Are there geogenic relationships for Lithium between geology, geochemical anomalies and low levels of violence in the region of Guanambi, State of Bahia, NE Brazil?

Existem relações geográficas para o Lítio entre geologia, anomalias geoquímicas e baixos níveis de violência na região de Guanambi, Estado da Bahia, NE do Brasil?

DOI:10.34117/bjdv8n4-616

Recebimento dos originais: 21/02/2022
Aceitação para publicação: 31/03/2022

Manoel Jerônimo Moreira Cruz
Doutor em Geologia pela Universidade Paris VI, França
Instituição: Instituto de Geociências, Universidade Federal da Bahia
Endereço: Av. Milton Santos S/N, Campus Universitário Ondina, CEP.40.170-110
Salvador, Bahia, Brasil
E-mail: jeronimo@ufba.br

Lana Carolina Sena Pena
Mestre em Geoquímica e Meio Ambiente,Pospetro
Instituição: Universidade Federal da Bahia
Endereço: Av. Milton Santos S/N, Campus Universitário Ondina, CEP.40.170-110
Salvador Bahia, Brasil
E-mail:lanasenacaroline@gmail.com

Olga Maria Fragueiro Otero
Doutor em Geologia UFBA
Instituição: Instituto de Geociências Universidade Federal da Bahia
Endereço: Av. Milton Santos S/N, Campus Universitário Ondina, CEP.40.170-110
Salvador Bahia, Brasil
E-mail:ofotero@gmail.com

Maria Orquídia Teixeira Neves
Doutor em Engenharia Geológica
Instituição: DECivil/CERENA, Instituto Superior Técnico, Universidade de Lisboa
Endereço: Av. Rovisco Pais, Nº 1, 1049-001, Lisboa - Portugal
E-mail: orquidia.neves@tecnico.ulisboa.pt

Manuel Vitor Portugal Gonçalves
Doutor em Geologia UFBA
Instituição: Universidade Católica do Salvador (UCSAL)
Endereço: Av. Prof. Pinto de Aguiar, 2589 - Pituaçu, Salvador - BA, 41740-090
E-mail: hidrovitor81@gmail.com

ABSTRACT

Lithium has been applied for therapeutic purposes in the treatment of mental health disorders, such as bipolar affective disease, in the prevention of behaviour changes, and may be related, to some extent, to the reduction of suicide and violence. In Brazil, the main occurrences of lithium are found in the east/northeast region. In the Guanambi domains, in south-central Bahia, until recently, there were no references to lithium occurrences. The geology of the region is characterized by the monzo-syenitic batholith of Guanambi and its associated late intrusions (2.05Ga), where important manifestations of a pneumatolithic character are described. There are also evaporitic levels, interspersed with carbonate members of the São Francisco Supergroup (Bambuí Group - 650Ma). The Geological Survey of Brazil (CPRM) carried out an extensive geochemical survey, sampling and analysing water, sediments and soils. The geostatistical treatment and interpretation of these data revealed the existence of lithium anomalies in the Guanambi domains, in sites that spatially overlap the rocks of the Guanambi batholith and the carbonate rocks of the Bambuí Group. According to Atlas da Violência (2019), in Guanambi the homicide rate was 30.8 deaths per 100,000 inhabitants, that is, it is lower than the average homicide rate in Brazil (31.6 deaths per 100,000 inhabitants), or the average rate in Bahia (48.8 deaths per 100,000 inhabitants). The relationships between lithium and health can be addressed by medical geochemistry. This article is relevant to the community of geoscientists and health planners, whose objective is to investigate the hypothesis put forward of the effective relationship between geogenic lithium levels and the homicide rate in these sites in the State of Bahia.

Keywords: lithium, medical geology, violence, guanambi.

RESUMO

O lítio tem sido aplicado para fins terapêuticos no tratamento de distúrbios de saúde mental, tais como doenças afetivas bipolares, na prevenção de mudanças de comportamento, e pode estar relacionado, em certa medida, à redução de suicídio e violência. No Brasil, as principais ocorrências de lítio são encontradas na região leste/nordeste. Nos domínios do Guanambi, no centro-sul da Bahia, até recentemente, não havia referências a ocorrências de lítio. A geologia da região é caracterizada pelo batholito monzo-senítico de Guanambi e suas intrusões tardias associadas (2,05Ga), onde são descritas importantes manifestações de caráter pneumatolítico. Há também níveis evaporíticos, intercalados com membros carbonatados do Supergrupo São Francisco (Grupo Bambuí - 650Ma). A Pesquisa Geológica do Brasil (CPRM) realizou um extenso levantamento geoquímico, amostragem e análise de água, sedimentos e solos. O tratamento e interpretação geoestatística destes dados revelou a existência de anomalias de lítio nos domínios do Guanambi, em locais que se sobrepõem espacialmente as rochas do batholito Guanambi e as rochas carbonatadas do Grupo Bambuí. Segundo Atlas da Violência (2019), em Guanambi a taxa de homicídios foi de 30,8 mortes por 100.000 habitantes, ou seja, é inferior à taxa média de homicídios no Brasil (31,6 mortes por 100.000 habitantes), ou à taxa média na Bahia (48,8 mortes por 100.000 habitantes). As relações entre lítio e saúde podem ser tratadas pela geoquímica médica. Este artigo é relevante para a comunidade de geocientistas e planejadores de saúde, cujo objetivo é investigar a hipótese apresentada da relação efetiva entre os níveis geogênicos de lítio e a taxa de homicídios nestes locais no Estado da Bahia.

Palavras-chave: lítio, geologia médica, violência, guanambi.

1 INTRODUCTION

The name lithium comes from the Greek lithos, which means stone. It is a lithophilic chemical element, according to the Goldschmidt classification, which occupies 32% in abundance in the earth's crust, occurring in a geogenic way in part: i) in mineral phases such as spodumene, lepidolite, petalite, amblygonite, montebrasite and eucryptite (LEE,1999), ii) on the other hand, replacing magnesium in the mineral's pyroxene, amphibole and biotite, so that it will be more pronounced as a function of temperature.

In this sense, the chemical weathering of minerals whose chemical composition contains Lithium supplies it to soils, sediments, water, dust, biota, that is, to surface geochemical reservoirs in ecosystems. Lithium is a light metal with a high oxidizing power and is often found in various salts or dissolved in water. Kabata-Pendias and Pendias (2011) point out that Li is released from primary minerals during weathering with relative ease in oxidizing and acidic media and incorporated into clay minerals, or is slightly fixed by organic matter or Mn oxides and accumulated in rocks. phosphates.

Lithium has been applied for therapeutic purposes in the treatment of changes in uric acid metabolism, gout, being applied, more recently, in the stimulation of granulocyte production in patients with granulocytopenia (https://www.adeb.pt/pages/tratamento -by-lithium). Lithium is also prescribed in the treatment of mental health disorders, such as bipolar affective disease, in the prevention of behaviour changes, and may be related, at some level, to the reduction of suicide and violence (Askari et al., 2020; Cipriani et al., 2005; Cipriani et al., 2013; Goodwin et al., 2003; Guzzeta et al., 2005).

In Brazil, the main occurrences of lithium are found in the east/northeast region, regardless of the existence of any production record, being described in the following regions: i) east of Minas Gerais, São João Del Rei area; in the south of Minas Gerais and northwest of Rio de Janeiro; southeast of Minas Gerais; in the domains of Itambé, in the south of Bahia and ii) Pegmatitic Province of Borborema, in the states of Rio Grande do Norte and Paraíba and the Sub-Province of Solonópole, in Ceará. The first group of Lithium geological occurrences is associated with the Araçuaí-Occidental Congo Orogen and the Brasiliana-Pan-African Orogeny, while the second group covers the Borborema Province, located in the eastern portion of the Seridó Belt. These Lithium geological provinces date from the Neoproterozoic to the Cambrian, with ages around 650-500 Ma. (CPRM, 2016).

In the south-central region of the State of Bahia, at the Guanambi sites, until recently, there were no references to the occurrences of Lithium in local and regional geology. In addition, the geology of the region is characterized by the Guanambi monzo-syenitic batholith and its associated late intrusions, aged around 2.05 Ga, where important manifestations of a pneumatolithic character are described. In this region, there is also evidence of Lithium associated with carbonate members of the São Francisco Supergroup (Bambuí Group), of age related to the Cryogenian (650 Ma) (Rosa, 1999; Gonçalves, 2014).

In the Guanambi and surrounding areas, the Geological Survey of Brazil (CPRM) carried out an extensive geochemical sampling effort, based on the main hydrographic basins. Samples from sediments, soils and water were analysed for various chemical elements, including lithium, creating a database. The geostatistical treatment and interpretation of these geochemical data revealed the existence of Lithium geochemical anomalies in the geological domains of Guanambi, in sites that spatially overlap the rocks of the Guanambi batholith and on the carbonate rocks of the Bambuí Group (Pena, 2022). The results of chemical speciation modelling in water samples indicate that there is precipitation of Lithium carbonate minerals in the drains of the region.

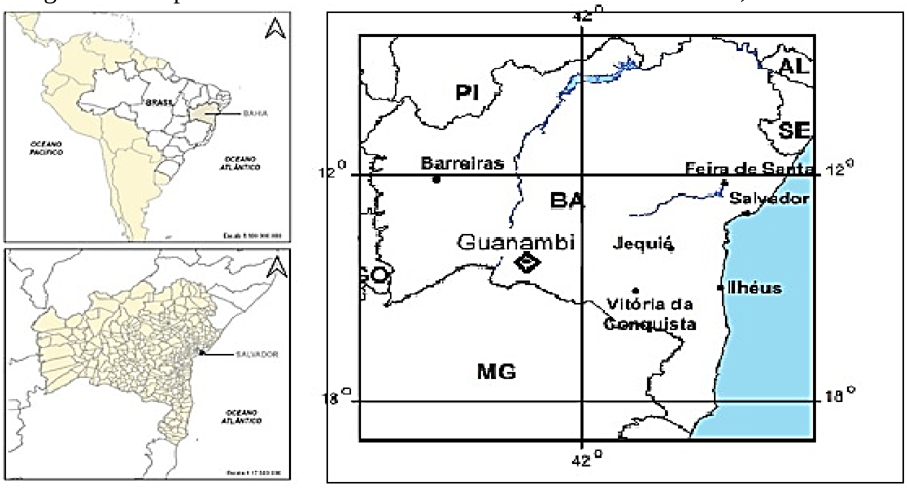
The relationship between lithium and health can be addressed by medical geochemistry, a new field of geology, which investigates the distribution of geological materials and possible influences on human and animal health. This work has relevance for the community of geoscientists and health planners, being carried out by the Geochemical Research Group of Interfaces of the Federal University of Bahia - UFBA, whose objective is to investigate the hypothesis put forward of the effective relationship between geogenic Lithium contents and low grade of violence and suicide in the Guanambi region, in south-central Bahia, Brazil.

2 LOCATION AND PHYSIOGRAPHIC ASPECTS

The Guanambi micro-region, in the centre-south of the state of Bahia, comprises a total area of 22507.18 km2, encompasses eighteen municipalities, with a total population density of around 17.5 inhabit/km2, located between coordinates 43° 54' 18" O; 15°08'15"S and 41°57'45"W; 13°16'6" S (Figure 1). The study site is located on the edge of the Brazilian semi-arid region, in a region of low rainfall (from isohyet 800 mm) and high risk of drought (around 60%), in addition to high annual temperatures (IBGE, 2018). In general, it has a temperature higher than 18 ºC and is classified as hot to medium and sub-hot to medium (IBGE, 2002; Miranda, 2005). The annual precipitation, in most of the territory's extension, has an average of 700 mm (IBGE, 2018; CPRM, 2021).

According to CPRM (2021), the dominant climate type or climate zone is Tropical Brazil Central with semi-arid characteristics.

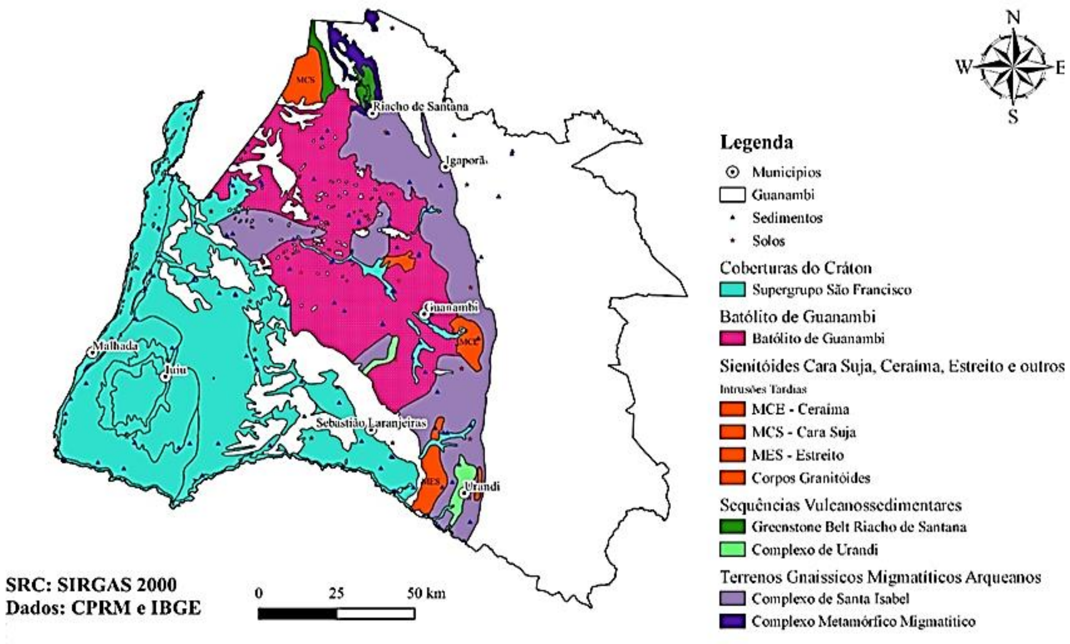
Figure 1 – Map of location and situation of the Guanambi Domains, State of Bahia.



3 GEOLOGICAL POSITIONING

The geological domains of Guanambi are completely inserted in the São Francisco Craton (Almeida, 1977). The geological synthesis of these sites in the State of Bahia is schematically presented in Figure 2. Furthermore, it is noted that, irregularly covering all the rocks in the area, mainly in the flat areas and shallows of water courses, there is an unconsolidated cover of sand-clay and alluvial Quaternary sediments.

Figure 2 – Simplified geology of the Guanambi domains. Pena source, 2021.



To the southwest of the municipality of Guanambi, São Francisco Craton Covers are observed (Figure 2), characterized as sediments of the São Francisco Supergroup (HassuI et al., 2012). According to Rosa (1999) and Hassui (2012) these are marine sediments, carbonate, of origin attributed to the Cryogenian and Neogene, with an age of about 650 Ma. The stratigraphy of this cover has two mega sequences: i) the glaciogenic one; and ii) the carbonate platform. Gonçalves (2014) described that the mega sequence of glaciogenic origin would be constituted by conglomerates, metagravuvacas, diamictites, pelite and quartzite, related to the glacio-continental to glacio-marine depositional environments and the second mega sequence, the carbonate platform, would be constituted by limestones, dolomites, marls, shale and siltstones. The Guanambi Batholith dominates the north-central portion of the area (Figure 2). According to Rosa (1999) it is a mega-intrusion originated during the Paleoproterozoic era, in the Riacian period. This plutonic body has a total area of 6000 km2 and consists of several lithological types that resulted from gradual magmatic occurrences, divided into: i) multiple intrusions and ii) late intrusions. The petrography of the rocks that make up the batholith describes leucocratic terms and the composition varies between syenitic and monzonitic (ROSA, 1999).

It should also be noted that multiple intrusions constitute most of the batholith. Noticeable magmatic pulses were described, characterized by rocks of coarse granulometry, phaneritic and porphyritic texture, of syenitic, monzonitic and granitic composition, reflecting the slow cooling of the igneous body. The mineralogy, characteristics of the lithic types present, both the multiple intrusions and the late intrusions are similar in composition, as observed and described by Rosa (1999) and later by Paim (2014).

Late intrusions with stock morphology associated with multiple main intrusions were described by Rosa (1999) and Paim (2014) as three massifs named Ceraíma, Cara Suja and Estreito (Figure 2). In this context, the Ceraíma intrusion is located south of the city of Guanambi, having an oval shape and comprising a total area between 120 and 128 km2. Furthermore, its lithology varies between easy separated into mesocratic alkali-syenitic, leucocratic alkali-syenitic and granitic-syenitic types. Its mineralogy varies between alkali feldspars, mica and clinopyroxene (Rosa, 1999; Paim, 2014).

The Cara Suja intrusion located north of Guanambi is circular in shape and has a total area of approximately 220 km2. Its lithology varies from leucocratic, porphyritic to medium and inequigranular phaneritic types, having the easy quartz-syenitic, monzogranitic and alkali-fedspathic syenitic (Rosa, 1999; Paim, 2014). In the quartz-syenitic facie there is the presence of granitic pegmatites and veins, rocky bodies known to have expressive concentrations of rare elements, including lithium (Rosa, 1999; Bowell et al, 2020).

Regarding the intrusion of Estreito, in the vicinity of Urandi (Figure 2), it can be seen that it has an elongated shape and a total area of about 210 km2. Its lithology varies from coarse to medium phaneritic and porphyritic facies, with alkali feldspar, plagioclase, quartz, mica and amphibole mineralogy (ROSA, 1999). Furthermore, associated with the Ceraíma, Cara Suja and Estreito massifs, there are granite bodies of the same age and characteristic mineralogy.

Following geo-chronostratigraphically, representatives of meta-volcano sedimentary sequences occur in the Guanambi domains. On the one hand, the Greenstone belt terrains, located north of Guanambi, are described, they are lithotypes of Mesoarchean age, whose lithology is distributed in metabasalt, schist, graphite schist, calc-silicate rock, marble, metachert, banded iron formation, metakomatiite and metagabbro (Rosa, 1999; Paim, 2014).

The Urandi Complex (Rosa, 1999; Paim, 2014), located in the vicinity of the city that lends it its name, with Neo-Arquena rocks, is formed by schist, banded iron and manganese formations, marble and metachert.

The other geological segments of the research area are dominated by crystalline terrains, represented by rocks of high metamorphic grade such as gneisses and migmatites. According to Paim (2014), these domains are subdivided into the Santa Izabel Complex and Migmatitic Metamorphic Complex. Rosa (1999) described the presence of basic and ultrabasic rocks, as well as xenoliths, characterizing this geological region as a regional basement. In this context, the Santa Izabel Complex is constituted from high-grade metamorphic features of Mesoarchean age. Its lithology is arranged in orthogneisses, metadiorite, kinzigite, methanothyre, metaperidotite as well as banded iron formations (PAIM, 2014).

The Migmatitic Metamorphic Complex presents high-grade metamorphic features, amphibolite facies, migmatized, of Paleoarchean age, comprising lithic representatives between orthogneisses, migmatites, of tonalitic, granodioritic and granitic composition, with calcisilicate and aluminous gneissified rocks and more restricted iron formations being described. bandaged (Paim, 2014).

4 LITHIUM GEOCHEMICAL ANOMALIES

The Geological Service of Brazil – CPRM undertook an important collection of samples of water, sediments and water in the central south region of Bahia, whose data were made available, in cooperation, to the Institute of Geosciences of UFBA (IGEO). In the samples, 53 elements were analysed, including Lithium, by the methods of Atomic Emission Spectrometry, with Plasma Source - ICP-OES and Inductively Coupled Plasma Mass Spectrometry - ICP-MS, after opening by hot aqua regia at the SGS-Geosol Laboratory in Vespasiano.

Lithium contents ranged from 0.5 to 22.0 mgL^{-1} (median of 5.0 mgL^{-1}) in soil samples and from 0.5 to 20.0 mgL^{-1} (median of 5.0 mgL^{-1}) in the sediment samples (Tables 1 and 2). These Li contents in the present study are between the contents related to crustal Li abundance, which range from 25 to 40 mgL^{-1} (Kabata-Pendias; Pendias, 2011). Furthermore, the present Li results were compared to the contents of this element in magmatic and sedimentary rocks. Thus, Li content can be organized by geo-environmental matrix, in ascending order, as follows: limestones and dolomites or soils or sediments (present study) < igneous rocks < sandstones < clayey sediments < shales.

Table 1 - Summary of descriptive statistics of measurements of geochemical variables (mgL^{-1}, or ppm) determined in 115 sediment samples collected in the Microregion of Guanambi, Bahia (Pena 2021)

SAMPLE ESTIMATOR	Li (ppm)	Be (ppm)	Cs (ppm)	Sn (ppm)	Rb (ppm)	Ta (ppm)	Al (%)	Mg (%)	K (%)	Na (%)
Minimum	0,5	0,1	0,2	0,2	4,8	0,03	0,3	0,01	0,03	0,01
Maximum	22,0	2,5	2,4	3,2	70,8	0,9	4,1	0,5	0,5	0,2
Average	6,5	0,9	0,7	1,2	20,2	0,1	1,3	0,1	0,2	0,01
median	5,0	0,8	0,7	1,1	19,5	0,03	1,1	0,1	0,1	0,01
1st Quartile (Q1)	3,0	0,5	0,4	0,9	11,7	0,03	0,8	0,1	0,1	0,005
3rd Quartile (Q1)	9,5	1,5	0,9	1,4	26,5	0,1	1,6	0,2	0,2	0,01
Interquartile range (IQR)	6,5	0,9	0,5	0,5	14,8	0,1	0,8	0,1	0,1	0,005
(1) Magmatic Rocks	0,5-X.0	0,X	0,1-2,0	0,35-0,50	0,X	0,02-1,0	-	-	-	-
(2) Magmatic Rocks	6,0-20,0	0,3-1,0	20,0-45,0	0,9-1,5	0,5-1,5	0,5-1,0	-	-	-	-
(3) Magmatic Rocks	20,0-28,0	1,0-1,8	100,0	1,3-1,5	0,6	0,7-2,1	-	-	-	-
(4) Magmatic Rocks	25,0-40,0	2,0-5,0	150,0	1,5-3,6	0,6	2,4-4,0	-	-	-	-
(5) Magmatic Rocks	15,0-45,0	5,0-6,5	100,0-200,0	2,0-3,0	3,0	3,0	-	-	-	-
Clay Sediments	60,0	2,0-6,0	120,0-200,0	6,0-10,0	5,0-10,0	0,8-1,5	-	-	-	-
Shalls	50,0-75,0	2,0-5,0	140,0-160,0	6,0	6,0-8,0	1,0-2,0	-	-	-	-
Sandstones	10,0-40,0	0,2-1,0	45,0	0,2-2,0	0,5-2,0	0,05	-	-	-	-
Limestones and Dolomites	5,0-20,0	0,2-2,0	5,0-30,0	0,2-1,0	0,5-2,0	0,05	-	-	-	-

Table 2 – Summary of descriptive statistics of measurements of geochemical variables (mgL^{-1}, or ppm) determined in 25 soil samples collected in the Microregion of Guanambi, Bahia. (Pena 2021).

SAMPLE ESTIMATOR	**Li (ppm)**	**Be (ppm)**	**Cs (ppm)**	**Sn (ppm)**	**Rb (ppm)**	**Ta (ppm)**	**Al (%)**	**Mg (%)**	**K (%)**	**Na (%)**
Minimum	0,5	0,1	0,1	0,2	2,8	0,03	0,2	0,01	0,03	0,01
Maximum	20,0	1,9	3,1	1,8	40,2	0,7	4,1	0,2	0,2	0,01
Average	5,9	0,7	0,9	0,7	16,8	0,1	1,8	0,1	0,1	0,01
median	5,0	0,7	0,6	0,8	14,8	0,03	1,8	0,1	0,1	0,01
1st Quartile (Q1)	4,0	0,5	0,4	0,2	9,2	0,03	0,8	0,03	0,06	0,01
3rd Quartile (Q1)	7,0	0,9	1,2	1,1	22,4	0,03	2,6	0,09	0,13	0,01
Interquartile range (IQR)	3,0	0,4	0,9	1,0	13,2	0,0	1,8	0,06	0,7	0,0
(1) Magmatic Rocks	0,5-X.0	0,X	0,1-2,0	0,35-0,50	0,X	0,02-1,0	-	-	-	-
(2) Magmatic Rocks	6,0-20,0	0,3-1,0	20,0-45,0	0,9-1,5	0,5-1,5	0,5-1,0	-	-	-	-
(3) Magmatic Rocks	20,0-28,0	1,0-1,8	100,0	1,3-1,5	0,6	0,7-2,1	-	-	-	-
(4) Magmatic Rocks	25,0-40,0	2,0-5,0	150,0	1,5-3,6	0,6	2,4-4,0	-	-	-	-
(5) Magmatic Rocks	15,0-45,0	5,0-6,5	100,0-200,0	2,0-3,0	3,0	3,0	-	-	-	-
Clay Sediments	60,0	2,0-6,0	120,0-200,0	6,0-10,0	5,0-10,0	0,8-1,5	-	-	-	-
Shalls	50,0-75,0	2,0-5,0	140,0-160,0	6,0	6,0-8,0	1,0-2,0	-	-	-	-
Sandstones	10,0-40,0	0,2-1,0	45,0	0,2-2,0	0,5-2,0	0,05	-	-	-	-
Limestones and Dolomites	5,0-20,0	0,2-2,0	5,0-30,0	0,2-1,0	0,5-2,0	0,05	-	-	-	-

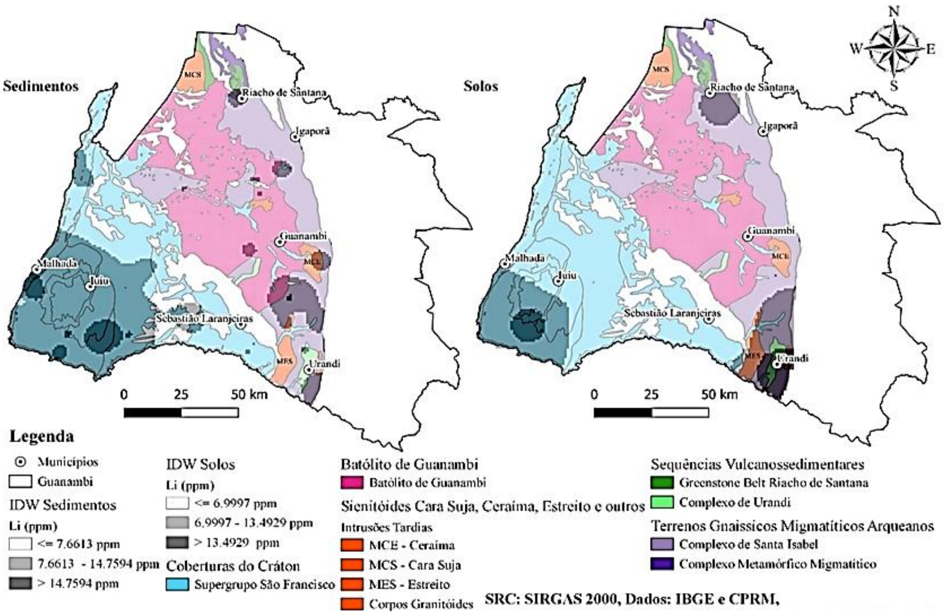
Tables 1 and 2 summarize the results of exploratory statistical analysis of geochemical data from sediments and soils. To this end, a review of the results of the research by Pena (2021) was carried out, based on an exploratory descriptive statistical analysis of the data. Thus, the behaviour of the variables in terms of normality was obtained. To choose the statistical tools, the concepts of Assumpsão et al. (2017), applying position and dispersion measures. To determine the quality of the data, the Shapiro-Wilk normality test, box plots and scatter plots were applied, with the aid of QGIS software (version 3.20.2), R with the Rcommander package and Excel .

Thus, from the statistical approach, a geostatistical treatment and the interpretation of the distribution of geochemical data were carried out, which allowed the construction of a map of the geochemical anomalies of Lithium in sediments and soils in the Guanambi region (Figures 3). In the geostatistical treatment, based on QIAO et al. (2019), the interpolation technique known as Inverse Squared Distance (IDW), which provided the foundation and interpretations of the results in the mathematical principle of estimation for unsampled points, based on the known measurements of the closest points.

It was also observed the existence of geochemical lithium anomalies in the geological domains of Guanambi, in sites that mainly superimpose the rocks of the

Guanambi batholith or on the Neoproterozoic carbonate rocks of the Bambuí Group. Furthermore, it is noteworthy that the results of the preliminary modelling of the lithium carbonate, in the drains of the region.

Figure 3 - Lithium anomalies in sediments and soils in the region of Guanambi, Bahia. (Source: Pena (2021)).



Lithium Clark is in the order of 18 mgL^{-1}, however the distribution of this element in the Earth's crust is very irregular (Linch, 2001). Thus, for the same author, contents of the order of 2.5 mgL^{-1} of Lithium can be considered as regional anomalies. Effectively, the data from Pena (2021) are numerically small when compared to the results of the research by Scholz et. al. (2010), so that these authors found lithium values in the order of 70 mgL^{-1} in pegmatitic deposits in Rio Grande do Norte, Brazil.

Closer to the values indicated by Linch (2001) and Pena (2021), using analytical data from the National Geological Service, the Lithium anomaly in the Guanambi region reached around 20 mgL^{-1}, both in sediments and in waters. In this way, he characterized the existence of two areas of distinct anomalies (Figures 2): i) the anomaly that he named A, located on sedimentary rocks of the carbonate covers of the São Francisco Supergroup (Bambuí), probably at the levels of evaporitic members, interspersed in the carbonate sequence, described by Gonçalves (2014); ii) the B anomaly covers the pneumatolitic, alkaline-affinity granitic plutonic rocks described by Rosa (1999) and Paim (2014).

The same analytical database mentioned above contains the numerical data of Lithium analysed in water collected at points close to the soil and water samples. Analytical results are often quite low, on the order of 0.05 mgL^{-1}, however often present.

5 GEOGENIC LITHIUM

Barjasteh-Askari et al. (2020), citing Cipriani et al. (2005); Cipriani et al. (2009), Goodwin et al. (2003) and Guzzetta et al. (2007), among others, endorse the characteristics of Lithium as a chemical element used for the treatment of mood disorders, including depressive and bipolar disorders.

According to Vita et al. (2015), therapeutic plasma lithium levels that act to exert mood-stabilizing effects are on the order of 0.6–1.0 mmol/l. According to Machado-Vieira et al. (2009), these values decrease aggressive behaviour, including acts that threaten life Silva e Silva, (2019). According to Sarai et al. (2018), Lithium also has anti-suicidal effects that can be exerted independently of its mood-stabilizing properties.

As a naturally occurring trace element, Lithium, being a light metal with high oxidizing power, is often found in various salts and/or dissolved in water, as a product of the weathering of primary minerals. After being leached by the weathering of minerals, Lithium can be naturally present in surface and groundwater (Ferrante et al., 2014; Mohammadi et al., 2017). Present in water, they are often absorbed by plant roots, following the food chain through Lithium-rich foods such as grains and vegetables (Figueroa et al., 2013; Law et al., 2017).

It should be noted that there are no recommendations and standards for lithium in drinking water, based on the WHO and the United States Environmental Protection Agency (USEPA), on the other hand, CONAMA Resolution no. 357/05 indicate, for the freshwater class, maximum levels of 2.5 mgL^{-1} of Li. According to Barjasteh-Askari et al. (2020), the concentration of Li in drinking water has been reported to range from 0–12 μgL^{-1} in Aomori, Japan (Sugawara et al., 2013), between 2.8–219 μgL^{-1} in Texas, USA (Blüml et al., 2013). After ingestion, lithium is excreted and was obtained between lithium in drinking water and lithium in urine (Dawson et al., 1972).

According to Neves et al. (2020) in some parts of the world Lithium contents reaching 2.5 mg/day could have been supplied from drinking water, confirming Dawson et al., (1972) who related Lithium contents of drinking water and lithium in urine. Neves eT al. (2020), also mentions that the effects of Li in therapeutic doses (600-1200 mg/day) in mental disorders are widely recognized by the psychiatric community. Contents of this order can be obtained in regions where lithium occurs geogenically.

Sarai et al., 2018 indicate that the anti-suicidal properties of lithium can be significant even at concentrations lower than therapeutic doses, therefore, considering the clinical relevance of lithium in reducing violence and life-threatening attempts and in the daily intake of lithium through drinking water throughout life, there is the hypothesis proposed by Barjasteh-Askari et al. (2020), that prolonged exposure to Li through drinking water consumption may be associated with decreased suicide rates even in the general population.

Numerous studies, especially epidemiological studies, have been carried out around the world to establish this hypothesis. They showed that, although natural lithium intake is limited, there is evidence of ant suicidal effects of lithium in patients with mood disorders and in the general population after chronic exposure to micro doses of lithium (Terao et al., 2009; Tondo; Baldessarini, 2018).

6 VIOLENCE AND SUICIDE IN THE DOMAINS OF GUANAMBI

Violence and suicide are a serious widespread problem of the modern era, the latter being one of the main causes of death worldwide for the general population. According to Brazil, (2021) there were about 112,230 deaths from suicide in Brazil, with a 43% increase in the annual number of deaths, from 9,454 in 2010 to 13,523 in 2019. Analysis of adjusted mortality rates in the period showed an increase in risk of death by suicide in all regions of Brazil. In this same period, it is estimated that the Brazilian population has grown from 190,732,694 to 210,147,125, resulting in a growth of 10.17%. The national rate in 2019 was 6.6 per 100,000 inhabitants.

In the Guanambi micro-region, the homicide rate was 30.8 deaths per 100,000 inhabitants, according to information from the Atlas of Violence (2019). This homicide rate is lower than the average homicide rate in Brazil (31.6 deaths per 100,000 inhabitants), or the average rate in Bahia (48.8 deaths per 100,000 inhabitants). The statistics on the number of suicides in the region are also very low.

7 CONCLUSIONS

The classical geochemical studies generated using the tools of geostatistics on the analytical quantities of chemical constituents present in soil, sediment and water samples collected in the Guanambi region, suggested the presence of two discrete lithium anomalies, present in two different locations, of different geological genesis, so that a part of the anomalies is associated with the evaporites present in carbonate rock levels of the São Francisco Supergroup (Bambuí Group) and the other part is associated with the pneumatolytic events of the igneous manifestations of the Guanambí Intrusive Batholith.

The research demonstrated the presence of lithium in secondary materials (sediments, soils and water), indicating the secondary diffusion of this chemical element to the ecosystem of the region. It is proposed, therefore, that the exposure of the individual and the community to the geogenic levels of lithium from the consumption of water and food can contribute to the promotion of mental health and to the reduction of violence rates in the Guanambi region. Previous studies confirmed the low rates of violence for the Guanambi region, which can be related to multiple health, social, cultural, economic and geo-environmental determinations. Research in other regions of the world shows that lithium in drinking water is negatively correlated with violence and suicide mortality in the general population.

These hypotheses put forward in this article indicate the extreme need to develop further geological studies, in terms of the natural quantity of lithium at Guanambi region, and to proceed, through the multidisciplinary team of scientists, to engender well-designed clinical trials to confirm the protective effect of the Lithium against violence and suicide, including in these studies, the difference in gender and lithium responses in men and women.

DECLARATION OF INTERESTS

The authors declare that they have no financial knowledge, competing interests or personal relationships that could have influenced the work reported in this article.

THANKS

This research was supported by the following institutions: FAPESB, POSPETRO UFBA, CPRM and CNPq. (Pro: 302613/2021-8).

REFERENNCES

Assumpção, H. C. P.; Hadlincht, G. M.(2017) Estatística descritiva e estacionaridade em variáveis geoquímicas ambientais. *Engenharia sanitária e ambiental*, n. 4, v. 22, p. 671-677.

Almeida. F. F. M. Cráton do São Francisco.(1977) *Revista Brasileira de Geociências*, 1, v. 7, n. 4, p. 349-364.

Askari, F. B, Homayoun, M.D., Ghorbanicg, M.M.Y,Yunesian,M. Mahavi,A.H Et Lester, D. (2002) Relationship between suicide mortality and lithium in drinking water: A systematic review and meta-analysis. *Journal of Affective Disorders Volume* 264, 1 March Pages 234-241 https://doi.org/10.1016/j.jad.2019.12.027

ADEB: https://www.adeb.pt/pages/tratamento-pelo-litio.Acessado em 01 de março de 2022.

Blüml, V., Regier, M.D., Hlavin, G., Rockett, I.R., König, F., Vyssoki, B., Bschor, T., Kapusta, N.D.(2013) Lithium in the public water supply and suicide mortality in Texas. J. *Psychiatr*. *Res.* 47, 407–411.2013.

Bowell, R. J.; Lagos, L.; De Los Hoyos, C. R.; Declercq, J**.** (2020). Classification and characteristics of natural lithium resources. *Elements*, , v. 16, p. 259-264.

Brasil, Ministério Da Saúde.(2021). Mortalidade por suicídio e notificações de lesões autoprovocadas no Brasil**.** *Boletim Epidemiológico*.33,52.

Cipriani, A., Hawton, K., Stockton, S., Geddes, J.R., (2013). Lithium in the prevention of suicide in mood disorders: updated systematic review and meta-analysis. *BMJ* 346,f 3646.

Cipriani, A., Pretty, H., Hawton, K., Geddes, J.R., (2005). Lithium in the prevention of suicidal behavior and all-cause mortality in patients with mood disorders: a systematic review of randomized trials. *Am. J. Psychiatry* 162, 1805–1819.

CPRM. Projeto Avaliação do Potencial Lítio no Brasil. (2016). *Série Minerais Estratégicos. Programa Geologia do Brasi*l. Serviço Geológico Nacional.

CPRM – COMPANHIA DE PESQUISA DE RECURSOS MINERAIS. Atlas pluviométrico do Brasi**l**. Salvador: (2021). Disponível em http://www.cprm.gov.br/publique/Hidrologia/Mapas-e-Publicacoes/Atlas-Pluviometrico-do-Brasil-1351.html. Acesso em 04 abr. 2021.

Dawson, E., Moore, T., Mcganity, W. (1972)Relationship of lithium metabolism to mental hospital admission and homicide**.** Dis. Nerv. Syst. 33, 546–556.1972.

FERRANTE, M., CONTI, G.O., RASIC-MILUTINOVIC, Z., JOVANOVIC, D.(1972). Health 7Effects of Metals and Related Substances in Drinking Water: *Research Report Series*. The international water association (IWA), pp. 63.2014.

Figueroa, L.T., Razmillic, B., Zumeata, O., Aranda, G.N., Barton, S.A., Schull, W.J., Young, A.H., Kamiya, Y.M., Hoskins, J.A., Ilgren, E.B. (2013). Environmental lithium exposure in the north of Chile—II. Natural food sources**.** Biol. Trace Elem. Res. 151, 122–131.

Gonçalves, M. V. P. Flúor nas águas subterrâneas do aquífero Bambuí no Sudoeste da Bahia (Brasil). 2014. 193 f. Tese (Doutorado em Geologia) – Instituto de Geociências, Universidade Federal da Bahia, Salvador.

Goodwin, F.K., Fireman, B., Simon, G.E., Hunkeler, E.M., Lee, J., Revicki, D.(2003). Suicide risk in bipolar disorder during treatment with lithium and divalproex. *JAMA290*, 1467–1473.

Guzzetta, F., Tondo, L., Centorrino, F., Baldessarini, R.J. (2007). Lithium treatment reduces suicide risk in recurrent major depressive disorder. J. Clin. Psychiatry 68, 380–383.

Hasui, Y.; Carneiro, C. D. R.; Almeida, F. F. M.; Bartorelli, A. (Org.).(2012) Geologia do Brasil. 1. ed. São Paulo: Beca, 2012. 900 p.

IBGE – Instituto Brasileiro De Geografia E Estatística. Geociências**:** informações ambientais - climatologia. Rio de Janeiro: (2002). Disponível em https://www.ibge.gov.br/geociencias/informacoes-ambientais/climatologia/15817-clima.html?=&t=o-que-e. Acesso em 31 mar. 2021.

IBGE – Instituto Brasileiro De Geografia E Estatística. **Geociências:** Organização do território – estrutura territorial – semiárido brasileiro. Rio de Janeiro: 2018. Disponível em https://www.ibge.gov.br/geociencias/organizacao-do-territorio/estrutura-territorial/15974-semiarido-brasileiro.html?=&t=sobre. Acesso em 03 ago. 2021.

IPEA. https://www.ipea.gov.br/atlasviolencia/download/19/atlas-da-violencia-2019

Kabata-Pendias, A.; Pendias H.(2001). Trace Elements in Soils and Plants. 3 ed. Boca Raton, Florida, USA: CRC Press Incorporation,. 403 p.

Law, B.Y.K., Wu, A.G., Wang, M.J., Zhu, Y.Z.(2017) Chinese medicine: a hope for neurodegenerative diseases? *J. Alzheimers Dis.* 60, S151–S160,

Lee, J. D. Química inorgânica não tão concisa.(1999), 5. ed. São Paulo: Edgar Blucher Ltda, 527 p.

Linch,O.A.B **A (**2001) Geoquímica Multielementar Na Gestão Ambiental Identificação E Caracterização De Províncias Geoquímicas Naturais, Alterações Antrópicas Da Paisagem, Áreas Favoráveis À Prospecção Mineral E Regiões De Risco Para A Saúde No Estado Do Paraná, Brasil. Tese apresentada como requisito parcial para obtenção do grau de Doutor. Curso de Pós-Graduação em Geologia, Área de Concentração - Geologia Ambiental, Setor de Ciências da Terra, Universidade Federal Do Paraná.

Machado-Vieira, R., Manji, H.K., Zarate Jr., C.A.(2009). The role of lithium in the treatment of bipolar disorder: convergent evidence for neurotrophic effects as a unifying hypothesis. *Bipolar disorders* 11, 92–109.. https://doi.org/10.1111/j.1399-5618.

Miranda, E. E. De; (Coord.). (2005) **Brasil em relevo.** Campinas: Embrapa. onitoramento por Satélite, 2005. Disponível em: http://www.relevobr.cnpm.embrapa.br. Acesso em: 16 Nov. 2021.

Mohammadi, A.A., Yousefi, M., Yaseri, M., Et Al. **(2017)** Skeletal fluorosis in relation to drinking water in rural areas of West Azerbaijan, Iran**.** Scientific Reports 7, 17300. https://doi.org/10.1038/s41598-017-17328-8.

Paim, M. M. (2014). Maciço de Cara Suja: expressão do magmatismo alcalino potássico pós-colisional no sudoeste da Bahia. Tese (Doutorado em Geologia) – Instituto de Geociências, Universidade Federal da Bahia, Salvador.

Pena,L.S.(2021) Processos Geoambientais do Elemento Lítio nos Domínios Geológicos da Microrregião Guanambi, Centro-Sul da Bahia, Nordeste do Brasil.Dissetação de Mestrado. Pospetro UFBA.

Qiao, P.; Li, P.; Cheng, Y.; Wei, W.; Yang, S.; Lei, M; Chen, T.(2019) Comparison of common spatial interpolation methods for analyzing pollutant spatial distributions at contaminated sites. *Environmental Geochemistry Health*, v. 41, p. 2709–2730, 2019.

Rosa, M. L. S. (1999). Geologia, geocronologia, mineralogia, litogeoquímica e petrologia do batólito monzo-sienítico Guanambi-Urandi (SW - Bahia). 1999. 186 f. Tese (Doutorado em Geologia) – UFBA, Salvador..

Sarai, S.K., Mekala, H.M., Lippmann, S.(2018**).** Lithium suicide prevention: a brief review and reminder. *Innov. Clin. Neurosci*. 15, 30.

Scholz,R, Romano,A.R., Belotti,F.M., Chaves,M.Ll.S.C. (2010).Prospecção Geoquímica De Berilo Variedade Esmeralda Na Região Da Fazenda Bonfim (Lajes, Rn). São Paulo, UNESP, Geociências, v. 29, n. 4, p. 613-621.

Sugawara, N., Yasui-Furukori, N., Ishii, N., Iwata, N., Terao, T**.** (2013) Lithium in tap water and suicide mortality in Japan. *Int. J. Environ. Res. Public Health* 10, 6044–6048.

Terao, T., Goto, S., Inagaki, M., Okamoto, Y. (2018). Even very low but sustained lithium intake can prevent suicide in the general population**?** Med. Hypotheses 73, 811–812.

Tondo, L., Baldessarini, R.J.(2018). Antisuicidal effects in mood disorders: are they unique to lithium? *Pharmacopsychiatry*.

Vita, A., De Peri, L., Sacchetti, E.,(2015) . Lithium in drinking water and suicide prevention: a review of the evidence. *Int. Clin. Psychopharmacol.* 30, 1–5.