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# Judging by color in the early history of geology and paleontology

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ABSTRACT

This paper presents an overview on some significant historical sources, particularly from 17th to 18th century Italian scientific literature, in order to understand how color was used as one of the 'external' features for identifying rock formations, also including fossils, regarded as having formed in different times by different causes or events. The reference to color was also considered the main feature used for lithostratigraphical purposes within the so called 'classifications' of mountains in the second half of the 18th century. Later geologists and mineralogists involved in the early development of stratigraphy referred to color when a rock formation or specimen appeared to be less distinguishable by other main characters (for example chemical and morphological features).



## 1. The meaning of color in the early geological language

The role of color is predominantly regarded by the historians of geology as a significant tool in order to understand the birth of a new visual language connected to the development of mineralogical, lithological and later geological mapping from the early 19th century (Rudwick, 1976). However, printed and unpublished historical sources may also provide more useful pieces of information on the early use of colors for identifying and characterizing not only minerals, but also different kinds of rocks and fossils, often included in strata and formations. The extent and the heritage of this particular methodological attitude, generally neglected within the historiography of the Earth sciences, clearly emerge from a preliminary survey on rarely examined literature represented by the early specialized dictionaries of mineralogy and later geology (which included paleontology), published since the late 18th century (e.g. Reuss, 1798; Aikin and Aikin, 1807; Sevrin, 1807; Bossi, 1819; Mitchell, 1823). In these works, where the definition "mineralogy" still had a broad meaning which included lithostratigraphical and paleontological subjects, the reference to a single color or to a range of colors was normally used to indicate the specific surface features of different rock units and minerals, more rarely fossils, and their chemistry determined through chemical analysis. Thus, for example, the cause of reddish or brownish-red color could be generally attributed to the presence of iron, while the brownish and blackish colors were often considered distinctive characters of volcanic or igneous rocks, as visible results of the alterations produced by the action of fire and heat. Other rocks or minerals showed various degrees of yellowish colors because they were thought to contain sulfur or "sulphuric acid" (Mitchell, 1823: p. 90) or in the case of the so-called "ash-coloured clay" its color was attributed to the "stain of coal" (Mitchell, 1823: p. 510). In the dictionaries published after the 1830's, however, the several references to colors appear to be more articulate and linked to stratigraphical issues. In fact, besides the normal use of color as one of the external characters for recognizing rocks or minerals, Humble (1843: p. 186), for example, recalled the importance of color within a stratigraphical sequence: in the entry "Oolite" – defined "a group of strata, whose order of superimposition is below the Purbeck and above the Lias, called also the Jura limestone" – it is specified that "in England, the limestone of the oolite has a yellowish brown, or ochreous color, by which it may at once be distinguished from the lias; and the fossils partaking of the color of the limestone, render it easy to separate them from the fossils of the lias". And the notable *Dictionnaire de cosmogonie et de paléontologie* by Jéhan (1854) quotes some significant passages from Alcide d'Orbigny's (1849–52) *Cours élémentaire de Paléontologie et de Géologie stratigraphiques*, where the reference to colors is made in order to understand possible phenomena of massive extinctions ("So we must believe that all the animals of the same genus and same species, which lived in the same time and have been enveloped with muds of the same nature and color, have been immediately killed by waters at the time of the final geological perturbation of this epoch". Translated herein from Jéhan, 1854: p. 1334) or to define the internal subdivisions of a stratigraphical unit ("Many divisions of the Jurassic terrains have been already proposed, some of them determined from the mineralogical characters of the strata, others based on the presence of a particular dominant fossil, or even on the color of the rocks (the Lias, the brown Jura and the white Jura of the Germans)". Translated herein from Jéhan, 1854: p. 795).

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During the second half of the 19th century, however, in spite of this new methodological attitude, the specific entries about "color" continued to be focused on the chemical–mineralogical context (e.g. Landrin, 1852: p. 117–118, "Couleur des minéraux"; Page, 1865: p. 145, "Colour of minerals"), while within the dictionaries of natural history, the entry "color" remained mainly related to ornithology and botany (e.g. Dictionnaire, 1807 p. 310:, "Couleur"; Dizionario, 1836: p. 354–355, "Colorato", "Colore", "Colori").

## 2. The colors of changing rocks

References to colors for understanding rocks and minerals may be found in the classic literature from Antiquity and Middle Ages: Theophrastus, in his treatise *On Stones* (c. 315 B.C.) regarded color as a specific feature which could radically change in the same substance mainly because of combustion (Theophrastus, 1956). In the essay *De coloribus*, generally attributed to Aristotle (Loveday and Forster, 1913), it is stated that the streak of a mineral (e.g. when it had been powdered) could reveal its actual color. Pliny the Elder, instead, devoted the 35th book of his *Natural History* (1st century A.D.; Pliny, 1961) on "mineral colors" used for dyeing and painting and often referred to color as a reliable identifying feature of minerals (copper, iron, lead in particular: Pliny, 1961: book 34), rocks and gems. In the latter case, color was considered an essential element for recognizing and listing the precious stones, using not only plain definitions such as "green" or "white", but also indications such as "fire color" or "smoke color" (Pliny, 1961: book 37). The use of color in order to distinguish one rock from another became a distinctive character, marked by definitions (e.g. "red like fire" or "ash-colored like smoke" and so on), which were taken from practical language and were adopted also in later works, ranging from the Medieval lapidaries up to the scientific treatises of the early modern age.

Leonardo da Vinci did not seem to pay much attention to the role of color within his studies on the strata of the Earth's surface. His unpublished observations, undertaken mainly in central and northern Italy between the end of the 15th and the beginning of the 16th century, did not consider the colors of rocks and fossils, but their shape and position within that strata or the rock formations of hills and mountains. These latter aspects were considered more relevant in order to understand the natural phenomena of the Earth's past (Leonardo da Vinci, 1938). A different attitude is instead evident in the works by Georgius Agricola (real name: Georg Bauer), which have been widely recognized at the origin of the science of mineralogy (Morello, 2006), but also involve several lithological and lithostratigraphical aspects related to the so-called "fossilia" (that is, all the bodies which could be found underground). In the *Bermannus* (Agricola, 1530) there is a particular attention for the changing of color, for example in the case of different kinds of fossil coal or mineral ores when "cooked" or smelted in different ways. In addition, the great variety and the range of colors of specific rocks, classified by Agricola together with minerals, are described in detail, as for example in the case of schist ("Saxum scissile colore quasi ceruleo, quod aliquando nigrius, aliquando albidius esse solet") and quartz ("Quarzum nostri vocant, modo candidissimum, modo subluteum, modo subcesium") (Agricola, 1530: p. 129).

Also in some fundamental early works on paleontology and stratigraphy in the 17th century (Morello, 1979"; Morello, 2003), such as the writings by Nicolaus Steno and Agostino Scilla, interesting references, although not homogeneous, to the role of colors may be traced. Steno clearly recalled the lithostratigraphical importance of color while observing that "in an argillaceous ground, I have seen that these strata, different for their colors, are broken in various parts and all the cracks, nearly perpendicular to the strata themselves, are filled with matter of the same color" (translated herein from Steno, 1667: p. 91–92): and this observation allowed Steno to suppose that "if we examine the cracks of the strata filled with matter of the same color, where the strata have a different color, it seems entirely possible that that ground was shaken by a violent movement while falling it broke itself, reaching in this way a new position. It is easy to demonstrate with numerous examples how great changes of the ground have been often produced by the earthquakes" (translated herein from Steno, 1667: p. 96). Scilla, instead, for his paleontological analysis of the "glossopietre" found in Sicily and Malta (recognized as fossil shark teeth), did not consider the diversity of colors found in the observed specimens and in their surrounding lithology as particularly significant, especially if compared with other more important data such as the identity of shape or morphological similarities ("they are not, although with very similar body, shiny and colored like those from Malta, but ash-colored, black, and often stained. The diversity of the colors is of a little importance;" translated herein from Scilla, 1670: p. 167) (Fig. 1).

## 3. The colors of strata in the study of mountains

The studies of mountain structures and on the 'anatomy' of mountains undertaken in Europe during the early 18th century, as in the case of Italian scholars and naturalists such as Luigi Ferdinando Marsili and Antonio Vallisneri, emphasized the central role of the strata, with particular attention to their shape and position, as well as to their lithology and fossils (Vaccari, 2003; Vai, 2006; Vaccari, 2008; Luzzini, 2009). Since the years of his first naturalistic travels through the mountain chain of the northern Apennines in Italy, from 1704 to 1711, and later in his works on the origin of springs, Vallisneri (1715; 1726) emphasized the importance of describing every feature of the observed strata, including their different colors (Vallisneri, 1726: p. 36, 38; Vaccari, 2007: p. 8). Also in the treatise on the presence of fossils in the mountains, *De' corpi marini che su' monti si trovano*, Vallisneri (1721: p. 3) also noted the difference between the great variety of colors of the fossil fish specimens from


**Fig. 1.** Frontispiece of Scilla, 1670.