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Characterization of the lapis lazuli from the Egyptian treasure of Tôd and its alteration using external μ-PIXE and μ-IBIL

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ABSTRACT

Lapis lazuli is among the earliest and most priced ornamental stone worked to produce carvings, beads and inlays as early as the 4th millennium BC. It is an heterogeneous rock composed of blue lazurite $Na_3Ca(Si_3Al_3O_{12})S$ mixed with other minerals like calcite, diopside and pyrite. The historical source of lapis lazuli in antiquity is supposedly located in Afghanistan, in the Sar-e-Sang district, while other sources are known in Tajikistan and Russia (Baïkal area).

This work focuses on the lapis-lazuli of the Egyptian treasure of Tôd dated from Middle Kingdom (20th c. BC). Deposited in four copper boxes, it consists of thousands of blocks of raw lapis lazuli, minute fragments, beads and carvings stylistically dated to various periods. This discovery raises the question of the use of lapis lazuli in ancient Egypt because there is no source of lapis in this country. In addition, most of the lapis lazuli artefacts are strongly weathered. The aim of this work is to understand the alteration process and to verify if its provenance can still be determined.

A few artefacts were analysed using the new external microbeam line of the AGLAE facility of the C2RMF. The mineral phases were identified and corresponding trace elements (e.g. Ti, As, Ni, Ba) were ascribed using the quantitative PIXE elemental maps collected on the entire artefacts or on cross-sections. In parallel, the IBIL spectrum recorded for each point in the image provided an additional fingerprint of the luminescent phases, notably mineral species belonging to the cancrinite group. Most alteration products appeared to derive from the oxidation of the pyrite FeS_2. It was observed that the alteration process extends to the core of most investigated artefacts. Despite such a strong alteration state, the chemical fingerprints recorded on the studied artefacts proved to be consistent with that of lapis lazuli from historical deposit of Badakshan, Afghanistan, previously investigated using the same μ-PIXE/μ-IBIL protocol.

1. Introduction

Among the earliest and most prized ornamental stone, lapis lazuli was used to produce carvings, beads and inlays since Neolithic times. The first lapis lazuli workshop excavated in Pakistan is dated from the 4th millennium [1] and its use in Mesopotamia and Ancient Egypt is largely attested since the 3rd millennium by the numerous artefacts adorned with this gemstone. From a mineralogical point of view, lapis lazuli is an heterogeneous metamorphic rock composed of minerals of the sodalite group such as lazurite $Na_3Ca(Si_3Al_3O_{12})S$ – to which it owes its blue colour – intermixed with other whitish minerals like calcite, diopside, wollastonite and strewn with golden pyrite crystals. The main deposit of lapis lazuli exploited in Antiquity is located in Badakshan, Afghanistan while other sources are located in Tajikistan and Russia.

The determination of provenance of ancient lapis lazuli, a recurrent archaeological question, has motivated the development of many analytical approaches, from chemical analyses to IR spectroscopy [2]. Recently, Re [3–5] and Calligaro [6] and their co-workers have independently shown that most historical sources of lapis lazuli could be differentiated by the presence of particular mineral assemblages coupled with specific trace elements fingerprints.

The present work focuses on lapis-lazuli artefacts of the Egyptian treasure of Tôd, dating from Amenemhat II (1911–1876 BC), third king of the 12th dynasty, that was excavated in 1936 from the basement of a temple dedicated to the worship of Monthu,

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