

Artigos da Professora Doutora Teresa Azevedo



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MARKINGS ON THE STONES OF TERCEIRA ISLAND, AZORES — ROCK ART OR NATURAL CAUSES?

M. Teresa M. Azevêdo

Abstract. The markings on the stones of Terceira Island, in the form of simple or crossed grooves, resemble similar occurrences found in other parts of the world and have occasionally been defined as petroglyphs. A satisfactory explanation for such markings has been hard to find, despite multiple attempts, and has ranged from mechanical and chemical alteration to bicycle tracks. The explanation for the ‘carvings’ on regolith blocks is by gradual abrasion of large tree roots due to aeolian oscillation and agitation of the trees, which accrues the effects of frequent microearthquakes in the Azores. This hypothesis, previously suggested by R. G. Bednarik for similar grooves found in siliceous sandstones in Queensland, New South Wales (Australia) and the Pennines (U.K.), and on granite in Tasmania, seems to be the one that adjusts best to all observations and the characteristics of the grooves on the volcanic rocks of Terceira Island.

Introduction

The location of the Azores archipelago and its Platform (AP) on the Mid-Atlantic Ridge (MAR) confers to these islands very particular features. The nine islands composing the archipelago, dispersed over 600 km on a WNW-ESE trend, are divided into three groups: the Western Group (Flores and Corvo), the Central Group (Terceira, Faial, São Jorge, Pico and Graciosa) and the Oriental Group (São Miguel and Santa Maria). In Terceira Island, the variety of lithologies with their different colours, volcanic caves, obsidian veins, trachytic coulees, the volcanic cones and their calderas, where abundant bovine fauna and flora of great beauty proliferate, as well as the unusual rock forms, contribute to a rare and colourful landscape and morphology, which attract both scientists and other visitors from all over the world.

The Azores belong to the biogeographic region of Macaronesia (which includes the archipelagos of Madeira, the Canary Islands and Cape Verde), one of the richest regions in Europe in terms of geodiversity and biodiversity (Azevêdo 2018). The complexity of the archipelago and the surrounding platform, located at the triple junction between the African, Eurasian and North American plates (Azores microplate; Fig. 1), has attracted the interest of researchers since the mid-16th century (Miranda et al. 2019). Its tectonic evolution and the nature of the plate boundaries have been controversial, and several models have been proposed in attempts to explain their ki-

netics. However, so far, none of the models presented has managed to clarify all the observed features, some of which are so enigmatic that they have led to the concept of the ‘Azores geosyndrome’ (Vogt and Jung 2019).

Terceira Island

Like the other islands of the Azores archipelago, Terceira Island consists of the emerged fraction of an underwater mountain that rises from the Azores Platform.

Initially named The Island of Our Lord Jesus Christ of the Terceira, it was once the administrative centre of the Terceira Islands, as the archipelago was called, because it was the third archipelago discovered in the Atlantic, the first being the Canary Islands and the second the islands of Madeira, in chronological order. Another plausible explanation appeals to the fact that this island was the third to be discovered, Porto Santo being the first and Madeira the second (Frutuoso 1978).

Due to its geostrategic location, halfway between Europe and America, Terceira Island, as it was eventually called, has played a relevant role throughout history in maintaining the Portuguese Empire, both in geopolitical and commercial terms.

From a geographical point of view, the island has an almost circular shape, is about 29 km long, 18 km wide, with a 90 km perimeter and 402.2 km² area. Its highest point is the Serra de Santa Bárbara, at 1021

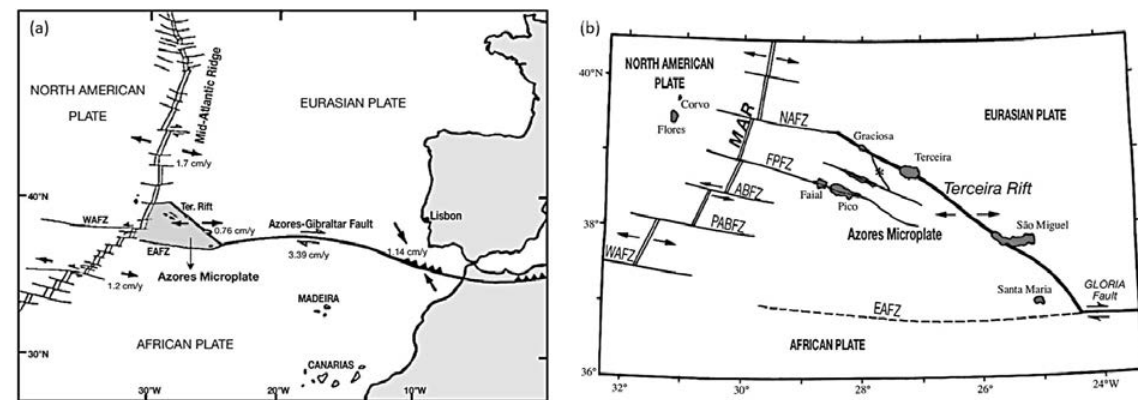


Figure 1. (a) General geo-tectonic framework of the Azores archipelago (after Forjaz 1983 and Buform et al. 1988; in Nunes 1999). Displacement rates from Nunes (1991). WAFZ – West Azores Fracture Zone; EAFZ – East Azores Fracture Zone; Ter. Rift – Terceira Rift. (b) Location of islands and main tectonic lineaments of the Azores triple junction (Nunes 1999). Asterisk shows the location of the 1 January 1980 earthquake. MAR – Mid-Atlantic Ridge; NAFZ – North Azores Fracture Zone; FPFZ – Faial-Pico Fracture Zone; ABFZ – Açor Bank Fracture Zone; PABFZ – Princess Alice Bank Fracture Zone; WAFZ – West Azores Fracture Zone; EAFZ – East Azores Fracture Zone (in Carvalho et al. 2001).

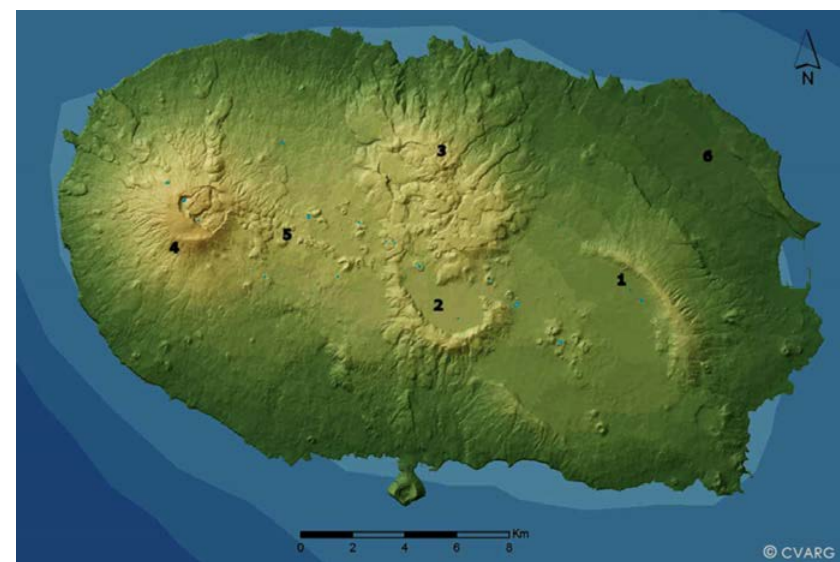


Figure 2. The six geomorphological units of Terceira Island. (1) Cinco Picos volcano; (2) Guilherme Moniz volcano; (3) Pico Alto volcano; (4) Santa Bárbara volcano; (5) basaltic fissural zone; (6) Lajes graben (adapted from CVARG/CIVISA n.d. in <http://www.ivar.azores.gov.pt/geologia-acores/terceira/Paginas/GA-Terceira-Geomorfologia.aspx>).



Figure 3. The 'dry stone' walls show the larger stones enclosed in smaller ones (photo TA).

m a.s.l. From a geomorphological point of view, it consists of six units (Fig. 2): the Cinco Picos volcano, the Guilherme Moniz volcano, the Pico Alto volcano, the Santa Bárbara volcano, the fissural zone and the graben of Lajes (Zbyszewski et al. 1971; Self 1974; Queiroz et al. 2001; Nunes 2000a and 2000b).

The emersion of the island took place in five stages, at about 3.5 Ma, the volcanic complex of Cinco Picos being the oldest and forming the island's core. Its building is quite dismantled, displaying a large caldera delimited only by two sections of its edges, the ridges of Cume and Ribeirinha. The relatively flat interior of the caldera contains five secondary volcanic cones.

Its most recent polygenetic volcano is the 808 m high Pico Alto volcano, about 140 000 years old, exhibiting an extensive caldera (3.5 km diameter) filled almost entirely by trachytic flows (Zbyszewski 1968; Zbyszewski et al. 1971; Self 1974, 1976; Fernandes 1986; Queiroz et al. 2001). Pico Alto suffered an important change of its eruptive style about 23 000 yr BP, with the extrusion of numerous domes and coulées of trachytic nature (Self 1974, 1976; Gertisser et al. 2010; Pimentel 2006, in Pacheco et al. 2013).

The dating of a tree trunk, probably of *Juniperus brevifolia* enveloped by lava, obtained for the Algar do

Carvão eruption, is 2148 ± 115 years BP (Zbyszewski et al. 1971). This occurrence, located inside the extinct volcano Guilherme Moniz, is a tourist attraction, and visitors can descend to a depth of 100 m.

Purpose of the study

One of the studied phenomena, previously observed in several other countries, including the U.K. and Australia, consists of thousands of more or less complex groove marks on rocks. No satisfactory explanation has been given for them so far, either by archaeologists, geologists, botanists or chemists. The literature describing them is lavish in theories, some of them quite sophisticated, but invalidated by careful observations of the phenomenon as in the case reported by Shepherd and Jolley in this journal (2016).

The evidence presented in this paper strongly suggests that the explanation offered by the Australian researcher R. G. Bednarik (2001: 26, 2016a) might also apply to the abundant markings found in Terceira Island, thus incidentally solving the enigma these marks have raised since their discovery.

Field observations

Since 2014, when we first had the opportunity to observe some enigmatic rock structures recently discovered in Terceira and Pico Islands, we found the grooves on the rocks of Terceira Island even more intriguing than the pyramids of Pico Island, not only for their unusual appearance but also for their abundance and dispersion throughout the island.

Particularly interesting is that most grooves occur on medium hardness trachytic and trachyandesitic rocks while being apparently absent in the other lithologies. These high-silica rocks of comenditic and pantelleritic composition are particularly abundant in Terceira Island, formed essentially by feldspars. They result from long effusive episodes of siliceous nature, forming domes and lava coulées, characteristic of the Terceira volcanism (Self 1976, in Larrea et al. 2019). However, we still ignore whether these rock grooves also occur on the other Azorean islands, where no



Figure 4. Different types of grooves, of variable size, isolated or overlapping, linear or sinuous (photos TA and A. Costa).



Figure 5. Different types of grooves, of variable size, isolated or overlapping, linear or sinuous. Note the claw and Y shapes (photos A. Costa and TA).

research has been carried out yet.

These marks are found in the thousands on trachytic rocks of all dimensions and shapes. In the exclusive case of the caldera of the Cinco Picos Volcano, in Serra do Cume, in an area of $3 \text{ km} \times 1 \text{ km}$, these were used to build the long walls (dry stones) which separate farming plots (*cerrados*), the larger blocks, about 1 m high, regularly separating others of smaller dimensions (Fig. 3).

The marks, or grooves, of variable size, usually between a few centimetres to several decimetres in length, can also be observed on flat and sub-horizontal slabs and surrounding the vertical blocks; their tracing can be either linear or sinuous, enveloping the stone. The patterns are parabolic, and their depths are also variable (up to 2 cm deep) and with a thinner end than the body of the mark. They may or may not cross and overlap each other, present dendritic forms with intricate paths, or be isolated and straightforward (Figs 4, 5 and 6).



Figure 6. Different types of grooves, of variable size, isolated or overlapping, linear or sinuous (photos A. Costa and TA).



Figure 7. Several types of rock basins (photos A. Costa).



Figure 8. Intricate drawings of figures in which A. Costa distinguished boats and dragons. However, the photo can lead to different interpretations when looking at it (photo A. Costa).

They may or may not be associated with cupule-like depressions and inscribed on the outer walls of hundreds of 'sinks' (rock basins), also present in the areas referred to (Fig. 7).

Careful observations have led researcher A. Costa (Costa 2013, 2015, 2017) to decrypt the tracing of the marks, finding symbology typical of recordings often present in archaeological contexts in the Mediterranean basin, such as the forms of boats, snakes and dragons. From her observations in situ and using photography, on which she outlined their respective layout, she concluded that overlapping figures often generate an intricate effect of super-imposed symbols (Fig. 8).

Our field observations of hundreds of marks of various shapes and contexts eliminated the hypothesis of a possible geological origin: no mechanical or chemical erosion agent could produce such features. Moreover, these markings do not correspond to any sedimentary structures, nor can they be classified as geological groove marks, as no fluid transport could be responsible for the incision of the rock. Our first hypothesis was, therefore, to include these 'engravings' in the category of pre-Historic anthropogenic phenomena.

However, several questions persisted: what instruments, in such a primitive society, could have been used to carve such hard rocks (trachytes and trachyandesites) so deeply, and what could be the purpose of such exhaustive work? Who would devote themselves to carving thousands of grooves so obsessively? What would be the purpose of such a Dantesque task? It would take thousands of carvers to produce such an immense number of engraved stones over time, as if a monstrous stone carving factory could have been at work.

Thinking of a possible ancient alphabet, we have searched for specialised literature (Ribeiro 1959), in which the oldest known alphabetic symbols were reproduced, copying the marks on parchment paper on photographs, attempting to find some meaning for them. However, the marks show no alignment, being scattered randomly, and their layout does not correspond to any of the symbols described. Nevertheless, a few forms are repeated with some frequency, especially those that resemble the first three fingers of the open hand (or claw shape) and the Y-shape (Fig. 5).

There are also curious forms similar to stylised moving human figures and other forms resembling

the Phoenician symbol of the goddess Tanit (Fig. 9).

Historical and anthropological facts

There has been much intensive international research on the possible origins for such unusual grooves, but no hypothesis seemed to adjust to the described characteristics of the grooves of Terceira Island. The area in question was visited recently by eminent geographers and archaeologists, like Emanuel Anati in 2007, Barry Cunliffe in 2014 and George Nash in 2015. Anati (2007) and Nash (2015) having written interesting reports about what they observed in the island and the difficulty of distinguishing between anthropic activities and natural events.

Some stories have reached us that Terceira Island was once so densely wooded that it became difficult to penetrate the close forest that covered it. Gaspar Frutuoso (1522–1591) is the author of the oldest chronicles of the archipelago, edited in six volumes (published in 1964, 1966, 1968, 1971, 1978, 1991), in which he describes each of the nine islands in detail. When reporting on Terceira Island, in the sixteenth century, he talks about 'demons that threw stones at the first navigators from the beach' or about the 'ghosts' with human figures and 'bull's heads' who attacked people with such violence that some of them ended up dying (Frutuoso 1978). There is also the legend about the 'gentiles', described in popular tradition as 'tall, strong men who only descended at night from the hills where they lived, to kidnap girls who were never seen again'. 'With the passage of centuries, the number of resident Portuguese increased, and these aboriginal people ended up being surrounded and taken to the prison of Castelinho. The majority resigned to convert to Christianity and to the customs of the islands. We also have el Edrisi's (1866) description about the eleven islands in the 'Ocean which bathes the western part of the "Tenebrous Sea", six of them being inhabited' (in F. Durão 2007). El Edrisi lived from 1100 to 1165 CE.

Although the veracity of this account written by an eminent Azorean historian, priest and humanist has never been questioned, the truth is that the people who inhabited the islands before their 'discovery' by the Portuguese in 1427 are never mentioned in the official history of Portugal, and few will have knowledge of them. Remarkably, the bullfighting tradition is ancestral in Terceira Island, where several *ganadarias* (bull ranches) are active, still feeding



Figure 9. Symbol of goddess Tanit and engraved blocks displaying 'human' figures (photos A. Costa).

traditional festivities, like 'bullfighting' and 'rope bullfighting', which remain favourite amusements to this day.

Despite the silence that surrounds the facts reported here, visitors of Terceira lacking prejudice or political interests can, if accompanied by knowledgeable locals, observe the presence of several megalithic structures, menhirs, concentric circles, hundreds of cupules and cut marks, other petroglyphs, cart-ruts (Rodrigues et al. 2018), hypogea (Ribeiro et al. 2011, 2012) and columbaria. The same can be said for more than a hundred stepped pyramids on Pico Island (Ribeiro et al. 2013) and dozens of caves carved into rock on Corvo island (Ribeiro et al. 2011), which suggests the presence of a previous people which inhabited the archipelago before the Portuguese navigators arrived there (Rodrigues et al. 2015).

The climate

The Azores' climate and that of much of the Northern Hemisphere are conditioned by the Azores Anticyclone (AA), a large subtropical semi-permanent centre of high atmospheric pressure typically found south of the archipelago in the Atlantic Ocean. In addition to the AA, the climate of the Azores is also strongly influenced by the Gulf Stream, due to which the archipelago's temperatures are mild throughout the year. Overall, the climate of the Azores is subtropical oceanic, reflected by the low thermal amplitude, high rainfall, relative air humidity and persistent winds (Agostinho 1938). The archipelago is sometimes affected by the passage of tropical cyclones and storms, resulting in many of the worst disasters it is subject to (PGRH 2015). In addition to these storms, since 1432, when the written records began, there is an endless list of natural hazards such as earthquakes, floods, landslides, slumps, mud and debris flows, and rockfalls on coastal cliffs.

Terceira Island, particularly, has an oceanic climate that means that it rains in all months of the year, precipitation increasing significantly with altitude

(PGRH 2015). A striking feature is a strong contrast between a dry season and a wet season variation that is a consequence of the annual oscillation of the positioning of the AA (Bettencourt 1979; Azevedo 2001). The same contrast can be felt daily. The annual temperature average is 21°C, and the annual precipitation averages 336 mm. The humidity average is 72%, and the UV index is 5. The wind intensity average on the Beaufort scale is 4. The climate average value in Terceira is calculated at 8.3 (Fórum de Meteorologia 2012).

The soil and the flora

Due to its geographical situation and the volcanic nature of the rocks, the climatic features of the Azores archipelago firmly control the type of soil in these islands. According to the Soil Taxonomy (Soil Survey Staff 2014), the Azorean soils are considered Andisols (characteristic of volcanic materials composed of minerals highly capable of absorbing water and nutrients, resulting in excellent productivity and fertility). These soils include both weakly altered soils, with abundant volcanic glass, and thoroughly altered soils, very susceptible to erosion on higher slopes (Pinheiro 1999).

As the existence of a dense forest of large tree species is an essential condition for the explanation presented here, some information about the ancient flora of the Terceira Island is needed, especially regarding beech, cedar and whitewood.

Before the introduction of allochthonous plants, brought by the new inhabitants during their settlement, the typical flora of Terceira Island was the Laurisilva forest, the remainder of the Paleogenic flora, dating from 66–23.03 Ma. This flora is now extinct from most of the European continent due to the glaciations, except for some areas in Portugal, such as the Serra da Arrábida, the Madeira Island and the Azorean islands (mainly in São Miguel Island, in the central plateau of Pico Island and in Terceira Island).

According to the description of Gaspar Frutuoso, until the 16th century, Terceira Island was rich in native species of the Macaronesia biogeographic region (Azores, Madeira, Canary Islands and Cape Verde), where cedars (*Juniperus brevifolia*), beeches (*Myrica faya*), white wood (*Picconia azorica*), laurels (*Laurus nobilis*), heath (*Erica umbellata*), sour cherries (*Prunus cerasus*), viburnum shrub (*Viburnum tinus*), Cape myrtle (*Myrsine africana*), heather (*Erika azorika*) and holly (*Ilex aquifolium*) predominate, and where the first three stand out for their size and behaviour of the roots.

Beech is a deciduous tree that easily adapts to thin soils, to which it contributes with its numerous leaves. It forms dense forests, and its thick canopy prevents sunlight from reaching the soil. This imposing tree may be more than 40 m high and has a thick trunk. Being the dominant species in the low-lying forest at the time of Portuguese settlement in the

Azores archipelago, the beech tree was at the origin of the name of the Faial Island.

Cedar has a thick trunk that can reach a perimeter of 14 m, and roots that penetrate so deeply into the soil that they reach the water table and allow the tree to not depend on rain or external factors to survive. Unlike other roots, which tend to stop growing or even die when they hit a rock, cedar roots 'hug' the rock, enveloping it and continuing to grow, becoming all the firmer and better attached, and can even reach depths similar to the height of the tree, that is, as much as 50 m. With a reddish colour and a pleasant odour, the wood is highly resistant to deterioration, being able to survive many hundreds of years, as evidenced by the discovery, in Sete Cidades, of uncorrupted trunks buried in volcanic materials for at least 2000 years. The tree is distributed from the seaside to the island's highest points, being the dominant forest above 500 m. Cedar planks of great width and thickness used in 17th-century furniture attest to the great dimension reached by these trees in the past.

Whitewood, endemic to Macaronesia, can reach about 20 m of height, at altitudes between 50 and 600 m in the Azores. It has a greyish and rough rhytidome, highly suitable for carpentry, such as the manufacture of furniture, agricultural implements and the Portuguese naval industry that, for centuries, impoverished not only the island forests but also those on the continent.

The author of the *Anais da Ilha Terceira* (Drummond 1981) also reports that the trees were of 'a rare monstrosity in thickness and height' (in Durão 2007; Agenda Açores n.d.). It is not difficult to realise that the need for wood for shipbuilding and the progressive human settlement in the island, with the consequent surrendering of many forested areas to agriculture or pasture, were gradually responsible for massive deforestation of the island, enhanced by rain and wind. This definitively ended with the native 'devils', unlike what happened in the Canary Islands, where, despite the carnage accompanying the invaders, sufficient natives survived and continued to populate the islands to this day.

The progressive receding of the soil over a few centuries, mainly due to the phenomena described above, combined with the strong winds and rains typical of this latitude, have contributed to the partial exposure of the rocky substrate, showing up rocks previously buried and covered by soil.

Findings from the RAMSAR convention 1971 state that above 500 m, in almost all islands, the clouds are permanent, either by orographic origin or under the influence of the Atlantic, always having enough humidity, being always at the saturation point (Ramsar Convention Secretariat 2013). The cloud forest is the wettest expression of the Laurisilva forest, making it the wettest forest in Europe. Experts estimate that there are about a thousand plant species in the

Azores, 75 of which are exclusive to the region, and many are at risk of disappearing.

Comparisons with previous studies

Although we have previously thought of an anthropogenic origin to explain the markings found in the Terceira Island, even though they did not appear to match any known form of writing or serve any evident function, the immeasurable number of rocks exhibiting such markings has recently led us to put aside that origin and to look for a natural one. Similarly,

as noted above, their origin cannot be attributed to weathering effects (mechanical or chemical) either. Neither wind nor heavy rain would produce such deep marks, and the acids released by the roots of plants are too weak to etch such grooves. That was demonstrated by the Sheffield Department of Plant and Animal Science, which reported that 'the organic acids exuded by plant roots are very weak acids and operate at a microscopic scale' (Shepherd and Jolly 2016). On the other hand, several factors contradict the hypothesis of a natural cause, such as the occasional grooves with stylised human shapes, cut marks, cupules, concentric circles, or presumed boats, dragons and snakes, or the large blocks possibly bearing zoomorphic figures (Fig. 10), which occasionally can be human-made, or are effects of pareidolia (Bednarik 2016b).

After extensive bibliographic research, and many failed attempts to reach a plausible explanation for those grooves, Bednarik's hypothesis (2001), repeated in his comments on the paper of Shepherd and Jolley (2016), seems to be the most fitting to explain the Terceira Island grooves. This is because they are located in areas once densely forested and swept by strong winds and occurring on blocks that lie at the present topographic surface.

Grooved stones like those of Terceira Island were reported and depicted by Bednarik et al. (2007) and Shepherd and Jolly (2016), these authors showing grooves with shapes and depths essentially similar to those found in Terceira Island. Shepherd and Jolly describe the numerous explanations for the origin of such rock markings proposed by academic experts, both geologists and geomorphologists and even experts in rock art. Although some of these scientists thought those marks might have a geological or geomorphological explanation, they were unable to find arguments for a natural origin, having put aside the hypotheses of their being fossils of plants or animals, ichnofossils, abnormal stratification, glacial stria-



Figure 10. Zoomorphic figures usually localised on the board of some calderas (photos by A. Costa).

tions, drag marks or any form of erosion or erosion pattern, therefore coming to suggest an anthropogenic origin.

Other hypotheses invoked the interaction between rock and the acids produced by tree roots (i.e. the exudation of organic acids by plant roots) or to marks left by polishers, but the latter was discarded when the engravings were compared with actual polishing marks. Other suggestions have included tyre marks left by bicycles, mountain bikes or traction vehicles, or impact marks of small firearms, bullets, mortars, chisels, explosives or even scars from small quarries.

Shepherd and Jolly concluded that the evidence 'might support a case for a process or mechanism affecting the rock surface post-formation and post-exposure' 'Alternatively, the features may be a previously unrecorded type of anthropogenic rock marking. Thus far, no definitive interpretation has emerged from extensive consultations, although some indications may be deduced'.

In response to the questions and doubts expressed by these authors, Bednarik (2016a) repeated his explanation (Bednarik 2001: 26), based on the fact that in densely forested areas with thin soils, tree roots can entrench themselves in the soil as if 'embracing' the underlying rock, strongly enveloping it as they penetrate deeper (Fig. 11). This author describes the case of the markings found on granodiorites and muscovite-biotite granites observed in Tasmania:

Typically, these grooves have been described as sometimes undercut (a characteristic that baffled Luckman); they are usually not very long, may meander over the rock and include branching. Their randomly orientated, rounded furrows often resemble petroglyphs, but their identification presents no difficulty to the rock art scientist (Bednarik et al. 2007: 166).

Likewise, they do not present difficulties to the trained sedimentologist, capable of distinguishing any grooves produced by geological mechanisms.



Figure 11. Tree roots 'hugging' stone blocks (photo on the left: Wilson Maia dos Santos, in <https://blogaultimafrombeta.wordpress.com/2018/07/23/crescendo-como-cedros-do-libano/>; photo on the right: Krzysztof Kowalczyk, in <https://www.dreamstime.com/big-stone-overgrown-tree-roots-singapore-bukit-batok-nature-park-stock-photo-big-stone-overgrown-tree-roots-stock-image141270270>).

Bednarik appeals to the kinematic factor due to the movement of the uppermost roots whenever the tree moves or oscillates with the force of the wind, these movements, being strong and constant in climates of high wind energy. This movement of the roots, with their radicles and dendritic forms, generates abrasion on the surface of the rock, 'carving' it more or less deeply and as randomly as the route they sought. The way the tree roots 'embrace' the rock, gnawing at it and often enveloping it, at the same time makes the trees remain stable, firmer and more attached to the ground, as described in the case of some cedars. Importantly, Bednarik (1916a) reports that when a tree at a Sydney national park was uprooted, it exposed 'a set of grooves clearly matching the morphology of the tree's roots'. These marks matched those he had observed previously on the sandstone in the vicinity, soundly confirming his interpretation.

This tightening of the roots on the rock originates a phenomenon of abrasion studied in tribology, the multidisciplinary science (physics, chemistry, mathematics, mechanic, fluid dynamics) which studies the interacting surfaces in relative motion, including the concepts and application of the principles of dynamic friction, lubrication and wear (Bednarik 2019, 2020). Tribology has been studied and applied, for half a century, almost exclusively in the field of engineering, in metal parts of machinery and industrial purposes, as in the ceramics industry (Belino et al. 2018). When considering living organisms, as in the present case, it is designated as biotribology.

As Bednarik (2016a) writes:

The precise process of [the grooves'] formation is a subject of tribology, the science of interacting surfaces in relative motion, and the technology of related subjects and practices (see article on the forensic science of cupules, this issue of *RAR* [33-1]). In this case, millimetre or sub-millimetre movements in

the main roots of trees, in combination with sand or silt-grade fractions acting as abrasive, effect a forensic transfer (cf. Locard's Exchange Principle) of material.

The wear phenomenon causes the progressive loss of material due to the relative movement between surfaces, resulting in a localised, permanent and progressive change in the structure, which occurs in the material subject to fluctuations in stresses and deformations. In particular, abrasive wear resulting from the skimming of the particles and lumps of the materials against each other along the contact surface seems to be the one that acts in forming the grooves. When abrasive wear is 'cut', loss of material occurs due to the shearing of particles causing the removal of small fragments of material, creating a small groove on its surface.

Abrasive wear, considered one of the main problems of current mechanics, can be reduced by lubricants whose viscosity is the most relevant factor. In the present case, it is suggested that viscosity may be provided by the mucilaginous substances exuded by plant roots. To provide anchorage and establish under unaccommodating environments, whatever they are (geological, soil compaction, or even chemical contamination), roots can exude different polysaccharides and weak acids, a food source for microorganisms attraction which in turn release their exudates. This activity enables plants to create their rhizospheric microbiome dependent on each environment to scavenge water and trace minerals. By promoting hydrodynamic lubrication, this type of microenvironment may become responsible for the greater or lesser depth of the grooves through the cutting effect by abrasive wear.

As the lubrication reduces abrasion, we wonder if the process would not be facilitated by a previous, even incipient chemical alteration or corrosion of the stone by the environment created around the roots. Despite the few existing Portuguese works on chemical analyses of trachytes, two try to explain the behaviour of trachytes degradation by weathering. The first one (Sequeira Braga et al. 2000) tries to understand to what degree the trachyte rocks that constitute the façade of the cathedrals of Angra do Heroísmo in Terceira and Misericórdia Church in Santa Maria are susceptible to weathering, comparing them with samples of healthy rock collected in a nearby quarry, using the same methodology. Petrographic, mineralogical, chemical and petrophysical analyses were carried out. Evident differences were noted between the trachytes of the two islands, but in each island, the characteristics of the samples from the quarry and the monuments are very similar. The authors (Sequeira Braga et al. 2000) concluded that all the rocks have very high porosities dominated

by large pores with a main radius mode between 0.1 and 10 µm, leading to high susceptibility to degradation due to salt crystallisation.

The second one is a very interesting master's thesis carried out to verify the geotechnical and chemical properties of the trachyte as an ornamental stone in a trachytic outcrop near Mafra (Porto Formoso stone, 50 km north of Lisbon). The samples tested were all compared with samples of trachytes of Terceira Island (Oliveira 2017). The more than 20 analyses of resistance to chemical agents allowed to classify the trachyte as resistant to the most aggressive reagents and with high concentrations, resulting only in a variation of colour, small crystallisations on the surface of the samples and, in general, a slight weight gain. This study (Oliveira 2017) showed that, despite its high degree of water absorption, trachyte is a rock resistant to mechanical actions and not very susceptible to environmental variations of high thermal, saline, leaching and chemical amplitudes. The author concluded that the experiments performed allowed classifying the trachyte as a rock resistant to intense mechanical actions, despite its high water absorption, a factor that may influence the behaviour of the material outdoors. In relation to the alteration study carried out on the rock, it proved to be not very susceptible to environments with high thermal amplitudes, salt, leaching and acids. According to the analysed parameters, this trachyte has a high quality, which can be used in various applications and products.

It would be of significant interest to extend the study of tribology to the area of rheology, applied to plant biology, since studying viscosity, plasticity, elasticity and changes in the shape and flow of material would allow a better understanding of the mechanisms behind rock material/root interactions.

However, the examples given by Bednarik (2001, 2016a, 2019: 72, 73) and Shepherd and Jolley (2016), even when mentioning previous works, differ fundamentally in one respect from the marks found in the Terceira Island. The marks referred to by those authors are almost always 'carved' in sandstones, with no example being given in volcanic regions. Therefore, the Terceira Island grooves are the first of such kind.

Nevertheless, it is worth noting the coincidence of the siliceous nature of the rocks on which these markings appear: silica-rich sandstones in the U.K. and other countries, granites and granodiorites in Tasmania and trachytes in the Terceira Island. Trachytes and trachyandesites are practically the only silica-enriched rocks, responsible for 80% of the rocks, present on Terceira and the only ones on which such grooves have been observed so far. We wonder whether silica-rich rocks might be more vulnerable to abrasion by tree roots. However, it has not been discarded that such grooves may yet be found on other lithologies, such as basalts.

Looking for explanations

The chronicles of Gaspar Frutuoso (1978) tell us that Terceira Island was densely forested, and the 'bush' almost reached the sea. The author never tires of praising the fertility of the island, where all kinds of animals, flowers and fruits grew, allowing us to understand that an incipient humanised landscape was already implanted during those times, about 100 years after the first Portuguese settlement. These statements, however, related to the flat areas of the volcanic calderas, whereas their slopes, on the contrary, were very rocky and of little use, except for large trees, whose wood was used for multiple purposes. He says that 'going to the discoverers of these islands, to the Infante (D. Henrique), he asked them for their things and qualities and, among others, asked if the trees had their roots deep in the earth'. The answer was, 'no, they are almost at the surface'.

This information complements the hypothesis placed by confirming the relative thinness of the soils outside the volcanic calderas, making the trees cling to the regolith by enveloping its blocks, 'embracing them' with their roots.

In short, according to the chronicles of Gaspar Frutuoso, in the sixteenth century, we know that:

- Terceira Island was previously covered with a forest that almost reached the sea.
- In the flatlands of the volcanic calderas, the soil was thick and fertile and responsible for extensive grazing areas and the enormous agricultural wealth and allowing the proliferation of cattle.
- On the contrary, in the interior and on outer slopes of volcanoes, the soil was poor and thin, with abundant stones and large trees.
- The trees included beeches, cedars and white-wood, the wood used by the island's residents, from the fourteenth century onwards, for the intensive construction of ships and various useful implements.

Applying the model proposed by Bednarik (2001) to the marks observed in the Terceira Island and reasoning from the geological and pedogenetic point of view, we can think of the roots as 'embracing' the regolith. They expand as the bedrock decays and fragments, transforming it into blocks of varying dimensions, depending on the process and the rock structure, the roots taking advantage of its fracturing pattern and other structural weakness.

The action of strong winds, as are typical in this geographic region, may not even be called for to explain the movement of the roots. The frequent micro-earthquakes felt in the islands of the Azores archipelago have been a constant over time and constitute a much more effective means to shake the trees and their roots so that their abrasion was increasingly active and deep and greatly favoured by the thinness of the soils described by Gaspar Frutuoso (1978).

As for those marks which seem intentional, such as those showing human configuration or similar-



Figure 12. Concentric circles petroglyph, cupules and potential cupules (photos TA and A. Costa).

ties to the symbol of the goddess Tanit, cupules, cut marks, concentric circles, boats, dragons, snakes and other zoomorphic figures, it is plausible that the ancestral inhabitants of the island, when observing these strange and unknown grooves, might have considered them as something magical and sacred, taking advantage of their tracing to carve out forms of their own (Fig. 12).

As Shepherd and Jolley (2016) note:

There is a modern dissociation between that which we know/suspect to be natural and that which we find acceptably anthropogenic in origin. Uncommon marks on rocks would not be perceived in the same dichotomous manner in pre-History, where (say) grooves, fossils, clasts, inclusions, exogenic fulgurites, cross bedding, slickenside, mineral veins and so on could not be rationalised in the same way.

A. Costa, author of several papers (Costa 2013, 2015, 2017), after many careful observations and drawing hundreds of grooves representing 'boats, snakes and dragons, the symbol of the Phoenician goddess Tanit' and others, also finds it plausible that all this symbology may have been created using pre-existent grooves. Bednarik (2016a) also observes that '[t]he possibility that pre-Historic people observed natural rock markings, were intrigued by them and sometimes added petroglyphs to them, such as cupules, is very real as has been demonstrated at numerous sites'.

However, he also says that the attribution of some symbols to intentional action can be a result of pareidolic interpretation (Bednarik 2017, see also 2016b):

In rock art interpretation, once the brain has been conditioned to anticipate specific patterns, it tends to discover them with minimal stimulation because most of the information processed by the human visual centre derives from within the brain. The creative pattern detection that constitutes rock art 'interpretation' is effectively a projection of invented meaning onto mute marks on rock.

The modern human brain has no relevant past experiences to draw on, and no such ability should be presumed to exist ... No scientific access to the meaning is possible in the absence of credible ethnography. All other modern interpretation of rock art is via pareidolia.

Final remarks

Despite all the technological progress of the last centuries, many scientific phenomena remain unexplained, even in the domains of geology and archaeology, and there are bulky books on secrets that Nature keeps and have not been revealed to this day.

Many explanations proposed so far have failed, for one reason or another, to adjust to the observations made on the Terceira Island volcanic blocks covered with thousands of random grooves. The groove forms do not resemble any known type of ancestral writing, and explanations of a meteorological nature were also discarded. The most plausible interpretation, calling for the penetrating abrasive action of the roots of large trees (such as beech, cedar and whitewood) on the regolith blocks appears to be the most consistent with all observations and the only one that explains them in their entirety. Taking into account the characteristics of the trachytes, this hypothesis, reiterated by Bednarik (2016a) in his comment on an article by Shepherd and Jolley (2016), where they describe and show images of grooves in sandstone in the Pennines (U.K.), quite similar in all their features to those of Terceira Island, is, according to our observations, here adapted to the Terceira Island rock markings.

It is possible that the ancestral inhabitants, when observing such strange and unknown grooves, attributed some mystical value to them, adorning the surroundings with other forms of veneration. These may have included cupules and circles, sinks (rock basins) and even taking advantage of their layout to give them known or mythical forms and using the morphology of certain blocks to carve animal shapes, of which the numerous zoomorphic figures are excellent examples.

We think that this model can be extended to the 'Gotland grinding grooves' (Gannholm 1993) and other grooves with the same pattern and context in other regions of the world, ending, eventually, the 'mystery' of their origin. In the Swedish case, the orientation of the grooves can be due to the direction of the prevailing winds, leading to the preferential inclination of the trees and consequently directed movements of the roots. On the other hand, the shape of the grooves is due to the different configurations of

the roots, depending on the type of the tree, considering, however, the multiple factors of the matrix, such as the soil temperature, the viscosity and density of the rhizospheric mucilages, the type and concentration of nutrients, the texture of the rock, for example — factors that will determine the exact conditions of biotribology.

It would be quite interesting to follow up these studies with the observation of other cases in which large trees, in poorly evolved soils and plucked from the roots during major storms, may show some sign of these 'hugs' to the underlying rocks and grooves resulting from their abrasive action, in addition to the case reported by Bednarik. Observation of such grooves under a binocular or electronic microscope might also be useful to check the course of the abrasion and the role of the silica in all this process.

We hope to have contributed to the resolution of a geo-archaeological phenomenon that has mystified many until now.

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Assoc. Prof. M. Teresa M. Azevedo
Departamento de Geologia
Faculdade de Ciências da Universidade de Lisboa
Edifício C6
1749-016 Lisboa
Portugal
terazeve@fc.ul.pt

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Excerto da Monografia

"The Rock Basins of Serra do Cume"

Excerto da Monografia “The Rock Basins of Serra do Cume” Antonieta Costa (2014, pp de 25 a 35)

Geologia

At this point and with so many interrogations growing it seemed necessary to ask for support from the part of Geology.

Next chapter is from the responsibility of Prof. Dr. Teresa Azevedo, Professor and Researcher from Faculty of Science of Lisbon University (FCUL)

VI Geology

The Terceira Island belongs to the Central Group of the Azores Archipelago. It is crossed by the Terceira Ridge (TR), or *Rift*, with WNW-ESE general orientation, which develops from Graciosa, Terceira and São Miguel, till Santa Maria islands. The Rift is about 500 km long, being splited by a number of tectonic basins separated by submarine volcanic ridges. It links with the Atlantic Middle Ridge through the Azores North Fracture and is considered by some authors as the present Eurasia-African plate board in this region.

In this segment of the plate board, relative displacement speeds between the Euro Asiatic and African plates of 0,76 scm/year, were determined (Buform *et al.*, 1988).

Petrography

It's curious to observe that the sacred sites in study in Terceira Island are all localized in trachyts and trachy-andesites, providing from lavas with a much bigger richness in silica than the rocks of the other islands. In São Miguel occur the more potassic rocks of all the archipelago and in Santa Maria, sodium dominates in the basalts (White *et al.*, 1979)

In petrographical terms, in Santa Maria, São Jorge and Pico Islands, basalts or picritic alkaline basalts dominate, while in the remainder islands there is a biggest variety, from picritic alkaline basalts to trachytes, including hawaites and mugearites (Self, 1976).

In Terceira Island lava presents a quite variable composition, since porphyric alcalyne basalts with phenocrystals of olivine and augite, till comenditic trachytes and pantelerites. There is no under saturated lavas. (Zbyzewski *at al.* 1971)

The excess of silica (63,71%), even if quartz is only present as a virtual component, in relation with the low tax in alumina (12,42), allows distinguish the petrography of Terceira from the other islands of the archipelago, essentially of basanitoide type, deriving from sub saturated lavas, the acidity values never surpassing the degree of saturation

The degree of oversaturation is quite high as the value of 4 and the Lacroix parameter q demonstrates (*idem*).

The big volume of effusive and explosive materials of siliceous nature represented by numerous eruptive centers of trachytic nature and about one hundred fifty domes (Nunes, 1998), must be emphasized. There are also eruptive centers responsible by “*coulees*” which are also associated to viscous magma eruptions.

Trachytes are leucocratic, effusive volcanic rocks composed essentially by alkaline feldspars (sanidine and orthoclase), with less quantities of plagioclase (oligoclase). It can also occur albite, biotite, hornblende, quartz, sodic amphibolite's and pyroxenes, in alkaline trachytes. There are yet as accessory minerals, apatite, zircon, iron oxides, magnetite, titanite, and allanite.

Trachytes are considered the volcanic correspondent of sienites.

Andesites are also rich in silica (52 a 63%), that is, they are also over saturated rocks in silica. However, they are, in general, darker, due to the presence of mafic minerals. They can be also dark grey to black or to be leucocratic (grey to light grey). As accessory minerals they can show phenocrystals of olivine (olivinic andesites), zeolits (zeolitic andesites) or sanidina (sanidinic andesites).

Besides this silica enrichment which dominates in Terceira, other siliceous deposits occur, as geiserites, as well as stalactites and stalagmites in caves and algars. In Pico Vulcan, a small bed of

obsidian, constituted by more than 70% silica, also occurs (Zbyzewski *et al* 1971).

Enriched silica rocks Hawaites and comendites correspond to the larger volumes emitted along the eruptive history of Terceira in the last 23000 years during which 116 volcanic eruptions were responsible by the emission of 5,46 km³ of the material, from which more than 4 km³ correspond to lavas of comenditic and panteleritic composition. These values allow calculating the average volcanic productivity in about 0,024 km³/century, in this period.

Once the oriental and central groups of islands are localized in the board of the Euroasiática-Africana plates, the alkaline character (Gaspar *et al*,1990) of the series allows to fit them in the basalts intraplate domain.

Quartz and megalithic monuments

In the Serreta and Penedinho area, in the south extremity of the Serra do Cume, is situated the main center of trachytic eruptions occurring in the Terceira Island. In the oriental slope, a light andesitic band over the trachytes, can also be observed along the waterlines (Zbyzewski *et al*. 1971)

The most common and important factor between all the megalithic monuments around the world, mainly those used as magic and initiatic sanctuaries, is the presence of quartz.

In fact, silica is an indispensable material in the building of these monuments. Even if they are not in granite, they all have a high tax of silica, as trachytes, shale's and sandstones or even some limestones, under the form of oolitic limestones. These are formed by the agglomeration of little eggs or granules which nucleus is, often, a quartz grain. It is also frequent to observe pegmatitic granites, with big ice quartz crystals or feldspar, like orthose.

The strange apparent coincidence that all the studied sacred sites are implanted in the rich silicon Terceira rocks, made us research the mystic importance of quartz taking in account:

- 1- some chemical and physical characteristics of silica
- 2- the mythic significance of silica in ancient times

3- the role of this mineral in the ancient choice of the sacred places.

Chemical and physical characteristics of Silicon/Quartz

Silicon was discovered by Jans Jacob Berzelius in 1824 and crystalline silicon, a second allotropic form of the element, was prepared by Deville in 1854.

After oxygen, silicon is the more abundant element in the earth crust. 26 to 28% of it is composed of silicon. It's known that the silica tetrahedron, is the building stone of the biggest part of all the minerals under the form of quartz, the silicon dioxide (SiO_2), present in almost all types of rocks.

The silicates represent about 60% of all the lithosphere. Silicon occurs mainly in the form of quartz but many other crystalline forms do exist. Granite, quartzite, sands and sandstones are the main rocks composed by silica.

Silica is essential to plant and animal life. In the seawater its concentration is quite low (3 mg of silica/l) but many sea microorganisms as diatoms, sponges and radiolarites build their walls of silica mainly in the zones of the ocean where upwelling currents are abundant. There, the cool deep sea waters rich in nutrients, as silicic acid resulting from the decomposition of sinking organic matter, are carried to the surface allowing phytoplankton extracting silica to use as a component of their cell walls.

In space only one atom of silicon exist to 30 000 atoms of hydrogen. It is present in the sun and stars and is a principal component of a class of meteorites known as aerolites.

Because it is the last mineral forming in the fractionated crystallization in the magmatic cameras, at the lowest temperatures (600°), it is more resistant to the weathering, more stable and harder (degree 7 of the Mohs scale) than the other minerals. Associated to a molecule of carbon it gives place to one of the hardest substances, the silicon carbonate, which structure is similar to that of diamond, reaching 9 to 10 in the Mohs scale.

The periodic system shows silicon and carbon to have a certain similarity, as they are closely related chemically. Silicon, as carbon, shows a strange duality: in the form of quartz it is extremely hard, yet in the organic sphere and in conjunction with water it may be extremely ductile or plastic.

Silica has a particular relationship to water. When finely dispersed it is able to absorb enormous quantities of water: One mole of silica will absorb the incredible amount of 330 moles of water. It means that 1 gm of silica is capable of absorbing approximately 100 gm of water or, one hundred times its weight. The result is organized, structured water, water that “has form”. This can be seen in the vitreous body of the eye that is such organized, structured water. In fact, all water in the human organism is of that kind. Swelling and gelling processes occur everywhere, and it always means water and silica. Connective tissue gives it form. In the plants, mainly in grass, for instance, small crystals of silica are responsible for the sharp character of the limbs where it is mainly stored.

Quartz is a Diamagnetic mineral, that is, when it is submitted to a magnetic field, a weak magnetization appears, which has the opposite direction of the applied field. This induced magnetization disappears when the field is retired.

This means that the magnetic susceptibility is weak, negative and reversible. Quartz and calcite have similar behaviours in different aspects. Both are, for instance, diamagnetic, with -10^{-6} , S.I units

Quartz has very particular characteristics from different points of view. These particularities, as piezoelectricity, allow it to be employed in hundreds of applications since ever and each year even more are discovered.

When quartz crystals are electronically “excited” they produce microwaves or radio waves with a very high frequency. A very narrow beam, named *maser* or “microwave amplification by the

stimulated emission of radiation” can go out from the crystals, at regular intervals and under specific conditions. The difference between *maser* and *laser* is in that while a laser is a directed energy tool or weapon based on “light amplification by the stimulated emission of radiation”, a *maser* instead uses microwave amplification, or electromagnetic fields as an alternative of coherent light beams, to produce similar results.

Quartz crystals can change their form and curvature when an electrical charge is applied. When form changes, mainly through compression, the crystal produces an electric charge that travel all over its surface. An example is the gas lighter which, when a quick pressing is applied, creates a thousand volts charge generating a spark strong enough to light the gas.

A mechanical deformation applied to a quartz blade generates its electrical polarization. This behavior is named *piezoelectric effect*.

In the inverse sense, if two poles of an electrical field are applied in both opposite faces of the slab, this will suffer a deformation. In a certain frequency of the electric field the blade will produce ultra-sounds, which can be applied in the sonar construction.

Another effect even more important of the quartz crystals is the Resonance. If the crystal is under tension when the charge is applied, it will expand or bend, going back to its initial position and producing an opposite charge. If the initial charge is maintained it will expand again generating an electronic as well as mechanical resonance which will repeat alternately and incessantly.

The reason for these amazing properties can be explained by the colloidal behavior of silica but this explanation is not in the scope of this text.

The piezoelectricity allowed using it in a variety of applications and it is also largely used in numerous industries. Because of its numerous uses quartz has been called the "Universal Crystal".

It has a very important interest in the production of basic material for transistors chips, solar cellules, armament,

computation, civil construction, aero spatial, electric, electronic and microelectronic materials, electro domestic, medical equipment, metallurgy, optical, chemical, telecommunications, solar panels, watches, lighters, motor vehicle industry, etc. Silica is also an important ingredient in steel.

For all these reasons the region of the USA (California) where several electronic and informatics enterprises are concentrated is called Silicon Valley.

Mystic significance of silica/quartz

The silicate group, includes a big variety of precious and half precious stones as tourmaline, onyx, topaz, amethyst, opal, garnet, sapphire, emerald, ruby, chalcedony, jasper, agate, etc, all used as magic materials since thousands of years ago. Clear Quartz, pure silicon dioxide, is also called Rock Crystal or Ice Crystal, from the Greek word "*krystallos*", meaning "ice", because crystal was believed to be water frozen so hard it could never thaw. In ancient Rome ladies of luxury carried crystal balls in their hands for cooling purposes during summer weather.

Power of crystals and of quartz, in particular, is recognized since immemorial times, namely in Egyptian culture, where they were used in healing and harmonization of the physical and energetic body, giving physical, mental and spiritual equilibrium. Registers tell that also in Greek and Indian, quartz crystals entered in the composition of elixirs applied as a cure method and they were used as common healing in medicine. Ancients believed these stones to be alive, taking a breath in a certain rhythm and many cultures thought them to be incarnations of the Divine.

For ancient Japanese it represented perfection and they believed it was formed from the breath of a white dragon. Australian Aborigines used quartz in rain rituals. Spheres of clear quartz have been used as crystal balls to predict the future at least since the middle ages.

The power of the quartz crystals is known as having a high frequency vibrational energy which can be directed to the points

of energetic deficit on the human body. According to the color and size they have a specific function. Nowadays, their power is still recognized even if the official medicine doesn't approve it.

The structure of silica is organized in hexagons and can be represented by 2x3, or two triangles, being the number six related with cosmic forces. Much more was known in the past when people were aware of the significance of numbers. In Hebrew, every letter of the alphabet has its numerical correspondent starting by the greatest, there is, the number One. One, the first letter of the Hebrew alphabet. Oneness, Unity, is the beginning of everything. The two triangles of the hexagon (six) is the image representing spiritual entities, creative spirits accurately described in the Bible as the Elohim.

"Cosmic light forces come to an end in silica on earth. Silica is thus the vessel or mediator of cosmic light forces. In its purest form, as rock crystal, it is pervious to light, though one might also say it is pervious to cosmic forces". Silica channels cosmic energy.

According to Rudolph Steiner, the father of the Antroposophy:

"Everything that lives in the siliceous nature contains forces which come not from the earth, but from the so called distant planets, the planets beyond the Sun- Mars, Jupiter and Saturn". Silica is the conduit through which the forces of the distant planets work. (Steiner, 1980). His ideas about silica were mainly based in that it can be considered as a process and as a substance and it acts differently in both cases.

He dedicates a whole chapter of one of his books (Steiner, 1991) just describing the importance of silica in the formation of the human body, mainly of the head. Because silica is responsible for the organizing principle behind it, the younger an organism is, the more silica does it contains.

The same can be said about water since human beings originally consist of water giving sense to the idea that we have our origin on water. But that water must be highly organized otherwise

the form could not enter into it. It is silica that allows the presence of form starting by the periphery. Organs with the highest silica levels are the skin, nails, hair, and the connective tissue that is present in all parts of the organism. The form is thus given to the embryo from the outside, the skin enveloping it having the highest silica content of the entire environment.

Dr. Steiner also implemented a new and revolutionary way of make agriculture, called byodynamic, just using quartz properties. His method is comproved and gives extraordinary results. Biodynamics is then, an agricultural method developed from indications given in 1924 by this doctor, that employs what is described as "a holistic understanding of agricultural processes". It laid the foundation for a new way of thinking about the relationship of the Earth and the formative forces of Nature.

Biodynamics, characterized as "spiritual science", is both practiced and taught, bringing health and wholeness to the land and the community and became the first organized organic approach to farming. It treats soil fertility, plant growth, and livestock care as ecologically interrelated tasks, emphasizing spiritual and mystical perspectives.

Even if the methods are controversial and critics have characterized biodynamic agriculture as pseudoscience on the basis of a lack of strong evidence for its efficacy and skepticism about aspects criticized as being magical thinking, biodynamic techniques were used on 142,482 hectares in 47 countries (2011 dates). Germany accounts for 45% of the global total the remainder average 1750 ha per country.

One of the most famous method of Biodynamic agriculture is just the use of preparations such as burying ground quartz stuffed into the horn of a cow, which are said to harvest "cosmic forces in the soil", that are more akin to sympathetic magic than agronomy.

Steiner says:

...“all quartz rocks are like eyes through which the Earth can see into the Cosmos. We are reminded of the many- faceted eyes of

insects which divide into numbers of parts whatever comes toward them from the outside. We should, and indeed must, picture innumerable quartz and similar formations on the surface of the Earth as being eyes enabling the Earth inwardly to reflect and indeed inwardly perceive the cosmic environment. And gradually the knowledge dawns in us that every crystal formation present in the Earth is a sense organ for perceiving the Cosmos

And in June 7, 1924 at Count Keyserlinck's estate in Koberwitz, Dr. Steiner said:

"On the other hand, when plants evolve in such a way that they become food for humans and animals, then Mars, Jupiter and Saturn, working via the siliceous nature, are involved in the process. The siliceous nature opens the plant being to the wide spaces of the Universe and awakens the sense of the plant in such a way as to perceive from all quarters of the universe the forces which are molded by these distant planets. Whenever this occurs, Mars, Jupiter and Saturn are playing their part. From the sphere of the Moon, Venus and Mercury, on the other hand, is received all that which makes plants capable of reproduction."

A quartz crystal is a kind of accumulator of energy. It can absorb, store, project, dissipate and focalize subtle energies. Silica can transmit more than 95% of the wave length of the infrared radiations. Its molecular structure is geometrically perfect and it is sensitive to a wide range of waves processing and emitting energy in frequencies imperceptible to human being. Its different varieties are used in crystal therapy in order to confer and stimulate energies or to protect against those that must be prevented.

Quartz is also an excellent all-purpose crystal healer stone, dispelling negativity and clearing away negative energy being considered a Master Healer stone. It is said to amplify healing energy and is used to perform diagnostic healing. Quartz crystals have a high frequency vibrational energy and are used in several treatments and therapies as color therapy. Each crystal has a specific function according to its color and size.

A personal quartz crystal can protect as a powerful instrument of psychic defense. Kirlian photos shows that the human biomagnetic field doubles when one handles a quartz crystal and it grows over time till a point in which it enters in resonance with the energetic pattern of the body providing lightness, harmony and balance.

This is only a little abstract about silica properties. Over the last centuries several famous scientists have made amazing discoveries. Between them was Marcel Vogel, one of the most prolific scientists in IBM history with over 100 patents in his name practiced along 27 years, as the invention of the magnetic coating for the 24" hard disc drive systems. In the 1970's his pioneering work in man-plant communication experiments led him to the study of quartz crystals. From continual experimentation came the first fundamental instrument for storing, amplifying, transferring and cohering the energies of the bodymind of an individual: a four sided faceted quartz crystal with pyramidal terminations which are known as Vogel-cut® crystals.

One of the most important researches in the application of quartz crystals was the relationship between quartz and water. With the Vogel-cut® crystals he could structured the water by spinning it around a tuned crystal, altering many of the characteristics of the water and converting it into an information storage system. (1996 2nd Annual Advanced Water Sciences Symposium and the 1998 United States Psychotronics Association Conference).

Although the extraordinary importance of his work and the incredible experiences he did, researching the amazing possibilities and potentialities and extraordinary energies of quartz, its name is almost unknown of the academic community. This is always so sceptic that only centuries of years later it will accept it...Galileu and Giordano Bruno between others, were witness of this!

After describing some of the numerous extraordinary properties of silica it seems obvious and understandable that our ancestors choose the enriched silica rocks, mainly granites, to build their

sacred places. In the goethean science, Goethe called the granite the Proteus of the mineral world. They knew all its potentialities and could use it to fertilize the soils, to cure illnesses, to connect with the stars and gods, to orient the soul in its path in direction of eternity...