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The Neapolitan Yellow Tuff: An outstanding example of heterogeneity

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HIGHLIGHTS

- NYT is the most used building material in the historical architecture of Naples.
- The study aims at providing an exhaustive petrophysical characterization of NYT.
- The investigation was carried out on four most representative lithofacies.

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ABSTRACT

The Neapolitan Yellow Tuff (hereafter NYT) is definitely the building material most used in the historical architecture of Naples (Southern Italy) since Greek times.

The high heterogeneity of NYT, resulting from the concomitant occurrence of lithic fragments, pumices, crystals and glass cemented by crystalline or amorphous phases, the latter highly sensitive to acid environments, define a strong attitude to weathering.

This research confirmed the inhomogeneous features of this volcanic formation, within the same deposit and sometimes within the same outcrop. Based on these premises, the investigation was carried out on four most representative lithofacies, according to their different textural and petrophysical features.

Actually, mechanical features are governed by two concurring factors: a) the mineralogical composition; b) the texture of the rock. In the first case, the predominance of anhydrous phases (analcime + feldspar) over zeolites improves its mechanical strength. By contrast, if the mineralogical composition is constant (similar total wt.% zeolite content), the petrophysical parameters are strictly related to the texture of the rock.

1. Introduction

Historical buildings of several ancient towns developed along the Tyrrhenian border of the Italian peninsula have been realized by using as building stones the volcanic tuffs linked to the numerous volcanic centers occurring in this area [1]. In particular, the Neapolitan Yellow Tuff (hereafter NYT), further than representing one of the largest volcaniclastic formations outcropping in Southern Italy, has always been recognized [2–5] as a historical material used as building stone since Roman and Greek ages (VI century B.C.). Worth to note is the huge monumental heritage scattered over Campania region and particularly in Naples, providing these areas a unique architectural fingerprint. To this latter respect, a survey carried out in the whole ancient center of Naples, the largest in Europe (ca. 17 km^2) revealed that NYT is one of the most diffused lithotype used "facciavista" (fair-face; Fig. 1a) [6]; in addition, NYT is also the basic building material used in Naples for no-load bearing plastered walls (Fig. 1b).

NYT also constitutes the backbone of Naples, which had been built on tuff with tuff. It is therefore evident how crucial is the knowledge of this stone from several points of view, for example how it supports loadings and stresses exerted by the overhead buildings, how it behaves when used as building stone or how it reacts to the weathering actions in ancient (up to several or tens of centuries) monuments [7–8].

Although this formation has been thoroughly investigated from a volcanological and petrographical point of view some genetic aspects are still debated which provide uncertainties for an accurate stratigraphic description. Without going into details, one

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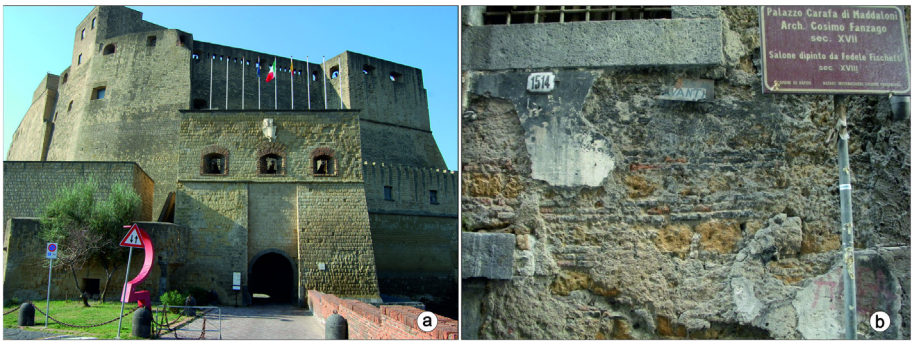

Fig. 1. Castel dell'Ovo, XIII-XVI century, unplastered tuff (a); Palazzo Carafa di Maddaloni, XVII century, NYT emerges from plastered wall (b).

aspect seems to be common, namely, the great heterogeneity of this material, as a result of the varying chemical composition of the formation and fluctuating emplacement conditions. Actually, NYT represents a problematic volcanic deposit exhibiting a pronounced vertical and lateral variation in lithification grade, phase content, textural features, fabrics, etc. [9–10].

Studies aimed at characterizing NYT from a physical and mechanical point of view are few and, most of them, also dated [11–14]. A recent paper tried to investigate these aspects by means of a comparative study among macroporous stones [15]. Moreover, the above-mentioned high heterogeneity of the material makes difficult an exhaustive and complete record of the most important physical and mechanical parameters of NYT.

The present research is an attempt at filling this gap. The wide knowledge of NYT based on a previous study [10] allowed us to have access to a very large sampling collected from well-defined stratigraphic units in different locations, representative of the entire formation. It was therefore possible to investigate and characterize the lithological units, in their different facies, trying to identify the variability range of any measured physical and mechanical parameter.

This was the challenge of this study, which aims at providing an exhaustive petrophysical characterization of NYT and that can therefore represent a technical reference for this stone. The large number of physical parameters considered, some of them never reported before, and above all, the number of representative investigated samples give back reliable boundaries for any investigated parameter.

2. Geological setting

The Phlaegrean Fields Volcanic District (Southern Italy) belongs to the Campania magmatic Province [16] that, further than Campi Flegrei, includes Somma–Vesuvius, Ischia, Procida, and the nearby islands of Ponza, Palmarola, Santo Stefano, Ventotene (Fig 2).

Along with the Campanian Ignimbrite (CI), NYT is the most important pyroclastic product of Campi Flegrei, both for thickness of deposit and areal distribution, linked to a phreatomagmatic eruption occurred 15 Ka ybp [17–18]. The eruption was accompanied by a caldera collapse episode [19–22] and by the emplacement of a pyroclastic fall and flow sequence.

The deposit can be distinguished in an unlithified member (A) and a lithified one (B) [22–23] (Fig. 3), on the basis of textural (grain size and sedimentary structures), compositional and depositional features.

The Lower Member A is a succession of cineritic and pumiceous lapilli layers, locally massive or stratified with sandwave, planar and cross lamination structures; impact sags are also present.

The Upper Member B, from which derive the investigated samples and described in details by Scarpati et al. [22], is a deposit made of cineritic layers with dispersed rounded pumices, locally rich in lithic fragments, interbedded with stratified, reversely graded, locally wavy layers, together with vesiculated ash beds.

As far as the eruptive mechanisms are concerned, the deposits belonging to the Member A suggest the occurrence of a first phreatoplinian phase, followed by the formation of an eruptive column with the emplacement of fall deposits. The partial collapse

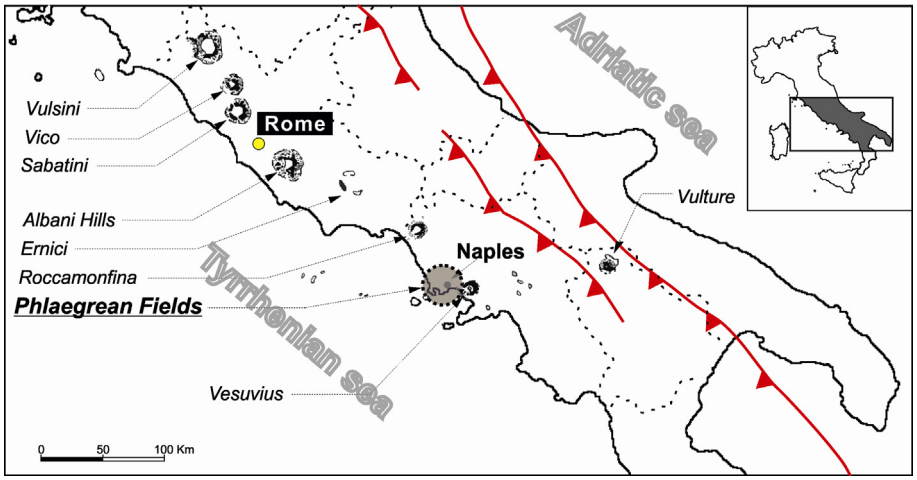

Fig. 2. Plio-Quaternary volcanic districts of central-southern Italy: Roman Province (Vulsini, Vico, Sabatini, Albani Hills), Ernici–Roccamonfina province, Campania Province (including Phlaegrean Fields, Mt. Somma-Vesuvius, Ponza and nearby islands) and Mount Vulture.