Searching for Trace Elements in Lapis Lazuli from Myanmar for a Provenance Studies

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INTRODUCTION

This work is a continuation of a provenance study of lapis lazuli by means of different analytical techniques that our group started in 2008 [1]. The final aim is to find markers allowing to identify different provenances of this precious stone (mainly trace elements and luminescence properties) [2-4]. Up to now the work has been focused on 4 provenances: Afghanistan, Tajikistan, Siberia and Chile; using samples from these provenances we developed a protocol for their distinction that has been successfully applied both on carved artefacts [5] and archaeological findings [6].

We recently acquired samples from Myanmar, and started their characterization, to insert this provenance in the protocol. After some preliminary measurements using XRF (X-Ray Fluorescence) on large areas of the samples, we noticed that the presence of bromine seems to be a peculiarity of this provenance. For this reason we decided to go deeper and try to understand in which mineralogical phases it is present, taking advantage of the micro-PIXE capability to map the elemental distribution and to evaluate the amount of trace elements inside materials.

EXPERIMENTAL

The 12 lapis lazuli stones analysed in this work have been acquired directly in Myanmar from local sellers (Fig.1a). Samples were prepared as semi-thin sections (about 100 µm thick), mounted on plexiglass slides (Fig. 1b) and carbon coated to make them conductive.

Micro-PIXE measurements were carried out at the AN2000 microbeam facility by using 2 MeV protons. The beam was focused to a spot size of ~5 µm and raster-scanned over the samples with a current of about 500 pA. To analyse simultaneously both light and heavy elements with the same detector we used an aluminum funny filter [7], that is a filter with a hole drilled at its center and placed in front of the detector window.

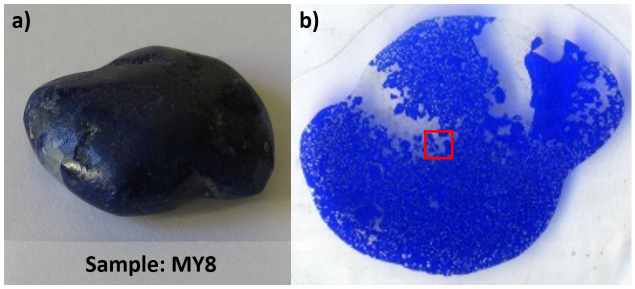

Fig. 1. a) One of the analysed lapis lazuli stones from Myanmar. b) the semi-thin section obtained from the same sample.

RESULTS AND DISCUSSION

The analyzed areas have been selected on the base of cold-cathodoluminescence (cold-CL) images preliminarily acquired (as shown for example in Fig.2). In these areas micro-PIXE elemental mapping was carried out and different mineralogical phases have been identified on the base of the emitted luminescence color from cold-CL and the main elements detected by means of micro-PIXE. An example is shown in Fig.2, where a cold-CL image and PIXE elemental maps of the same area are shown. In this area three main phases are present: diopside ($CaMgSi_2O_6$ [8]), characterized by a yellow luminescence and the presence of Mg, Si and Ca; calcite ($CaCO_3$ [8]), characterized by an orange luminescence and the presence of Ca; lazurite $(Na_6Ca_2(Al_6Si_6O_{24})(SO_4,S,S_2,S_3,Cl,OH)_2$ [8]), characterized by low levels of luminescence and the presence of Al, Si, S and Ca.

Using these elemental maps to select the crystals to be analyzed, we focused on more than 30 crystals of 7 different phases. After this preliminary run of measurement we revealed bromine (over the detection limit) only in lazurite and in another mineralogical phase of the same group (probably sodalite).

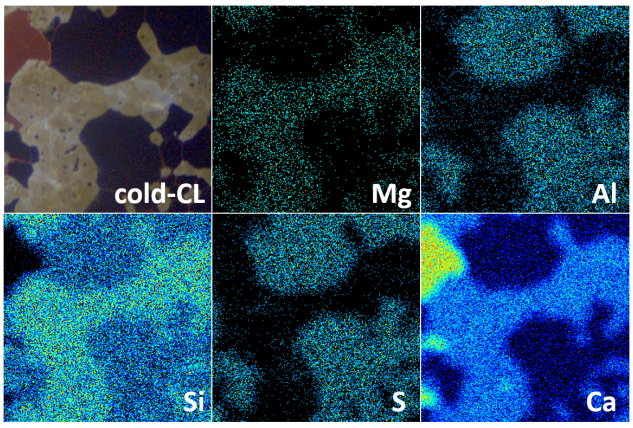

Fig. 2. Cold-CL images and micro-PIXE elemental maps of the same area (indicated by a red square in Fig.1): different mineralogical phases can be identified. Each square side is around 1.4 mm.

CONCLUSIONS

The preliminary obtained result encourages to continue the measurements on lapis lazuli from Myanmar to find new markers allowing to distinguish them from the ones of other provenances. More measurements are required to confirm the presence of bromine only in mineralogical phases of the sodalite group and a higher statistics is necessary to have a significant result.

Moreover a quantitative analysis to evaluate the concentration of bromine and other trace elements has to be performed to insert this provenance in the protocol developed in the last years.

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