Scientific	Diamond formation and occurrence (kimberlite + alluvial deposits)
	Economic	
Canastra Cheese	Cultural	Cheese production process
	Cultural	

5 Final Considerations

River heritage embraces geo and biodiversity elements, vital and social functions, therefore river values are given by the reconnaissance of such elements. Water stands out as the first element to study in a river, for is tied directly to the life preservation. Notwithstanding the heritage value of a river is beyond its bed and water sheet – it embraces all the river surroundings elements, i.e., rivers emerge as the bond between water, margin and communities.

This paper aimed to reinforce the geodiversity values traditionally attached to the stretch between São Francisco river headwaters and the Casca d'Anta waterfall as well as recognize new ones. It is clear the need of expanding this type of analysis to other stretches of the São Francisco River and to other rivers. Attach heritage values to rivers and river stretches through identification of values helps protect river heritage by the proposition of more effective legislations and appropriate planning and management of hydric resources and fluvial environments, besides secure fluvial heritage for the future generations.

São Francisco has cultural relevance and its importance goes beyond common water uses (navigation, energy generation and irrigation). From its headwaters to its mouth, the river runs through cities, communities, cultures and rites, pass through several lithologies and

landscapes and its richness is carved in its riverbed and margins. Recognition of São Francisco river heritage is the recognition of the own river in its essence and fundamental environmental and cultural functions.

According to Minas Gerais state law 14007, from 04/10/2001 (ALMG, 2001) São Francisco River is acknowledged as cultural, landscape and touristic heritage of Minas Gerais State, and the river and is an area of permanent conservation after the law 15082 from 27/04/2004 (ALMG, 2004). Some stretches are within conservation units as the case of Canastra Range National Park. Geological, morphological and biological aspects of the Canastra Range constitute legitim conditions of natural heritage, as they corroborated to create the CRNP and to indicate it as a Geopark for the Brazilian Geological Service (CPRM) (Schobbenhaus & Silva, 2012). Nevertheless, existing legislations do not present clear and specific criteria for the heritage recognition of rivers, and the real status of the São Francisco River shows the need of more effective instruments of management and conservation.

Initiatives and conservation efforts are necessary to complement existing legislations, besides favoring a holistic approach of the rivers. As complementary action to the CRNP, the cultural landscape official reconnaissance is suggested (Alvarenga *et al.*, 2018). The cultural landscape reconnaissance is a juridical instrument to protect the aspects

of biodiversity, geodiversity and culture and furthermore helps to obtain the Geopark title from UNESCO (Alvarenga et al., 2018).

Foremost, identify fluvial heritage is to determine elements and factors related to physical, ecological, biological, and social equilibrium of rivers or river stretches. Although it is still a complex task due to its broad approach and integration to environmental sciences, a river is priceless, so recognize fluvial heritage is crucial to identify pressures and impacts in order to propose efficient conservation measures.

The stretch of the São Francisco River within the Canastra Range National Park presents scientific, cultural, environmental, economic, and scenic values, and their identification corroborates to the recognition of river heritage, for it has some very singular aspects. Therefore, river heritage integrates the intrinsic importance of a river and its surroundings' natural and cultural elements, besides representing the identity of the local communities and their social relations.

6 Acknowledgements

The authors would like to thank FAPEMIG for the doctoral scholarship granted to Carmélia Oliveira and CNPQ for the Level 2 Research Productivity Grant for Úrsula Ruchkys and Paulo de Tarso Amorim Castro.

7 References

- Ab'Saber, A.N. 2003. São Paulo: *Ensaio e Entrevistos*. São Paulo: Editora da Universidade de São Paulo/ Imprensa Oficial do Estado de São Paulo, 522 p.
- Ahri. 2016. *American Heritage Rivers Initiative*. Available at: <<http://www.cooperativeconservation.org/viewproject.aspx?id=916>>. Accessed: October 22, 2016.
- Alvarenga, L.J.; Castro, P.T.A.; Bernardo, J.M. & Campos, I.C. 2018. Paisagem cultural e geoconservação: contributos conceituais aplicados na Serra da Canastra, Brasil. *Anuário do Instituto de Geociências*, 41(2): 241-251.
- ALMG. 2001. Assembleia Legislativa de Minas Gerais. *Lei 14007, 4 de outubro de 2001*. Declara o Trecho Mineiro Do Rio São Francisco Patrimônio Cultural, Paisagístico e Turístico do Estado e dá outras Providências.
- ALMG. 2004. Assembleia Legislativa de Minas Gerais. *Lei 15082, 27 de abril de 2004*. Dispõe sobre Rios de Preservação Permanente e dá outras Providências.
- Benítez, L. & Chaves, M.L.S.C. 2007. Província diamantífera da Serra da Canastra (Minas Gerais). In: 14º Simpósio de Geologia de Minas Gerais, Diamantina. Livro de Resumos do 14º SGMG, v. 1, p. 138-138.
- Benítez, L. 2009. *Províncias diamantíferas de Minas Gerais: uma proposta para a caracterização de populações de diamantes típicas como subsídio à Certificação Kimberley* [manuscrito]. Tese. Universidade Federal de Minas Gerais. Instituto de Geociências, 223 p.
- Brilha, J. 2005. *Patrimônio geológico e geoconservação: a conservação da natureza na sua vertente geológica*. São Paulo: Palimage editora. 144 p.
- Brilha, J. 2018. Geoheritage: inventories and evaluation. In: REYNARD, E. & BRILHA, J. (ORG.). *Geoheritage: assessment, protection and management*. 1ed.: Elsevier, p. 69-85.
- Brilha, J.; Gray, M.; Pereira, D.I. & Pereira, P. 2018. Geodiversity: An integrative review as a contribution to the sustainable management of the whole of nature. *Environmental Science & Policy*, 86: 19-28.
- Carvalho, F.A. 2012. *Entre a palavra e o chão: memória toponímica da Estrada Real*. Tese (Doutorado em Semiótica e Linguística Geral) - Faculdade de Filosofia, Letras e Ciências Humanas, Universidade de São Paulo, doi:10.11606/T.8.2012.tde-14032013- 101812.
- Chaves, M.L.S.C.; Brandão, P.R.G.; Girodo, A.C. & Benitez, L. 2008. Kimberlito Canastra-1 (São Roque de Minas, MG): geologia, mineralogia e reservas diamantíferas. *Revista da Escola de Minas*, 61: 357-364.
- Chaves, M.L.S.C.; Benitez, L.; & Andrade, K.W. 2009. Cachoeira da Casca D'Anta, São Roque de Minas, MG - Berço do Velho Chico, o Rio da Integração Nacional. In: WINGE M. ETAL. (Eds.) *Sítios Geológicos e Paleontológicos do Brasil*, Brasília: CPRM, v. 2. 515 p.
- Chrs. 2018. *Canadian Heritage Rivers System*. About the CHRS. Available at: <<http://chrs.ca/>>. Accessed: 18 abr. de 2018.
- Couto, M. 2005. Moçambique - 30 Anos de Independência: No Passado, o Futuro era Melhor. *Via Atlântica*, 8: 191-204.
- EMATER. 2004. Empresa de Assistência Técnica e Extensão Rural de Minas Gerais. *Caracterização da Microrregião da Canastra como Produtora de Queijo Minas Artesanal. São Roque de Minas*. 20 p. Available at: http://www.emater.mg.gov.br/doc/intranet/upload/queijo_historico/caracteriza%3a7%3a3o%20do%20queijo%20canastra.pdf. Accessed: 20 jan, de 2018.
- Ferrão, A.M.A & Braga, L.M.M. 2015. Gestão Integrada de Bacias Hidrográficas: paisagem cultural e parques fluviais como instrumentos de desenvolvimento regional. *Confins*, 23: 1-13.
- Grandgirard, V. 1997. *Géomorphologie, protection de la nature et gestion du paysage*. Thèse de doctorat N.º 1163, Université de Fribourg, Institut de Géographie.
- Gray, M. 2004. *Geodiversity: valuing and conserving abiotic nature*. Londres: John Wiley e Sons Ltd, 448 p.
- Gray, M. 2013. *Geodiversity - Valuing and Conserving Abiotic Nature*. 2th ed. Wiley Blackwell, Chichester, 495 p.
- IPHAN. 2008. Instituto do Patrimônio Histórico e Artístico Nacional. *Titulação de patrimônio cultural do Brasil ao modo artesanal de fazer queijo de Minas nas regiões do Serro, da Serra da Canastra e Salitre/Alto Paranaíba*. 142 p. Available at: http://portal.iphan.gov.br/uploads/publicacao/dossie_queijo_de_minas_web.pdf. Accessed: 20 jan. de 2018.
- Liccardo, A. & Mendes, J.C. 2001. *Saint-Hilaire nas Nascentes do São Francisco*. 1. ed. Ouro Preto - MG: Independente. v. 1. 74 p.

- Lins, L.V.; Andrade, R.D.; Ribeiro, F. & Rigueira, S.E. 2011. Distribuição e biologia reprodutiva do pato-mergulhão (*Mergus octosetaceus*) na região da Serra da Canastra, Minas Gerais. *MG. Biota*, 4(3): 4-33.
- Marrero, N.J.S. 2016. *Programa de Ríos Patrimoniales, Ríos de Alto Valor Natural y Ríos Recreacionales*. Departamento de Recursos Naturales y Ambientales (DRNA) e División de Protección Ambiental del Caribe de la Agencia federal de Protección Ambiental (EPA). 81 p. Available at: https://data.fs.usda.gov/research/pubs/iitf/iitf_gtr_50_spa_lowres.pdf. Accessed: 02 mar. 2017.
- MMA. 2005. Ministério do Meio Ambiente. *Plano de manejo: Parque Nacional Serra da Canastra*. 104 p. Available at: https://www.icmbio.gov.br/portal/images/stories/imgs-unidades_coservacao/pm_pnsc_resumo_executivo.pdf. Accessed: 12 mai. De 2018.
- Nazar, T.I.S.M.; Silva, G.A. & Rodrigues, S.C. 2017. Chapadão do Diamante, Serra da Canastra-MG: um olhar sobre a geodiversidade. In: XVII Simpósio Brasileiro de Geografia Física Aplicada, 2017, Campinas/SP. Anais Campinas. v. XVII, 01-12.
- Nazar, T.I.S.M. 2018. *O Chapadão do Diamante na Serra da Canastra/MG, Brasil: caracterização geomorfológica e análise integrada do meio físico a partir de dados multífontes*. Tese (Doutorado) – Universidade Federal de Uberlândia, Programa de Pós-Graduação em Geografia, 270 p.
- Oliveira, C.K.R.; Salgado, A.A.R. & Lopes, F.W.A. 2017. Proposta de Classificação de Relevância de Quedas D'Água como Subsídio à Conservação do Patrimônio Natural. *Revista Brasileira de Geomorfologia*, 18: 465-481.
- Ollero, A. 2017. *Hidrogeomorfología y geodiversidad: el patrimonio fluvial*. Centro de Documentación del Agua y del Medio Ambiente, Ayuntamiento de Zaragoza, 111 p. Available at: <http://www.zaragoza.es/contenidos/medioambiente/cda/Ollero17.pdf>. Accessed: 13 fev. 2017.
- Pereira, P.J.S. 2006. *Patrimônio geomorfológico: conceptualização, avaliação e divulgação. Aplicação ao Parque Nacional de Montesinho*. Tese. (Doutorado em Ciências – Geologia). Universidade do Minho. Portugal. 395 p.
- Rodrigues, A.S.L. & Castro, P.T.A. 2008. Protocolos de avaliação rápida: instrumentos complementares no monitoramento dos recursos hídricos. *Revista Brasileira de Recursos Hídricos*, 13(1): 161-170.
- Saint-Hilaire, A. 1847. *Voyages dans l'intérieur du Brésil. Troisième Partie, Voyage aux sources du Rio de S. Francisco et dans la province de Goyaz*. Paris: Arthus Bertrand. v 2.
- Saint-Hilaire, A. 1975. *Viagem as Nascentes do Rio São Francisco*. Tradução Regina Regis Junqueira. Belo Horizonte/São Paulo: Ed. Itatiaia/EDUSP.
- Schobbenhaus, C. & Silva, C.R. 2012. O papel do Serviço Geológico do Brasil na criação de geoparques e na conservação do patrimônio geológico. In: SCHOBHENHAUS C. AND SILVA CR (Eds.). *Geoparques do Brasil: propostas*, vol. 1. Rio de Janeiro, CPRM, p.11-28.
- Silva, A.C.A.B. 2017. *As águas do rio São Francisco: disputas, conflitos e representações do mundo rural*. Tese de Doutorado – Universidade Estadual de Campinas, Instituto de Filosofia e Ciências Humanas. 406 p.
- Silva, F. 2016. *Biologia Reprodutiva do Pato-mergulhão Mergus octosetaceus na região do Parque Nacional da Serra da Canastra, Minas Gerais, Brasil*. Dissertação de Mestrado em Ecologia (Conservação e Manejo da Vida Silvestre) - Universidade Federal de Minas Gerais.
- Vidal, L. & Gandara, G.S. 2015. Geohistória das cidades e rios (Brasil, Estados Unidos). Paris: (Dossier presentation of São Francisco river Revue Confins Paris). *Confins* 23: 1- 4.

Received: 3 October 2020

Accepted: 4 December 2020

How to cite:

Oliveira, C.K.R.; Castro, P.T.A.; Ruchkys, U.A.; Pereira, D.I. & Sordi, M.V. 2021. A Geodiversidade como Elemento dos Rios Patrimônio: O Exemplo do São Francisco, Rio da Unidade Nacional - da Nascente até a Cachoeira Casca d'Anta. *Anuário do Instituto de Geociências*, 44: 38723. DOI 1982-3908_2021_44_38723