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Editorial

A Two-Way Avenue of Knowledge: An Editorial for the Special Issue "Geoscience of the Built Environment 2019 Edition"

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Abstract: This editorial presents the papers published in the 2019 edition of this series of special issues in the context of the contribution of geological studies to the development of knowledge on the built environment (namely materials) and in the opposite sense, that is the potential contribution of studies of the Built Environment to geoscientific knowledge. This is discussed considering the major framework of the Anthropocene.

Keywords: Anthropocene; geomimicry; materials; mineralogy; climate change

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According to a report from the Working Group on the 'Anthropocene' (Subcommission on Quaternary Stratigraphy, a constituent body of the International Commission on Stratigraphy, a scientific organization within the International Union of Geological Sciences), the Anthropocene is being considered as a possible new series/epoch of the geological record distinctly influenced by human impact and whose base will mark the end of the Holocene [1].

According to this document, the start of the Anthropocene is being proposed for mid-20th century, which, incidentally, will make the Anthropocene almost coincidental with the clear rise of the environmental movement and the idea that humans should, in "Homo Deus" fashion, "protect the planet as a whole" [2].

Among the distinguishing features of the Anthropocene proposed in the document of the Working Group mentioned above is included the "global dispersion of many new 'minerals' and 'rocks' including concrete, fly ash and plastics, and the myriad 'technofossils' produced from these and other materials" [1]. This indicates that, notwithstanding the reservations suggested by the inverted commas around minerals and rocks, the structures of the built environment and their materials are being considered as suitable subjects for geosciences' studies by themselves and not just insofar as they concern existing geological objects (groundwaters, terrains and the extraction and use of products from those terrains).

This relation between the built environment and geosciences can be seen as a two-way avenue in the search for knowledge. In one sense, the design of materials and structures can benefit from the study of existing geological objects, which can be included in the relatively recent grand theme of geomimicry [3] but that has older roots. Indeed, one can speculate whether certain geomorphological dispositions of rock blocks (as are frequently seen in granitic regions) inspired the design of dolmens and whether the observation of pyroclastic rocks, resulting from welding of volcanic ash, contributed to the invention of Roman hydraulic concrete (Vitruvius [4] attributes the effects of volcanic pozzolanic ash in concrete to the geological origin of this product, albeit in the language of the time, with reference to "the force of fire"). One can also recall the story of the discovery of the environmental impact of leaded fuels that resulted from studies by Clair Patterson to measure the age of the Earth, also helping to launch the studies of ice cores (an engaging rendering of this story can be found in a Bill Bryson book [5]).

The observation of processes in the built environment, such as the alteration of materials and the formation of new products, can offer contributions in the symmetrical sense, i.e., to the understanding of geological features outside the built environment, including the question of time spans involved (in a book about the geological perspective of time, Bjornerud [6] discusses the interest of highlighting also fast rate processes as they help to underscore the impact of human activities on Earth processes). As already mentioned in the editorial of the previous edition of this series (Geoscience of the Built Environment), one can find this perspective already in the works of Lyell, as when he uses the observation of crusts formed on the vertical walls of large steam-boilers to explain certain features in travertine [7].

Geological methods, techniques and knowledge have been extended to human-made materials, namely through petrographic studies of ceramics, mortars and concrete, which, just like rocks, are polyphasic aggregates of crystalline substances where structural and textural relations can affect the behaviour of the whole. Petrographic studies are essential to understand the results of macroscopic physical tests such as mechanical strength. In the case of cementitious materials, there are even standards regarding this kind of studies, such as ASTM C856-18a [8]. This is set to gain even higher importance in the future due to the importance of recycling diverse kinds of wastes and hence using diverse kinds of aggregates for concrete as is shown in the paper by Petrounias et al. [9].

Environmental reasons have also promoted the current high interest in earth architecture (using geological materials that frequently were considered waste and that present appreciable thermal properties and with extraction techniques that present lower emissions of pollutants such as CO_2 or noise). One of the points that might cause concerns to eventual end-users is the frequently presumed lower durability of these granular products when compared to stone, concrete or brick. Frost is considered to be a potentially hazardous agent for building materials and while there are many papers on frost effects on stone, concrete and bricks, there are much fewer papers on earth materials.

The paper by Rempel and Rempel [10] is a pertinent contribution to the major theme of structures made with earth materials, regarding their durability in relation to frost action, comparing materials with different characteristics (representing different contributions from humans, namely in terms of raw materials) under different climatic scenarios. This links our special issue to another major issue of the Anthropocene: climate change. Obviously, most attention has been given to major impact consequences such as sea-level rise and extreme climatic events. However, climate change will be a pervasive condition and this paper also relates the potential effects of frost to climatic conditions, making clear predictions about their effects and the effects of climatic change.

In the same way that biologists have embraced urban speciation for organisms, geoscientists could embrace the occurrences of crystal structures that are formed in the built environment that are not the products of human projects. Indeed, one can argue that in the same way that there are patterns of speciation specific for organisms in the urban environments [11], there are undesigned crystal-forming processes that could be specific to the urban environment. The interactions between building materials and weathering agents contribute to the formation of products that are chemically and structurally similar to mineral species found outside the built environment, and the paper by Novoselov et al. [12] presents a very detailed study of carbonate neoformations. My research has also involved this kind of products and indeed in a 2017 publication [13] based on extensive field observations, we concluded that they were the most extensive alteration feature in recent structures as they can occur in outside and inside places (some underground stations of Lisbon and Porto Metro systems in Portugal present easily observable examples).

Field observations are a characteristic, distinguishing method in geological studies and previously I have alluded to the example of how Lyell [6] highlighted the importance of field observations in refuting Werner theory about the genesis of igneous rocks. The paper presented in this special issue by Novoselov et al. [12] presents extensive field studies asserting the frequency and diversity of carbonate neoformations but goes significantly further with laboratory studies that show how studies in the built environment can contribute to the discussion of some fundamental issues of geosciences (in this case, mineral genesis). The hypothesis proposed by the authors on the biological contribution must be highlighted given the present interest in biomineralization, namely of calcium carbonate. There is extensive research on fast forming forms of calcium carbonate, precursors of calcite, which can be of interest also in terms of carbon sequestration, and the study of Boch et al. [14] showed the fast formation of ikaite in built structures (in conditions with some geochemical affinities with those studied by Novoselov et al. [12]). The present year even saw the publication in the journal Science of the proposal of a new hemihydrate calcium carbonate found in laboratory experiments [15]. It will be exciting to see whether such phase spontaneously forms outside the laboratory and I will not be surprised if it is found in the neoformations of the built environment.

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