Argentinean Northwest Archaeoptics: Nanotechnology to reflect solar light?

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ABSTRACT

In an excavation performed in 1999 at the Campo del Pucara, Alamito site, which belongs to the Condorhuasi Culture (From 0 to 500 AD), and is placed near the frontier of Catamarca and Tucumán provinces in the Northwest of Argentina, Víctor Núñez Regueiro and Marta Tartusi Paz found an intriguing archaeological artifact: Remains of a thin slab of schist covered by a mica sheet, dated from 360 and 480 AD. The mica was analyzed by photometric and interferometric procedures and experimental results suggest that it behaves as an interferential dielectric mirror to reflect the Solar light particularly in the 600 – 700 nm spectral region.

1. INTRODUCTION

The archaeological cultures of the Argentinean Northwest which were not seen, heard of, or described by anyone and which have not left written testimony about them, are to be considered totally mute? In fact, the archaeological objects are considered by themselves as documents, that is, objects that serve as proofs. Proofs, at least, in a double sense: a) Proof of some hypothesis previously stated, or b) Proof that researchers are capable of posing new questions whose answers will help to enlarge and to deepen the valid knowledge. The case presented here corresponds to the study of an intriguing archeological remain from the Argentinean Northwest, assumed to be an optical piece: a flat mirror composed by a ground made in a thin schist slab 1.75 – 2.09 mm width, covered by a thin mica sheet 100 – 150 μm, which acts as a front reflective surface. These remains were dated from 360 to 480 AD. Note that the schist slab covered by the mica sheet was produced before than the metallurgical activity started in the Argentinean Northwest area, more than 1000 years before of the annexation of most of the cultures of the Argentine Northwest to the Inca Empire, in 1471. This Inca period ends in 1536 with the arrival of the first Hispanic contingents coming from Perú.

2. MATERIALS, METHODS, RESULTS AND INTERPRETATIONS

There are many remains of Argentinean Northwest pre-Incaic circular bronze dishes [1]; a dozen of which was analysed from the optical point of view. Preliminary results allow arguing that such concave bronze dishes could have been used as metallic mirrors, but these results are controversial because they are not generally accepted by archaeologists and anthropologists. So, we also presume that our results on the study of the schist slab covered by a thin mica sheet assumed to be a dielectric mirror could also be at the spot of a new controversy.

Figure 1 shows photographic reproduction of the archaeological remain: the ground base of the dielectric mirror made in a thin schist slab 1.75 – 2.09 mm width covered by a thin mica sheet 100 – 150 μm width, which acts as a front reflective surface. The schist slab appears fractured in various small pieces, while de mica sheet is divided into two portions, the smaller one called AM1 and the other AM2. AM2 is wider than AM1.

Photometric measurements were done as it is usual. The light of a small incandescent halogen lamp was focused on the test samples through an optical system. It generated a well defined 20 mm diameter illuminated area on the sample. The specular reflected light was measured using a LMT luminance meter (L_M), type 1009. At the chosen measurement distance, a 6′ aperture was used in

order to measure the light reflected only by the illuminated area. In order to quantify the reflection at different visible spectral regions, yellow, green and violet filters F were introduced in the optical path.

Figure 1. Photographic reproduction of the archaeological remain: The ground base made in a thin schist slab 1.75 – 2.09 mm width, 13 cm height and 18 cm wide, and its cover thin mica sheet 100 – 150 μm.

The experiment was done for the following test object: a Corning thin cover glass, selected clear areas of the archaeological mica samples AM1 and AM2, and four samples of ordinary mica from different argentinean mountain districts, called OM1, OM2, OM3, and OM4. The absolute reflection obtained for the three coloured lights is shown in Figure 2. The yellow light was the most reflected one, but the relationship between yellow/green or yellow/violet were higher in the archaeological mica samples AM1 and AM2 than in the ordinary micas.

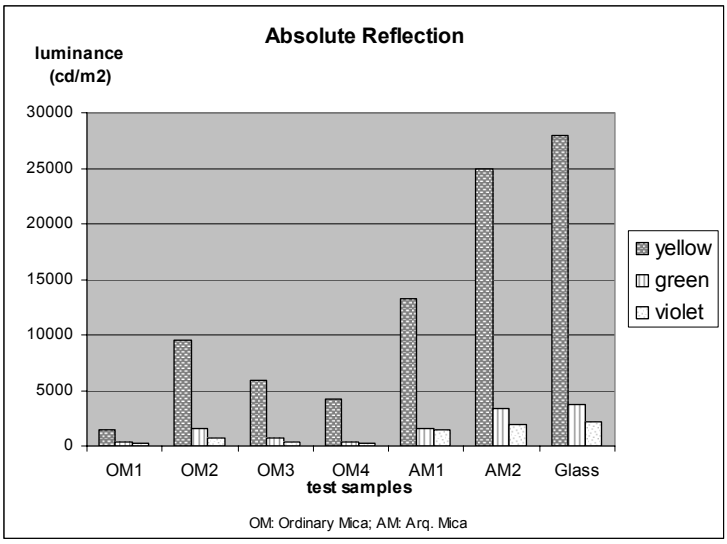
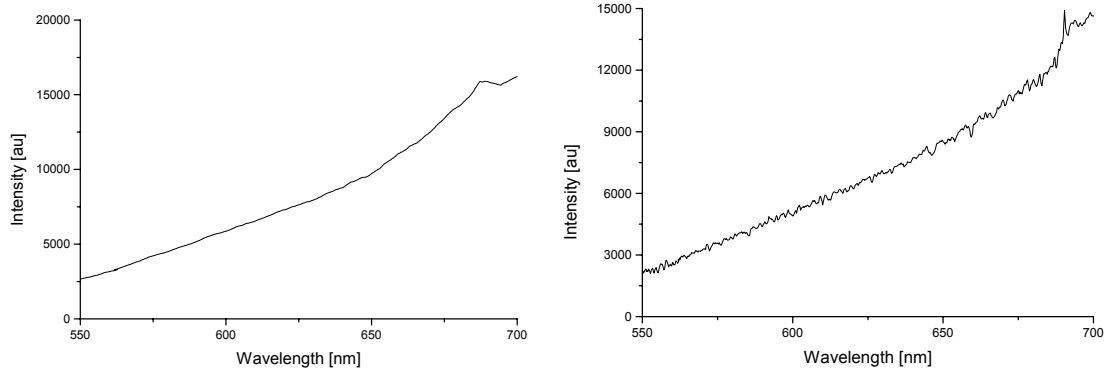


Figure 2. The absolute reflection from archaeological and modern samples.

Reflection spectra were recorded from different samples using an echelle cross dispersion spectrograph (Multichannel Instruments, Sweden). A beam of collimated white light was incident on the sample at a small angle and its reflection was collected by the input optical fiber of the spectrograph. Typical visible spectra from the lamp itself and reflection from a sample of Corning thin cover glass are shown in Figure 3. It can be seen that the spectrum of the reflected light in the glass closely follows the shape of the lamp spectrum, adding only a certain amount of noise.



a) b)

Figure 3. a) Direct lamp spectrum, and b) Reflection spectrum from a Corning thin cover glass.

When the thin glass sample is replaced by the AM1 mica sample, a different reflection spectrum is obtained, as can be seen in Figure 4. It can be seen that oscillatory features appear, resembling interference patterns.

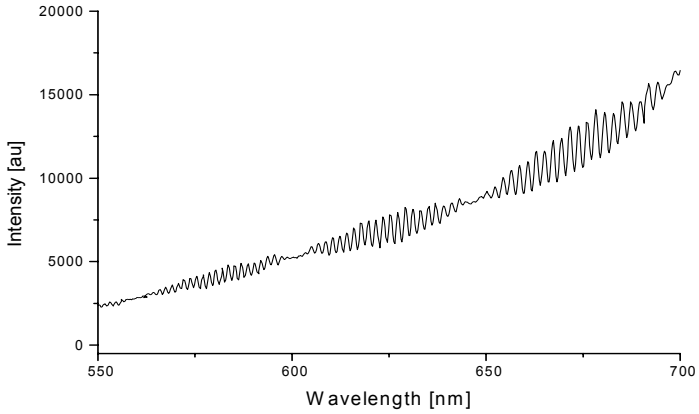


Figure 4. Reflection spectrum from mica AM1 sample. It resembles a modulated channeled spectrum.

Differential spectrum is obtained by subtracting the lamp baseline from the above spectrum, as shown in Figure 5. a) and b) for mica AM1and mica AM2, respectively, confirming their high intensity reflection particularly at yellowish reddish spectral region.

If a plane parallel plate of uniform width d and refractive index n is illuminated by white light and the transmitted light is observed through a spectrograph the channeled spectrum appears. Heterochromatic fringes in channeled spectrum [2] are separated each other by a spectral distance $\delta\lambda$ which depends on the spectral region of wavelength λ, according with:

$$\delta\lambda = \lambda^2 / (2nd + \lambda) \quad (1)$$

From the channeled spectrum recorded in Figure 5. a), $\delta\lambda$ results $\delta\lambda = 2.17$ nm at $\lambda = 675$ nm, and assuming the mica refractive index $n = 1.6$, the width of the investigated clear area of AM1 mica sheet equals to $d \approx 65$ μm. The modulation of the heterochromatic fringes intensity in channeled spectra a) and b) in Figure 6 is due to an optical beating process related with the lack of uniformity Δ

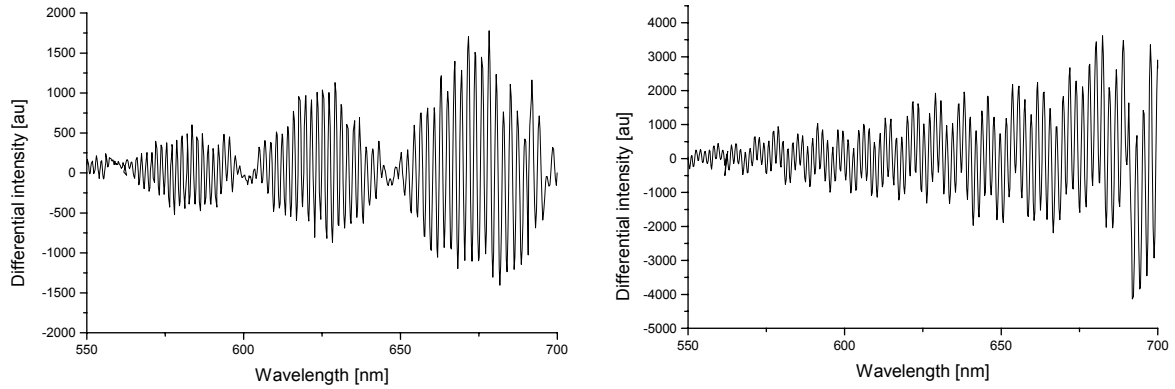


Figure 5. a) Differential reflection spectrum of mica AM1, and b) Differential reflection spectrum of mica AM2.

in the mica width *d*. Then, if $\Delta\lambda$ is the spectral interval between to successive absolute intensity minima, the lack of uniformity Δ is expressed as:

$$\Delta = \Delta\lambda / 2n \qquad (2).$$

In case of channeled spectrum at Figure 6. a), $\Delta\lambda \approx 50$ nm at spectral region 657 nm, then for the investigated clear area of AM1 mica sheet, Δ equals to:

$$\Delta \approx 50 \text{ nm} / 2n = 16 \text{ nm} = 0.016 \ \mu\text{m} \qquad (3)$$

Spectrum at Figure 5. b) corresponds to a little more complex physical effect. As AM2 is wider than AM1, the observed beating process at Figure 5. b) corresponds to the association of at least three mica layers like AM1. These results confirm those obtained by calliper and micrometric screw.

3. CONCLUSION

In the introductory section we pose a question: Archaeological cultures of the Argentinean Northwest that were not seen, heard of, or described by anyone and which have not left written testimony about them, are to be considered totally mute? There are two types of documents: a) Historic documents written in well known languages, and b) Archaeological documents, most of them written in completely unknown languages. In the case of the archaeological remains of a thin slab of schist covered by a mica sheet, considered as a document, we can read it by using the powerful language of Physics. The photometric and interferometric experimental results suggest that these archaeological remains behave as an interferential dielectric mirror which reflects particularly the 600 – 700 nm spectral region. Moreover, the fact that the intensity reflected by the mica mirror, which is larger in the yellowish reddish than in the other spectral regions, also suggest an intimate relation with the Solar Andean religious faith.

4. ACKNOWLEDGEMENT

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