Synopsis

The State of Espírito Santo is the main producer of Natural Stones in Brazil. More than a half of the Brazilian quarries production comes from this state, with some marble and large reserves of igneous and variable metamorphic rocks. The complexity and unique geotectonic evolution of this region have provided migmatites, gneisses, granites, norites, monzosyenites, deformed granitoids and high-grade marbles. The lithological assemblages exhibit different mineralogical composition and structural-textural behaviour depending on the genetic characteristics according to the evolutionary geotectonic stage. Four production poles are identified in the state of Espírito Santo. Two of them in the northwest where yellow, white and green granites from Carlos Chagas, Ataléia, and Aimorés Suites, and other late-collisional leucogranites are extracted. In the central region green charnockites and black norites from Aimorés and Espírito Santo Suites, respectively, are quarried and, in the South, migmatitic gneisses and marbles from the crystal basement and also tonalite-monzogranitic granitoids of the pre-collisional stage and post-collisional zoned igneous plutons, give grey monzogranites, diorite-gabbros and brown monzonite-syenite rocks.

Keywords

Espírito Santo State, Natural Stone, Geotectonic, Lithological assemblage.

Introduction

The State of Espírito Santo is known worldwide for the great production of granites and marbles. However, granites and marbles aren’t the only ones making up the lithological framework of the state. Due to the peculiar tectonic evolution of the region, several lithologies are recorded. High-grade metamorphic rocks predominate in spatial distribution and natural stones production. Igneous rocks like monzogranites, charnockites, norites, gabbros, syenites, and monzonites have, also, a significant spatial and natural stones production distribution. In the state of Espírito Santo, the production of natural stones is concentrated in four main poles. In the northwest area of the state, there is one pole where are quarried yellowish and white granitoids from the Carlos Chagas and Ataléia Suites and another pole with gabbros, syenites, and charnockites from the Aimorés Suite with black, brown and green colours. Other late-collisional leucogranites are exploited too in this area (Silva & Castro, 2012).

In the central area of the state, green charnockites of the Aimorés Suite, black norites of the Espírito Santo Suite and migmatitic gneisses of the Nova Venécia Complex are the dominant natural stones produced. The third pole and the main natural stones’ production centre of the country is located in the South, around the municipality of Cachoeiro de Itapemirim. With many quarries and processing industries, which started with the marbles from the Itaóca Ridge in the middle of the 20th Century, has today a quite diversified stones production, processing stones from all around the country. Yet, in this area, are also quarried high-grade marbles of the Itaóca Ridge, from the Italva Complex, monzogranites and gabbros of the Santa Angélica Suite, black diorites from Juiz de Fora and kingizites from São Fidelix Complex (Silva & Castro, op. cit.).
Regional Geology

The administrative boundaries of the state of Espírito Santo are fully inserted in the northern part of the Mantiqueira Structural Province (Almeida, 1977 apud Pedrosa-Soares, 2007). More precisely, within a lithodemic unit called the Araçuaí Orogen (Pedrosa-Soares et al. 20015) from Neoproterozoic age with Northeast-North-Northwest structural vergence and limited to the West and North by the São Francisco Craton.

The tectonic subdivision of the region is very complex. In the literature, two models are shown with different interpretations. The first, proposed by several authors (Uhlein, 1991; Pedrosa-Soares & Weidmann-Leonardos, 2000; Heilbron et al. 2004 apud CPRM, 2015), defines three zones with distinct ambience, being the deformed covers of the Craton, representative of foreland area basin. The outer zone would be characterized by thrusts and folds towards the craton and marked by low-grade metamorphic paragenesis, whilst the inner zone stands out by the occurrence of high-grade metamorphic rocks and intense generation of granitic magmas with different compositions.

The second proposed model (Alckmin, 2006) presents a subdivision in structural domains, based on the regional kinematic analysis. Among these structural domains, the zones of high metamorphic degree, representative of the orogenic nucleus, are coincident with the geographic territory of the state of Espírito Santo. It can be divided into two subdomains: one in the north of the state, which would be represented by rocks of the middle crust, while the other, in the southern part, is represented by rocks that reached depths of the infra-crust, showing gneiss and mylonitic fabrics.

In the second subdomain, in the south and central parts of the state of Espírito Santo, it is common that the outcrops present kinematics related to shear with thrusting faults and folding phases during the main deformation period, with west vergence and presence of late dextral transcurrent to thrusting faults in the syn-collisional period. Already in the northern subdomain, coincident with north portion of Espírito Santo State, extreme northeast of Minas Gerais and extreme south of Bahia, there are minor transcurrent faults, predominating thrusts of medium to low angle, with main vergence in the western portion to the west with the Craton as a shield, while the eastern portion has east vergence, towards the Congo Craton. This change of tectonic vergence occurs north of the parallel 20 ° S, near the capital Vitória.

Evolutionary model

Alkmin and others (2003), based on these kinematic interpretations, and inspired by the tectonic scenario that resulted in the formation of Western Gondwana, proposed a genetic model of the Araçuaí Orogen still unknown in the literature, where the subduction of an oceanic crust restricted by a cratonic bridge is induced by distant collisions, similar to the mechanism of a "Nutcracker".

Briefly, four evolutionary stages are defined for the Orogen. The first, when the opening of the Maçaubas Basin occurred, is indicated by the ophiolitic remains with isochronic ages by Sm-Nd dating of 816 +/- 21 Ma (Pedrosa-Soares et al. 1998, 2001; Suita et al. 2004; Queiroga et al. 2006 apud CPRM, 2015). The second happened between 630 Ma and 580 Ma and is highlighted by the processes of subduction and formation of the magmatic arc, culminated with the convergent interaction of the paleo-plates of São Francisco, Congo, Amazonas,
Paraná-Paranâpanema-Rio de la Plata, and Kalahari, forming the supercontinent Western Gondwana. The third stage was syn-collisional, with intense deformation, regional metamorphism and intensive generation of anatectic magmas. The fourth stage was initially marked by intense kinematic tangential motion to the South, towards the Ribeira Orogen. In the end, the gravitational collapse of the Orogen occurred, particularly in the central portion, with the formation of normal shear zones and intense generation of plutonic bodies in three different stages (CPRM, 2015).

With the stabilization of the South American shield in the Paleozoic and the construction of a continental platform free of large deformations, a magmatism in Paleocene (last 56 Ma), associated with Abrolhos Vulcanism in the state of Bahia still happened and it can be seen in the state of Espírito Santo as small rhyolitic spills and diabase dikes that structurally cut older rocks along the entire length of the Araçuaí Orogen (Salino, 2013).

**Geological units**

All geological units and commercial lithotypes presented in this paper are subdivided by (CPRM, 2015) into four main lithological domains, classified by age, genesis and tectonic environment.

- Bottom crust fragments: Paleoproterozoic rocks (2,3 Ga to 2,0 Ga), which are remnants of crustal roots, predominantly charnockites, diorites, and para-derived rocks, represented by the complexes of Caparaó, Serra do Valentim, Juiz de Fora, and Ipanema. One example is the dioritic gneiss “Black Stype” from the Juiz de Fora Complex.

- Neoproterozoic sedimentary basins (1,0 Ga to 0,6 Ga): basal portion of the orogen, representative rocks of the sedimentary fill of the Macaúbas Basin, a precursor to the beginning of the magmatic arc. The representative units are called Rio Doce Group, Nova Venécia Complex, Italva Group, Rio Negro Complex, São Fidélis Group, Jequitinhonha Kinzigito Complex, and Bom Jesus do Itabapoana Group. Generally, they are para-derived rocks, composed by quartzites, peraluminous gneisses, marbles, pyroclastic and volcano-sedimentary rocks. Kingizites from the São Fidelis Complex like “Black Indian” and “Blue Fantasy”, syenogranitic gneiss “Blue Jaguar” from Nova Venécia Complex and marble “Cristalita” from the Italva Group in Cachoeiro de Itapemirim are the most produced;

- Granite-genesis of Araçuaí Orogen (Neoproterozoic to Phanerozoic):
  - Pre-collisional stage (630 Ma to 590 Ma), with the subduction of the oceanic crust and the beginning of the magmatic arc formation and acidic plutons generation, corresponding to the mesocratic type I granites, found in the south of the State. Representatives of this stage are leuco-mesocratic tonalitic-monzogranitic granitoids like “Cinza Imperial” and “Cinza Andorinha”.
  - Sin-collisional to the late-collisional stage (590 Ma to 575 Ma), represented by softly or high deformed anatectic granites S-type. Representative of this stage are the rocks of the Ataléia and Carlos Chagas Suites, mostly located in the north of the State and commercialized as the renowned yellow and white granites: “Giallo Ornamental”, “Giallo Veneziano” and “Yellow Santa Celícia”;
and late-orogenic leucogranites with small granodes, as “White Dallas” and “White Siena” as intrusive apophysis on gneisses of Nova Venecia Complex;

• Post-collisional stage (575 Ma to 490 Ma) is composed by igneous rocks which represent the gravitational collapse of the mountain ridge, positioned in most cases, in regional transcurrent structures. Three stages of magmatism are recognized during this period. The first one represented by plutons of granitic to dioritic/noritic composition, who receive the designation of Espírito Santo Intrusive Suite and are represented by norites “Black São Gabriel” and “Black Aracruz”. The second magmatic stage is represented by the Santa Angélica Intrusive Suite, predominant in the southern region of the State and is composed by zoned batholith plutons with granitic edges and mafic cores, represented by “Grey Corumbá” and “Black Santa Angélica” and minor bodies with alkaline composition like the brown monzo-syenite “Ocher”. The third is characterized by the occurrence of rocky bodies of metaluminous composition, noritic, gabbroic and charno-endbitic, denominated Aimorés Intrusive Suite, dominant from the central portion of the state of Espírito Santo to the border with state of Minas Gerais, where the city of Aimorés is and its bodies give rocks predominantly charnockitic like “Green Butterfly” and “Green Labrador”.

• Cenozoic Covers, represented by Espírito Santo Group haven’t commercial interest and no lithotypes of this hedge are produced. Initially represented by the Abrolhos Formation (60 Ma), occurring in the oceanic platform cost. Novais et al. (2007 apud CPRM, 2015) describe the existence of ignimbrites and pyroclastic rocks with rhyolitic to dacitic compositions along São Mateus River in an aulacogen structure. That Formation is correlated by Ar-Ar dating methods with an igneous province called Abrolhos Volcanic Complex, associated to the continuity of the Vitória-Trindade chain and connected to many oceanic fault zones and which has an extension equivalent to a meso-oceanic chain.

The Rio Doce Formation (56 Ma to 34 ma) represents the sedimentation of the paleodelta of Rio Doce and is composed of sandstone, shale, and limestone. The Barreiras Group (23 Ma) in the state of Espírito Santo covers the crystalline basement. It is composed of white, yellow and reddish sandstones; fine and coarse-grained argillites with a ferruginous matrix. It occurs as coastal boards that form the cliffs.

• Surface covers (2,6 Ma to recent): At the end of the Pleistocene, the coastline extended 27 km east of the current line. From then on, the exposed surface of the Barreiras Group began to erode, favoured by a marine regression that aided in the excavation of deep valleys along the Doce, Barra Seca, and São Mateus Rivers and some of their tributaries. After a new transgressive cycle between 25,000 and 5,000 years ago, the coastline began to form one similar to the current one, where the valleys excavated by the regressive cycle begun to be filled by fluvial and marine sediments.
References


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