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## Cobalt in blue materials at Ugarit: identification, characterisation, origin

Valérie Matoïan, Anne Bouquillon

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RAS SHAMRA – OUGARIT XXVIII

OUGARIT, UN ANNIVERSAIRE

BILANS ET RECHERCHES EN COURS

édité par  
Valérie Matoïan



PEETERS  
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## TABLE DES MATIÈRES

<i>IN MEMORIAM</i> .....	V
PRÉFACE, par Nicolas GRIMAL .....	XIII
INTRODUCTION .....	XV
REMERCIEMENTS .....	XIX

### LES ACTIVITÉS DE LA MISSION

Valérie MATOÏAN, KHOZAMA AL-BAHLOUL « Recherches de terrain et études de matériel : les membres et collaborateurs de la mission d'Ougarit 1929-2020 » .....	3
Valérie MATOÏAN « Les publications 2008-2020 de la mission » .....	27
Valérie MATOÏAN « La mission d'Ougarit : les opérations de valorisation 2008-2019 » .....	37
Valérie MATOÏAN, Marielle PIC « L'exposition <i>Ougarit, une cité méditerranéenne</i> au musée du Louvre (6 juillet 2019-2 mars 2020) » .....	91
Thomas SAGORY « Ras Shamra – Ougarit et la collection <i>Grands sites archéologiques</i> » .....	115
Marielle PIC « Dans les années 1950, un projet d'architecture novateur pour valoriser Ougarit » .....	129

### OUGARIT : BILANS ET RECHERCHES EN COURS

Bernard GEYER, Nicolas JACOB-ROUSSEAU, Marie-Laure CHAMBRADÉ, Myriam TRABOULSI, Jean-Philippe GOIRAN « Enquêtes géographiques à Ras Shamra – Ougarit : les acquis » .....	155
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Nicolas JACOB-ROUSSEAU, Bernard GEYER, Marie-Laure CHAMBRADÉ « Enquêtes géographiques à Ras Shamra – Ougarit : les perspectives de prospections hors-site vues par la photographie aérienne » .....	185
Gaëtan COLIN avec la collaboration de Nicolas JACOB-ROUSSEAU et Bernard GEYER « Les stéréophotographies anciennes autour de Ras Shamra, une approche géomatique » ...	215
Herbert NIEHR « Ba'al du Šaphon et Ba'al d'Ougarit. Quelques réflexions sur les relations et le culte de deux dieux de l'orage à Ougarit » .....	247
Moussab ALBESSO, Jwana CHAHOUD, Emmanuelle VILA « L'histoire des relations entre l'homme et l'animal sur le littoral syrien et en Syrie occidentale du Néolithique à l'âge du Fer » .....	273
Éric COQUEUGNIOT, Fiona PICHON « L'industrie lithique de Ras Shamra – Ougarit au Bronze récent : bilan, mise en contexte et nouvelles approches. 40 années d'études renouvelées » .....	299
Jean-Claude BESSAC, Valérie MATOÏAN « Le programme d'étude des stèles d'Ougarit : approches technique et contextuelle. Les stèles inscrites et les stèles sans décor » .....	321
Valérie MATOÏAN, Anne BOUQUILLON « Cobalt in blue materials at Ugarit: identification, characterisation, origin » .....	343
Bérénice LAGARCE-OTHMAN « Statuettes égyptiennes à Ugarit : éléments nouveaux et questions » .....	389
Bérénice LAGARCE-OTHMAN « Un scarabée d'Amenhotep II à Ugarit. Reflets de ce règne dans la documentation ougaritique ? » .....	409
Hélène BOUILLON « La cuillère d'offrande à la nageuse RS 25.109 : une découverte inédite de la tranchée "Sud-acropole" » .....	421
Françoise ROUGEMONT, Juan-Pablo VITA « Administration à Ougarit et dans le monde mycénien : réflexions méthodologiques pour une approche comparative » .....	441
Andrew BURLINGAME « Constraining the Future in Ugaritic Juridical Composition and The Indefinite Semantics of <i>šhr tltt</i> » .....	461

#### DE CHYPRE AU KURDISTAN

Michel AL-MAQDISSI, Georges MOUAMAR « Tell Sianu dans la plaine de Jablé » .....	491
Nele ZIEGLER « La Syrie occidentale avant Zimri-Lim » .....	519

Dominique CHARPIN « “Année où Zimri-Lim est allé en renfort du Yamhad” : une campagne des armées de Mari dans le royaume d’Alep » .....	535
K. Aslihan YENER « Some Thoughts about Middle Bronze Age Alalakh and Ugarit: Reassessing an Alalakh Wall Painting with Archival Data » .....	573
Philippe ABRAHAMI, Brigitte LION « La vie religieuse à Nuzi » .....	589
Joachim BRETSCHEIDER, Jan DRIESSEN, Athanasia KANTA « Cyprus and Ugarit at the end of the Late Bronze Age: Insights from Pyla-Kokkinokremos » .....	607
Communications données au colloque international, <i>Ougarit, 90 ans après</i> .....	639
TABLE DES MATIÈRES .....	641

## **COBALT IN BLUE MATERIALS AT UGARIT: IDENTIFICATION, CHARACTERISATION, ORIGIN**

Valérie MATOÏAN \*, Anne BOUQUILLON \*\*

### RÉSUMÉ

Le bleu était incontestablement une couleur très appréciée des habitants d'Ougarit comme l'attestent à la fois les sources textuelles et la fréquence de son utilisation au sein de l'ensemble d'environ 20 000 objets en matières vitreuses découverts lors des fouilles sur les sites de Minet el-Beida et de Ras-Shamra et, dans une moindre mesure, sur celui de Ras Ibn Hani. La palette colorée est riche, du bleu très clair au bleu-noir, en passant par les infinies nuances de turquoise ou de bleu-gris, cette couleur bleue était obtenue de diverses manières. L'article porte plus spécifiquement sur l'un des colorants bleus connus – le cobalt – dont l'utilisation est bien avérée dans la documentation archéologique d'Ougarit à la période du Bronze récent. Nous proposons une synthèse des différents programmes d'analyses chimiques, minéralogiques et structurales, réalisés au Centre de recherche et de restauration des musées de France. Ces études ont permis de mettre en évidence la présence de cobalt dans un nombre important d'objets manufacturés d'Ougarit, faïences surtout et quelques verres, appartenant à la période du Bronze récent. Cet élément colorant a aussi été détecté dans un bloc de matière première (verre). Plus inattendue fut son identification, récente, dans des incrustations bleues sur un vase en albâtre.

Plusieurs « types » de cobalt semblent coexister dans les corpus étudiés.

Dans la grande majorité des cas, la source de ce cobalt est l'Égypte (aluns des oasis du désert occidental égyptien, Kharga et Dakhla) et la plupart des objets qui en contiennent sont considérés comme des importations égyptiennes. Les faïences illustrent majoritairement une catégorie spécifique, bien représentée, dénommée « faïences monochromes bleu-gris », qui est caractérisée par une glaçure et un corps de même couleur. Ce répertoire ougaritain, très varié, est de loin le plus important en dehors de l'Égypte. La présence de concentrations plus élevées de manganèse, particulièrement dans une série de perles à décor de rosette à glaçure bleu-gris foncé pourrait indiquer un mélange colorant spécifique pour l'obtention de cette nuance qui n'est pas fréquente et pose la question d'une éventuelle production locale.

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\* UMR 7192 Proclac, CNRS – Collège de France, Paris.

\*\* Centre de Recherche et de Restauration des Musées de France, Institut de Recherche Chimie Paris, PSL Research University, Chimie Paris Tech-CNRS, UMR 8247.

Ce cobalt des oasis a aussi été identifié dans trois objets manufacturés en verre. Si l'hypothèse d'une importation égyptienne est avancée pour deux pièces (un vase et une perle), le troisième objet, une perle en forme d'oiseau, pourrait être une importation mycénienne (réalisée à partir de verre bleu importé d'Égypte). Enfin, le même cobalt a été mis en évidence dans un bloc de verre brut, confirmant l'importation à Ugarit de matière première en provenance d'Égypte.

Un second type de cobalt, dont l'origine reste inconnue, a été identifié pour un groupe spécifique de faïences, qui présentent un corps siliceux « blanc » recouvert d'une glaçure bleu-gris. Les caractéristiques de ce cobalt semblent correspondre à celles du cobalt dit « R low Mn », mis en évidence par les chercheurs japonais (Y. Abe *et al.* 2012) dans des faïences et des verres d'époque ramesside.

Ces résultats viennent compléter les travaux d'A. Kaczmarczyk qui avait identifié un troisième type de cobalt, de provenance iranienne, dans quelques faïences proche-orientales découvertes à Ugarit.

Ces recherches sont également susceptibles d'éclairer les savoir-faire d'autres civilisations et de relancer des investigations sur des matériaux ou des technologies jusqu'à présent passés inaperçus : en témoignent les fragments du vase en albâtre dont le décor gravé est souligné par un pigment au cobalt (spinelle de cobalt) que l'on ne connaissait jusqu'à présent que sur les peintures de certains vases égyptiens en terre cuite du Nouvel Empire.

## ABSTRACT

*Blue was undoubtedly a very popular colour for the inhabitants of Ugarit, as both the textual sources and the frequency of its use in the set of about 20,000 objects in vitreous materials discovered during the excavations at Minet el-Beida and Ras-Shamra and, to a lesser extent, at Ras Ibn Hani attest. The colour palette is rich, from very light blue to blue-black, through infinite shades of turquoise or blue-grey, this blue colour was obtained in various ways. This article focuses on one of the known blue colorants –cobalt–whose use is well documented in the archaeological documentation of Ugarit during the Late Bronze Age. We propose a synthesis of the different chemical, mineralogical and structural analysis programmes carried out at the Centre de recherche et de restauration des musées de France. These studies have revealed the presence of cobalt in a significant number of manufactured objects from Ugarit, especially faïences and some glasses, belonging to the Late Bronze Age. This colouring element was also detected in a block of raw material (glass). More unexpected was its recent identification in blue inlays on an alabaster vase.*

*Several “types” of cobalt seem to coexist in the studied corpus.*

*In the vast majority of cases, the source of this cobalt is Egypt (alums from the oases of the Egyptian Western Desert, Kharga and Dakhla) and most of the objects that contain it are considered to be Egyptian imports. The faïence mostly illustrates a specific, well-represented category called “monochrome blue-grey faïence”, which is characterised by a glaze and a body of the same colour. This Ugaritic repertoire, which is very varied, is by far the most important outside Egypt. The presence of high concentrations of manganese, particularly in a series of rosette-decorated beads with a dark blue-grey glaze, may indicate a specific colouring mixture for the production of this shade, which is not common and raises the question of possible local production.*

*This oasis cobalt has also been identified in three manufactured glass objects. While the hypothesis of an Egyptian import is advanced for two pieces (a vase and a bead), the third object, a bird-shaped bead, could be a Mycenaean import (made from blue glass imported from Egypt). Finally, the same cobalt was found in a block of raw glass, confirming the import of raw material from Egypt to Ugarit.*

*A second type of cobalt, whose origin remains unknown, was identified in a specific group of faïences, which present a “white” siliceous body covered with a blue-grey glaze. The characteristics of this cobalt seem to correspond to those of the so-called “R low Mn” cobalt, highlighted by Japanese researchers (Y. Abe *et al.* 2012) in faïence and glass of the Ramesside period.*

*These results complement the work of A. Kaczmarczyk who identified a third type of cobalt, of Iranian origin, in some Near Eastern faïence discovered at Ugarit.*

*This research is also likely to shed light on the know-how of other civilisations and to re-launch investigations into materials or technologies that have so far gone unnoticed: witness the fragments of the alabaster vase whose engraved decoration is highlighted by a cobalt pigment (cobalt spinel) that was previously known only on the paintings of certain Egyptian ceramic vases from the New Kingdom.*



## الخلاصة

آن بوكييون وفاليري ماتويان: الكوبالت في المواد الزرقاء في أوغاريت: التعريف والخصائص والأصل.

كان اللون الأزرق لوناً محبباً جداً بلا منازع لدى سكان أوغاريت، كما تشهد على ذلك المصادر النصية وتكرار استخدامه في مجموعة تتكون من حوالي 20.000 منتج زجاجي اكتشفوا أثناء التنقيب في موقع مينة البيضا وبدرجة أقل في موقع رأس ابن هاني. فلوحة الألوان غنية، من الأزرق الفاتح للغاية إلى الأزرق والأسود، مروراً بفروقات لا نهاية لها من اللون الفيروزي أو الأزرق الرمادي، وقد تم الحصول على هذا اللون الأزرق بطرق مختلفة. تركز المقالة بشكل أكثر تحديداً على إحدى الصبغات الزرقاء المعروفة - الكوبالت - والتي تم توثيق استخدامها بشكل جيد في التوثيق الأثري لأوغاريت خلال العصر البرونزي المتأخر. ونقترح تقديم عرض مختصر لمختلف برامج التحليل الكيميائي والمعدني والبيئي التي أنجزت في مركز البحوث وترميم المتاحف الفرنسية. ولقد سمحت هذه الدراسات بتأكيد وجود الكوبالت في عدد كبير من المنتجات المصنعة في أوغاريت، وخاصة الأواني الفخارية وعدد قليل من الأكواب التي تعود إلى العصر البرونزي المتأخر. كما تم اكتشاف عنصر التلوين هذا في كتلة من المواد الأولية (الزجاج). ولم يكن من المتوقع اكتشافه مؤخراً في تطعيمات زرقاء على مزهريّة من المرمر. يبدو أن هناك العديد من "أنواع" الكوبالت التي تتواجد معا في المجموعة المدروسة.

إن مصدر هذا الكوبالت في الغالبية العظمى من الحالات هو مصر (تأتي كبريتات الألومنيوم أو شب البوتاسيوم من واحات الخارجة والداخلية في الصحراء الغربية المصرية) وتعتبر معظم الأشياء التي تحتوي الكوبالت على أنها من الواردات المصرية. وتوضح المواد الخزفية بشكل أساس فئة خاصة، حاضرة بامتياز، تسمى "الخزف ذا اللون الأزرق الرمادي"، والذي يتميز بتزجيج وجسم من اللون نفسه. إن هذا الدليل الأوغاريتي للألوان، شديد التنوع، وهو إلى حد بعيد الأكثر أهمية خارج مصر. إن وجود تركيزات كبيرة من المنغنيز، لاسيما في سلسلة من الخزرات المزخرفة بوردة مع تزجيج ذي لون أزرق رمادي داكن، يمكن أن يشير إلى خليط تلويني معين للحصول على هذا الفارق غير المألوف وي طرح تساؤلاً حول إمكانية الإنتاج المحلي.

كما تم التعرف على كوبالت الواحات هذا في ثلاث قطع مصنوعة من الزجاج. إن كانت فرضية الاستيراد من مصر لقطعتين (مزهريّة وخرزة) قد طُرحت، أما القطعة الثالثة، فهي خرزة على شكل عصفور، ويمكن أن تكون مستوردة من اليونان الموكيانية (مصنوعة من زجاج أزرق مستورد من مصر). أخيراً، تم العثور على الكوبالت نفسه في كتلة من الزجاج الخام، مما يؤكد استيراد أوغاريت لمواد أولية من مصر.

ولقد تم التعرف على نوع آخر من الكوبالت، لا يزال مجهول الأصل، في مجموعة معينة من الأواني الخزفية ذات جسم سيليسي "أبيض" مغطى بطبقة زجاجية زرقاء رمادية. يبدو أن خصائص هذا الكوبالت تتوافق مع الكوبالت الذي يطلق عليه تسمية "R low Mn"، الذي اكتشفه الباحث الياباني ي. إيب وزملائه (Y. Abe et al. 2012) في الأواني الخزفية والكؤوس العائدة لعهد الرعامسة.

هذه النتائج تكمل أبحاث إ. كيزمارتشيك (A. Kaczmarczyk) الذي اكتشف نوعاً ثالثاً من الكوبالت، إيراني الأصل، في بعض الأواني الخزفية الشرق أوسطية المكتشفة في أوغاريت.

ومن المحتمل أيضاً أن تلقي هذا البحث الضوء على المهارة الفنية لدى الحضارات الأخرى ويعيد إطلاق النقصي عن المواد أو التقنيات التي لم يلاحظها أحد حتى الآن: ويتضح ذلك في كسرات المزهريّة المرمية التي تم إبراز زخارفها المنقوشة بصبغة الكوبالت (إسبينل أو لعل الكوبالت) التي لم تكن معروفة حتى الآن سوى في طلاء بعض المزهريات الفخارية المصرية من عصر الامبراطورية الحديثة.



*Fig. 1—Selection of objects from Ugarit made of blue vitreous materials (computer graphics by G. Devilder).*

*Spacer-bead RS 23.599 (photo V. Matoian), rosette-shaped bead Louvre 81 AO 640 (C2RMF—photo D. Bagault), grape-shaped bead Louvre 84 AO 894A (C2RMF—photo D. Bagault), Fragment of faience bowl (photo V. Matoian), frit cylinder seal coloured with Egyptian blue RS 3 087 (C2RMF—photo D. Bagault), cylinder seal in Egyptian blue RS 6.372 (C2RMF—photo A. Maigret), faience cylinder seal RS 7.190 (C2RMF—photo A. Maigret), Faience bowl with blue-green glaze and black painted decoration RS 26.256 (photo V. Matoian), detail of the decoration of the glass bead RS 94.608/154 (C2RMF), blue glass block Louvre AO 30763 (C2RMF—photo D. Bagault), dark blue glass block (photo V. Matoian).*

## INTRODUCTION

Blue was undoubtedly a very popular colour for the inhabitants of Ugarit, as the textual sources attest, as well as the frequency of its use in the nearly 20,000 objects made of vitreous materials discovered during the excavations at the sites of Minet el-Beida and Ras Shamra and, to a lesser extent, at Ras Ibn Hani. In the archaeological record, with the exception of a few pieces carved from lapis lazuli, the majority of blue-coloured objects are made from artificial materials.

It would be more correct to speak of “the blues” because the palette is so wide, from very light blue to blue-black, passing through the infinite shades of turquoise or blue-grey. Depending on the material, the surface aspect is also very variable, shiny, matt, grainy, opaque or translucent (*fig. 1*).

The materials are homogeneous or heterogeneous, coloured in the mass or only on the surface (glaze). Silica is the main constituent of three of them: glass, faience and Egyptian blue. A fourth material is defined by a clay ceramic body covered with a coloured glaze.

In many cases, the colours observed today are no longer the original ones due to the alteration of the materials. The conditions of burial in these sites of the Levant are indeed very aggressive; the alterations are marked by the leaching of the constituent elements of the glasses (alkalis and colorants), leading, among other things, to an irreversible degradation of the colours (from blue to green, greenish, even yellowish).

It should be noted that not all objects made of vitreous materials are monochrome; some are two-coloured and others are polychrome. There were also objects combining a vitreous material with one or more other non-vitreous materials (stone, wood, ivory), but the associations that have survived to this day are exceptional because of the fragility of the materials.

While visual examination is essential for establishing an initial classification of the material and an initial identification of the materials, only laboratory analysis can provide a precise definition. The analyses, carried out at the Centre de recherche et de restauration des musées de France<sup>1</sup>, of part of the corpus of vitreous materials from Ugarit were decisive in establishing a precise characterisation, in obtaining discriminating data in order to define the origin of the material, as well as in identifying the colouring agents.

The results of the chemical and X-ray diffraction analyses showed that the blue colour was obtained in various ways.

–Copper is the most common agent used to colour vitreous matrices. As the glasses and glazes in this case are of sodic or calco-alkaline type, the addition of copper gives a turquoise colour, more or less shaded in green depending on the presence, voluntary or natural, of other metallic elements, iron or manganese.

–Another artificial material, Egyptian blue, is coloured by the presence of cuprorivaite crystals (double silicate of calcium and copper), set in a vitreous matrix also containing silica. Depending on the size of the cuprorivaite crystals and the number of grinding and firing cycles, there is a whole range of blues, from

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1. With the exception of a few Egyptian blue objects previously analysed by C. Lahanier, the first large-scale study of the vitreous materials from Ugarit was carried out in the 1980s as part of a vast programme on ancient NearEastern faïences initiated by A. Caubet and A. Kaczmarczyk from the collections of the Department of Oriental Antiquities of the Louvre Museum (Bouquillon, Caubet, Kaczmarczyk and Matoïan 2007). From the 1990s onwards, four operations dealing respectively with glazed pottery (Matoïan and Bouquillon 1999), Egyptian blue (Matoïan and Bouquillon 2000), blue-grey monochrome faïence (Bouquillon and Matoïan 2007) and glass (Biron, Matoïan, Henderson and Evans 2012), initiated by V. Matoïan, were carried out in collaboration with A. Bouquillon, I. Biron, S. Pagès-Camagna, and with the participation of Y. Coquinot and A. Leclaire (C2RMF). This research was carried out in collaboration with the Centre de recherche et de restauration des musées de France, the Syro-French Archaeological Mission of Ras Shamra-Ougarit, the Louvre Museum, the UMR 5133 Archéorient (CNRS–Lyon 2), and, for the glass programmes, with the University of Nottingham and the British Geological Survey. The laboratory studies were carried out on pieces kept in museums in Syria, temporarily exported thanks to the authorisation of the General Directorate of Antiquities and Museums of Syria, and in the Louvre Museum. We are very grateful to these institutions. Our thanks also go to the AGLAE team of the C2RMF, to C. Doublet, in charge of the electron microscope and to the C2RMF photographers, Anne Maigret and Dominique Bagault.



dark blue to pale blue. When Egyptian blue is used as a colorant, the shade it gives to the vitreous material is a bluish white.<sup>2</sup>

–In this article, we will focus on the other blue colouring element: cobalt, whose use is well attested in the archaeological documentation of Ugarit in the Late Bronze Age. This metal oxide with strong colouring powers is mainly found dissolved in the vitreous matrix of massive glasses or in the glaze of a particular category of blue-grey faience. Our objective is to propose a synthesis of the different chemical and mineralogical analysis programmes carried out at the Centre de recherche et de restauration des musées de France. These studies concerned glass and faience (mostly monochrome blue-grey), as well as the inlays of a fragment of alabaster vase, the analysis of which revealed the presence of cobalt in crystallised structures (spinel) of a beautiful deep blue hue. We will comment on the data obtained for four glasses and thirty-five faience.

This article is also an opportunity to make available colour photographs of a selection of these objects.<sup>3</sup>

## THE COBALT

Cobalt is found in metallic deposits, which are few in number, in contrast to the fairly widespread copper deposits. Furthermore, accessible deposits of cobalt are much smaller and the extraction of this metallic element is more difficult. Cobalt is often associated with a variety of other elements that can indicate different geological environments, and thus reveal the origin of the deposits mined. Chemical elements traditionally associated with cobalt are aluminum (Al), sulphur (S), potassium (K), iron (Fe), manganese (Mn), nickel (Ni), copper (Cu), zinc (Zn). The presence or absence of these elements in the overall composition, as well as their relative abundance, are parameters that need to be identified and quantified.

Since the 1980s, various researchers have studied the use of cobalt as a colouring agent in ancient vitreous materials, glasses, faïences, glazes from Egypt and the Near East and also as a pigment in ceramic paintings in Egypt. These studies have led to several syntheses that also address the origin of cobalt.<sup>4</sup>

According to the current state of knowledge, several sources of cobalt used during ancient times are recognised, based on the chemical elements naturally associated with cobalt: the alums of the Egyptian Western Desert (Dakhla and Kharga oases) and the asbolanes<sup>5</sup> of Iran are the main ones. The results of recent studies suggest the use of other deposits, the location of which is still debated (*table 1*).

Thus, concerning the Egyptian material of the New Kingdom, works have highlighted the use, for the productions of the Ramesside period (glasses and faïences discovered in the sites of Dahshur North and Saqqara North West, in the region of Memphis), of a cobalt (Type “R”) whose signature differs from that of the cobalt of the alums of the oases of the Western Desert<sup>6</sup> (*table 1*). However, the geographical location of the deposit is not yet identified.

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2. Bouquillon, MatoĀian and Pagès-Camagna, in press.

3. They are often illustrated in black and white in publications. In the book *Faïences de l'Orient ancien* (Bouquillon *et al.* 2007), the selection of colour plates does not include monochrome blue-grey faïence. Several colour photographs can be found in the catalogue of the exhibition *Faïences de l'Antiquité. De l'Égypte à l'Iran* (Caubet and Pierrat-Bonnefois 2005): the pendant Louvre AO 14803 (p. 61, no.144), the grape beads Louvre AO 30738 (p. 62, no.146), the ring Louvre AO 30655 (p. 61, no.145), the lantern bead Louvre AO 30744 (p. 61, no.147). See also: MatoĀian 2008a, fig. 9; 2015, fig. 25-26.

4. Kaczmarczyk and Hedges 1983; Kaczmarczyk 1986; Lilyquist and Brill 1993; Rehren 2001; Shortland *et al.* 2006; Tite and Shortland 2008; Abbe *et al.* 2012; Henderson 2013; Hodgkinson *et al.* 2020.

5. Asbolane is a type of hexagonal mineral containing cobalt, hydrogen, manganese, nickel and oxygen.  $(\text{Ni, Co})_{2-x}\text{Mn}^{4+}(\text{O, OH})_4 \cdot n\text{H}_2\text{O}$ .

6. Abe *et al.* 2012.

Other studies have furthered our knowledge of the evolution of uses in the post-Bronze Age period. For example, a study of the blue cobalt glasses from Nimrud revealed the use, in the Neo-Assyrian period, of cobalt which is thought to have come from Egyptian alums.<sup>7</sup>

Finally, work has shown the impact of the preparation of the ore, particularly the alums, on the final compositions of the colorant.

*Table 1—Known Bronze Age sources of cobalt.*

Label	Origin	Significant Elements	Transition Elements—impurities associated with cobalt	Bibliography
A	Alums of the oases of Dakhla and Kharga	Al, K, Mg	Ni, Zn, Mn	Kaczmarczyk 1986; Shortland <i>et al.</i> 2006
N1 (with Mn) N2 (avec Mn)	N1: Iran? N2 : Iran (asbolanes)		Zn (with or without Mn)	Kaczmarczyk 1986; Henderson 1991; Abe <i>et al.</i> 2012
R	Unknown		Ni	Abe <i>et al.</i> 2012

#### THE FIRST IDENTIFICATIONS, USING X-RAY FLUORESCENCE METHOD, IN GLASS AND FAIENCES

The first identifications were made in the 1980s. by Alexander Kaczmarczyk, a specialist in Egyptian faience. He<sup>8</sup> analysed, non destructively, some sixty objects in vitreous materials from Ras Shamra and Minet el-Beida in the collections of the Department of Near Eastern Antiquities at the Louvre Museum using Xray fluorescence method.

This technique allows for immediate, panoramic, non-destructive analysis; however, it has moderate sensitivity (elements below aluminum are not detected) and is only applicable to surfaces, which are often altered.

The sample included a selection of pieces (beads, pendants and a vase fragment, *fig. 2-4, 6*) from Minet el-Beida and Ras Shamra illustrating the group of monochrome blue-grey faiences, for which most parallels are Egyptian. The analysis revealed the use of cobalt as a colouring element in both the glaze and the siliceous body of these faiences (*fig. 4*).

The results were presented, in synthetic form, in an article published in 1987,<sup>9</sup> and then developed in a general book on ancient Near Eastern faience,<sup>10</sup> confirming the hypothesis of a probable Egyptian origin of these objects.

7. Reade, Freestone and Simpson 2003.

8. This study followed on from an earlier work on faiences in ancient Egypt. In 1983, R.E.M. Hedges and A. Kaczmarczyk published the results of an extensive research programme on Egyptian faience through the ages, from the pre-dynastic period to the Roman era.

9. Caubet and Kaczmarczyk 1987, p. 50. In this first publication, the authors indicate that no vase testifying to this technique has been identified at Ugarit, a fact that was later invalidated (Bouquillon *et al.* 2007, no.228). A. Kaczmarczyk refers to the material from Ugarit in his article on the sources of cobalt used in ancient vitreous materials (Kaczmarczyk 1986, p. 374).

10. The geographical limits of this study were those of the Departement of Near Eastern Antiquities, i.e. from the Maghreb to Iran, with a strong emphasis on the Levant, inner Syria, Mesopotamia and western Iran (Susa), and with works dating back to the 3rd millennium BC for some of them, and up to the first centuries of Islam for the most recent. A selection of approximately 300 objects formed the basis of this research. See Bouquillon *et al.* 2007: two grape cluster pendants (no.234, 235), a grape cluster bead (no.236), a lantern bead (no.238), a rosette bead (no.239) and the vase fragment (no.228). The lion's head pendant, mentioned in Caubet and Kaczmarczyk 1987, p. 50, is not included in Bouquillon *et al.* 2007.



Fig. 2—Grape beads Louvre 84 AO 896A (Ras Shamra Mission, photo V. Matoian, computer graphics by G. Devilder).

### Grape beads and pendants in monochrome bleu-grey faience

Grapes, vines and wine are frequently mentioned in the textual documentation of the recent Bronze Age of Ugarit,<sup>11</sup> where they are mentioned in writings of various kinds: administrative, legal, medical, equestrian, cultic and literary texts. The economy of Ugarit was partly based on the exploitation of its land for the needs of the kingdom's inhabitants and for export, and the vine is, alongside the cultivation of cereals and olive trees, one of the three components of the Mediterranean trilogy.

The representation of grapes, however, is not very frequent in the material culture of the kingdom. With the exception of a local series of precious metal earrings decorated with motifs interpreted as bunches of grapes, representations are limited to two groups of monochrome blue-grey faience objects, most probably imported from Egypt.<sup>12</sup>

The first group consists of thin beads 1.4 to 1.5 cm high, with one side flat and the other decorated in slight relief with a bunch of grapes (*fig. 2*). They were usually fitted with a small suspension ring at their upper end. Sixty-five specimens have been recorded, the majority (59 pieces, several of which have been analysed) coming from the same context—the “dépôt” no.43 of Minet el-Beida. Two other contexts are known: a tomb in the “Ville Basse ouest” (tomb LVII [62]) and the eastern sector of “Building B” in the “Grand-Rue” area. The shape and technique are typically Egyptian and many parallels are known in Egypt, notably at El-Amarna and Qantir where moulds have also been found.<sup>13</sup> This type of bead was often associated with multi-row necklaces of the *ousekh* type. A few specimens of similar shapes have been found at other sites in the southern Levant, such as Lachish,<sup>14</sup> Megiddo,<sup>15</sup> and, further north, at Kamid el-Loz in Lebanon.<sup>16</sup> The finds from Ugarit are by far the most numerous.

The second type corresponds to larger objects: pendants in the shape of a bunch of grapes in monochrome blue-grey faience (*fig. 3*). The Ugaritic corpus now includes 9 specimens, found in different contexts including the royal palace:<sup>17</sup> four pendants are complete (the height varies from 4.2 to 5.2 cm) and only one specimen, found at Minet el-Beida, still has the bronze suspension ring (RS 3.9, Louvre AO 14803).

11. Matoian and Vita 2018, with references.

12. Matoian 2013.

13. Amarna: Petrie 1894, pl. XIX: 445; Peet and Woolley 1923, pl. XIII: 2,3. Qantir: Herrmann 2007, no.181-182.

14. Tufnell *et al.* 1940, pl. XIV, XXXVI, 94.

15. McGovern 1985, p. 117, no.110.

16. Hachmann *et al.* 1980, pl. 28: 1-5, p. 89, no.24-28; Metzger and Barthel 1993, p. 107-108, 314317, no.999, 1006, 1020, pl. 56, 9-10. The material indicated for these pieces is a blue “frit”. Five pendants in the shape of a bunch of grapes were found in a temple in the city, near numerous other earthenware pieces (plates, beads and pendants of various shapes) that may have belonged to adornments or been used as inlays.

17. The work on the faïences of the Louvre Museum mentions only 5 pieces.



Fig. 3—The grape pendant RS 3.9 (Louvre AO 14803)  
(C2RMF—photo D. Bagault,  
computer graphics by G. Devilder).

Amarna (EA 25, letter from Tushratta, king of Mittani, to Pharaoh Amenhotep III, col. III, line 36)<sup>19</sup> specifying a list of luxurious goods, attests the circulation of such objects.

Observation of the objects clearly shows that they were cast in two identical parts, joined before firing. The joining line is clearly visible on the complete specimens. Incomplete specimens show two modes of shaping, the interior of the object being either solid or hollow (fig. 4).

The parallels come mainly from Egypt (El-Amarna, Medinet Habu, Malkata, Gurob, Qantir, Memphis...)<sup>18</sup> (fig. 5) where they could have been used as an element of adornment or architectural decoration (decoration of an artificial trellis, of a royal canopy). The hypothesis of similar uses for the Ugarit pendants is conceivable, but the absence of texts documenting these objects and the lack of available information on their context of discovery do not allow us to know if they were acquired for their commercial, aesthetic or symbolic value, and what their precise function was. Were the activities of the owner related to viticulture or winemaking? Were these objects used for banquets or ceremonies where wine was consumed? The mention of “golden grapes” in a letter from El-



Fig. 4—Grape cluster pendants: RS 18.244, left, RS 3.71, right  
(Ras Shamra Mission, photos V. Matoïan, computer graphics G. Devilder).

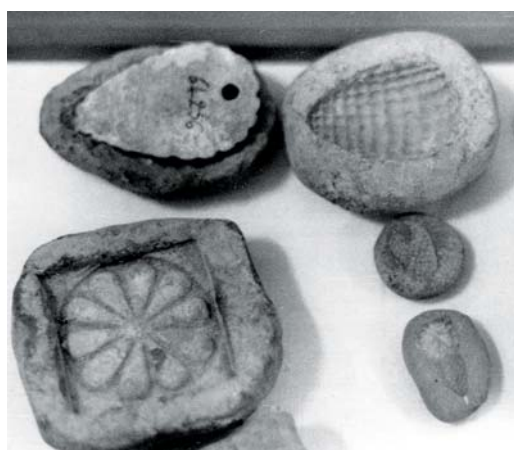


Fig. 5—Clay moulds from Qantir, presented in a display case of the Egyptian Museum in Cairo  
(photo V. Matoïan).

18. Friedman 1998, p. 189-190. For the moulds, see: Hermann 1985, no.952-955. Stone specimens are also known (Samson 1978, p. 73, fig. 44, bottom right).  
19. Moran 1987; Rainey 2015.



### The fragment of vase in monochrome blue-grey faience RS 11.854

Discovered in 1939 at the Ras Shamra site, this fragment of a vase (RS 11.854, Louvre AO 30638, *fig. 6*) is remarkable in more than one way. It is the only blue-grey monochrome faience vase identified to date among the material from Ugarit, this category being rare in Egypt itself. The object also attests to the use of the inlay technique for the rendering of the decorative frieze. Inlay is mostly attested in Egyptian productions, but is only known in Ugarit on a few typically Egyptian faience (including a monochrome blue-grey faience ring), unlike Cyprus where it was adopted for some exceptional creations from Kition.

Traces of red glaze are still visible in the inlays of the Ras Shamra fragment. The decoration shows a band of lanceolate leaves, a motif frequently seen on the necks of some Egyptian closed-form vases. It is difficult to know whether the fragment belonged to a jar, a jug or a pot.<sup>20</sup> The restored diameter of 10 cm indicates a large vase.

The object is unique in the Levant. Its exceptional character is reinforced by the context of its discovery. The fragment was uncovered during the excavation of the main entrance of the Royal Palace. Its original location is not known; however, it is possible to associate it with the luxurious material that was in the building. The same area also yielded a fragment of an alabaster jar that is considered an Egyptian import.<sup>21</sup> The type it illustrates is remarkable for the decoration of its handles, in the shape of a gazelle's head, and for its rarity outside Egypt. Only a few examples are known from the southern Levant (Megiddo, Beth Shean)<sup>22</sup> and Cyprus,<sup>23</sup> in addition to the specimens from Ras Shamra and Minet el-Beida.

The evidence of an Egyptian cobalt in the blue glaze of vase RS 11.852 supports the hypothesis of an Egyptian import.



*Fig. 6—The fragment of vase RS 11.854 in monochrome blue-grey faience (Louvre AO 30638, 81 AO 261) (Ras Shamra Mission, photo V. Matoian, computer graphics G. Devilder).*

20. The band of lanceolate leaves is attested on faience vases found in the Levant and Cyprus (Jacobsson 1994, no.235, brown-black painted decoration on a greenish-blue glaze).
21. This is vase RS 11.849 (Louvre 84 AO 861), found at topographical point 2445, (depth 2.45 m), see Matoian 2008b, p. 57-58 (Caubet 1991, p. 228, pl. IV: 2, pl. XI: 5, indicates only “north-western butte of the tell”). According to the excavation notes, the faience vase RS 11.854 was found at the topographical point SR 2454 which corresponds to the “déblais provenant de la région du vase en albâtre pt 2445”. Another fragment of a handle in the shape of a gazelle's head preserved in Damascus (RS 14.276) comes from the area in front of the entrance to the Royal Palace (topographical point 224).
22. Sparks 2007, p. 81, 327, fig. 18.1, 25.7, 27.2.
23. RS 11.849 and RS 14.276: Caubet 1991, p. 228, pl. IV,2 et XI, 5, p. 229; Matoian 2008a, p. 57-58, fig. 17; Matoian 2008b, p. 132, fig. 2-3. See Jacobsson 1994; Karageorghis and Raptou 2016, p. 56, 57-58, pl. XXXII, LXXXVII : vase no.9, Tomb 194 from Palaepaphos-Skales.



The blue-grey monochrome faïence technique is mainly known in Egypt where it was first recognised by A. Lucas as early as 1962 (called “Variant D”).<sup>24</sup> In 1983, A. Kaczmarczyk and R.E.M. Hedges distinguished, within the Egyptian production of the New Kingdom, two sub-groups: “During the 18th Dynasty the production of the traditional Variant D in which copper is the chief pigment (...), is supplemented by the creation of two sub-variants. One, which might be termed D1, has a green body covered by a green glaze both coloroud by a mixture of CuO and  $Pb_2Sb_2O_7$  (...). The other, tentatively labelled D2, has cobalt oxide as the principal pigment at comparable concentrations in the body and the glaze”.<sup>25</sup> The Ugarit objects correspond to the group of cobalt-coloured earthenware (“Variant D2”), now called monochrome blue-grey faïences. Among the faïence, they represent one of the rare categories in which the body is intentionally coloured.<sup>26</sup>

The work of A. Kaczmarczyk has shown that the cobalt used in New Kingdom Egyptian production was always accompanied by manganese, iron, nickel, zinc and aluminum, and that it came from the alums present in the oases of the Western Egyptian desert.<sup>27</sup>

The same elements (aluminum, manganese, iron, nickel, zinc) associated with cobalt were detected in the body and glaze of the Ugarit objects. Copper oxide is also present in some glazes<sup>28</sup> (see below).

–The analyses also revealed the presence of cobalt, of different origin(s), in the glazes of two objects not belonging to the category of monochrome blue-grey faïence. A. Kaczmarczyk has proposed an Iranian origin for this cobalt.<sup>29</sup>

The first piece is a fragment of a vase (Louvre AO30646/83 AO 34A), found in tomb VI of Minet el-Beida (*fig. 7*). It belongs to the category of “buckets”. The body of the vase are covered with a whitish glaze, while the rim retains traces of yellow and blue glazes. The analysis revealed copper, iron and cobalt oxides in the glaze covering the rim.<sup>30</sup>



*Fig. 7–Bucket in faïence (Louvre AO30646/83 AO 34A), tomb VI, Minet el-Beida (Ras Shamra Mission, photo V. Matoïan, computer graphics G. Devilder).*

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24. “The name “Variant D” has been assigned by Lucas to a hard and compact blue-bodied or green-bodied faïence coated with a distinct glaze of similar colour” (Kaczmarczyk and Hedges 1983, p. 205). See Lucas and Harris 1962.
25. Kaczmarczyk and Hedges 1983, p. 206.
26. Kaczmarczyk and Lahanier 1983, p. 98.
27. Kaczmarczyk 1986.
28. Bouquillon *et al.* 2007, the vase no.228, the lantern-bead no.238, the rosette bead no.239.
29. Bouquillon *et al.* 2007, p. 32-33.
30. Bouquillon *et al.* 2007, n 229.

The second piece (RS 7.090, Louvre AO 18522) is a group of figurines (two figures, a chariot, a horse), uncovered in the area of the “Ville Basse ouest” on the Ras Shamra tell. The analysis revealed the presence of manganese, iron and cobalt oxides in the black glaze.<sup>31</sup>

–The book *Faïences et matières vitreuses de l’Orient ancien* also gives the results of the analysis of some glass pieces from Ras Shamra and Minet el-Beida. Cobalt was found in two small blocks of dark blue glass<sup>32</sup> and in a decorative element (a blue-black band) of a glass vase mounted on a core. This vase (RS 4.139, Louvre AO 15759), found at Minet el-Beida, was part of a group of objects identified by the excavator as “dépôt 43”<sup>33</sup> which also included the blue-grey monochrome faience grape beads studied here (supra, fig. 2).<sup>34</sup> Analysis showed cobalt correlated with manganese, nickel and zinc. Moreover, the shape (ovoid bottle) and the decoration of the vase allow it to be linked to Egyptian productions;<sup>35</sup> the closest parallels are indeed to be found in Egypt.<sup>36</sup> Thus, “dépôt 43” at Minet el-Beida most probably included several imports (the glass vase and the earthenware beads) from Egypt.

These first analyses by A. Kaczmarczyk revealed, on the one hand, the use of cobalt as a colouring agent in materials of different nature (faience and glass) as well as in a block of glass raw material, and, on the other hand, two different sources of supply for cobalt (Egypt and Iran). Cobalt is mainly present in objects whose typological and stylistic study allows them to be linked to contemporary Egyptian production, the hypothesis of an Egyptian origin being supported by the evidence of cobalt from Egyptian deposits.

## TWO STUDIES ON UGARIT GLASSES

Two studies of the glasses have identified three pieces of evidence for the use of cobalt.

### *A block of raw material*

In 1999, a study of several Late Bronze Age glasses found at Syrian sites (Meskene-Emar, Tell Ashara-Terqa<sup>37</sup> and Ras Shamra-Ugarit) provided the opportunity to analyse two small blocks of glass from Ugarit, out of the twenty or so blocks identified to date.<sup>38</sup>

Examination with the naked eye of the blocks from Ugarit showed differences in colour and texture. Two principal groups are distinguished: in the first, the material is sugary in aspect and turquoise blue in colour; in the second, it is homogenous (often with the presence of bubbles visible on the surface). The aspect is vitreous, the colour turquoise to dark blue, sometimes almost black. A block of each type was

31. Bouquillon *et al.* 2007, no.203. Caubet and Kaczmarczyk 1987, p. 51: “The presence of cobalt (0.1-0.3%) in the black glaze (...) is rather surprising and difficult to explain at the moment, except that another unique source of manganese and iron might have been use”.

32. Bouquillon *et al.* 2007, no.248.

33. The excavation of “Dépôt 43” at Minet el-Beida, recognised by the excavator in the area of “tranchée 2. V”, took place from 16 to 20 May 1932. The precise nature of this context, close to the large tomb VI, is not known, as the excavation notes provide only very brief data.

34. Bouquillon *et al.* 2007, no.231.

35. According to the excavation notes, a second, “similar” glass vase was found in the same context: Matoian 2000a, cat. verre 961, tome II-A, p. 398.

36. Nolte 1968, p. 95, no.24a, p. 162; Barag 1970, appendix; Matoian 2000a, cat. verre 961; 2000b, p. 30, fig. 2.

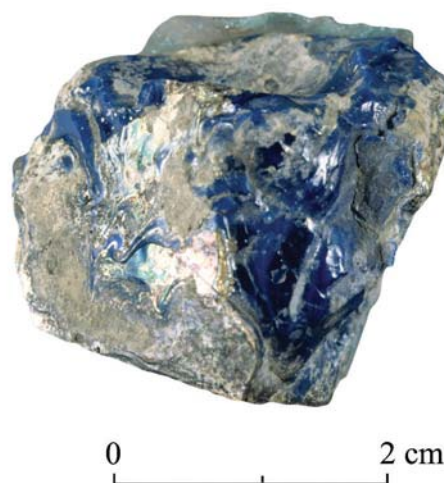
37. Matoian and Bouquillon 2007.

38. Laboratory number: L28368 (Louvre 84 AO 926) and L. 28369 (Louvre 84 AO 522). Matoian 2000a, vol. IB, p. 540-541; Matoian and Bouquillon 2003, p. 336.

analysed with an electron scanning microscope coupled with the EDS system.<sup>39</sup> The results indicated two different materials.

The block of dark blue glass (Louvre AO 30763/84 AO 926)<sup>40</sup> is very well preserved (*fig. 8*). Only the surface presents iridescence typical of the first stages of alteration.

*Fig. 8—The block of blue glass  
Louvre AO 30763/84 AO 926  
(C2RMF—photo D. Bagault,  
computer graphics G. Devilder).*



Its chemical composition (*table 2*) indicates that it is a calco-sodium glass coloured by cobalt. At the time of the investigations in 1999, we were unable to measure the manganese, nickel and zinc contents potentially associated with cobalt because of the quality of the detectors available at the time on the scanning electron microscope. Nevertheless, the concentrations of magnesium and aluminum are totally compatible with what is known about Egyptian cobalts.<sup>41</sup>

The antimony ( $\text{Sb}_2\text{O}_3 = 1\%$ ) in the composition reflects the presence of calcium antimonate, a traditional opacifier in Late Bronze Age glass. Scanning electron microscope observations confirm this and also highlight the heterogeneity of the distribution of microcrystals within the vitreous phase.

*Table 2—Chemical composition of the blue glass fragment-EDX data expressed as % oxides.*

Louvre inv. number	Na <sub>2</sub> O	MgO	Al <sub>2</sub> O <sub>3</sub>	SiO <sub>2</sub>	SO <sub>3</sub>	Cl	K <sub>2</sub> O	CaO	Fe <sub>2</sub> O <sub>3</sub>	CoO	Sb <sub>2</sub> O <sub>3</sub>
AO 30763	17,5	3,9	3,9	60,7	0,6	0,4	0,8	9,7	0,7	0,3	1,2

The hypothesis of an importation from the Nile valley is thus possible. It could be correlated with the discoveries of the Uluburun shipwreck, found off the southern coast of Turkey, of which the cargo is exceptional evidence for glass circulation in the eastern Mediterranean around 1300 BC. The wreck contained among other things many glass ingots of an intense blue coloured with cobalt like that of Ugarit, and whose composition is similar to that of Egyptian glass.<sup>42</sup>

39. Matoian 2000b; Matoian and Bouquillon 2003.

40. Louvre AO 30763, 84 AO 926: Matoian 2000a, vol. IA, p. 418-419, cat. verre 976.

41. Kaczmarczyk and Hedges 1983, p. 41-54; Kaczmarczyk 1986; Lilyquist and Brill 1993; Shortland 2000, p. 47-50.

42. Bass *et al.* 1989; Nicholson *et al.* 1997; Pulak 2008; Jackson and Nicholson 2010.

### Two glass beads

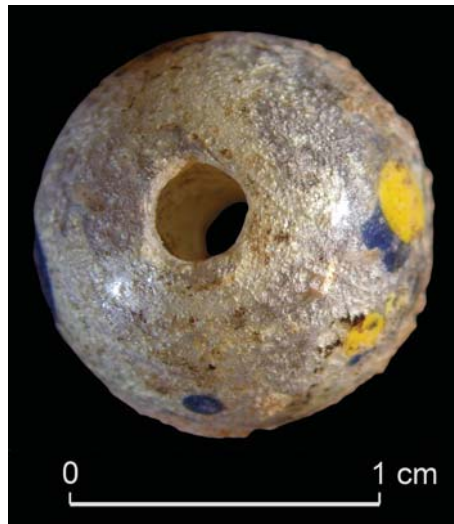
More recently, in 2007, a new analysis programme was initiated with the collaboration of Isabelle Biron. This study focused on an exceptional assemblage of glass beads discovered in a ceramic jug found in a Late Bronze Age private house of the area called “Centre de la Ville”, of which about a quarter were analysed (i.e. 12 beads and 36 samples of beads).<sup>43</sup>

The surfaces of the glass samples were analysed with a 2.8 MeV proton beam extracted in air produced by the AGLAE accelerator of the C2RMF using PIXE and PIGME methods (particles induced X-ray emission and particles induced Gamma-ray emission). Like Mesopotamian and Egyptian glass of the same period, the Ugarit glasses analysed are sodium plant ash silicates. Two blue colorants are observed: copper and cobalt.

Cobalt is attested in two translucent glass beads: a dark blue bird-shaped bead (RS 94.608/26), with copper *fig. 9*), and the dark blue decoration of one globular bead (RS 94.608/154) (*fig. 10*). The two dark blue cobalt glass beads contain higher levels of aluminum, manganese, iron, nickel and zinc than detected in copper blue turquoise beads. A cobaltiferous alum from the western desert of Egypt could have been used to colour these glasses<sup>44</sup> similar to Egyptian,<sup>45</sup> to some Mycenaean<sup>46</sup> and some glasses from Knossos on Crete.<sup>47</sup>



*Fig. 9—Bird-shaped bead in blue glass RS 94.608/26, Ras Shamra, “Centre de la Ville” (Latakia Museum) (C2RMF, photo S. Pistre, computer graphics G. Devilder).*



*Fig. 10—Globular glass bead decorated with nodules of different colours RS 94.608/154, Ras Shamra, “Centre de la Ville” (Latakia Museum) (C2RMF, photo S. Pistre, computer graphics G. Devilder).*

The globular bead (RS 94.608/154) shows a decoration of nodules of different colours: translucent dark blue, opaque white, opaque yellow and opaque bluish white. This type of bead with ocellated decoration is rarely attested in Ugarit and this specimen could be imported. We have only identified about ten specimens (out of the thousand glass beads listed), associated with different contexts: in addition to the specimen from the “Centre de la Ville”, five beads come from the “dépôt 213” of Minet el-Beida, which yielded numerous

43. Biron *et al.* 2012.

44. Kaczmarczyk 1986; 2007, note 12.

45. Shortland 2000; Nicholson and Shaw 2000.

46. Brill 1999, p. 57; Nikita and Henderson 2006, voir note 7.

47. Tite *et al.* 2008, see note 10.

items of vitreous adornment (glass, Egyptian blue, faience), two beads come from built tombs and one specimen was found in the Royal Palace.<sup>48</sup> This type of bead, which is very sophisticated, is attested in New Kingdom Egypt as well as in the Eastern Mediterranean and it should be noted that numerous specimens were found in the Uluburun wreck.<sup>49</sup>

The blue glass bird-shaped bird (RS 94.608/26), now incomplete, is unique to Ugarit.<sup>50</sup> The only identified parallels (6) come from one context: a chamber tomb from Mycenae (tomb 103).<sup>51</sup> This led us to propose an Aegean provenance for the Ugarit piece.<sup>52</sup> The question of the origin of the production is however complex because of the rarity of the occurrences and the specialists of the Aegean have proposed a Near Eastern provenance.<sup>53</sup> The analysis of the Ugarit bead provides new data.

Nickel, manganese and zinc are correlated with cobalt for Egyptian glass dating to the 18th Dynasty<sup>54</sup> but the two beads from Ugarit contain lower amounts in these elements than found in Egyptian glasses. The bird shaped bead from Ugarit is closer compositionally to some Mycenaean blue glasses than to Egyptian ones, with the low levels of zinc, manganese and nickel.<sup>55</sup> These results could point towards the hypothesis of a Mycenaean production, perhaps from imported Egyptian blue glass.

Although, to date, cobalt has only been identified in a small number of glass pieces recovered from Ugarit, the results of the analyses are very interesting: the import of raw material (for the Louvre glass block AO 30763/84 AO 926) produced in Egypt is likely, as well as the import of an exceptional blue glass bead in the shape of a bird (RS 94.608/26) which we interpret as Mycenaean production. It should be noted that Mycenaean glass beads are rare outside the Mycenaean world;<sup>56</sup> Ugarit also yielded two Mycenaean moulded glass beads (one in the shape of a rosette and the other showing an anthropomorphic figure), is one of the few Levantine sites where this type of *realia* is attested.<sup>57</sup>

#### A MORE IN-DEPTH STUDY OF THE BLUE-GREY MONOCHROME FAIENCE

A few years after the publication of A. Kaczmarczyk's first work (*supra*), the study of all the faience objects discovered at Ugarit allowed us to highlight the large number of blue-grey monochrome faience pieces. With more than 2200 pieces, the majority of which are small annular and crenellated discoidal beads, the Ugarit corpus is the most important outside Egypt.<sup>58</sup>

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48. Matořan 2000a.

49. Ingram 2014.

50. Matořan 2003, p. 153.

51. Xenaki-Sakellariou 1985, pl. II, 142, no.4936; Nightingale 2008, p. 71, fig. 4.2[1].

52. Matořan 2000b; 2003.

53. This is based on parallels identified at Nuzi. Bird-shaped beads are indeed reported by the excavator of the site (Starr 1939, p. 451, pl. 120, SS; Starr 1937, pl. 120: SS). The latter mentions green, white and amethyst coloured glass beads; no blue specimens are reported. In his 2009 study, with the exception of one such bead which is said to be glass, S. Kirk does not define the glass material precisely, stating: "composition". It should also be noted that the Nuzi beads are of a different type from the Ugarit bead and the Mycenaean specimens. Finally, studies of the Nuzi blue glasses do not attest to the use of cobalt (Shortland *et al.* 2018).

54. Biron and Pierrat-Bonnefois 2002, see note 15.

55. Nikita and Henderson 2006, note 7; Tite *et al.* 2008, note 10; Brill 1999, note 16; Shortland 2000, note 11; Biron and Pierrat-Bonnefois 2002, note 15.

56. Cf. Nightingale 2008; Ćinardali-Karaaslan 2012, p. 135; Eder 2015.

57. These two beads come from different contexts. Matořan 2000b; 2003, p. 152; Nightingale 2008, p. 86.

58. Matořan 2000a.



We observe that most of these faience objects present many parallels with the Egyptian material dated to the New Kingdom. The Near Eastern parallels are rare on the contrary and concern most often the sites of the southern Levant or Eastern Mediterranean.

The typological and stylistic study revealed three main categories of objects:

–pieces with typically Egyptian forms (among which beads and pendants in the form of a bunch of grapes (*fig. 2-4*), vase (*fig. 7*), figurine of a dog (*fig. 13*), scaraboid (*fig. 14*), finger ring decorated with the sign *ankh* (*fig. 15*), rectangular pendant (*fig. 16*);

–pieces of more widely seen forms known in Egypt, the Near East and Eastern Mediterranean (among which spacer-beads, *fig. 1* (top left), rosette beads, *fig. 17*, lantern-bead, annular beads);

–finally, pieces of which parallels outside of Ugarit are rare or even inexistent (“button-beads”, *fig. 22-23*).

In 2003, we wanted to develop a specific research programme on this category and selected twenty-five objects for analysis.<sup>59</sup> Ten years later, this first corpus was enriched by five pieces.<sup>60</sup> The selection was made on the basis of visual observations, gathering pieces whose blue-grey colour, more or less dark, seemed characteristic. On most of the broken or chipped objects, the colour observed for the body is more or less the same as that of the glaze; only a few pieces differ from each other in that they have a siliceous body that is white to the naked eye.

We used a non-invasive analytical protocol based on ion beam analysis (PIXE) to determine the elemental chemical composition.<sup>61</sup> These analyses were preceded by a campaign of observations with a magnifying glass and an optical microscope. We thus obtained important information for a first and necessary identification of these ancient materials, but it was necessary to add data on the microstructures or on the levels of alteration of the vitreous phases, to claim to characterize the material more intimately. Indeed, ion beam analyses, however precise they may be, only correspond to analyses of the surface of the object (to a depth of about 50 µm), the site of all the pollution linked to its use, burial or conservation in museums.

Up to now, we have carried out micro-sampling of millimetre scales with a scalpel on less than 10 pieces that were already broken; these micro-fragments, embedded in resin, then polished and observed with a scanning electron microscope, allow us to observe the microstructures and to analyse the chemical composition of the internal vitreous phases and glaze areas with an EDX probe, and to evaluate the degree of alteration. We thus obtain a critical view of the PIXE data collected.

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59. Bouquillon and MatoĀian 2007.

60. In addition, three beads studied in 2003 were again analysed.

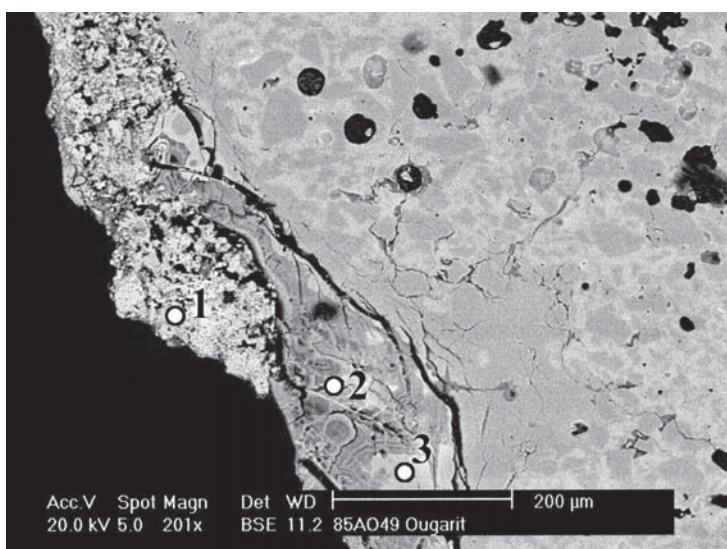
61. Experimental requirements have already been published in previous paper; 3MeV extracted proton beam, helium flux, area analyzed: 500 µm\*500 µm max, count rate: 200000 pulses, acquisition time: 200 seconds, simultaneous use of three detectors (Si-Li and HpGe)–Used softwares: GupixWin and Traupix. Calligaro *et al.* 2005.

### Weathering of buried vitreous materials

The weathering of ancient vitreous materials is complex. In the early stages, there are few structural changes, at most a slight opacification and an increase in surface hydration. Gradually, the hydrated layer develops on the surface and in areas of fragility (cracks, interfaces, unmelted grains, etc.), interdiffusion processes between the water in the environment and the elements making up the vitreous covering (glaze) lead to clear changes in the chemical composition: elements such as sodium and potassium are leached and  $H^+$  or  $H_3O^+$  ions enter the glass network, creating a zone on the surface that is very rich in hydrated silica, known as the “hydrated layer”. Some elements are less sensitive, notably certain colouring elements

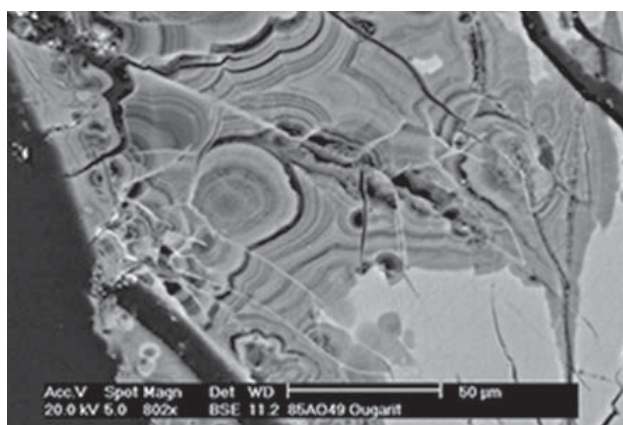
This hydrated layer becomes more complex and we observe in most old glazes around the remains of “preserved” glaze (3) a typical laminated structure (2) which creates the impression of iridescence, or even a metallic aspect characteristic of altered glasses. This is what we find here in most of the samples studied. This laminated zone can be thick and is largely made up of silica nanoparticles, but it can also trap certain elements. Finally, on the surface, more or less adherent crusts (1) may develop, most often consisting of carbonates, phosphates or sulphates, signs of the recombination of elements from the burial medium and the glass being altered.

The thickness of the weathered layer can reach several tens of microns. In this case, a comparison of the composition of a weathered and a preserved area of the same glaze shows that the melting elements (sodium and potassium) have almost completely disappeared in the weathered area but that the colouring elements have moved relatively little. This implies that we can use the PIXE data to study the colouring elements (Fe, Co, Ni, Zn, Cu, Pb...) but that the lighter elements (K, Ca, Na...) will not be representative of the original compositions. To have access to them, we have to use EDX measurements on the stratigraphic sections.



*Fig. 11—Example of an altered glaze showing areas of preserved glaze (3), the laminated area (2) and the surface encrustations (1) (C2RMF A. Bouquillon, computer graphics G. Devilder).*

*Fig. 12—Detail of the laminated area (C2RMF A. Bouquillon).*



## SYSTEMATIC PRESENCE OF COBALT WITH A FEW EXCEPTIONS

The majority of the pieces in the corpus have cobalt contents between 0.1 and 0.3% CoO, with a maximum of 0.5%. As cobalt has a very high colouring power,<sup>62</sup> these concentrations are more than sufficient to ensure a homogeneous and intense blue colouring.

However, the results of the PIXE analyses led us to discard the three cylinder seals (Louvre AO 18546, Louvre AO 18559 and Louvre AO 19417) and some tiny beads (Louvre 83 AO 537)<sup>63</sup> which are not coloured by cobalt. For the former, the colouring oxide is copper and further analysis by X-ray diffractometry reveals the presence of cuprorivaite, typical of Egyptian blue<sup>64</sup> (see below). For the small pearls, which have a very grey shade compared to typical blue-grey faience, it is probably the high concentrations of iron (more than 5% Fe<sub>2</sub>O<sub>3</sub>) that give the colour.

For the sake of clarity, we have decided to present the results by separating the objects with a “white” body, presented afterwards.

**Blue-grey monochrome faience**

This group is largely dominant in our corpus and gathers mostly pieces with typically Egyptian forms or for which the Egyptian parallels are the most numerous. Some types are illustrated by only one specimen, sometimes two, others by series.

The first analyses correspond to surface studies by PIXE with the AGLAE accelerator (*table 3*). If we focus our observations on the metallic elements, colouring or not, several observations are obvious.

*Table 3—Concentrations of colouring elements (or associated with the colouring element) in glazes.*

*PIXE data expressed in % of oxides—Values of oxide ratios.*

*In italics, aluminum and magnesium contents—\* pieces having been sampled.*

Louvre inv. number	<i>MgO</i>	<i>Al<sub>2</sub>O<sub>3</sub></i>	MnO	Fe <sub>2</sub> O <sub>3</sub>	CoO	NiO	CuO	ZnO	CoO/ NiO	CoO/ ZnO	CoO/ MnO	Al <sub>2</sub> O <sub>3</sub> / CoO
83 AO 148	<i>1,40</i>	<i>3,36</i>	0,24	0,43	0,26	0,21	0,01	0,69	1,24	0,38	1,11	12,9
83 AO 39* ( <i>fig. 15</i> )	<i>0,34</i>	<i>5,67</i>	0,07	0,35	0,09	0,06	1,12	0,10	1,64	0,90	1,38	62,9
83 AO 728 ( <i>fig. 14</i> )	<i>1,63</i>	<i>3,73</i>	0,19	0,97	0,16	0,11	0,94	0,35	1,48	0,44	0,84	24,0
84 AO 896A* ( <i>fig. 3</i> )	<i>0,43</i>	<i>2,00</i>	0,16	0,26	0,15	0,06	0,01	0,10	2,50	1,50	0,94	13,3
85 AO 149* ( <i>fig. 16</i> )	<i>0,91</i>	<i>3,96</i>	0,11	1,30	0,13	0,07	0,04	0,13	1,79	0,96	1,14	31,6
85 AO 553 ( <i>fig. 19</i> )	<i>0,35</i>	<i>1,69</i>	0,14	0,23	0,14	0,06	0,01	0,10	2,33	1,40	1,00	12,1
AO 14803 ( <i>fig. 12</i> )	<i>0,82</i>	<i>2,97</i>	0,31	0,57	0,22	0,10	0,09	0,19	2,20	1,16	0,72	13,5
AO 17419 ( <i>fig. 13</i> )	<i>0,62</i>	<i>5,46</i>	0,28	0,85	0,11	0,08	1,10	0,08	1,40	1,31	0,38	52,0
84 AO 617* ( <i>fig. 20</i> )	<i>0,66</i>	<i>2,86</i>	0,24	0,55	0,19	0,08	0,28	0,19	2,53	1,00	0,79	15,1
85 AO 596* ( <i>fig. 19</i> )	<i>1,49</i>	<i>4,18</i>	0,12	1,48	0,14	0,12	0,84	0,02	1,17	7,00	1,17	29,9
84 AO 901	<i>0,73</i>	<i>3,67</i>	0,31	0,99	0,58	0,27	0,24	0,58	2,15	1,01	1,87	6,3
81 AO 640 ( <i>fig. 17</i> )	<i>0,41</i>	<i>2,67</i>	0,77	0,40	0,20	0,06	0,58	0,02	3,55	9,75	0,25	13,7

62. Hamer and Hamer 1997, p. 64.

63. Objects discovered in 1952 from the Royal Palace of Ugarit.

64. Bouquillon, Matoian and Pagès-Camagna †, in press.



### The figurine of a dog in monochrome blue-grey faience RS 6.97

This small figurine representing a seated dog (Louvre AO 17419, *fig. 13*), very well preserved, is unique in Ugarit. Recent research has identified its place of discovery, in a building on the Acropolis located north of the “rue du dieu Alein”. However, the excavation of the building in 1934 was not published in detail by the excavators and we have no information on the context of its discovery.<sup>65</sup>

This object is very close, in form and technique, to Egyptian productions.<sup>66</sup> Parallels remain exceptional in the Levant.<sup>67</sup>



*Fig. 13—The figurine of a dog RS 6.97 in blue-grey faience (Louvre AO 17419), Ras Shamra (C2RMF—photography D. Bagault, computer graphics G. Devilder).*

### The scaraboid in monochrome blue-grey faience RS 6.177

The exploration of the Ras Shamra and Minet el-Beida sites has yielded an exceptional corpus of scarabs and scaraboids. More than one hundred and fifty pieces, mostly in stone but also in vitreous materials, have been recorded to date.<sup>68</sup> There are very few scarabs whose backs are not shaped like beetles but like other animals. The faience RS 6.177 (Louvre AO 30718, *fig. 14*) shows an animal lying down, rolled up on itself, perhaps a dog as proposed by the excavator or a cat.<sup>69</sup> The Egyptian Blue corpus also includes a scaraboid decorated on the back with a tilapia nilotica (RS 14.179).<sup>70</sup>

According to the excavation notes of 1934, RS 6.177 was found in a building located on the Acropolis, north of the “maison du Grand-prêtre”. This is certainly the house with one of the largest ashlar tombs in the city, as well as sophisticated fittings including a stone bath. The excavation of this house also uncovered an Egyptian stone statuette dating to the Middle Empire (RS 5.227).<sup>71</sup>

RS 6.177 (1.79 x 1.42 cm) is very well preserved. The base of the object is without decoration or inscription. Parallels can be found in Egypt.<sup>72</sup> A faience piece, published by G.A. Riesner in 1907, is very close to the specimen found in Ugarit.<sup>73</sup>



*Fig. 14—The scaraboid RS 6.177 in blue-grey faience (Louvre AO 30718, 83 AO 728), Ras Shamra (C2RMF—photography D. Bagault, computer graphics G. Devilder).*

65. Matoïan 2000a, cat. faïence 17369; 2015, p. 58-59, fig. 26.

66. Riesner 1907, pl. XXIII: 12406, green faïence, H. 2,2 cm.

67. Megiddo: Loud 1948, pl. 205, 4, level IX; McGovern 1985, p. 39, no.95, pl. 8. From Lachish comes a green stone pendant in the shape of a cat (?): James and McGovern 1993, pl. 58: 15.

68. Lagarce-Othman 2016.

69. Matoïan 2000a, cat. faïence 17568, tome IA, p. 140.

70. Matoïan 2000a, cat. bleu 230.

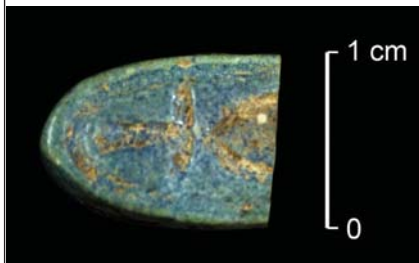
71. Matoïan 2018, p. 256-257.

72. On scaraboids whose shape refers to other animals than the beetle, see Andrews 1994, p. 53-54.

73. Riesner 1907, pl. XXIII: 12408, en faïence bleue verte, 1,5 cm. For further examples, voir Samson 1978, p. 86. On moulds, see Herrmann 1985, no.279-280.

### The ring in monochrome blue-grey faience Louvre 83 AO 39

The vast majority of the rings found at Ugarit are made of metal (bronze, gold, silver, iron). A few specimens are made of stone or bone/ivory. Two incomplete blue-grey monochrome faience rings have also been identified (*fig. 15*). Their bezels are



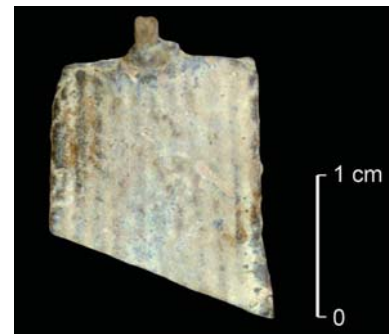
*Fig. 15—Ring with ankh sign decoration in blue-grey monochrome faience (Louvre 83 AO 39), Minet el-Beida (?) (C2RMF—photography D. Bagault, computer graphics G. Devilder).*

decorated with an Egyptian hieroglyphic sign, assimilating these ornaments to amulets: an *oudjat* eye, for the ring RS 84.106 discovered in 1984 in a house (house C) in the sector called “Centre de la Ville”,<sup>74</sup> and an *ankh* sign for the ring discovered in 1932 and today kept in the collections of the Louvre Museum (Louvre 83 AO 39). The provenance of the Louvre specimen is not certain:<sup>75</sup> the object could have come from one of the largest tombs (tomb VI) of the coastal site of Minet el-Beida, the main port of Ugarit. This tomb, looted in antiquity, yielded above all an abundance of luxury vessel, in ceramic, stone and faience, including several faience bowls with Nilotic or hieroglyphic decoration. The latter have been interpreted as Levantine productions inspired by Egyptian creations.<sup>76</sup> The ring Louvre 83 AO 89 is typically Egyptian. Tomb VI of Minet el-Beida contained, at the time of its excavation by C. Schaeffer, only rare elements of adornment including a gold ring (RS 4.090).<sup>77</sup> Among the alabaster vessel from this burial, some pieces certainly came from Egypt, such as the jar with handles in the shape of a gazelle head (RS 4.074, Louvre AO 15722).

Faience rings of this type were produced in large numbers in Egypt from the 18th Dynasty onwards (Deir el-Medineh, Amarna, Gourob, Quantir).<sup>78</sup> A few specimens are known from the Southern Levant, for example from Lachish and Beth Shan.<sup>79</sup>

### The rectangular pendant in monochrome blue-grey faience Louvre AO 30766

The pendant, now incomplete, takes the form of a thin rectangular piece, 2 mm thick, decorated on one side with longitudinal striations (*fig. 16*). The object was found during the excavation of the palatial area.<sup>80</sup> It is unique in Ugarit. Moulds for making rectangular small plates of the same type were found at Amarna.<sup>81</sup> A suspension ring could be added once the object was moulded. Levantine parallels are rare:<sup>82</sup> fifteen purple plates from the “Fosse Temple” of Lachish and two blue specimens found in Lebanon, at the site of Kamid el-Loz. The latter came from the temple and were found in the same room, which also yielded numerous earthenware objects, including other trapezoidal plates, pendants in the shape of bunches of grapes and beads with rosette decoration.<sup>83</sup>



*Fig. 16—Rectangular pendant in monochrome blue-grey faience (Louvre AO 30766/85 AO 149), Ras Shamra, palatial area (C2RMF—photography D. Bagault, computer graphics G. Devilder).*

74. Gachet 1996, p. 165-166, no.22.

75. Marchegay 1999, p. 764.

76. Caubet and Kaczmarczyk 1987.

77. Marchegay 1999, p. 763.

78. Petrie 1891, pl. XVII: 16; Peet, Woolley 1923, pl. XI: 3; Boyce 1989; Andrews 1990, p. 60; Herrmann 1985, no.1343-1346; Herrmann 2007, no.342.

79. Rings decorated with the Udjat eye: Tufnell *et al.* 1940, pl XXXIII B: 57; James and McGovern 1993, fig. 74: 1 (blue-green glaze). For other types of decor, see also Golani 2009, p. 618-619.

80. The context of discovery is not precisely known.

81. Petrie 1894, pl. XX: 558-559.

82. Lachish: Tufnell *et al.* 1940, pl. XXXVI: 97; McGovern 1985, no.217.

83. Hachman *et al.* 1980, p. 90, no.34 et 36, pl. 28: 11 et 13; Metzger and Barthel 1993, p. 107, pl. 55: 13-14. The material indicated for these pieces is a blue “frit”.

### Cobalt and associated metals

In the glazes of these twelve blue-grey body objects, the cobalt content varies between 0.1 and 0.6% CoO. Aluminum, the traditional marker of Egyptian cobalt alums, is quite high but fluctuates between 1.7 and 5.7% Al<sub>2</sub>O<sub>3</sub>.

Two pieces (fragment of a grape cluster pendant Louvre 83 AO 148, lantern-bead Louvre 84 AO 901) are characterised by higher levels of nickel and zinc. These two elements have no particular colouring powers but their presence, associated with cobalt, is perhaps indicative of a specific deposit. Two other beads (spacer bead Louvre 85 AO 596, rosette bead Louvre 81 AO 640) are totally devoid of Zn in their glaze.

The study of the other oxides, Fe, Mn, Cu and their relative contents leads to individualize several sets of objects:

–% CuO>1%: ring Louvre 83 AO 39, scaraboid Louvre 83 AO 728, dog figurine Louvre AO 17419 and spacer-bead Louvre 85 AO 596;

–% MnO>0.7%: rosette decorated bead Louvre 81 AO 640;

–% MnO<0.1%: ring Louvre 83 AO 39;

–% Fe<sub>2</sub>O<sub>3</sub>~1%: scaraboid Louvre 83 AO 728, lantern-bead Louvre 84 AO 901, spacer bead Louvre 85 AO 596, dog figurine Louvre AO 17419, plate-shaped pendant Louvre 85 AO 49.

These three elements are likely to modify the final colour of the glaze. Their concentrations may reveal a desire to broaden the palette of blues by deliberate mixtures: cobalt combined with copper to obtain a blue tending towards turquoise, with manganese to darken the blue hue and with iron for a similar but less marked effect (see discussion below).

#### Rosette beads in monochrome blue-grey faience

This type is well represented in Ugarit, where nearly two hundred specimens have been found. The beads have a flat face, the other being decorated in slight relief with a rosette. Their diameter varies from 0.9 to 1.4 cm for the largest specimens and their thickness from 0.2 to 0.4 cm. They are all covered with a blue-grey glaze, usually dark, with the exception of one brick-red bead.

The vast majority (157 beads) come from the Royal Palace, where four sets were found in different spaces (“cour I”, loci 62 and 68) (*fig. 17b*). A few specimens were also found in several large houses in the city (“Palais Sud”, “Maison aux albâtres”). The beads RS 10.119 (*fig. 17a*), which have been analysed, belong to a set of twenty-two pieces of the same shape, of the same dimensions (diameter of 0.9 cm) and all covered with a dark blue-grey glaze.<sup>84</sup> They were found in 1938 in the area known as “Ville Basse Est”. This area, which corresponds essentially to a sector of dwellings, has not been the subject of a detailed publication by the excavators, and the precise context of the discovery of the beads is therefore not known.

The most numerous parallels are to be found in New Kingdom Egypt. Hundreds of specimens (grey, yellow and dark red) were found at Gurob.<sup>85</sup> Clay moulds have also been found, for example at Amarna.<sup>86</sup>

The form is also attested, in faience of different colours, on sites in the Southern Levant<sup>87</sup> and Cyprus,<sup>88</sup> in the wreck of Uluburun,<sup>89</sup> and even in the Middle Euphrates region (Meskene-Emar, el-Qitar).<sup>90</sup> The corpus from Ugarit is by far the most important numerically.

We would also like to mention the discovery in Ugarit of a univalve stone mould (RS 3.459) with two dies on one side for the production of plano-convex pieces with rosette decoration (*fig. 18*). According to the inventories and excavation notes, the

84. Bouquillon *et al.* 2007, no.239.

85. Brunton and Engelbach 1927, pl. XLIII: 54.

86. Petrie 1894, pl. XVIII: 355. See also Hachman 1985, specially no.630-631, 682-709.

87. Cf. Tell Abu Hawam: Hamilton 1935, pl. XXV: 398. Beth Shan: James and McGovern 1993, fig. 63:11; Golani 2009, fig. 11.3: 62 (95), p. 631. Megiddo: Blockman and Sass 2013, fig. 15.11: 464, 466 et fig. 15.12: 490. Tel Yin'am: Liebowitz 2003, p. 356-357, fig. 16: 10-12.

88. Aström 1983, p. 68, fig. 269: N2023a (d).

89. Ingram 2005, p. 44-47; Ingram 2014. The author describes a buff coloured body for the 5 specimens identified in the wreck material.

90. Meskene: Bouquillon *et al.* 2007, n° 175. El-Qitar: McClellan 2019, p. 309, fig. 13.19: 290, 274 (material: frit, no colour indication).

object was found in 1931 in the Acropolis area.<sup>91</sup> For the most part, we only know the object, kept in the Museum of Latakia, through a photograph recently identified in the archives of the Schaeffer collection (Collège de France).<sup>92</sup> This document is not sufficient to draw conclusions on the possible uses of this mould, which could have been used to shape objects in precious metal, or perhaps to mould beads in vitreous material.

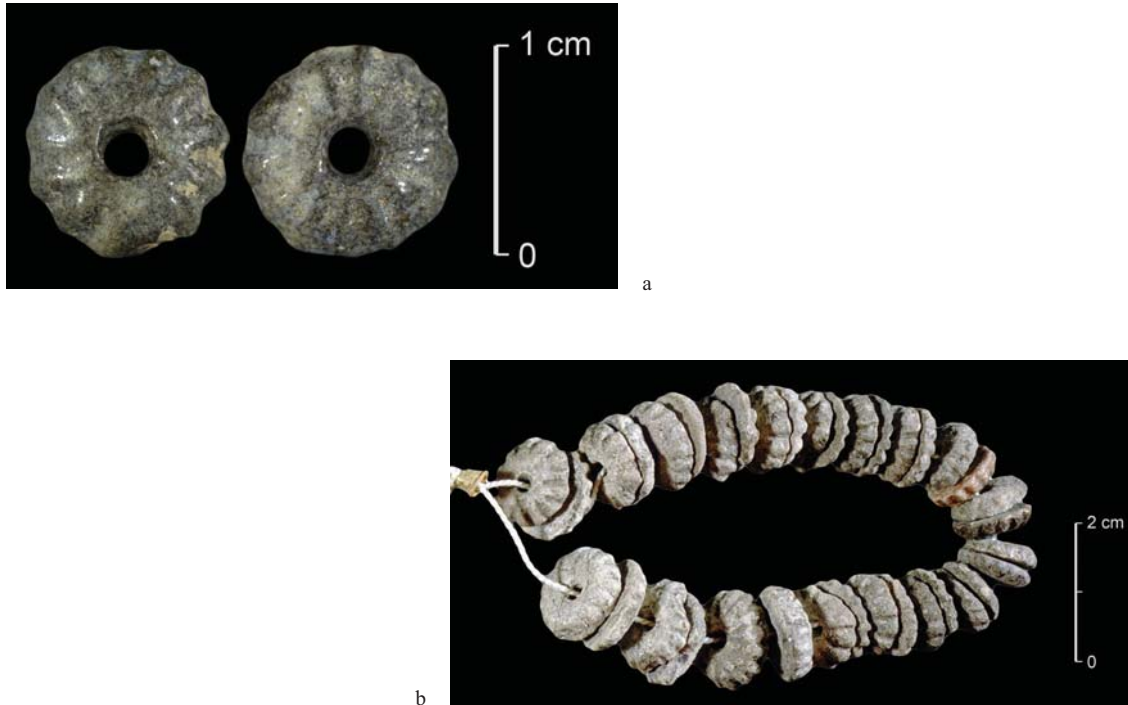
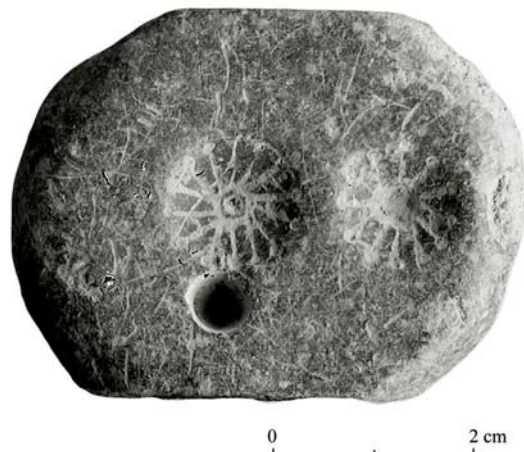


Fig. 17—*a*/Rosette beads RS 10.119 (Louvre AO 30639/81 AO 640), Ras Shamra, “Ville Basse est” (C2RMF).  
*b*/Rosette beads RS 15.106 (Damas 4065), Ras Shamra, Palais royal  
 (Ras Shamra Mission, photograph by V. Matoïan).

Fig. 18—Stone mould RS 3.459 (Latakia Museum)  
 Ras Shamra, “Acropole” (Ras Shamra Mission,  
 Schaeffer collection, Collège de France, computer  
 graphics V. Matoïan, G. Devilder).



91. Sector “B1, point 39”, depth: 1.30 or 1.40 m.

92. The object is mentioned by E. Dardaillon, who gives its dimensions (5.08 x 3.8 x 1.68 cm) and indicates that the stone (the inventory of finds indicates “green stone”) could be a pebble (Dardaillon 2006, cat. 153). The author’s description of the dies is as follows: « deux cercles y sont représentés avec des hachures rayonnantes ».



### Microstructures

In addition to the aspect related to the colouring, it was important to observe the microstructures of these faience pieces. The size and shape of the quartz grains, the proportions of the internal vitreous phase and its composition are all indications of the technique used by the craftsmen. As mentioned, this phase of the research involves micro-sampling, so that only six objects could be studied. Two different types of microstructures (I and II) could be identified:

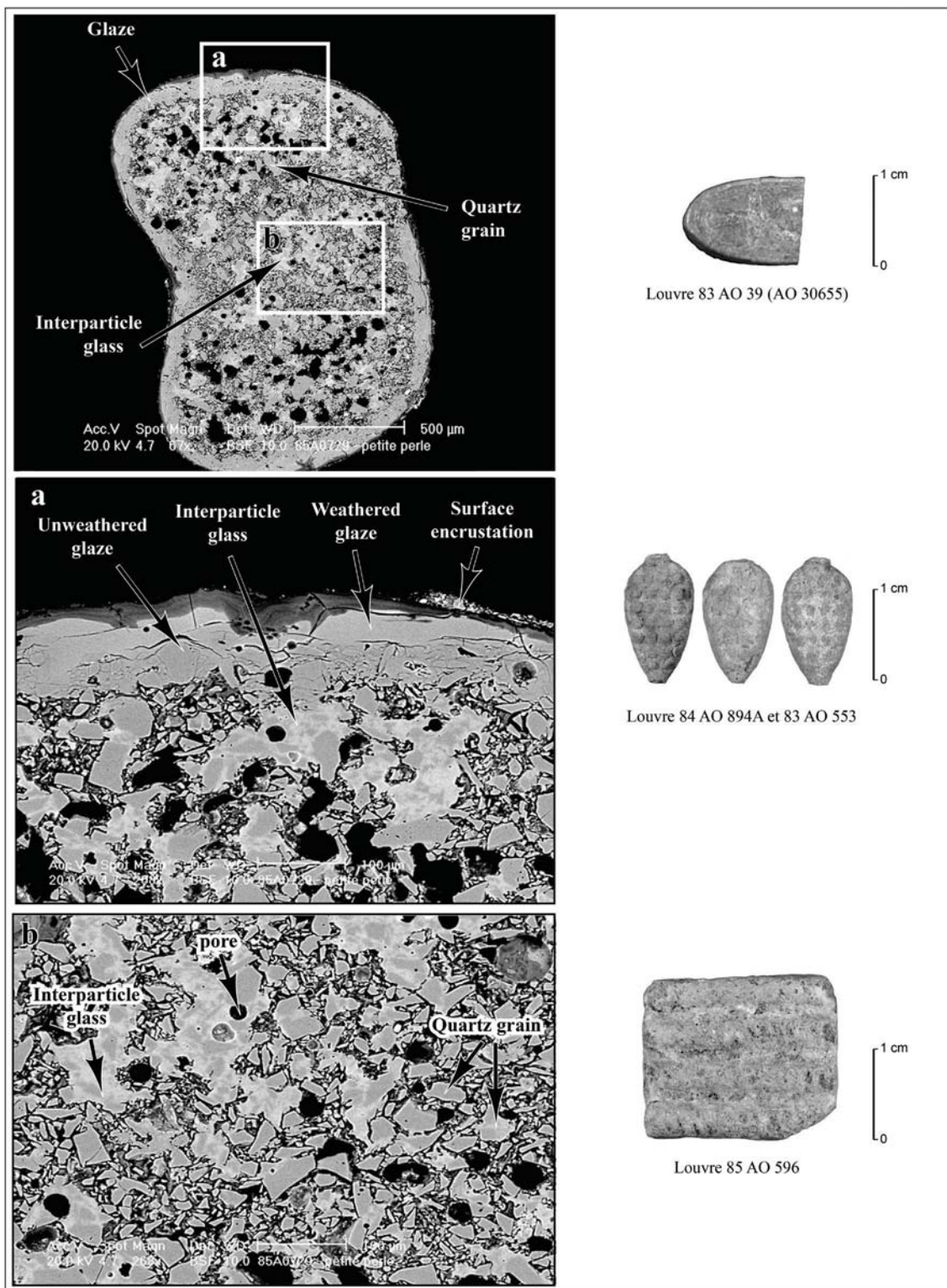


Fig. 19–Blue-grey monochrome earthenware from Ugarit showing a type I microstructure (© C2RMF–photos A. Bouquillon). On the right, ring Louvre 83 AO 39, grape-shaped beads Louvre 84 AO 894A and 83 AO 553, spacer-bead Louvre 85 AO 596 (© C2RMF–photos D. Bagault) (computer graphics G. Devilder).

–The first type (I) (*fig. 19*)–ring Louvre 83 AO 39, grape cluster bead Louvre 84 AO 896A, small annular bead Louvre 85 AO 729, spacer-bead Louvre 85 AO 596–is characterised by a body containing quartz grains of very heterogeneous granulometry surrounded by an internal vitreous phase that is globally well preserved. The porosity, in black on the microphotographs, is quite important. On the surface, there is a homogeneous zone with numerous cracks, most often parallel to the surface, which corresponds to the glaze. This glaze has a variable thickness, of the order of 50  $\mu\text{m}$ . It is well preserved but nevertheless shows signs of alteration marked by a dark grey layer on the surface, made up of hydrated silica. Finally, very sporadically, surface crusts corresponding to complex secondary deposits of gypsum, calcite and clays are still visible. These are the most frequent microstructures. The study of the composition by SEM-EDX of the internal glassy phases (*table 4*) reveals the initial recipe of the mixture that maintains the cohesive quartz grains. All are very rich in sodium, less potassium ( $3 < \text{Na}_2\text{O}/\text{K}_2\text{O} < 6$ ), which would imply the use of a sodium flux probably close to natron. Aluminum contents are high, always above 4%  $\text{Al}_2\text{O}_3$ . It should be noted that, apart from iron, the colouring oxides (cobalt, copper and iron) are fairly consistent and that the zinc contents, when they could be determined, are close to 1%  $\text{ZnO}$ .

*Table 4–Composition of internal vitreous phase zones–SEM-EDX analyses (C2RMF)  
(data expressed in % of oxides).*

Louvre inv. number	Na <sub>2</sub> O	MgO	Al <sub>2</sub> O <sub>3</sub>	SiO <sub>2</sub>	SO <sub>3</sub>	Cl	K <sub>2</sub> O	CaO	TiO <sub>2</sub>	MnO	Fe <sub>2</sub> O <sub>3</sub>	CoO	NiO	CuO	ZnO	Na <sub>2</sub> O/ K <sub>2</sub> O
85 AO 729	10,5	1,5	3,5	76,5	0,5	0,5	1,8	2,5	0,2	0,3	1,0	0,4	0,2	0,3	nd	5,8
83 AO 39	7,8	2,0	5,4	78,9	0,1	0,2	1,6	1,1	0,1	0,3	0,6	0,3	0,2	0,1	1,4	4,8
84 AO 896A	7,4	2,4	8,1	75,1	0,1	0,5	2,5	1,1	0,0	0,4	0,4	0,4	0,2	0,1	1,1	3,0
85 AO 596	7,8	1,6	6,2	76,2	0,4	0,2	2,9	1,1	0,2	0,2	1,0	0,5	0,4	0,1	0,9	2,7

–A second type of microstructure (II), much denser, characterises two objects: the fragment of a bunch of grapes Louvre 84 AO 617, the rectangular pendant Louvre 85 AO 149 (*fig. 20*). Here, the internal vitreous phase is very largely present, it encompasses all the quartz grains and the porosity is extremely reduced. It is thought that a frit may have been added to the original mixture as suggested by localised concentrations of micro-bubbles observed within the glassy phase. This type of faïence is referred to as “glassy faïences”. The internal glassy phases have quite different compositions from each other (*table 5*). In the first case (Louvre 84 AO 617), we find the same characteristics as for the pieces described above. On the other hand, the pendant Louvre 85 AO 149 is quite different: the vitreous phase is less sodic and much more potassic, which would tend to suggest the use of a different flux (vegetable ash?) and the aluminum concentrations reach 9%, which is very high for this type of internal vitreous zone. Calcium also varies. On the other hand, the colouring elements remain relatively close.

*Table 5–Composition of internal vitreous phase zones–SEM-EDX analyses (C2RMF)  
(data expressed in % of oxides).*

Louvre inv. number	Na <sub>2</sub> O	MgO	Al <sub>2</sub> O <sub>3</sub>	SiO <sub>2</sub>	SO <sub>3</sub>	Cl	K <sub>2</sub> O	CaO	MnO	Fe <sub>2</sub> O <sub>3</sub>	CoO	NiO	CuO	Na <sub>2</sub> O/K <sub>2</sub> O
84 AO 617	8,7	1,7	3,7	78,1	0,3	0,2	1,4	3,4	0,7	0,4	0,5	0,1	0,6	6,2
85 AO 149	4,2	2	8,8	74,6	0,7	0,2	4,4	0,5	0,7	1,4	0,5	0,2	0,3	1,0

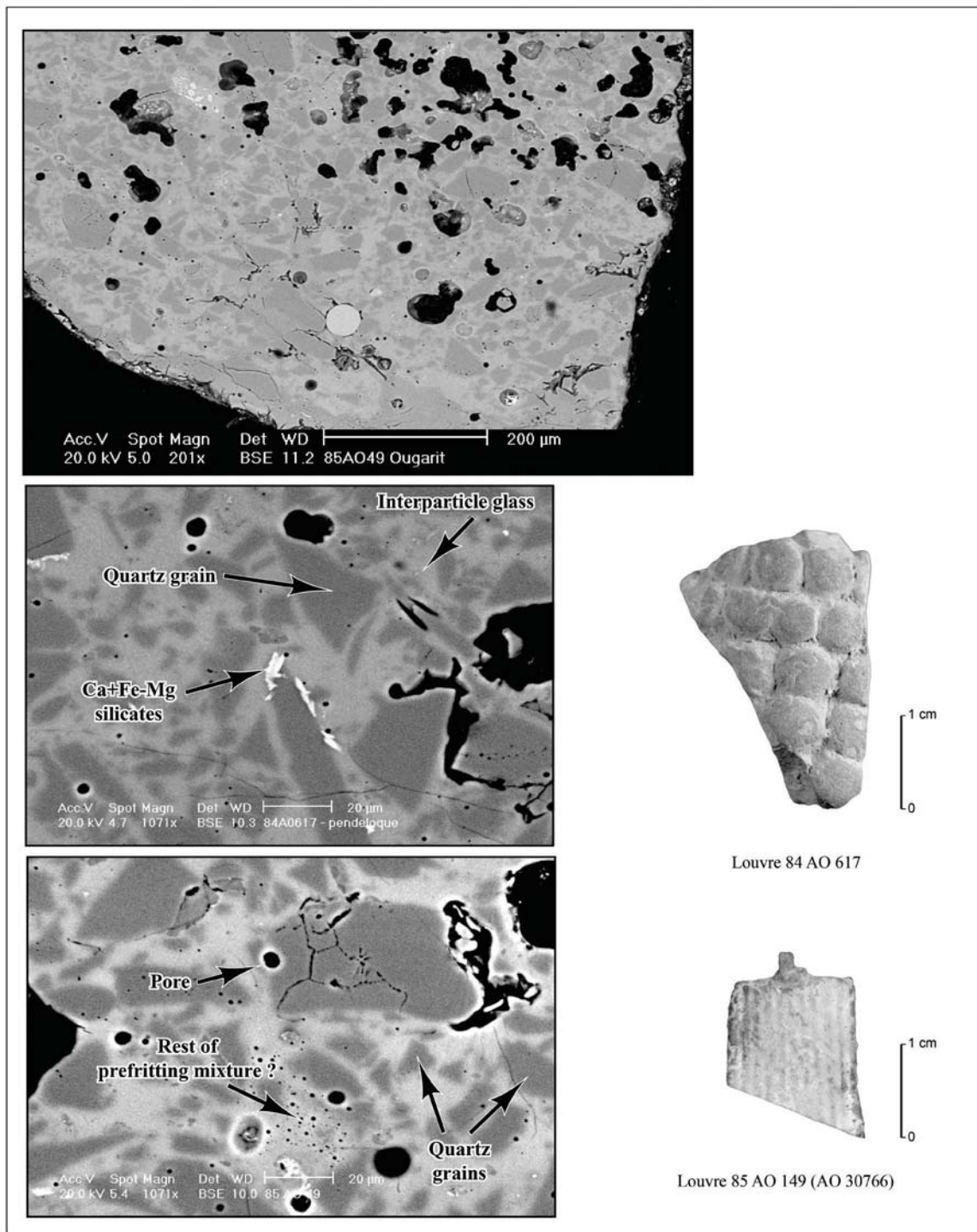


Fig. 20—Ugarit blue-grey monochrome faience with a type II microstructure  
 (© C2RMF—photos A. Bouquillon).

On the right, fragment of a pendant in the shape of a bunch of grapes Louvre 84 AO 617 and rectangular pendant Louvre 85 AO 149 (© C2RMF—photos D. Bagault) (computer graphics G. Devilder).

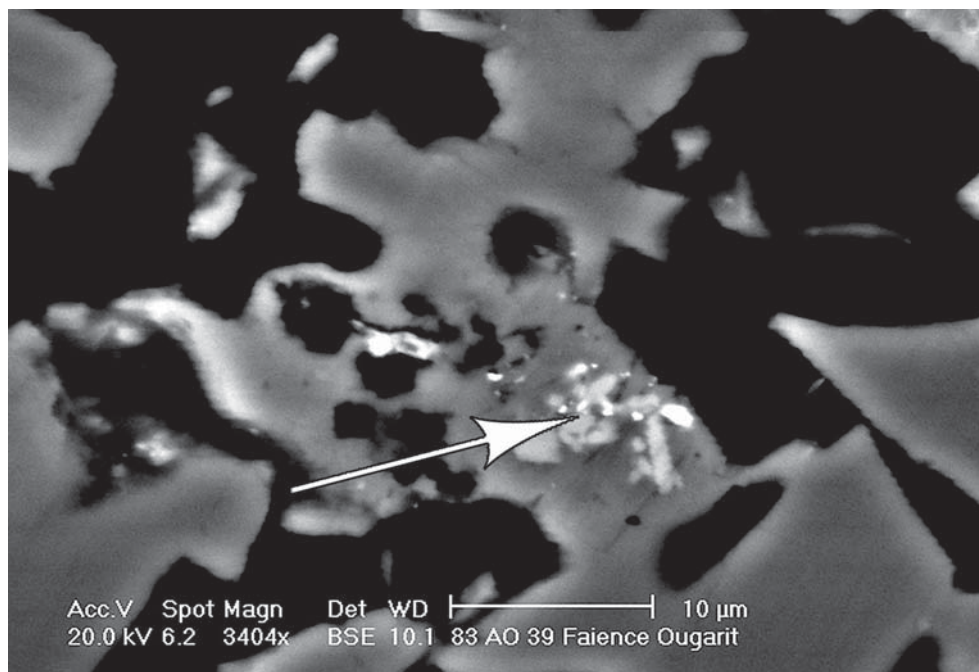
The comparison of these data with those in the bibliography allows us to propose the origins of the raw materials used:

The group of blue-grey monochrome faience (with blue-grey body) presents all the characteristics of the alums of the western deserts as described in the publications of A. Kaczmarczyk, A. Shortland and



Y. Abe to name but a few. It is a cobalt rich in aluminum and magnesium. Cobalt is associated with other metallic elements: iron, manganese, nickel, zinc. If we compare our data with those obtained directly from the alums, we can reasonably believe that this cobalt comes from the Dakhla ores (in the synthesis, Kharga is also indicated).

Moreover, we have found in one of the pieces (the Louvre ring 83 AO 39) a grain of unmelted pigment that allows us to confirm our hypothesis (*fig. 21*).



Ring Louvre 83 AO 39	Na <sub>2</sub> O	MgO	Al <sub>2</sub> O <sub>3</sub>	SiO <sub>2</sub>	SO <sub>3</sub>	Cl	K <sub>2</sub> O	CaO	TiO <sub>2</sub>	MnO	Fe <sub>2</sub> O <sub>3</sub>	CoO	NiO	CuO	ZnO
Colorant	5,05	1,88	24,69	57,86	1,21	0,49	1,69	1,35	0,66	0,18	0,43	1,15	0,76	0,28	2,02

*Fig. 21a/b—Unmelted cobalt pigment grain in a glassy phase of the ring Louvre 83 AO 39 and its analysis by SEM-EDX (C2RMF) (data expressed in % of oxides).*

Within this group, copper and manganese can vary significantly. Several authors have studied this variability, which is found in glassy material. Several hypotheses coexist:

–Either it is a question of voluntary additions of oxides in order to slightly vary the coloured shades, more purplish when the manganese content is more important, more greenish when it is copper that is important;

–Either copper and manganese are naturally present impurities in the mined ores and their variability would then reveal the exploitation of several cobalt-bearing levels of different mineralogies;

–Or it could be random pollution of the vitrifying mixture resulting from the diversity of production within the same workshop.

#### *Faiences with blue-grey glazes and “white” bodies*

These faiences belong to three types of “button-beads”: rosette-decorated button-beads (12), dome-shaped button-beads (5), and crenellated profile button-beads (2). Their diameter varies from 1.25 cm to 2 cm, with rosette-decorated bead-buttons having the largest dimensions (mostly between 1.7 and 2 cm).



Of the twelve specimens of rosette-decorated button-beads, eleven have a more or less well-preserved blue-grey glaze. For seven of them, the alteration of the glaze allows the body to be seen; for the others, it is entirely hidden by a very well preserved glaze. Four beads have a “white” body (Louvre 85 AO 545; Louvre AO 30722, AO 30723, AO 30724), the others have a blue-grey body (RS 13.23, RS 81.560, RS 81.598).

Button-beads with rosette decoration in faience are attested at a few sites in the southern and central Levant (Palestine, Jordan, Lebanon<sup>93</sup>), and as far as the Middle Euphrates at Emar.<sup>94</sup> However, the corpus of Ugarit appears to be the most important numerically. The origin of this type of earthenware is to be sought in Egypt, where several New Kingdom sites have indeed yielded numerous moulds for the production of a wide variety of decorative rosette-shaped faience pieces.<sup>95</sup> For the domed and crenellated profile types, however, no parallels have been found.



Fig. 22—“Button-beads” with rosette decoration Louvre 84 AO 473 and 84 AO 472 (C2RMF).

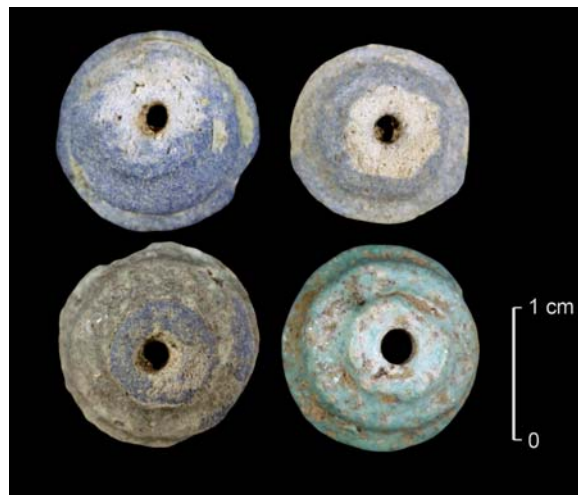


Fig. 23—Domed “button-beads”, top: Louvre 84 AO 478 and 84 AO 478, bottom Louvre 84 AO 476 and 85 AO 470 (C2RMF).

Contextual analysis provides a particularly significant finding: most of the white-bodied specimens identified so far come from the same context, tomb I [1003] from Minet el-Beida.<sup>96</sup> This tomb yielded three rosette-decorated button-beads (Louvre AO 30722, AO 30723, AO 30724), four domed button-beads (Louvre AO 30725, AO 30727, AO 30728, AO 30729) and one stepped profile button-bead (Louvre AO 30726).

Tomb I [1003] belongs to the category of large burials built of ashlar. Because of the looting in antiquity, archaeological excavations have brought to light only a few objects: a few ceramics, Cypriot and Mycenaean, imported from the West,<sup>97</sup> and, above all, a set of pieces, in steatite (8)<sup>98</sup> or in ivory/bone (16),<sup>99</sup> of shapes quite similar to the faience specimens, i.e. in the shape of “spindle whorls” or conical or domed

93. Megiddo: Blockman and Sass 2013, fig. 15.11: 452. Tell Abu Hawam: Hamilton 1935, pl. XXIV: 392. Kamid el-Loz: Hachmann *et al.* 1980, pl. 28: 28-29; Metzger and Bartel 1993, pl. 57: 14-17. Sahem: Fischer 1996, p. 69 et fig. 26: 9.

94. Louvre AO 27885.

95. Cf. Hermann 1985; Hermann 2007.

96. For the fourth piece, the context is not known.

97. Al-Maqdissi 2019.

98. Marchegay 1999, tome II, p. 735.

99. Gachet-Bizollon 2007, cat. 519 (5 buttons with rounded cap, diameters from 1.45 to 2.75 cm) and 573 (11 buttons with spread edge cap, diameters from 1.4 to 2.6 cm).

“buttons”, but without decoration. The hypothesis of a decorative use of these “buttons” (in earthenware, stone and ivory/bone) to decorate a garment, a headdress or a textile is, in our opinion, conceivable.<sup>100</sup>

The surface analyses by PIXE, focusing on the colouring elements, show much more homogeneous data than for the previous group (*table 6*). Figure 24 illustrates this observation perfectly. It also reveals other interesting elements: if the cobalt contents are close to those of the blue-grey monochrome faience objects with a coloured body (*supra*), we note in the faience with a “white” body, higher concentrations of nickel whereas zinc, aluminum, iron and copper fall.

*Table 6—Concentrations of colouring elements (or elements associated with the colouring agent) in glazes—PIXE data expressed as % oxides—Values of oxide ratios. In italics, aluminum and magnesium contents—\* pieces having been sampled.*

Louvre inv. number	MgO	Al <sub>2</sub> O <sub>3</sub>	MnO	Fe <sub>2</sub> O <sub>3</sub>	CoO	NiO	CuO	ZnO	Co/Ni	Co/Zn	Co/Mn	Al <sub>2</sub> O <sub>3</sub> /Co
85 AO 470	<i>0,14</i>	<i>1,03</i>	0,07	0,18	0,22	0,29	2,38	0,04	0,75	5,38	3,07	4,8
AO 30722 (84 AO 472)	<i>0,26</i>	<i>0,93</i>	0,04	0,29	0,15	0,18	0,53	0,03	0,85	5,98	3,56	6,1
	<i>0,14</i>	<i>1,19</i>	0,09	0,35	0,15	0,14	1,07	0,03	1,07	5	1,67	7,9
AO 30723 (84 AO 473)	<i>0,15</i>	<i>0,79</i>	0,03	0,25	0,13	0,16	0,04	0,02	0,85	7,84	4,05	5,8
	<i>0,16</i>	<i>0,93</i>	0,06	0,36	0,22	0,24	0,07	0,04	0,92	6,29	3,67	4,2
AO 30724 (84 AO 474)	<i>0,23</i>	<i>1,03</i>	0,08	0,35	0,18	0,2	0,06	0,02	0,87	8	2,27	5,9
84 AO 476*	<i>0,31</i>	<i>0,97</i>	0,09	0,45	0,26	0,27	0,45	0,04	0,95	6,5	2,89	3,7
84 AO 477	<i>0,23</i>	<i>1,03</i>	0,04	0,4	0,28	0,31	0,11	0,04	0,9	7	7	3,7
84 AO 478	<i>0,15</i>	<i>0,83</i>	0,05	0,23	0,17	0,19	0,15	0,02	0,89	8,25	3,67	5

Only two of the beads (rosette-decorated button-bead Louvre 85 AO 473, crenellated-profile button-bead Louvre 85 AO 476) were subjected to micro-sampling. These were more complicated to carry out because the beads have a saccharoid aspect which makes any sampling risky (the object risks being destroyed) and it is difficult to obtain a correct millimetric sized scale with a scalpel which does not fall into dust. The complete stratigraphy was only obtained on one of the beads, the other sample corresponding to the body without the glaze.

The microstructures allow us to understand immediately what we had suspected at the time of the sampling: they are characterised by a very important porosity (*fig. 25*), the internal vitreous phases are very reduced, they appear in fact in the form of very fine and clearer lines on the photographs of figure 25; the quartz grains of very heterogeneous granulometry, with very sharp angles are not very cohesive. On the surface, what should represent the glazed zone corresponds to more compact silica grains; cracks parallel to the surface explain the extreme fragility of this cover. Nevertheless, we were able to analyse the composition of the internal vitreous phases (*table 7*).

*Table 7—Composition of the internal glass phase zones—SEM-EDX analyses (C2RMF) Data expressed as % oxides.*

Louvre inv. number	Na <sub>2</sub> O	MgO	Al <sub>2</sub> O <sub>3</sub>	SiO <sub>2</sub>	SO <sub>3</sub>	Cl	K <sub>2</sub> O	CaO	TiO <sub>2</sub>	MnO	Fe <sub>2</sub> O <sub>3</sub>	CoO	NiO	ZnO	Na <sub>2</sub> O/K <sub>2</sub> O
84 AO 473	6,3	2,1	3,3	78,9	0,2	0,2	3,5	0,8	0,1	0,3	0,9	1,1	1,2	1,1	1,8
84 AO 476	6,2	2,1	3,7	78,1	0,2	0,1	3,4	1,1	0,04	0,3	1,3	1,4	1,3		1,8

100. In Egyptian statuary, rosette-shaped elements appear on headdresses and garments (cf. some New Kingdom statues of a goddess or queen: Aldred *et al.* 1979, p. 139, fig. 129; Bryan 2008, who suggests that these rosette-shaped elements were originally covered with gold).

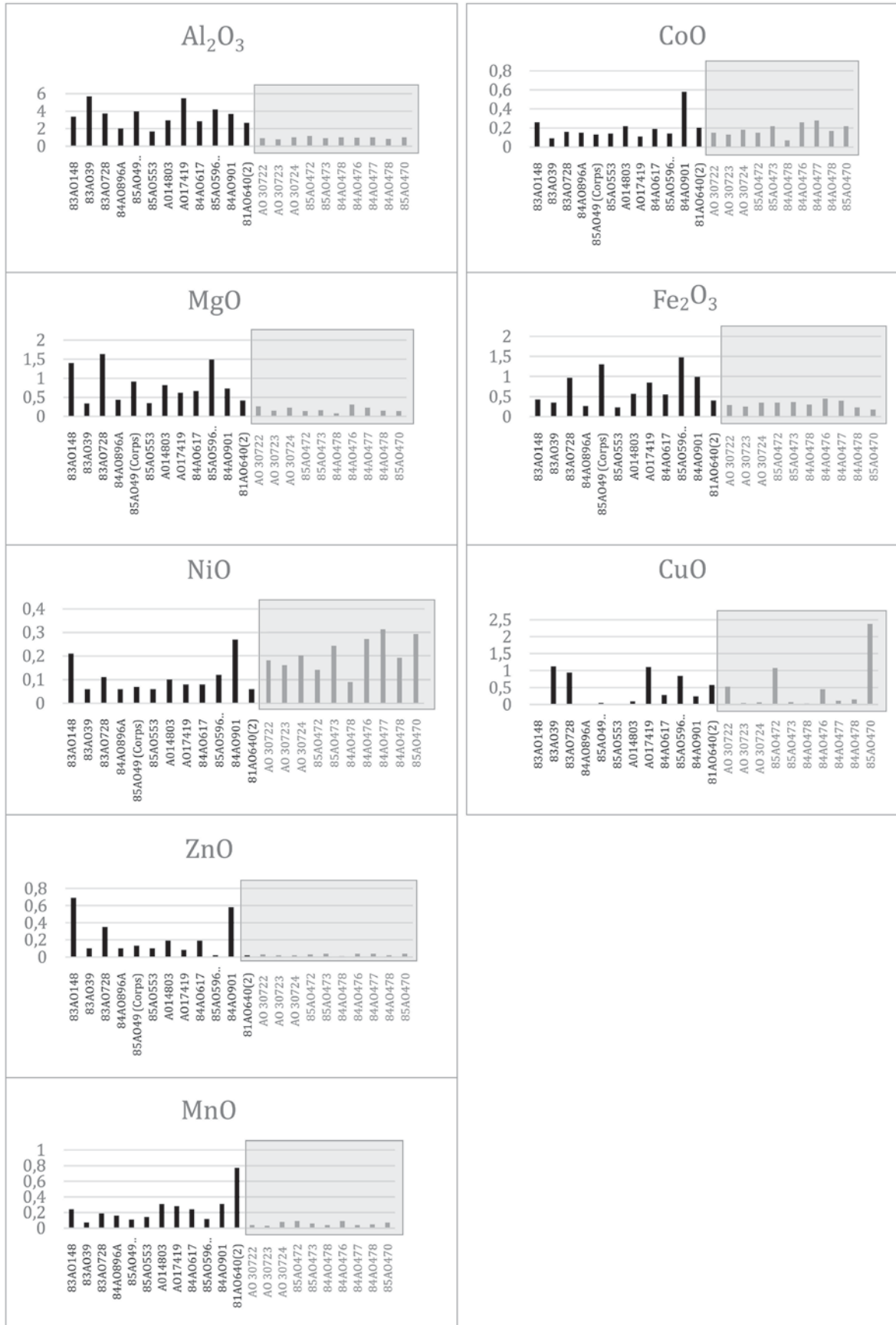
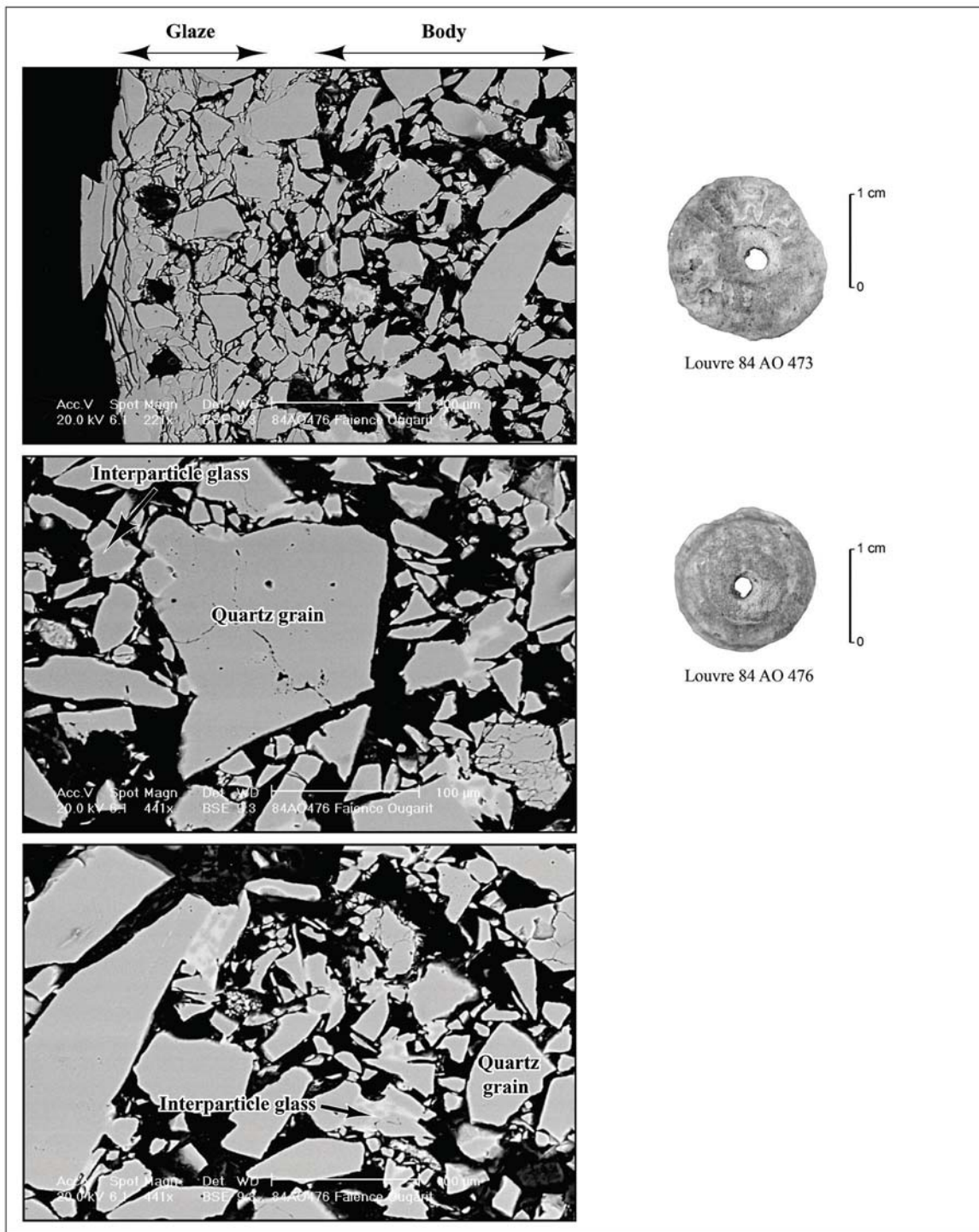


Fig. 24–Distribution of cobalt-related element concentrations (in the rectangle, the objects with a “white” body and blue glaze) (C2RMF, A. Bouquillon).



*Fig. 25—Microstructure of a white body bead. Top, cross-section showing the stratigraphy of the bead from the very weathered glaze on the left to the very porous body on the right. Middle and bottom, details of the white body, showing the angular and heterogeneous quartz grains (light grey), the remains of a poorly developed vitreous phase (white) and the high porosity of the material (black) (© C2RMF/photographs A. Bouquillon). On the right, beads Louvre 84 AO 473 and 84 AO 476 (© C2RMF—photographs D. Bagault)(computer graphics G. Devilder).*



The potassium ( $K_2O$ ) content is higher, the  $Na_2O/K_2O$  ratio is globally lower than what we had observed for the other faïences analysed (except for the Louvre 85 AO 49 pendant) suggesting a different, more potassic flux (vegetable ash?).

But we noticed the presence of high quantities of cobalt associated with nickel and, in one case at least, with zinc (note that this value, detected on a single analysis, should be confirmed by other measurements). This observation might seem unexpected for white materials. However, the quantities of internal glassy phases are so small that their colouring power compared to the largely dominant white silica grains is minimal, and on the other hand, the high porosity may also induce a higher light diffusion which intensifies the visual impression of a white body.<sup>101</sup>

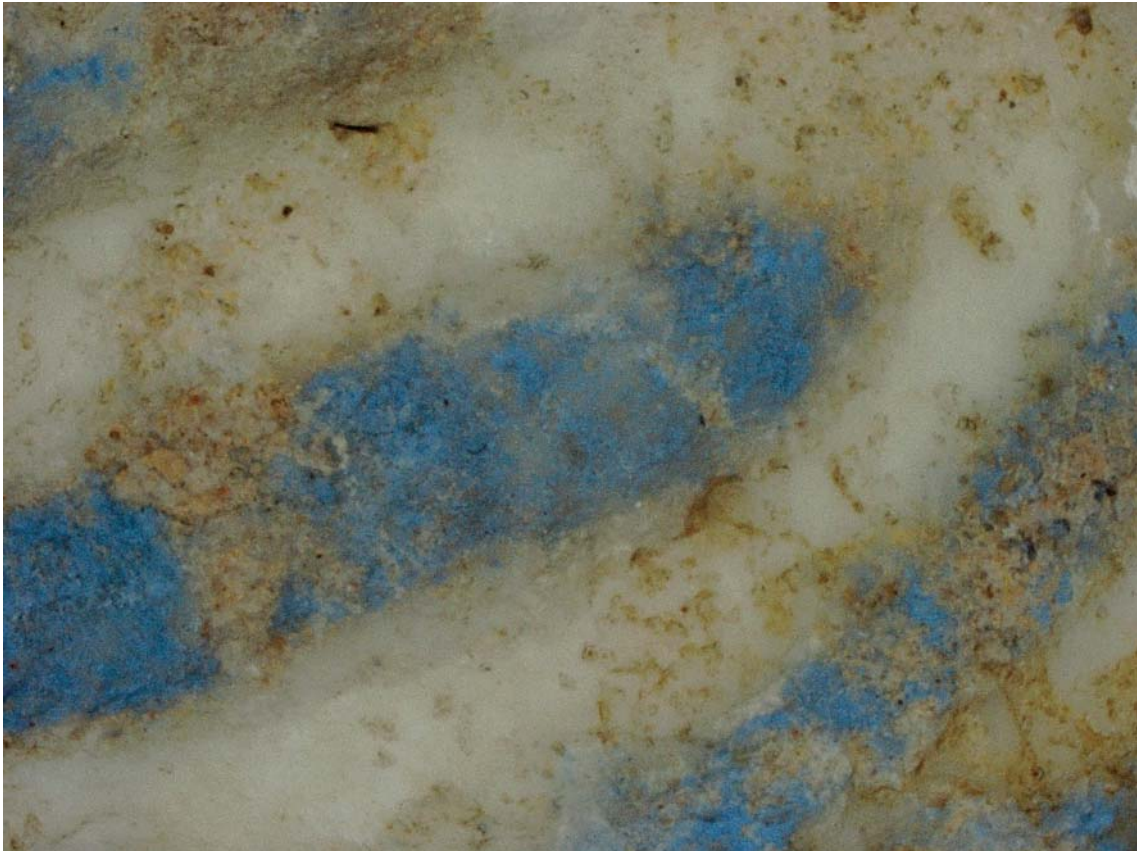
#### A NEW USE OF COBALT

During the study of two joined fragments of a Ras Shamra stone vase whose body shows blue inlays (*fig. 26-27*), another use of cobalt was revealed. The work is listed under the Louvre inventory number AO 27127. Neither the excavation inventory number nor the precise provenance of the object is known.



*Fig. 26—Fragment of a calcite alabaster vase from Ras Shamra, Louvre AO 27127 (H. 10.4 cm, L. 11.5 cm) (© Cliché C2RMF, A. Maigret, computer graphics G. Devilder).*

101. Bouquillon *et al.* 2015, p. 275.



*Fig. 27 – Detail of the blue inlay of vase AO 27127 (© C2RMF – S. Pagès-Camagna).*

The fragments belong to a jubilee vase bearing the name of Pharaoh Amenhotep III (c. 1392-1354 BC) of the 18th Egyptian dynasty. It is part of a limited series of Egyptian calcitic alabaster vases<sup>102</sup> inscribed with the names of several pharaohs of the New Kingdom of Egypt (Amenhotep III, Amenhotep IV-Akhenaten, Horemheb, Ramses II); found in Ugarit in the Royal Palace and in large residences of the city, these vases are interpreted as gifts from Pharaoh as a testimony of the good relations between Egypt and the kingdom of Ugarit.<sup>103</sup> Two other alabaster vases bearing the name of Amenhotep III have been identified in Ugarit: RS 17.58 (Damascus DO 4465) and RS 11.329 (Louvre 84 AO 548).<sup>104</sup> The first one was uncovered during the excavation of the Royal Palace, while the second one comes from the sector known as “Ville Basse ouest” (*fig. 28*).

The results presented in 2019 showed that, contrary to what several researchers had thought, the blue inlays were not made of Egyptian blue.<sup>105</sup> It is in fact a cobalt-rich pigment with aluminum, iron, zinc, iron, manganese and nickel (*table 8*).

102. Icart, Chanut and MatoĀian 2008, p. 184-185.

103. Lagarce 2008; Lagarce-Othman 2013; Grimal 2013.

104. Lagarce 2008. Seven scarabs bearing the name of this pharaoh were also found at Ras Shamra, including a large commemorative scarab bearing the names of the pharaoh and his wife, Queen Tiy (Lagarce-Othman 2017).

105. MatoĀian and Bouquillon 2019.



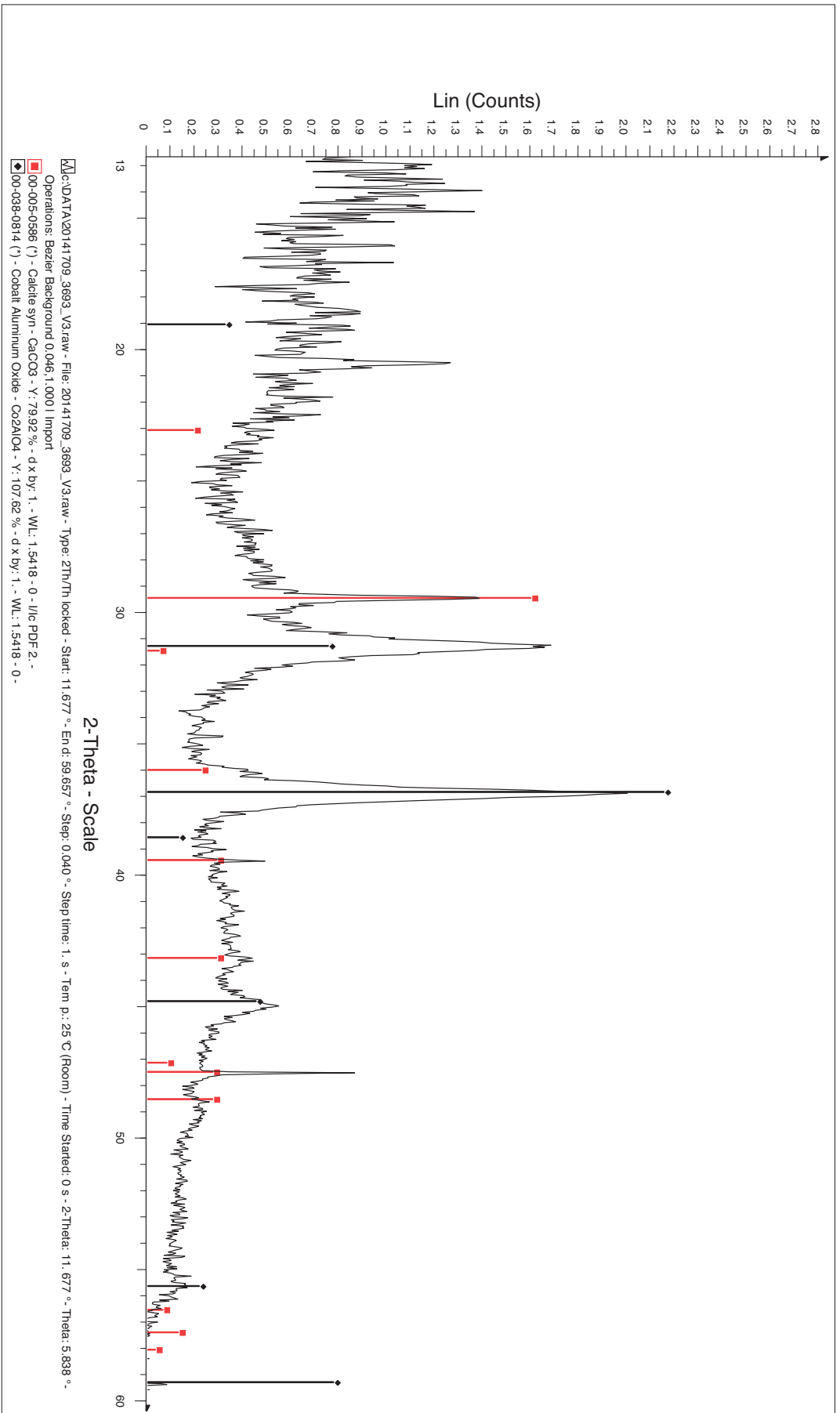


Fig. 29—Mineralogical characterisation of the inlay. On this diffractogram, the cobalt aluminate (in blue) and the calcite, (in red) which corresponds to the constituent material of the vase, appear (© C2RMF—M. Dubus).





*Fig. 30–Egyptian Painted Pottery, New Kingdom, exhibited in the Department of Egyptian Antiquities of the Louvre Museum (photo V. Matoian computer graphics G. Devilder).*

#### SYNTHESIS AND PROSPECTS FOR RESEARCH

Several analysis programmes carried out at the Centre de recherche et de restauration des musées de France have revealed the presence of cobalt in a large number of manufactured objects made of vitreous materials from Ugarit belonging to the Late Bronze Age, especially faïences and some glasses. This colouring element was also recognised in a block of raw material (glass). More unexpected was the recent identification of cobalt in blue inlays on an alabaster vase.

On the subject of the production of vitreous materials, information was obtained on the history of techniques in general, as well as on the crafts and exchanges of raw materials and manufactured goods in the Near East and the Eastern Mediterranean during the Late Bronze Age. The results shed significant light on the *ægyptiaca* at Ugarit, while also highlighting possible links with the Mycenaean world on the one hand and Kassite Mesopotamia on the other. This dossier allows us to question the circulation of craftsmen and technological transfers, questions that will be developed in the final publication.

##### *The origin of the colouring raw material*

All the analyses we have carried out allow us to address several questions, the most obvious of which is the origin of the colouring material, and hence the origin of the objects. On the basis of chemical analyses, we have shown that two “types” of cobalt seem to coexist in the corpus studied.<sup>106</sup>

The first type that we have recognised is characterised by the presence of aluminum, magnesium, manganese, nickel and zinc associated with cobalt. In the second type, aluminum, magnesium, manganese and zinc are much less abundant, and only nickel concentrations are higher. We have never identified arsenic in any of the blues studied.

The two triangular diagrams below (*fig. 31* and *32*) allow us to compare our data with those published on contemporary glass and faïence.

106. A third “type” (from Iran) having been highlighted by A. Kaczmarczyk in some Ugarit faïence: Caubet and Kaczmarczyk 1987.

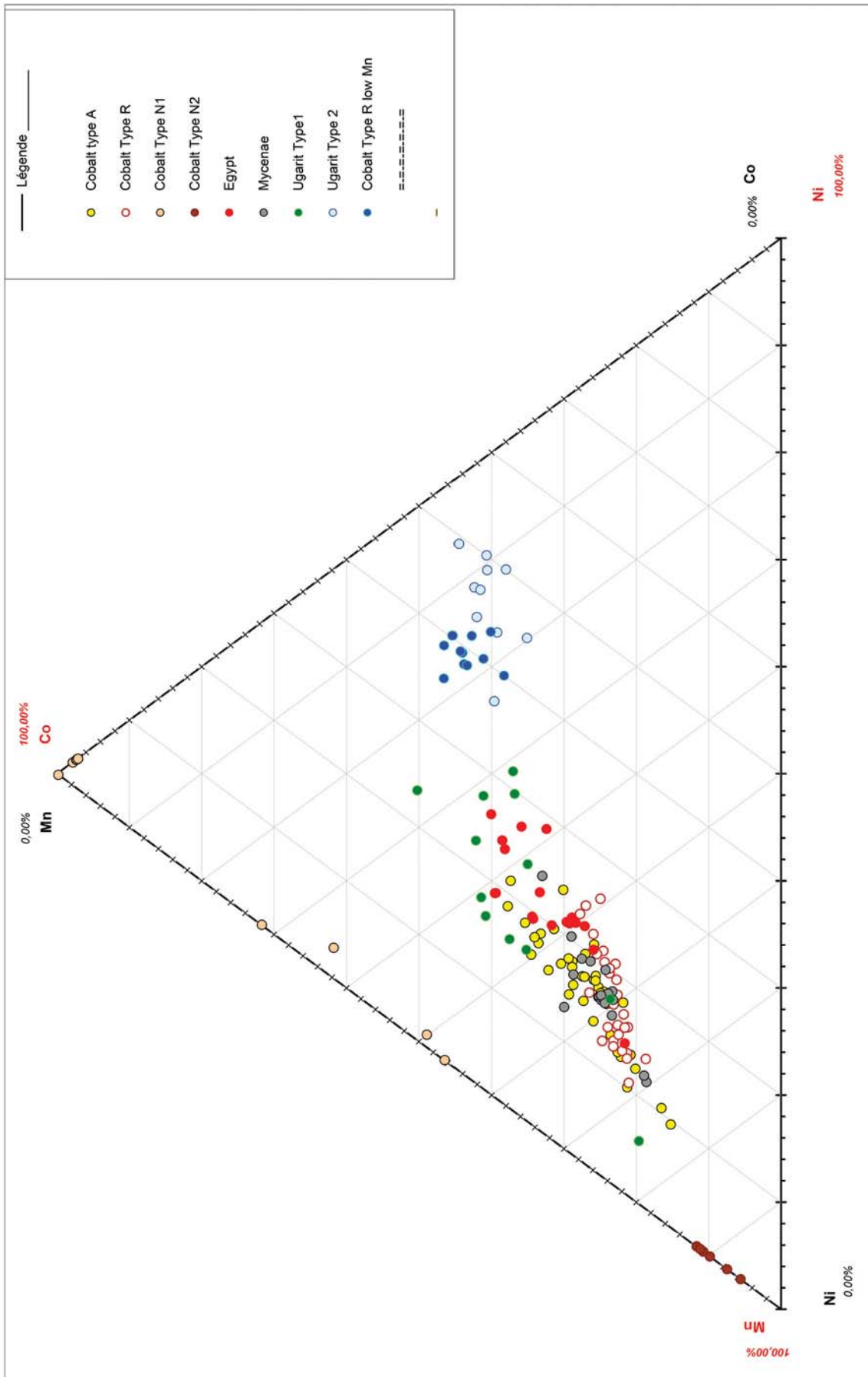


Fig. 31–Ternary diagram of the ratios Co–Ni–Mn in Ugarit blue–grey faïences (types 1 and 2) compared with data published in Abe et al. 2012 (cobalt types A, R, N1, N2, R low Mn), Smirniou and Rehren 2013 (Egypt, Mycenae).

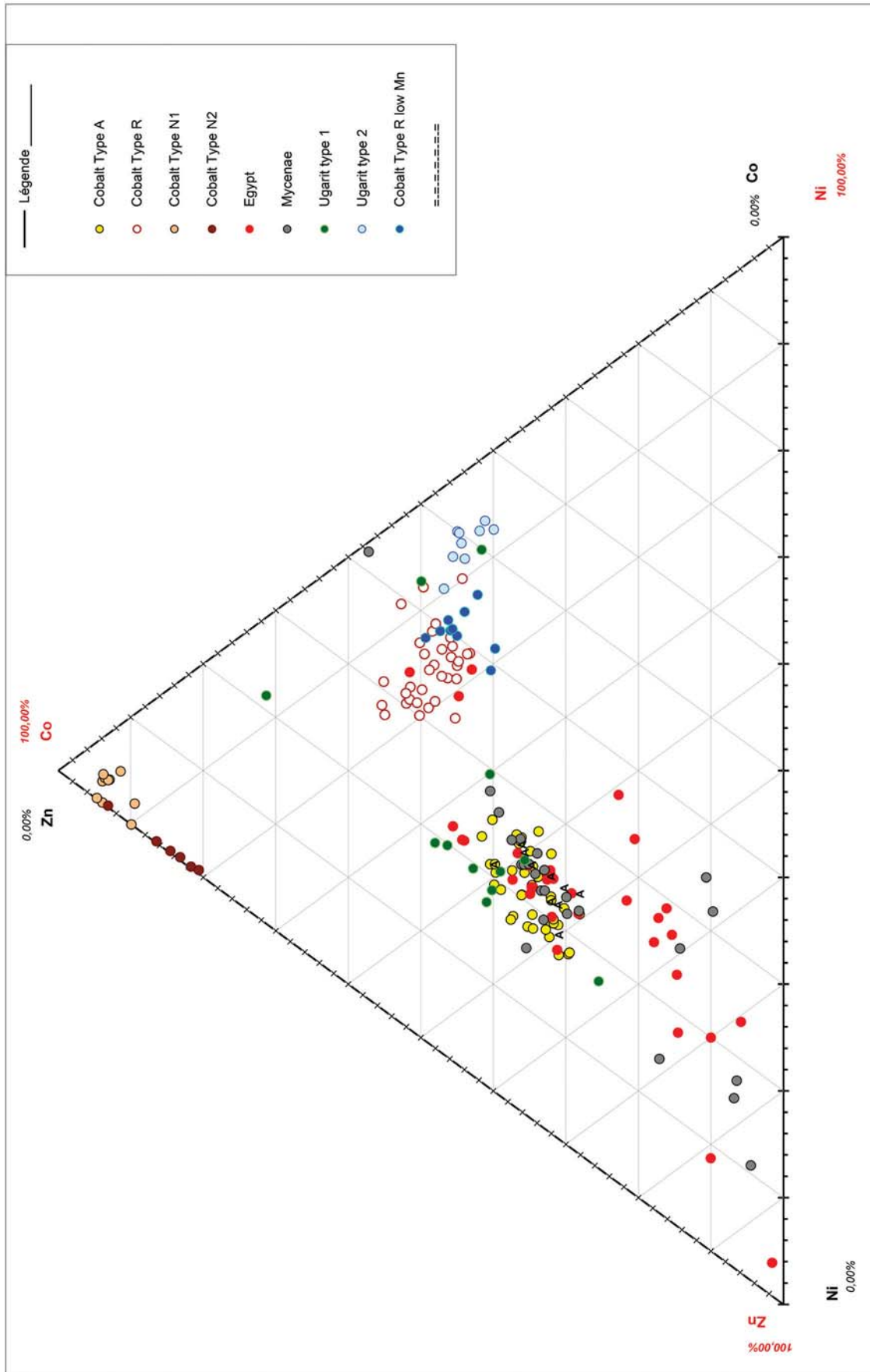


Fig. 32—Ternary diagram of the ratios Co-Ni-Zn in Ugarit blue-grey faïences (types 1 and 2) compared with data published in Abe et al. 2012 (cobalt types A, R, N1, N2, R low Mn), Smirniou and Rehren 2013 (Egypt, Mycenae).

In the vast majority of cases, the source of this cobalt is Egypt (alums from the Egyptian Western Desert oases, Kharga and Dakhla)–“Group A” of Y. Abe *et al.* 2012<sup>107</sup>–and most of the objects are considered as Egyptian imports, this interpretation being supported by the technique as well as by the typological (and iconographic) analysis for part of the corpus.

–The faience mostly illustrates a specific category, called “blue-grey monochrome faience”, which is characterised by a glaze and a body of the same colour. Typically Egyptian, this category is very well represented at Ugarit, where a varied typological repertoire is attested. Although most of the objects are small, with a majority of beads, the repertoire includes remarkable pieces such as a fragment of a vase, a small dog figurine, rings and a remarkable series of pendants in the shape of bunches of grapes.

The Ugaritic corpus is by far the most important outside Egypt. However, this observation is subject to qualification insofar as the description of the vitreous materials in the archaeological literature is, in most cases, not sufficiently detailed to allow precise identification.

The monochrome blue-grey faience of the Egyptian type (beads and pendants in the shape of a bunch of grapes, rectangular pendant, rings, scaraboid, figurine, vase) are among the objects that we can classify with certainty as *ægyptiaca*. These objects were found in different sectors and contexts (Royal Palace, dwellings, burials) of the city of Ugarit, as well as in Minet el-Beida, the palatial sector that yielded the greatest number.

It would also be relevant to increase the number of structural analyses and to study the types of blue-grey monochrome faience that have not yet been analysed, in particular the crenellated discoidal beads that correspond to the type best represented at Ugarit,<sup>108</sup> the inlays in the form of rectangular plates<sup>109</sup> or a fragment of a semi-hemispherical object with inlaid decoration of a unique type.<sup>110</sup>

–This cobalt was identified in three manufactured glass objects –a vase and two beads–as well as in a block of raw glass. Concerning the origin of the productions, we propose three interpretations: we consider the vase as an Egyptian import; the globular bead with ocellated decoration could also be classified as an Egyptian import or be interpreted as a local/regional production with blue glass imported from Egypt; the bird-shaped bead could be a Mycenaean import (made from blue glass imported from Egypt).

The evidence from Ugarit of raw material probably originating from Egypt adds to our knowledge of the Late Bronze Age glass trade in the eastern Mediterranean and, as noted, can be paralleled by the discovery of numerous ingots of blue cobalt-coloured glass in the Uluburun wreck.

As yet, only a few small blocks of raw glass have been discovered. Texts provide different information. Both Ugaritic *iqnû* and Akkadian *uqnû* denote the colour blue as well as lapis lazuli, and even artificial materials that look like lapis lazuli. However, the differentiation between natural and artificial material is not always explicit. We have already mentioned two letters in Akkadian (RS 17.422; RS 17.383), discovered in 1953 in the Palais royal d’Ugarit/Royal Palace of Ugarit/that are particularly interesting for our topic.<sup>111</sup> Addressed to the king of Ugarit by a high-ranking official in the Hittite court, called Taguḫli, they refer to the obligation that Ugarit had to supply Hatti with tribute in the form of lapis lazuli.<sup>112</sup>

107. Because of low alumina and iron concentrations in the blue glazes on white bodies from Ugarit, we decided not to include data from blue glasses from Nippur characterized by the typical assemblage Co+Al+Fe (Walton *et al.* 2012) in the ternary diagrams. The compositions are not comparable.

108. Damas: RS 17.170.

109. Damas: RS 16.412: Matoian 2008a, fig. 10.

110. Louvre O2 AO 233.

111. Matoian and Vita 2015.

112. On this topic, see also the letters RS 94.2523 and RS 94.2530: Lackenbacher and Malbran-Labat 2016.

One of these documents describes how the king of Ugarit sometimes attempted to evade this obligation by supplying a substitute for lapis lazuli.<sup>113</sup> The deception made the king of Carchemish extremely annoyed: the two materials have different values. The Akkadian word used to denote the substitute for lapis lazuli that was sent [NA4(*abna*) *ka-am-ma: nu-ut-ki*] is based on the root meaning “to pour, flow”. Jean Nougayrol proposed the translation “quelque pâte (de verre) ‘coulée’”<sup>114</sup> and S. Lackenbacher suggested “fritte”.<sup>115</sup> Recently, J.N. Ford has identified an Egyptian term meaning “cast (= poured) lapis lazuli” (in respect of Papyrus Harris I).<sup>116</sup> Accordingly, it is possible that the substitute in question is glass. However, it is clear that the scribe did not choose the term *meku*, generally translated as “glass”. A very interesting text (RS 17.144), discovered in the Palais royal, mentions the despatch of glass (*meku*) from Ugarit. This letter in Akkadian is by Zulanna, a member of the royal family of Carchemish, addressed to the prefect of Ugarit.<sup>117</sup> The same term is also used in the letters from El Amarna to denote a material, identified as glass, sent to the Pharaoh by the minor kings of the coast of Palestine and by the king of Tyre.

One letter (RS 94.2587) from the archive of the “maison d’Urtēnu”, published recently, deals with a request to the king of Ugarit mentioning a significant amount of glass: (l. 9-11) “Also, my lord, send me 30 ingots of glass or else 40 ingots –send me good ones– (l. 12-13) *no-one has indicated the amount*. (l. 14-16) Furthermore, *my lord*, I will have alum sent to you, to (you,) my lord; (l. 17-18) send me *shiny lapis lazuli*,<sup>118</sup> in large amounts: (l. 19-20) I need some for *a house...*”<sup>119</sup> Was Ugarit an intermediary in the trade of this raw material or does this letter provide indications that there was a primary workshop in that city?

Most unexpected was the identification, for a specific group of faïence, of a cobalt whose characteristics seem to correspond to those of the so-called “R low Mn” cobalt, highlighted by Japanese researchers<sup>120</sup> in faïence and glass of the Ramesside period: the colouring raw material is much less rich in aluminum and magnesium; the relative contents of manganese and zinc are much lower. The exact origin of this cobalt is to our knowledge not yet identified: Y. Abe *et al.* envisage either another area within the alums of the Egyptian desert oases or a source not yet identified. The exploitation of this source around the 19th Dynasty seems compatible with the dating of the context of discovery associated with the faïence found at Ugarit.

These objects—bead-buttons of different shapes—are characterised by a blue-grey glaze over a “white” siliceous body. The analyses also showed a different technique, indicating the use of different fluxes in the glaze recipe than those identified for the other vitreous materials in our corpus.

Finally, as mentioned above, the laboratory study showed the presence of cobalt of Iranian origin in two cases. This cobalt, according to A. Kaczmarczyk<sup>121</sup>, would have been identified by the absence of correlation with Al, Ni, Mn, Zn, and by the presence of arsenic in significant quantities. In the current state of our research, we have not yet detected any arsenic in the blue glazes of our corpus. It would now be advisable to deepen the analyses made by A. Kaczmarczyk in the 1980s and to search for chemical elements present in traces, likely to sign more precisely the origin of the raw material. This would be particularly

113. Lackenbacher 2002, p. 91-92.

114. Nougayrol 1956, p. 222, note 1. See also Sanmartin 1992.

115. Lackenbacher 2002, p. 91.

116. Ford 2008.

117. Lackenbacher 2002, pp. 196-198. This is an important text for several reasons, as it provides the equivalence *meku* = *ehlipakku*.

118. According to the editors of these texts, it is hardly likely that this is genuine lapis lazuli; more probably they are glass ingots with this colour or with decorations in this colour.

119. Translation by Wilfred Watson (Lackenbacher and Malbran-Labat 2016, n° 73 : « (l. 9-11) Aussi, mon seigneur, envoie-moi 30 lingots de verre, sinon 40 lingots – envoies(-en) moi de beaux – (l. 12-13) *il n’y a personne qui en ait indiqué le décompte*. (l. 14-16) Par ailleurs, *mon seigneur*, je te fais envoyer de l’alun, à (toi,) mon seigneur; (l. 17-18) envoie-moi du *lapis-lazuli brillant*, en quantité : (l. 19-20) j’(en) ai besoin pour *une maison...* »).

120. Abe *et al.* 2012.

121. Kaczmarczyk 1986, p. 374.



interesting for the faience bucket (Louvre AO 30646), whose origin is still disputed. This vase belongs to a category of small faience vessels that is illustrated in the Near East by a long series of objects found from Cyprus to Elam. Mesopotamia and the Middle Euphrates region provided the majority of specimens.<sup>122</sup> Ugarit provided the most important Levantine corpus (six buckets) and the question of the Mesopotamian provenance of these pieces arises. Concerning the vase in the Louvre Museum (Louvre AO 30646), we would like to compare its composition with those of Mesopotamian objects. Recent analyses of blue glasses from Nippur have indeed shown a coloration due to the use of a cobalt that clearly has a different origin from that of Egypt and copper.<sup>123</sup>

#### *The colour palette*

The illustrations in the article show the wide range of blues that can be obtained with cobalt, from an almost turquoise blue for the ring, for example, to a black blue for the glass block. These shades can be obtained with or without deliberate mixing of cobalt with other colouring oxides: copper, iron or manganese for example.

In monochrome blue-grey faience (with a blue-grey body), in which copper is present in large quantities (>0.84% CuO), there is no evidence to support the hypothesis of a deliberate mixture of two colouring agents: the same associations typical of Egyptian alums can be found (the aluminum content is always as high, and even higher in some glazes), there are no real markers of a specific addition of copper, which in these periods could be associated with tin or lead (the copper used to colour vitreous materials was often obtained from bronze residues). The results obtained are very similar to those presented by M. Smirniou and T. Rehren<sup>124</sup>. In the current state of our research, we agree with their conclusions and more particularly with one of their hypotheses linking copper-rich cobalts to a particular area of the Egyptian alum.

We must nevertheless mention that for two objects – the scaraboid RS 6.177 (Louvre AO 30718, 83 AO 728) and the dog figurine (Louvre AO 17419) – traces of tin (850 or 200 ppm SnO<sub>2</sub>) and lead (about 200 ppm PbO) are detected by PIXE. One must remain very cautious, as these lead and tin concentrations were only detected on the surface, locally in areas rich in calcium sulphates (which could correspond to encrustations linked to burial).

In two “white” body button beads (Louvre AO 30722 [84 AO 47]) or 85 AO 470), copper is also more abundant (about 1% CuO), but not associated with aluminum, nor with tin and lead.

On the other hand, as far as manganese is concerned, the relationship between the very dark colour observed and the high concentrations of MnO (0.77% MnO) on the rosette-decorated beads (Louvre 81 AO 640) could indicate that this element was added to the initial mixture to obtain a specific chromatic result. It should be noted that such concentrations of manganese are not found in the compositions of cobalt-coloured glasses published to date. Could this specific “recipe” be the result of local production? This hypothesis deserves to be posed in view of the discovery, at Ugarit, of the stone mould RS 3.459. In this perspective, the direct examination of this mould is envisaged in order to evaluate whether it could have served as a matrix for the manufacture of beads with rosette decoration.<sup>125</sup>

#### *Research issues*

There are many research challenges in the fields of the history of techniques, archaeology and the history of the Levant in the Bronze Age, and cultural interactions in the Eastern Mediterranean and the Near East.

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122. Clayden 1998.

123. The recognised assemblage is as follows: Co + Fe + Al (+ or - As) (Walton *et al.* 2012). It should be noted that excavations at this Mesopotamian site have also yielded faience buckets (Clayden 1998).

124. Smirniou and Rehren 2013.

125. It should be noted that this mould is very different from most of the jewellery moulds found at Ugarit, which belong to the category of bivalve moulds (consisting of two parallelepipedic valves) designed to receive molten metal.

The previous paragraphs have focused in particular on the question of the origin of materials and manufactured objects.

The evidence for the existence of workshops producing vitreous materials at Ugarit, although tenuous, exists: specific types of objects and ‘recipes’, a mould possibly used for shaping faience beads and the existence of small blocks of blue glass. Most of the latter have been found in a palatial context. It would be justified to devote a specific programme to these pieces, which would allow, among other things, to determine the number of blocks coloured with cobalt (and to distinguish them from those coloured with copper). The cobalt-coloured block we analysed certainly comes from a primary workshop in Egypt. Its use in a secondary workshop for the production of blue glass objects is possible. Could this workshop have taken place in the palace space? As a hypothesis, we have proposed that this raw material could have been used to make decorative elements or inlay pieces for the palatial furniture. Excavations have revealed several types (tongue-shaped, loop-shaped, or petal-shaped) in the Royal Palace. The glass is, for all these specimens, very altered. In the case of some fragmented pieces –baguettes and loop-shaped inlays– observation of their cross-section revealed glass of an intense blue colour at the heart. Laboratory analysis would allow us to validate or invalidate our hypothesis.

This raw glass could also have been used in the manufacture of other vitreous materials.

We should also mention other lines of enquiry that stem from our recent studies of other materials, notably Egyptian blue. Our analyses have recently allowed us to characterise more precisely a series of cylinder seals (Louvre AO 18546, AO 18559 and AO 19417), which we had initially classified in the category of monochrome blue-grey faience on the basis of an examination with the naked eye, their surface being in fact of a homogeneous blue-grey colour, with a satin-like aspect, sometimes even slightly shiny. Contrary to our assumption, no cobalt was detected, the colouring being due to the presence of cuprorivaite. We have not yet understood the nature of this surface colour and it is possible that we are dealing with a specific treatment of the material (glaze?). These objects could testify to a local production. Much remains to be analysed and studied in the techniques mastered and perhaps even invented or adapted by the craftsmen of Ugarit.

But the discoveries made at Ugarit are so rich that they are also likely to shed light on the know-how of other civilisations and to re-launch investigations into materials or technologies that have so far gone unnoticed: witness the fragments of the alabaster vase whose engraved decorations are underlined by a cobalt pigment (cobalt spinel) that until now was only known on the paintings of certain Egyptian ceramic vases dated to New Kingdom. This discovery should encourage us to look for other evidence of this pigment in Egyptian and Levantine collections, to analyse it and to better understand its technique, its evolution and possibly its transmission.

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