Preliminary Report

External Expert Opinion on three Stone Items

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Ossuary, limestone, bearing engraved Aramaic inscription (”James Ossuary”)

Dark stone tablet of metamorphic arkose origin, inscription engraved in ancient Hebrew script (“Jehoash Tablet”)

Stone lamp, bearing "menorah" and fruit ornamentation ("Stone Lamp")

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W. E. Krumbein studied geology, geochemistry and microbiology, and is Professor of Geomicrobiology at Carl von Ossietzky University Oldenburg since 1974. He was the founding director of the Institute for Chemistry and Biology of the Marine Environment at this university (12 Chairs, 200 collaborators).

Professor Krumbein is considered one of the world's renowned experts on:
- stone surface transformation
- patina of rocks and stone and the formation of biofilms on stone
- the development of organisms and microorganisms on stone
- the study of ancient stone items and buildings
- preservation of stone buildings
- climatic, mineralogical and pollution effects on stone erosion and degradation.
- alteration of mineral composition of objects, surface colonization, material degradation, and the creation of neo-mineral formations by microbes and microorganisms.

Over his scientific career, Professor Krumbein has been active in the fields of Biogeochemistry (chemical processes by living organisms in the natural environment), Material Ecology and protection of Cultural Heritage, Microbiology, Palaeontology (the study of fossils), Geology, Sedimentology (the study of rock deposits), Soil Science and Theory of Science.

Recently Professor Krumbein has directed special attention to the study of molecular ecology, bio-receptivity (the study of how mineralogical composition of geological objects affect nature), and bio-diversity of microorganisms damaging art and archaeological materials, the study of extreme desert sites and exobiology (study of the origins of the universe and life through the study of minerals, molecular fossils, and interactions between biology and environment). In the field of remote sensing, he participated in the genesis of the Life science programme of NASA and was Co-director of three NASA courses on Planetary Biology and Microbial Ecology (PBME). Professor Krumbein has also published studies in the fields of marine microbiology, biomineral formation and mineral degradation.

He currently serves as advisor to several major global projects on stone building preservation, including the Acropolis and Delos projects in Greece, and is advisor on cultural heritage and assets through Biogema.

Professor Krumbein has received degrees in geology, geochemistry and microbiology from the University of Munich, Würzburg University, the Pasteur Institute and the Sorbonne. He also took courses in History of Art at the Universities of Munich and Würzburg. In 1974 he was appointed as the first Professor of Geomicrobiology worldwide. Krumbein is also a Professor honoris causa of the Lomonosov University, Moscow, and a PhD. honoris causa of Gdansk University, Poland. He is ordinary and honorary member of ICOMOS (International Council of Monuments and Sites) and of the Society of Natural History, St. Petersburg, Russia. Krumbein acted twice for two terms as president of the German National Board of Marine Sciences (KLMN) and the committee on impact of air pollution on mineral and metallic materials of the VDI (German Association of Engineers).

Over the span of his career, Professor Krumbein has been invited as a visiting Professor to many universities worldwide, including Harvard University (US), Messina University (Italy) and St Petersburg and Moscow Lomonosov Universities (Russia). Since his post-doctorate research conducted at the Hebrew University of Jerusalem, Professor Krumbein has visited Israel many times for joint research projects in Israel and neighboring countries, and has headed international conferences, which took place in Israel. Professor Krumbein is also active in international conservation

organizations and serves as an advisor on the protection of cultural heritage, specifically on ancient stone buildings.

Professor Krumbein has published over 400 scientific papers with more than 150 graduate and 50 doctoral students from Austria, Australia, Egypt, France, Greece, Iran, Israel, Italy, Korea, Myanmar, the Netherlands, Poland, Russia, the USA, and - naturally - Germany. He edited 15 books and organised over 75 scientific conferences and symposia, most of which were international in nature. His activities were supported by over 100 national and international research grants awarded to him and his group. His scientific achievements won international acclaim and prestigious prizes, including Pasteur-Medal, Credner-Prize, Georg-Knetsch-Prize (Plinius), Lise Meitner - Alexander von Humboldt Prize.

Professor Krumbein was recommended for this expert opinion by Professor Steven Weiner, Director of the Kimmel Center for Archaeological Science, Weizmann Institute of Science, Rehovot (Israel).

General

The purpose of my work was:

1. To examine two inscriptions engraved in stone and a stone lamp, in an independent manner, using multi-disciplinary scientific techniques, and to assess when they were produced, especially on the basis of the examination of their patina (more specifically, whether they were produced recently, or several hundreds of years ago).

2. Present my opinion on the premises, mineralogical and isotopic tests, and conclusions of the team of researchers on behalf of the Israel Antiquities Authority [IAA] (Professor Goren, Dr. Ayalon, Dr. Dahari and their colleagues).

3. Evaluate scientific articles and criticisms voiced in response to the reports of these researchers by various scientists worldwide.

My tests and analyses were conducted in Jerusalem and at the University of Oldenburg, Germany. Samples were also re-tested in a mineralogy laboratory in Hanover and at the Chair of crystallography, Würzburg, in Germany. Our complete report will be published in November 2005 and will be accompanied by documentation of these tests including photographs. My work does not refer to any aspects of ancient language or ancient arts.

Notably, in contrast to organic materials (which can be dated using the Carbon-14 dating technique), or clay artifacts (which can be dated using thermo-luminescence technique), there is no currently available technique to date the manufacture, engraving or processing of stone artifacts. **Existing scientific tests may, at most, cast doubt on the authenticity of such items, or provide evidence that reinforces the probability that the items are ancient** e.g. by the detailed analysis of multi-layered and structured patina grown with time.

The IAA team apparently concurs that the rock material of the ossuary, the stone lamp and the dark stone tablet themselves are of ancient origin, i.e. have been quarried and shaped many hundred years ago. Consequently, any tests and opinions refer primarily to attempts to determine the date of the engraving on the two inscriptions, and the production of the ornamentation on the stone lamp, which according to the IAA experts should have been produced within the 20th Century.

The findings and conclusions of Goren, Ayalon and colleagues, rely primarily on four sets of findings:

1. Results of isotopic tests conducted to determine oxygen delta values of the items' patina, and compare them to values of patina, which was known to have formed in a limestone cave in the Jerusalem area. They based these comparative tests on the implicit assumptions that the patina on the three items is comprised of pure calcite, and that the three items were each exposed to the atmospheric conditions of a cave environment in the Jerusalem vicinity, with no contact with soil or outdoor climatic conditions throughout their entire history, and at a generally stable average temperature of 24^{o}.
2. Results of microscopic tests of the patina on the three items, specifically the discovery of marine microfossils in the patina of the lettering zones. The IAA

team assumed that the existence of marine microfossils indicates that the lettering patina is not authentic.

3. Comparative results of morphological tests of the items' surface and the nature and strength of the substance inside the inscriptions' letters, to the morphology and attributes of patina samples taken from other sites on the ossuary which the team claimed to be authentic. The IAA team assumed that the "granular" material inside the ossuary inscription letters, and the "soft" material inside the Jehoash Tablet inscription letters represent and/or was designed to represent and/or was devised to represent the patina on the items.
4. Presence of "transparent material" that sometimes contains bubbles, in the ornamentation of the stone oil lamp, which Goren assumed to be indicative of modern epoxy glue or sodium silicate to glue supplemental materials, possibly particles of natural patina, to the ornamentations.

In my work, I examined the items and their coating and patina in a thorough, comprehensive manner, with reference to the work of the IAA team and its conclusions, all on the basis of:

a. **Morphological and ultra-morphological tests** of the items, their surfaces, engraving techniques, material processing, coating and patina (on the surface and inside the inscriptions/ornamentation).
b. **Chemical and mineralogical analyses** of the stone, coating and patina.
c. **Organic tests** (microorganisms) on samples from the items and inside the inscriptions
d. **Tests on the microfossils** found on the items and in the inscriptions.
e. **Isotopic tests** on the patina: We also addressed the reliability of the tests conducted in Israel at the Geological Survey of Israel (GSI) laboratory.
f. **Published and unpublished data and professional literature, including relevant scientific material published on the internet.**

Conclusion

Based on the **microscopic**, **ultra-morphological**, **chemical**, **mineralogical**, **microbiological** and **palaeontological** work (**Microfossils** and **recent to sub-recent microorganisms)** we conducted on the rock and patina of the three items, as well as the analyses of samples taken from them**:**

1. I found no indisputable evidence confirming the claim that any or all of the three items had been produced in the last several decades, or that ancient patina had been artificially attached to any of these items using adhesives or other bonding materials.
2. Based on a combination of several findings, there is a high probability that the two inscriptions and the ornaments on the stone lamp were produced many hundred years ago.
3. A period of at least 50-100 years was required for the formation of (a) the specific composition of the patina we found inside the ossuary inscription and the stone lamp ornamentation, or (b) the specific composition of patina, which developed subsequent to the engraving of the Jehoash Tablet and was identified inside the fracture.
4. Both inscriptions underwent various treatments, using a sharp implements and application of detergent/cleansers.

Results of multi-disciplinary tests indicates inter alia that:

- The ossuary with the entire inscription was, for several hundreds of years, under atmospheric conditions that significantly differ from a typical cave environment;
- The engraving of the Jehoash inscription predates the original fracture, which was created at least many decades ago and possibly several centuries ago.
- All three items show indications of continuity of patina morphology from inside the inscription/ornamentation to the surface of the respective item.

The conclusions noted in the reports by Goren, Ayalon and their colleagues, originate from a series of errors, biases, mistaken premises, use of inappropriate methodology, mistaken geochemistry, defective error control, reliance on unconfirmed data, disregard of information (such as the cleaning and preservation actions performed on the items), and the use of a comparative isotope methodology despite the fact that the two inscriptions fail to meet the cumulative prerequisite conditions for such tests and comparisons. Unfortunately, it is not rare to find such errors in scientific research The publishing history of an article of Goren et al. hints at the fact, that external referees also had doubts about the conclusions derived by Goren et al..

The Findings

Ossuary

1. Chemical and mineralogical tests to the stone and patina indicate that, contrary to the statements or premises of Ayalon and Goren, **the patina on the ossuary is not comprised of pure calcite**.
   Besides calcite (calcium carbonate) the patina on the ossuary is also comprised of the following minerals (in descending order of volume): **Apatite** (calcium phosphate), **Whewellite** (hydrated calcium Oxalate), **Weddelite** (calcium Oxalate) and **quartz** (SiO_2).

   The first two minerals are typical compounds of a **biogenic patina growing over longer periods of time** under exposure to open air and under the influence **of lichens and other microorganisms, especially fungi and bacteria, the quartz particles being most probable wind-blown dust**.

2. The microscopic, morphological and ultra-morphological tests we conducted confirm that the ossuary inscription have been **cleaned and treated more than once over a period of many years, sometimes clumsily.** This is consistent with the findings of the tests conducted in Canada and in Jerusalem in 2002).

3. Based on a comparison of the ossuary surface to many other ossuaries, it appears that the cave in which the James ossuary was placed, either collapsed centuries earlier, or alluvial deposits penetrated the chamber together with water and buried the ossuary, either completely or partially.

   Further the root or climbing plant marks as well as the severe biopitting on the top and bottom parts of the ossuary indicate that the ossuary was exposed to direct sunlight and atmospheric weathering and other conditions that are not typical of a cave environment, **for a period of at least 200 years**.

4. As a result of the above (the patina is not comprised of pure calcite; the inscription was in extended contact with soil; the item was outside atmospheric conditions of a cave; the inscription underwent intensive cleaning and preservation), δO^{18} isotopic tests are irrelevant to the question of authenticity for the ossuary inscription**, and cannot provide any indication of the date of the inscription engraving, because the item fails to meet several prerequisites for drawing any conclusions from such comparative tests**. In our report we refer in detail to these preliminary conditions.

5. I found traces of **natural patina inside the ossuary inscription**, in at least three different sites of the inscription (in the **first and last sections** of the inscription). *See attached pictorial with photographs.* Although the ossuary inscription was recently contaminated by the IAA and/or police who, perhaps inadvertently, recently removed almost all the material inside the letters of the inscription, we found miniscule traces of the natural patina inside some of the letters. Additional traces of patina inside the inscription letters are evident from photographs taken in 2002 and 2003 (including photographs taken in 2003 and presented by the IAA in public presentations).
   IAA reports make no mention of the finding of natural patina inside the inscription's letters, although traces of such patina are evident in photographs of several letters, taken in 2002 and were evident in the word "Yeshua"

(Jesus) (letters shin and ayin) in photographs displayed by Dahari and Goren in 2003/4.

6. We found **no indications that the ossuary inscription was produced in two stages**.

7. It is clear in any case that the granular like substance shown in the photographs made by the IAA in 2003, is **not a substance that was produced artificially in order to create an appearance of natural patina.** (See complete report for **several explanations that can account for the occurrence of this "cement-like" substance found inside the inscription** which may be related to the cleaning and/or enhancement efforts performed on the inscription).

8. We identified microfossils (Coccoliths and Foraminifers) in the ossuary patina taken from sites, which the researchers defined as authentic (including samples we took at a distance from the inscription). Goren and Ayalon identified the same kind of microfossils in the inscription patina (see J. Archeol. Sci., 2004), but erroneously believed that this finding is an indication of forgery. **Microfossils**, especially in stone items from the Jerusalem area, have been well documented in the professional literature for over 100 years. Notably, **the existence of wind-blown microfossils and quartz in the lettering zone and general ossuary patina reinforces the items' authenticity.**

9. **The isotopic tests** conducted on the ossuary inscription patina **are irrelevant** and can provide no indication of the dating of the inscription production, because the item **fails to meet the prerequisite conditions,** which are necessary if such tests should bear any scientific meaning.

10. The material sampled by the IAA is apparently not the ossuary's patina in its natural state. It may originate from the chemical reactions resulting from enhancement and cleaning efforts applied to the inscription **or from reaction of the rock material with water and temperatures far above 24°C**. This would be obvious, in case the ossuary was located outdoor for considerable spans of time. The biopitting and plant traces speak a clear language in this direction.

In summary**,** the patina on the ossuary, traces of which were also found in several letters at the beginning and end of the inscription, is not comprised of pure calcite. Its composition consist also of apatite (calcium phosphate), whewellite (hydrated calcium oxalate), and probably also weddelite (both calcium Oxalate) - of a microbiological origin and (probably windblown) quartz. This fact, together with the findings of microfossils found in the patina, and microorganism remains indicate, that **the ossuary and the inscription in entirety were held for several centuries under atmospheric conditions that differ from typical conditions of a cave environment.**

All the above reinforces the probability that **the inscription is ancient and most of the original patina has been removed** (by cleaning or use of sharp implement), **and the inscription was treated more than once over a period of several years. It is very probable from our investigations, that the inscription part was cleaned especially vigourously in order to make it more visible to the viewer.**

1. Contrary to the statements or premises of Ayalon and Goren, results of **mineralogical tests** indicated that the **patina in the letters of the inscription is <u>not</u> comprised of pure calcite**. The Jehoash tablet rock is not limestone, even by observation and is clearly of sedimentary quartzitic arkose origin with some signs of metamorphosis.
2. Microscopic photographs confirm that the item **underwent significant cleaning and enhancement efforts** sometime in the past.
3. Tests indicate that the stone was in the **soil of a Tel or in alluvial deposits** for an **<u>extensive period</u>** and was probably **never maintained in the atmospheric conditions of a cave**.
4. It is probable that the **stone was used in secondary construction, i.e. moved from its original use to another place in an undefined past**.
5. As a result of the above (the patina is not comprised of pure calcite; the rock is not a limestone; the inscription was in extended contact with soil; the item was used in secondary construction; the item was outside atmospheric conditions of a cave; the inscription underwent intensive cleaning and preservation, etc.), δO^{18} **<u>isotopic tests</u>** are irrelevant to the question of authenticity for the Jehoash Tablet inscription**, and cannot provide any indication of the date of the inscription engraving.** This is because the item **fails to meet several prerequisites for drawing any conclusions** from **s**uch **comparative tests**. In our report we refer in detail to these preliminary conditions.
6. An examination of the underside of the tablet indicates that it is apparently in its **natural state** as it was found in the quarry: the patina on this side of the tablet may have developed over millions of years as a result of cracking or exposure to the atmosphere prior to quarrying. Therefore, the comparison to the patina on the engraved side is meaningless. As the inscription has clearly been cleaned, it is probable that traces of calcitic weathering and transformation products remaining on the smooth side of the tablet, were removed in the cleaning process. A mineralogical analysis of the tablet surface including patina layers has been done by us. Five X-ray diffraction diagrams were analysed in Oldenburg, Hannover and Würzburg.
7. Microscopic examinations revealed that the surface pattern inside several letters is similar to the surface pattern of the tablet**. The inside or basis of the lettering zone (underneath the recent deposits) and the surface of the tablet show continuity**. There is no evidence pointing to any recent engraving that disturbs this morphological continuity. This morphological pattern was also found in several sites, when the "soft" material filling the letters is removed. **This may indicate that the letters were engraved in the distant past.**

   The "soft" material inside the letters appears to be the **<u>natural patina in a different state of crystallization and morphology</u>**, as a result of the application of cleaning agents and the use of a hard brush and sharp implement. Furthermore patina within grooves and depressions on natural rocks of the Jerusalem and Negev area is usually less hard and consistent, than on flat surfaces.

8. The new break on the tablet, dividing the slab into two unequal halves, occurred on an older thin fracture that appears clearly in photographs taken several years ago.

   My examination found that the fracture is very old. Closer to the surface, the natural patina inside the break is thicker and exhibits some bleaching and initial steps of patina formation which are not visible at the lower parts of the crack surface where it was separated very recently by breaking.

9. The brownish to black (not yellowish or reddish, as in the case of the ossuary and oil lamp) patina within the grooves of the lettering and in the adjacent surface areas, is perhaps indicative of a higher extraction of iron and manganese from the rock itself over the time of patina formation. Participation of black fungal melanins as in the case of Sinai and Negev patinas cannot be excluded. The whitish or yellow layers covering especially the lettering grooves may be a product of different patina formation conditions or of cleaning and remains of cleansers.

   The surface morphology as shown in the scanning electron (SEM) micrographs, however, hints to a natural fire or a natural "cement-oven" process (such as in the case of the “natural cement oven” on the road from Jerusalem to Jericho reported and analyzed by Profs. Picard and Prof. Bentor). Whether or not the very thin fibrous minerals observed on the material represent cement minerals produced at very high temperatures cannot be determined without further sampling.

10. An examination of the letters in the region of the crack strongly suggests, that the letters were engraved prior to the formation of the crack. It does not appear to be possible to make a new engraving on a fractured segment of this type of stone: Any engraving action could immediately cause the fractured stone to split into two, along the fracture line (which is what occurred when the police and/or the IAA failed to protect the item properly when transferring it from place to place).

    An examination of the crack and the photographs of the tablet before breakage indicates that the crack was very fine and thin, and no artificial patina could be introduced through this crack onto the inner parts of the stone. The patina was exposed only after the tablet broke into two. Therefore it allows us to determine with certainty that the fracture was very old and the bleaching of the upper part was due to access of air and oxygen.

11. Goren and Ayalon identified Coccoliths and Foraminifers (microfossils) in the inscription patina, but erroneously believed that this finding is an indication of forgery. **Microfossils**, especially in stone items from the Jerusalem area, have been well documented in professional literature for over 100 years. Notably, **The existence of microfossils in the patina reinforces the items' authenticity since the accumulation of wind blown microfossils needs extended periods of time of exposure to climate.**

12. The patina was reported to contain microscopic **gold globules** and **ancient microscopic carbonic particles** (which were sent for Carbon-14 dating test in the USA and found to be of ancient origin). There is no known technology that enables the manufacture of microscopic gold globules and their insertion of the globules and carbon particles into patina (either ancient or recent).

13. SEM results of the patina sampled from the Jehoash Tablet indicate that the composition and morphology of the patina significantly differ from those of the patina on the remaining two items. Only in the patina from the Tablet did these tests reveal minerals which are usually formed in fire.
    The discovery of carbon traces and microscopic gold globules embedded in the patina, may also indicate that the Tablet was, sometime in its history, adjacent to a fire, sparks, and high temperatures.
14. Goren's hypothesis that the stone was taken from a coastal Crusader fortress (he suggested the site of Apollonia) could not be verified. The patina distinctly differs from patina forming in the coastal region. No report of any similar stone discovered in Apollonia or in any other Crusader fortress in Israel exists in the literature.
15. We found no scientific indication that artificial patina was caused to adhere to the inscription. We also found **no indications of adhesion or material binding the patina to the stone** in our observations and samples.
16. The **isotopic tests** conducted on the tablet inscription patina are **irrelevant** and can provide no indication of the dating of the inscription production, because the item **fails to meet the prerequisite conditions**, which are necessary if such tests should bear any scientific meaning.

Summary : The tablet (with the inscription) may have been used in secondary construction for an extended period. The underside of the tablet is most probably in the rock's natural state and the patina covering this side of the tablet is millions of years old. The tablet was in the earth of a "tel" or alluvial deposits for many years. The fracture (preceding the break in the tablet) most probably occurred several decades or centuries ago, and **the inscription was engraved prior to the formation of this fracture**. The inscription was treated and cleaned, sometimes clumsily, using sharp implements and cleaning solvents. Morphological continuity was found between the tablet's surface and the inside of several letters.

In other words, **the inscription and fracture appear to have been produced either many decades or centuries ago.**

Lamp

1. The patina on the stone lamp is **multi-layered** and indicates slow development of patina over an extended period of time.
2. Morphological analysis of the patina on the stone lamp indicates that the **patina is continuous and uninterrupted**. Traces of partially different looking and layered patina were found on all sides, its underside, on the ornamentation as well as the outer rim and inside the lamp itself, including inaccessible sites such as inside the nozzles. The outer rim and ornament area patina, however, is identical and coherent. This finding supports the natural development of the patina on the item in a cave environment. **This conclusion is anyway also supported by the results of the isotopic tests performed by Dr. Ayalon of the GSI**. [SEM and X-Ray test results were performed at the University of Oldenburg and will be published shortly].

   There is no indication that the surface of the stone lamp was cut, scratched or etched down in certain places. The opposite may be true; test results confirm that **the entire item was produced at the same time**. Observations under a microscope, especially of the thin fracture site, leads to the conclusion that the production of the stone lamp and the ornamentation work date from the same period of time, and no changes were made to the stone lamp's surface other than basic cleaning and, perhaps, fixation by wax or other chemicals.
3. The mineralogical analysis of the oil lamp patina resulted in calcite associated with apatite (calcium phosphate), small amounts of Whewellite (calcium oxalate) and only traces of quartz.
4. I found **no indications of any adhesive**. However the existence of isolated traces of adhesive (as Goren claims) could be an indication of a conservation attempt to prevent the "peeling" of the patina which could detract from the item's appearance and value, and certainly does not indicate the artificial application of the patina on the item. Another possibility is that the glue-like substance (see SEM photos from Oldenburg) is **sodium chloride crystals** partially dissolved under **influence of rain or cleaning**. Such occurrences are reported very frequently in the scientific literature.

   There is no known technique for gluing or affixing uninterrupted sections of ancient patina particles to a new item, especially not to three-dimensional items such as the stone lamp, without such actions being noticeable under a microscope or through results of mineralogical tests. Chemical analyses found no traces of any adhesive or bonding substance in the patina.
5. Although the stone lamp is, similar to the ossuary, made of local limestone, the two items and especially their patina, have a different morphological and mineralogical structure, indicating that these items were in different conditions for extended periods of time. The stone lamp most probably was continuously in an undisturbed (cave?) environment and underwent no cleaning or handling such as did the ossuary and especially the inscription of the latter. However, the use of fixatives by dealers cannot be excluded. The dominance of calcium phosphate over calcium oxalate in the oil lamp patina would also indicate the same. I have examined the stalactites of the Beit Shemesh cave years ago and found large amounts of calcium phosphate. The data were presented at the 1979 Jerusalem sedimentology Congress.
6. The fracture in the stone lamp also developed long time ago and it is highly probably that it occurred during the lamp's production, which may imply that the lamp was hardly used. Traces of carbon (soot) were found on the nozzles but the

lamp was apparently not in use for an extensive period. Mass GC and HPLC mass spectroscopy might help to analyze the oil used within the lamp.

7. The item is limestone and we found no indication that the item had been significantly treated, cleaned or enhanced. Calcium carbonate may form within patina of caves. However such deposits have a totally different morphology as many experts on weathering rinds and reaction zones have reported.

8. The results of the isotopic tests on the stone lamp patina, performed by the Geological Survey of Israel, may indicate that the patina is consistent with **patina that developed naturally in a cave over several centuries**.

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In summary, the **patina** on the stone oil-lamp was found to be **multi-layered** and was also identified in concealed, inaccessible crevices (such as the lamp's nozzle). Due to the state of the item and the fact that it appears to have undergone limited treatment or cleaning if any, we can say with a **high level of probability** that the item, "**as is**" (including its ornamentations) **was produced many centuries ago***)*.

Cleaning, conservation and enhancement performed on the inscriptions

In his report to the IAA, Goren notes: "The inscription has been engraved **or cleaned over its entire length** in the modern age" (Appendix 6-J of the IAA Report). In their scientific publication in J. Archeol. Sci. (2004), Goren, Ayalon, and Bar-Matthews note that :" In a previous study, the inscription was observed as being "freshly cleaned", but coated in places with calcitic patina [reference to a publication by Dr. Ed Keal of the ROM, published in the BAR, and others]… . The letters cut through the varnish**,** hence the entire inscription postdates it, **or it has been cleaned by a sharp tool after its deposition**…"

However, although evidence of cleaning and treatment on both inscriptions was identified in microscopic tests, the IAA completely ignored these statements and specifically ignored the ramifications of the cleaning and treatment that the two inscriptions underwent.

Notably, the Geological Survey of Israel (GSI) failed to determine or prove that either of the two inscriptions is not authentic.

Dr. Amos Bein, director of the GSI himself, explicitly wrote to the Minister of Education in a letter dated June 27, 2003 (immediately after the first publication of Ayalon et al.): " The [isotopic] test [on the patina] do not contradict the possibility that the inscriptions are themselves authentic..". In a statement to the Discovery Channel, Dr Bein also explained under which circumstances cleaning and enhancement actions could lead to the production of the material found on the inscription. (I received a copy of the letter to the Minister of Education by Dr. Bein, and a transcript of his interview with Discovery Channel researchers, from the owner of the ossuary.)

Important notes on approaches and trends to cleaning, enhancement and conservation of ancient stone artifacts

Conservation and exhibitions policies of museum and non-museum institutions regarding ancient artifacts change over time. The approach to treatment and conservation of ancient stone items, which was accepted until several decades ago, is now considered "out-dated" and unfashionable. With respect to stone items, museums today tend to preserve everything that appears on an item, as it is received by the museum, including any "additions" created over its history. Such "additions" may include indications of vandalism, sedimentation, patina, biofilm, results of previous conservation or reproduction efforts, etc. In the event of reconstruction, some museums intentionally color the reproduced sections to facilitate identification of the early original sections of the item. Other museums, in contrast, invest efforts in concealing the reproduction as skillfully as possible.

However, contemporary conservation and enhancement policies of museums is not necessarily identical to the approaches used by the individuals who discover, deal in or collect ancient artifacts, designed to clean, enhance the appearance of and preserve these items. Efforts of such individuals, reflecting different degrees of skill, reflect a "personal" approach according to the understanding of each at the time. Sometimes these efforts are intended to enhance the item's appearance or increase its market value, or both.

Such "individual" or "unofficial" approaches frequently include the removal of patina (through the application of acids and the use of mechanical implements), removal of deposits, stains and microbial growth layers; sealing or reconstructing cracks, filling holes; obliterating any damage to the item caused by excavation tools; removal of traces of mechanical manipulations; cleaning and enhancement, including increasing contrast of unique features, etc. In the case of artwork, rehabilitation efforts may include reinforcement of color hues (e.g. Sistine Chapel; Roman frescos). Sometimes artificial substances are added to emphasize the original colors and/or preserve a sense of "freshness" of appearance. In other cases, such as ancient metal items, all traces of patina and/or rust are removed and a new fine layer of artificial patina, in an attractive hue, is applied (e.g., bronze sculpture of Hadrian at the Israel Museum and some bronze statues in Greek museums).

Nonetheless, it should be recalled that such cleaning and treatment operations necessarily affect the results of any subsequent tests performed on the item, in the context of any debate on their authenticity[1].

[1] In some cases, a final conclusion regarding the authenticity of stone items cannot be based solely on scientific evidence as, for example, in the case of the Getty Kouros (sculpture), which is currently exhibited in the Getty museum. This is despite extremely comprehensive tests, analyses and comparative studies by renowned experts in history, archeology, art and all relevant branches of science. Today this item is exhibited with the caption "530 BC, or modern forgery."

Dating patina and engravings on stone items using of microbial and micro-organic analyses

Extended exposure of stone to air and the environmental effects causes chemical reactions between the stone (rock) and its environment (air, oxygen content, sunlight, contact with soil, water, humidity, dust, cycles of moisture and aridity, activities of organisms and micro-organisms, changes in temperature, impermeability, etc).

These reactions may cause a number of effects, such as: oxygenation of the stone surface; the extraction of minerals from the stone; sedimentation of airborne dust particles and other particles such as bacteria, micro-organisms, micro-fossils on the stone surface; the development and pitting or chipping activity of micro-organism colonies; bio-geo-chemical and morphological changes of the surface, including changes to the color of the stone surface. The combined products of these effects on the stone are generally known as "patina," which is formed in the process of "patination."

Biodeterioration of stone can be caused by microorganisms, such as bacteria, fungi and lichens, or plants such as mosses. Whilst bacteria tend to biodeteriorate by etching surfaces due to acid excretion, fungi have also been found to degrade stone by physical penetration of the surface itself. Bacteria and fungi may act synergistically to release calcium by chelation and dissolution by their exopolymeric substances (EPS). **Oxalic** acids and other acids (such as acetic, carbonic, glucuronic, nitric, phosphatic, polyphenolic and sulfuric) produced by the microorganisms are also implicated in this process.

Organisms and microorganisms on the stone surface cause two types of changes to the stone surface over time: First, when stone items come into contact with soil, water, sunlight and fresh air, especially when such contact is maintained over a prolonged period, the above chemical reactions leave traces on the stone and its patina, and change the mineralogy of the stone surface. Findings of phosphates and oxalic acid products, such as apatite (calcium phosphate), whewellite (hydrated calcium Oxalate), weddelite (calcium Oxalate), in the patina and on the surface of these items are evidence of such (often biogenic) chemical reactions. The quantity and percentage of oxalic acids present in the patina and on the stone surface provide a direct indication of the duration of these biogeochemical lifecycles and reactions on the stone. Second, microorganisms cause unique morphological changes such as etching, biopitting and changes in color.

Therefore, an analysis of the composition of the materials found at the stone surface (in our case – the substances found in the inscriptions and on the surface of the items) and microscopic tests, may allow us to determine whether the formation of the materials occurred over a short period of several years or decades, or over a longer period of many decades or centuries.

The stone items' exposure to cycles of precipitation, aridity, dust storms, alluvial deposits, changes in temperature and other climatic effects, also cause degradation of the stone, sedimentation of airborne microorganisms including microfossils (sometimes after traveling thousands of kilometers in the air), the consolidation of substances with which the item was in contact, and other indications from which it is possible to determine the duration of such exposure.

Chemical and microscopic analyses and tests I performed on the surface of the items, and specifically on the samples taken from inside the inscriptions, inside the new

break line of the Jehoash Tablet, and from the stone lamp ornamentation, allow a comparison to stone items from archeological excavations and historical monuments that were exposed to climatic and biogeochemical effects over extended periods of time. According to the results of these comparisons, we can state with certainty that a period of 50-100 years, at least, was necessary for the formation of the specific composition of patina whose traces were identified inside the ossuary inscription and the stone lamp ornamentation, or for the formation of the specific composition of patina found inside the former hairline fracture on the Jehoash Tablet. Notably, this does not imply that the biogeochemical evidence was not formed over a much longer period of hundreds of years.

However, an estimation of the age of the patina found inside the inscriptions must take into consideration other firm evidence we have available to us. Specifically in the case of the ossuary, it is clear - based on evidence found on the ossuary (the presence of biopitting, microfossils, microorganisms and oxalic acid), that the patina on the ossuary developed over several hundreds, if not thousands of years. The IAA in fact concurs with this conclusion.
Yet, patina sampled from the surface of the ossuary, far away from the inscription, was found to be identical to the microscopic traces of patina, which I found inside the ossuary inscription and sites sloping from the surface into the inscription grooves (and no indication of any kind was found of any adhesives on this patina). Therefore, we must conclude that the patina formed over the entire ossuary and the remains of patina in the inscription area were formed over the same period of time.

It cannot not be excluded, however, that any person has excavated the ossuary in the late 18^{th} or early 19^{th} Century, used it as a decorative element in a garden or terrace and has added the inscription at that time. According to all knowledge the scientific community collected about patina and patina formation on calcareous rock, marble or other rock types **a minimum of 100 years is needed to create such drastic chemical changes and multilayered deposits as depicted on the three stone items analyzed by us.**

The traces of plant growth, biopitting and aerial exposure on the ossuary further make it possible that any calcium carbonate freshly formed during this reaction time may have reacted with rain water or any other water (e.g. garden sprinkling) at temperatures changing with seasonal effects from freezing point to higher than 50°C. This is what happens daily in the area of Jerusalem. Therefore it would not be astonishing, if very different oxygen isotope ratios were recorded at individual places of the object.

3 items – 3 different sets of findings

Based on analyses of the patina samples taken from each of the three items, the patina on each item was significantly distinct from the others.

- Assuming that the ossuary inscription / Tablet inscription / stone lamp ornamentations are ancient, the differences in the patina may indicate that the items were maintained in **very different environmental conditions over extended periods** (from decades to centuries). The existence of biopitting and microfossils in the ossuary indicate, for example, that the patina developed over centuries in conditions that **differ** from those of a typical cave environment.
- Any forgery of three very distinct types of patina, if ever possible, requires the development of ultra-advanced techniques, in-depth knowledge and extensive collaboration of a **large number of experts from various fields**: geochemistry, geology, micro-paleontology, microbial ecology, and other multi-disciplinary sciences, in addition to experts in archaeology, epigraphy, paleography, bible, ancient Hebrew and Aramaic, ancient art, and others. To all the above we must add sophisticated technical skills and access to chemical laboratory equipment, tools, ovens and other complex materials.

Some of the minerals found in the patina are typical micro-organismic deposits, which are **extremely difficult to reproduce in laboratory** conditions. Also the growth of a **subaerial biofilm with subsequent mineral deposition takes great microbiological skill**.

Moreover, it is very difficult if not impossible to embed microscopic fungi into patina (real or authentic). Any attempt to do so, requires the knowledge that the patina developing on items exposed to air contains mostly apatite and calcium oxalate with quartz, clay and dust particles, and windblown and trapped microfossils. Furthermore, such attempts would also require the production of adhesive that cannot be identified using conventional methods.

If a group of skilled scientists had managed to overcome such gigantic hurdles as above, several questions still remain: Why they would choose to produce items whose international marketability is very limited (in contrast, for example, to ancient Greek or Roman art which has a strong global market and would fetch much higher prices than Israeli archeological artifacts, unique as they may be)? The recent debates between the State of Italy and the Getty Museum or within the German archeologist community about the origin, composition and age of the Nebra sun disc are only two prominent examples of this discussion.
Furthermore, why in the case of the ossuary would the forgers have used both a primitive method of forging patina in a way which is so evidently inauthentic (the so-called “James Bond” granular material) together with a more sophisticated technique of producing patina - which appears by all the tests performed to date, to be true patina?

The organic origin of the patina found inside the ossuary inscription, as well as the microfossils and microorganisms in the patina, strongly indicate that the patina on the ossuary inscription developed over a period of at least 200 years outside a cave environment.

An examination of the patina exposed inside the new fracture in the tablet (which was created along a very old crack), the continuity and structure of the tablet surface, the composition of the patina etc. – all strongly indicate that if the stone was used in

ancient construction prior to the engraving of the inscription (as Goren and Dahari claimed in their presentation), the inscription was made at least 100 years ago.

As noted, there is no available technique with which we can date the inscriptions or ornamentation. However, **even if the authenticity of these items cannot be proven with absolute certainty, it is scientifically certain that the relevant inscription or ornamentation was produced <u>at least 50 years ago</u>**: This is the minimal timeframe required for the formation of micro-organismic and organic particles (in the ossuary inscription patina or patina on the oil lamp), or the formation of patina on the Jehoash Tablet crack, which postdate the inscription.

Notes on mysterious changes of the object during the period in which the object was in the possession of IAA and/or police

1. The ossuary inscription recently was altered and contaminated by the IAA and/or police. Almost all the material inside the letters of the inscription was removed. Further the inscription and surrounding area was contaminated using silicon like red material, preventing more comprehensive tests to confirm or disprove previous test results.
2. Photographs (4"x5" slides) taken in 2002 and published in BAR prior to the occurrence of the crack in transit to Canada (October 2002) show hardly any filling inside the letters (yud and vav of Yosef, and Het of Ahui). However, photographs subsequently presented by Goren and Dahari of the letters Yud and Vav (Yosef) and Het (ahui), which they claim to have photographed by the IAA in 2003, show the presence of a "granular" coating (similar to a Meyer Cement conservation material) filling these letters. Goren called this coating "James Bond." (The photographs of these letters were also published on the Internet on the Cornerstone University website).

   At my visit in July 2005 (when the ossuary was in the possession of the IAA) I saw no traces of such granular coating inside these letters, because these had been recently removed by the IAA /Israel police, perhaps during a casting with the red material or by other means.

   This could be taken as a documentation of deliberate manipulation of the inscription patina by the IAA and/or police during the custody period, although this goes beyond the scope of my work presented here.

Procedural aspects

Dr. Steven Weiner of the Weizmann Institute, Rehovot, recommended me to an attorneys' office in Israel (Lior Bringer) as an independent external expert on ancient patina, i.e. weathering and other transformation products on exposed rock surfaces. On 19/May/2005 I was contacted to provide such an expert opinion.

I was asked to study some antiquities made of stone material, which were covered by a surface reaction layer or deposit (patina) of uncertain composition and origins. On the basis of this letter, I accepted to look at the materials and, if necessary, to take samples and analyze the materials as well as searching for other experts, who might be helpful in solving some problems concerning these antiquities.

After some hesitation based on the fact that I was about to leave for a longer period of work in Russia I accepted to go to Israel early in July 2005 and look at the items.

Only then and during my stay in Israel from 9/July/05 to 13/July/05 I realized that the objects were under custody of the Israel Antiquities Authority (IAA).

Together with the advocate and the owner of the objects I went to the Rockefeller Museum near the Old City of Jerusalem. The objects were exposed in a small secretarial room for my inspection. The working conditions were quite bad. I had procured myself with an old dissecting microscope, my own analytical lenses (surgical microscope, Zeiss) and a camera as well as some tools for sampling and containers for microbiological and analytical work (Eppendorf snap caps, injection syringes and a Wolfram needle) to exert a preliminary examination.

On the second day of work at the Rockefeller Museum suddenly the Israeli police (Superintendent Pagis) requested to check my personal belongings. I replied that security check was already done and wanted to know why the police wants to see my bag. They replied that some items were suddenly missing from the IAA offices and that they may be found among my papers and materials. Although I found the request and the procedure strange, I agreed with the inspection without further protest. Nothing was found. The missing objects, however, were 'found' in the IAA after three hours and the archaeologist of the IAA stated that he had misplaced them. In my view one could perhaps assume that this was an attempt to influence an independent scientific expert.

I was allowed to study the objects during only two days with three hours of interruption by the Israeli police. I took several microscopically small samples of the 3 objects. The tests were documented.

Later I received materials showing the background of the inquiry, i.e. that all the three objects were thought to be forgeries at least in essential parts.

I decided to make my analysis based on the following approaches:

1) Visual experience with hundreds of stone sculptures, architecture and natural rock outcrops in the whole Mediterranean area including Israel and rock outcrops and petroglyphs in the Judean, the Negev and Sinai deserts as well as in the Western desert (Sahara).
2) A detailed analysis of all three objects by dissecting microscopy and medical **microscopy.**
3) **Mineralogy and electron microscopy of 7 samples taken from the objects**, namely 1 sample from the stone slab at the place of the crack dividing the slab including inscription patina, the original rock and a surface part of the crack dividing the plate into two parts, 1 sample from the top and 1 sample from the

bottom of the oil lamp, and 4 samples from the ossuary i.e. 2 samples from the remaining patina within the inscription (one from the initial part of the inscription another from the second part), one sample from the patina near the inscription and one sample from a biopitting area.

Critique of Israel Antiquities Authority (IAA) premises, methodology, findings and conclusions

I found that the conclusions of Goren, Ayalon, Bar-Matthews, Dahari and their colleagues are **not precise enough, often incorrect, often lack scientific base, or are biased in several aspects:**

- **Incorrect premises and assumptions**

  For Example:

  Contrary to the presumption, that the composition of the patina on the items is not pure calcite and allusions to dolomite which appeared in several articles and statements by Goren, our mineralogical tests found that the ossuary patina has been found to consist besides **calcite** and traces of **apatite** (calcium phosphate), **whewellite** (hydrated calcium oxalate), **weddelite** (calcium oxalate) and of **quartz** (silicium dioxide), rather then pure calcite and dolomite.

  The origin of the first three minerals is in lichen, fungi and other micro-organisms and their effects which developed over an extended period on the stone, when it was exposed to open air, under conditions that were very different from those in a typical cave environment.

  Microfossils and microorganisms remains in the patina indicate that at least 2 of the 3 items (the ossuary and the Jehoash Tablet) were outside a cave environment for a prolonged period of time (see roots, biopitting etc. on the ossuary and typical iron oxidation patterns on the tablet), in contrast to the team assumption that the items were in a cave environment since their production until shortly prior to the tests.

- **Flawed methodologies**, absence or irrelevant mineralogical analyses of the patina samples prior to comparative isotopic tests, analysis of findings and conclusions. Flawed methodologies led to erroneous interpretation of results.

- **Flawed comparative techniques** – The basic condition for the use of *Delta O* ^{18} comparative *isotopic tests* (proposed as a basis for comparison) interpreted as "paleotemperatures", is not fulfilled by the authors of the publication (I seriously doubt, that such a publication would have been accepted by Geochimica and Cosmochimica Acta e.g.).

  Moreover, the use of comparative isotopic tests on the patina sampled from the above items (and certainly, regarding the 2 inscriptions) is unreliable and may lead to mistaken conclusions (for a detailed explanation, see below on Isotopic Tests). The reason is, that neither the mineralogical composition nor the composition of the water in reaction with the items and the temperature the water may have reached during reaction with rock and patina was known to the authors. Exact knowledge of the mineralogy of the rock or patina material, and the composition and temperature history of the water reacting with rock and patina, however, is one of the prerequisites for the validity of paleotemperature calculations (Dr. M. Boettcher and Prof. Hoefs, Goettingen pers, personal communication). Further most reliable oxygen isotope based temperature analyses

stem from the stable marine environment. The terrestrial environment poses much more complex problems to exact and detailed temperature identification.

- **The Conclusions of the above quoted authors were represented as unequivocal despite their reliance on assumptions not evidenced by analytical data.** The conclusions of why deviating oxygen isotope ratios occur in the individual patina samples analyzed by the IAA experts, are, to say the least, one-sided and not based unequivocally on all the required data. Because none of the following necessary prerequisites are well defined: the composition of the material analyzed, its origin, fate, and the history of the water reacting with the rock during the patina formation (see X-Ray diffractometric analysis data attached and data on climate conditions near Jerusalem available through meteorological services).

- **Reliance on unconfirmed climatic data**
The assumption that precipitation and temperatures in the Jerusalem area have not changed in the last three millennia is in great doubt. Further temperatures between 0°C and 55°C have been recorded for many rocks in the Jerusalem area by many individual scientists to presently occur and to have occurred in the past.

- **Reliance on flawed chemistry**:
The researchers erroneously assumed that ground calcite dissolves in hot water and will exchange oxygen isotopes with the water. They also erroneously assumed that heating calcite in an oven may affect its dO^{18} value.

- **The potential effects of several actions of cleaning, restoration and enhancement** including modern chemicals performed on the two inscriptions **have not been regarded or analyzed**. Indications of these actions had been previously identified in microscopic tests, and should have been known to Goren and Ayalon. Nevertheless these were not disclosed to the IAA committee members and other authorities.

- **Wrong or at least misleading interpretation** of the existence of microfossils in the patina (see section on "microfossils").
Goren and Ayalon erroneously assumed that the existence of microfossils inside the coating on the inscription and the patina, indicate a forgery. On the contrary, the existence of these microscopic traces reinforces the probability that the patina developed over an extended period.

- **Unfounded hypotheses** (*such as*: Goren's claim that the stone of the Jehoash Tablet originated from a Crusader fortress near the sea, after being imported from Cyprus). Patina test results, however, show that the item was never maintained in a coastal area. Alternative and convincing interpretations of the petrology and origin have repeatedly been suggested by several independent and reliable geologists. The author of this expertise has traveled the Arava rift and Sinai several times since 1967 and has seen several types of rock corresponding to the tablet petrography and mineralogy. Data by Arie Shimron confirm this experience collected partially during the 1979 International Sedimentology Congress.

- **Disregard of relevant information**:
For example:
(a) Traces of ancient patina were found inside the area of the inscriptions not only by us.
(b) The results of Carbon Isotope Tests performed on all three items and the results of oxygen isotopic tests performed on the stone lamp are not recorded in the statements of Goren at al. These could perhaps confirm that the patina is

consistent with patina forming naturally in a cave or natural (atmosphere exposed) environment.

(c) Further the opinion of several experts and researchers including E. Keal, O. Cohen, R. Reich, J. Harrel, A. Bein and others were disregarded in the final conclusions, leading to the accusation of a fake or forgery by the experts nominated by the IAA to their committee.

Isotopic Tests

In the case at hand, Ayalon and his colleagues sought to apply an analytical technique based on the comparison of the patina's isotopic composition to that of patina on items discovered in limestone caves in the Jerusalem region. It is obvious that many of the conclusions in the IAA report are based on the results of this analysis. However, this technique is not applicable in the case at hand because the basic conditions for this comparison are absent.

Isotopic tests can, at the most, be used as an additional means of examination and control, and only when there is certainty that the required conditions for these tests are met. It is not surprising that criticism rose worldwide against the reliability of this technique by scientists. Numerous critical comments have been published on the issue, some in response to the publication of reports by Ayalon and Goren. Critics noted that their work was not convincing. In any case, tests used to date patina on the basis of isotopic composition have never received broad scientific recognition by the scientific community due to its numerous limitations and this type of analysis is not considered to constitute unequivocal evidence.

Isotopic tests on the composition of the patina, and the comparison of these results to artifacts discovered in calcite caves from the same area, may provide an indication of that the tested patina did or did not develop naturally **only if the following cumulative conditions are met:**

1. The tested item was, with certainty, in a calcite cave.
2. The tested patina was never in contact with soil (was not buried in the earth), over the item's entire history (minerals in the soil have a significant effect on isotopic results).
3. The tested patina was never exposed for an extended period of time to a natural atmospheric environment including sun,drastic temperature changes, rain and wind deposits.
4. The tested patina never underwent any chemical treatment of any kind, over the item's entire history, especially the use of acids or harsh detergents (which can produce all range of isotopic values).
5. The tested patina developed on a limestone item (otherwise, minerals in the stone itself could affect isotopic composition).
6. Climatic conditions and precipitation did not change in the region over the item's history.

For both the Jehoash Tablet and the James Ossuary, there is neither scientific evidence that contradicts the above conditions, nor a basis to make such assumptions. Therefore, a comparison of isotopic composition lacks scientific significance.

The only object, in respect of which the isotopic results may be of significance, is the stone lamp. This item is comprised of limestone, which, on the basis of microscopic tests, has apparently not been cleaned or handled, and there is a high probability that itwas located in a burial cave until its discovery. However, even in this case, we have no firm evidence of the source of the lamp or its history – and the mineralogical composition of the stone lamp indicates that it is possible that the item was not discovered in a cave.

The isotopic tests on the composition of the patina on the three items under examination are entirely inappropriate for these items, because they meet few, if any, conditions for the comparisons intended by the researchers:

1. Patina samples taken from the ossuary indicate that it **hardly consists of pure calcite**. It is comprised also of calcium phosphate and oxalate with quartz and other minerals admixed.
2. a) Microorganism and (wind-blown) fossil findings indicate that the ossuary was affected by **atmospheric conditions other than those in a cave environment <u>for a period of at least 200 years</u>**, and was in direct contact with the soil in which it was buried, either partially or entirely for another undefined period of time.
   b) Assuming its authenticity, the Jehoash Tablet is an architectural feature designed to be placed in a building wall. **There is no foundation to assume that it was ever in a cave**, and certainly not for thousands of years. [It is more probable to assume that it was used in secondary construction after the collapse of the original building in which it was placed, or lay in the soil of a Tel or was covered by alluvial deposits.
   c) **The history of the stone lamp is not known** (the item may have been either in a cave or in a "Tel" soil). There is no information regarding the geographical origin of the lamp.
3. Microscopic tests indicate that both the ossuary and the Jehoash Tablet had **been cleaned and handled repeatedly during different periods**. The ossuary also underwent a process of dismantling and reconstruction at the ROM Museum (Canada).
4. The Jehoash Tablet is comprised of **metamorphosed sandstone** or quartzite stone rather than limestone. The mineralogical implications of this fact on the patina composition were never analyzed.
5. One of the conditions of the isotopic comparisons is the knowledge that the two compared items were subject to more or less stable and invariable climatic conditions (temperature, water) over the entire period of their history. Recent studies indicate that the **climate** in Jerusalem underwent major changes over the last millennia, and without doubt, during specific periods, reached several highs and lows that deviated from the average conditions. Further, as mentioned above, daily temperature changes involve a repeated sequence of changes between less than **0°C** and maximally **55°C**. During such times a lot of groundwater and rainwater may have evaporated many times and interacted with the mineral forming process of a (biogenic) patina. (Biogenicity is implied by the presence of calcium phosphate and calcium oxalate as well as the characteristic biopitting structures on the ossuary).

   The ossuary at least, if not also the tablet, was exposed for extended periods of time to atmospheric conditions including rainfall, wetting and drying under a sometimes cruel sunlight. Otherwise plant growth and biopitting cannot be explained. This implies temperature changes from near or below **0°C** to maximally **55°C** and evaporation of rainwater of very different compositions in contact with the limestone and the patina forming under such variable temperatures.

   Under such conditions, even in the absence of certain data on the precise location of the discovery of these items or the conditions of their burial, the isotopic tests can provide no more than a speculative guess of the authenticity of these items, and are **certainly unable to provide a conclusive scientific**

assessment of recent forgery (this also by the way is true for the importance of microfossil findings).

6. Prof. Harrel additionally noted that the use of cleansers commonly used in Israel, during any cleaning process of the inscriptions, could have easily affected the isotopic results. In his statement (December 17, 2004), Harrel noted that he tested the isotopic values of several Israeli cleansers in which soda is one of the ingredients. (The numbers are as follows: delta O-18 = −19.88 per mil, delta C-13 = −18.15 per mil). Thus a simple mixture of only baking soda and powdered limestone, with its much less negative delta O-18 values, could easily have produced the full range of isotopic values reported by Ayalon for the inscription coating on the James ossuary. The powdered limestone could be the result of abrasion during vigorous cleaning, such as would happen if the baking soda were applied with a stiff-bristle brush. Or perhaps the powdered limestone was residue leftover from scraping the letters clean with a sharp tool.

7. In his report to the director and deputy director of the IAA, Goren noted: "The sediment inside the ossuary is brown Rendzina soil, enriched by approximately 50% microscopic bone particles, most showing evidence of having been considerably heated (having higher interference colors and pleochroism). The reason for this phenomenon is yet undetermined."

   The above implies that the ossuary was subject, at least during a specific timeframe or event, to temperatures higher than temperatures typical of a sealed cave environment. Consequently, the comparison of isotopic findings comparing the ossuary inscription to the isotopic findings of ossuaries which had been in caves with unchanging temperatures over several centuries – is inappropriate.

Isotopic tests - Stone Lamp

Dr. Ayalon noted that all the isotopic tests performed on the samples taken from various sites on the patina of the stone lamp (most from the area of the ornamentation) indicate that the patina on the lamp developed naturally in a cave in the Jerusalem area over several centuries.

Microfossils in the Patina

Professor Goren reported the results of microscopic tests that indicated microfossils in the inscription, and inside the patina taken form the letters of the Jehoash Tablet inscription. He believed that no patina that developed naturally in the Jerusalem area would contain such microfossils and that the latter were added by preparing a fake patina from grinded carbonate rock or beach material.

Furthermore, the IAA team stated in *Elsevier* (Available online 11 May 2004, that "Micromorphologic study of the letters patina from James Ossuary show that it contains marine microfossils of nannoplankton (coccoliths), unlike all other surface and letter patinas, which do not contain any microfossils**."**

However, contrary to Professor Goren's opinion, marine microfossils, unobservable to the naked eye, are commonly found in the patina on stone artifacts from the Jerusalem region and were found by us on the ossuary also at places far away from the inscription. Not only do they not indicate a forgery, their presence in the patina reinforces the arguments supporting the authenticity of such items (see the article of Ehrenberg, 1848 and later findings).

Over 150 years of literature it was established that all kinds of microfossil remains are permanently blown by wind and storm into the atmosphere and deposited on exposed surfaces and even penetrate into caves. Such dust samples containing "microfossils" have for example been sampled on the sails of the "Beagle" by Charles Darwin and were analyzed by Prof. Ehrenberg in Berlin. It is also established that these include foraminifera and other marine carbonate skeletons or skeleton particles. It is also established that cavities, grooves and especially sticky biofilm growth are better traps for such foreign particles, than even and flat surfaces.

Deposition of wind blown dust especially on wet surfaces covered by a slimy biofilm at times happens continuously. Atmospheric dust contains all kinds of organic particles including many organisms of marine, terrestrial and fossil origin. This is documented in thousands of samples by Ehrenberg, Shinn and other aerial dust experts. Christian Gottfried Ehrenberg (1848) reported the analysis of the dust deposited after a storm in Jerusalem. In this paper Ehrenberg describes many debris among which whole shells of Foraminifera and diatoms as well as other inorganic and organic items originating partially from the Mediterranean Sea and partially from the desert as a source of dust on surfaces, which winds and especially dust storms transported and deposited far away from the place of origin. These particles will adsorb better and more frequently in cavities or grooves than on smooth flat surface areas. Thus it is not astonishing, that the particles sampled on the pitting grooves of the ossuary contained clearly discernable coccoliths (see SEM-photomicrographs attached).

The amount of dust annually deposited on arid and Mediterranean area surfaces is enormous and may accumulate all kinds of foreign particles that settle especially in grooves, pits and other cavities. Further the chemist Bloch (formerly director of the Dead Sea Works) published several internationally accepted papers on the transfer of chemicals from the Sea to the desert by surf bubble explosion and wind drift. He also made convincing experiments on the amounts delivered and transported. Thus chemical changes in stone surface may occur in a natural way and cannot prove human additions.

Microscope-enhanced tests (which I conducted) indicated that the patina sampled from all sites on the ossuary contains microscopic traces of fossils, specifically coccoliths (fossils shells) and also foraminifera (erroneously assigned as phorams in reports for the IAA by Goren et al.).

The existence of these particles in the patina as well as in the "granular" like material in the inscription, should **actually reinforce the probability that this is the original patina**, even if it underwent morphological changes as a result of cleaning and treatment.
It can be said that the patina covering several of the inscription letters is no less authentic than the patina covering the other parts of the ossuary, which, according to IAA team, is authentic.

Microfossils were also found on the Jehoash Tablet, especially inside the patina on the inscription, on the upper side of the tablet that was most probably more exposed to atmospheric dust deposition.

Some microfossils or microscopic land snails were also found in the oil lamp patina (see SEM photomicrographs).

The Ossuary Inscription Coating

Ayalon, Goren and Bar-Matthews reported: "The inscription area, especially the words "his brother of Yeshua", are coated by fine textured to finely gritty, grayish matter. This matter is found **only in and around the inscription**." [Elsevier, Available online 11 May 2004 and J. Archeol. Sci. (2004)]. The researchers initially assumed that this material was the patina on the ossuary in its natural state, and therefore sampled this material.

In his report to the IAA committee, Goren also noted that: "The inscription coating is very soft (can be easily removed with a toothpick), it is sometimes gritty but generally homogeneous and **usually fills the low areas of the inscription and around it**."

This description may be characteristic of a hardening of liquid substance or material that dissolved and re-settled (re-crystallized), especially in the lower parts of the ossuary inscription.

According to the photographs shown at presentations by IAA representatives, the mortar-like granular substance, appears similar to "Meyer Cement", formerly used for restoration works, such as made at the Acropolis of Athens, Greece (1900-1930).

Based on the appearance and coloration of this substances as shown in photographs claimed to be taken by the IAA in 2003 (assuming they were not "computer-enhanced"), we can state with certainty, that this "cement" or mortar-like "granular" substance does not have the appearance of patina which formed naturally on the ossuary. **If this substance was artificially produced, it is clear that it did not purport to appear natural patina** and its presence on the inscription did not stem from a desire to imitate natural patina, since it so obviously does not look like natural patina to the naked eye (sand grains in a cement-like substance). As a result, there was no significance in comparing this substance to the natural patina taken from other sites on the ossuary.

Microscopic analyses and tests can point to **several explanations for the existence of this "granular substance" in the inscription-coating**, **other than by forgery**, including:

a. The substance is a naturally altered product resulting from a cleaning process performed on the ossuary.
   If soluble and insoluble (powder) detergents were used to clean the ossuary, and the inscribed side of the ossuary was facing upward, and the dissolved cleaning agents were not properly removed, they would have resettled inside and around some of the inscription letters. This sedimentation, however, would have a different morphology than the original patina, and would be soft and granular-like. The distinct color of this substance would be a result of the mixture of the dissolved detergent with dirt and dust on the ossuary and inside the inscription.
   This explanation is reinforced by reports, which indicate that traces of this granular material were also found in the area surrounding the inscription, not only inside the inscription letters.

b. The substance represents traces of a “cement-like” liquid used for conservation purposes, and was applied in restoration efforts when the ossuary was fractured or even before.
c. This substance on intention applied to the ossuary by the finders or dealers in order to enhance the letters' appearance of the inscription and the entire appearance of the item. Since the inscription is engraved in white limestone, it is very difficult to read in daylight without any contrast. Concerning this conventional technique used in antiquities markets, also see the lecture by Dr. Richard Newman, Head of Scientific Research at the Museum of Fine Arts in Boston (November 2003).
d. The substance was applied to disguise the effect of clumsy cleaning actions performed on the ossuary using a sharp implement. Similar processes are known in antiquities markets in attempts to disguise cracks or adhesives, or even in adding "enhanced" patina in cleaned, ancient items such as ancient metal and coins, with the aim of improving their appearance.

The removal of the ossuary inscription coating by the IAA/Israeli police**, possibly together with additional traces of natural patina that may have remained under the granular substance, prevents us from performing any comparative tests,** which could shed light on this “grainy” material and confirm any of the above-mentioned possibilities.

Appendix A

Some of the arguments used by other experts:

1) According to the experts of the Israel Geological Survey the patina analyzed in the case of the ossuary consisted of calcium carbonate possibly including dolomite. However, the X-ray diffraction analysis of the samples taken to Oldenburg convincingly demonstrates also calcium phosphate and calcium oxalate peaks, which is consistent with many other patina analyses worldwide.
2) If one would want to dissolve larger amounts of calcium carbonate in water one would consider the solubility, which is lower at high temperature and higher at low temperatures.
3) In order to relatively clearly define the formation temperatures of any carbonate or other materials soluble in acids one must know which carbonate phase (high or low Mg-calcite, aragonite or dolomite) was present and also the water phase should be clearly known. This is relatively easy in ocean water created marine carbonates but very complex with terrestrial samples and plant materials.

   For this and other reasons 95% of all paleotemperature data used in paleoclimate research rather base on tree rings and pollen analyses. Further it is well known, that rocks exposed to the atmosphere (**and in the case of the ossuary this undoubtedly has been the case at least in the past 200 years) may reach evaporation temperatures of rainfall or other rock adsorbed water sources of up to 50°C**. Equilibration of any mineral precipitate under such conditions may yield largely different oxygen isotope ratios depending on many factors such as time of sun exposure, differential heating of morphologically different relief etc.

   Prof. Danin (Jerusalem) and Prof. Garty (Tel Aviv) e.g. have made analyses of rock surfaces showing totally different case histories of patina formation and weathering structures on North or South exposed hill slopes in the Negev desert. **It would not be astonishing to receive largely varying isotope ratios in such cases. The biopitting and root or other plant imprints on the ossuary clearly indicate such differences in exposure and patina formation as well.**

5) Literally no case of authigenic dolomite formation on exposed rocks during the process of patina evolution is documented. Thus a statement like *"The research focused on the authenticity of the patina covering the letters. The term "patina" refers to the outermost weather layer. Patina forms as a result of a host rock dissolution and re-precipitation. In carbonate terrains (such as the Judean Mountains) the patina is composed mainly of limestone (CaCO3) and dolomite"* (quoted from a paper by the representative of the IAA committee) **is not only incorrect in comparing a rock (limestone) with a mineral (dolomite) but also because the implied formation of dolomite during the process of patina formation is not documented in any case of studied patina to my knowledge**. Limestone may consist of calcium carbonate of different Mg content including low and high magnesium calcite, aragonite and some dolomite. Dolomitic limestones or rocks consisting only of dolomite, a mineral in which 50% magnesium replaces the calcium in the mineral lattice are usually interpreted as a metamorphose of former aragonite or calcite under increased temperature and/or pressure.

CONCLUSIONS FROM PICTORIAL (see separate file)

1) There are many places in the letter sequence (from the beginning to the end) where yellow patina of different thickness slopes into or goes through the lettering
2) The whole ossuary is scraped and partially cleaned using different cleaning devices
3) Besides the major (yellow to brown) patina many places are covered by greyish and whitish mostly younger deposits which cover ossuary and letter grooves at places. Whether these represent true patina or remains of cleanser powders and reaction products of these with the rock material and patina cannot be decided and was not the question.
4) The grainy whitish patina with yellow and grey particles embedded existing prior to 2005 and documented by the IAA as „James Bond" material looks like Meyer cement used around 1900-1920 at the Acropolis Monuments in Athens and other places. Unfortunately these materials are presently no longer existing on the ossuary and have been totally eliminated for reasons unknown.
5) The pictures further document recent (2005) addition of a reddish sticky or powdery and also rock staining material. In places also scratches and dark (black) material was recently added. These materials do not exist in photographic documents prior to 2005.
6) Microfossils of different origin are found not only in the inscription area but also in the biopitting near the bottom of the ossuary and at the upper rim. (SEM-photomicrographs). The use of microfossils found in the inscription zone as an indication of forgery is certainly inappropriate and misleading because the same fossils are also found on other places of the ossuary.
7) Biofilms, biopitting and the patina itself are evidencing long periods of exposure of the ossuary to sunlight including probably different places. The probability, that the ossuary was located in a cave until a few decades ago can be eliminated. This indicates that oxygen isotope fractionations in some of the materials sampled cannot be calibrated via cave water analyses. Also rain water analyses are not appropriate. Rain water evaporated to almost dryness and in constant contact with rock particles and patina during exchange with the atmosphere and the rock material should be used as reference.
8) Due to the present conditions of the ossuary and the above made statements the photographic documentation does not allow to state authenticity of the inscription. It is also impossible to conclude from any of the data collected, that forgery of the inscription or parts of it was attempted. Certainly cleaning has strongly affected the whole ossuary and especially the inscription. This is to be expected, however, with any item (see the beautifully cleaned and restored ossuaries in the Israel Museum). No major differences in morphology and patina were found between the first and last part of the inscription. No evidence was found for recent additions exclusively in the lettering zone (except the so-called „James Bond material" no longer available for analyses, which also covered parts of the plain surface by the way).
9) The photography implies that the patina within the inscription as well as outside it may have formed under biological influence, which is also enforced by the mineralogical analyses made by us on two small inscription samples.

The photo-documentation is not complete. We have chosen almost arbitrarily from more than 700 photomicrographs and macrophotos as well as SEM photomicrographs collected on the three stone objects in question.

Summary

The main arguments of the experts assigned by the IAA committee to establish evidence of forgery for three stone items (James Ossuary, stone lamp and Jeoash Tablet) were

1) oxygen isotope based temperature determinations of objects exposed to cave atmospheres and temperatures
2) Findings of microfossils in the ossuary inscription apparently not belonging to the original rock and being introduced by ”powdered carbonate material from elsewhere”.
3) Traces of glue or other binding material in patina covering the ornamentation of the oil lamp.
4) Lack of patina in the lettering grooves of the ossuary and the tablet.

The arguments brought forward by the experts are not justified.

1) oxygen isotope based temperature identifications lack scientific value even if the objects in question were in a cave environment for very prolonged periods of time. Deviating temperature values can be explained by (a) inappropriate use of carbonate and water composition data (unlike oceanic carbonates), (b) exposure to changing temperatures under an arid climate regime, (c) incorporation of data from cleansers and other materials used during cleaning attempts.
2) Microfossils occur not only in the ossuary inscription but also in parts far away from the inscription area. Their presence is explained by dust deposition rather than by deliberate addition of foreign carbonate material in order to create an artificial patina. In this case the microfossils should only be detected in the “forged” parts of the inscription.
3) Traces of glue or adhesives in the oil lamp and other items could not be detected. Similar substances or views can also be produced by partially dissolved mineral deposits such as drop-like or bubble-like dissolving deposits of sodium chloride (NaCl).
4) The lettering grooves of the ossuary and of the tablet show a continuous patina of different composition and kind in both, Ossuary and tablet inscription. It is very difficult to produce a continous multilayered “fake” patina as observed by Dr. Preusser and us in the case of the oil lamp.

Our preliminary investigations cannot prove the authenticity of the three objects beyond any doubt. Doubtlessly the patina is continuous in many places throughout surface and lettering grooves in the case of ossuary and tablet.

On the other hand a proof of forgery is not given by the experts nominated by the IAA.