



pXRF study of pottery: State of the art and perspectives

Philippe Colomban, Gulsu Simsek

► To cite this version:

Philippe Colomban, Gulsu Simsek. pXRF study of pottery: State of the art and perspectives. TECH-NART 2019 – International Conference Non-destructive and microanalytical techniques in art and cultural heritage, May 2019, Bruges, Belgium. hal-03964390

HAL Id: hal-03964390

<https://hal.science/hal-03964390>

Submitted on 31 Jan 2023

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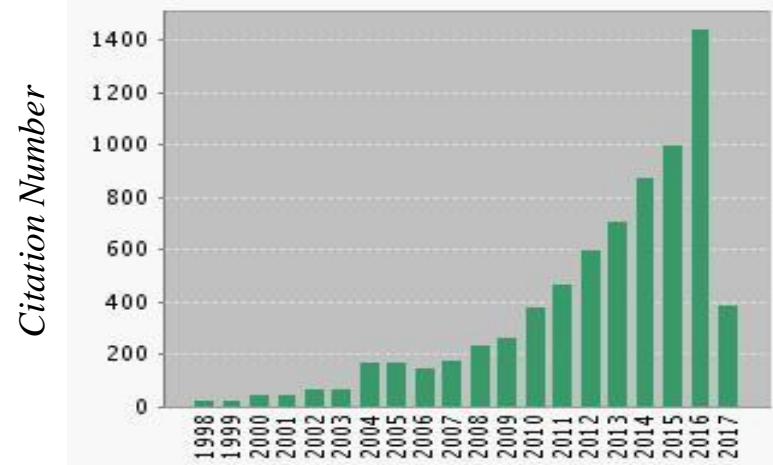
Portable XRF study of pottery: State of the art and Perspectives

¹KOÇ UNIVERSITY, KUYTAM
Rumelifeneri Yolu, 34450 Istanbul, Turkey
gusimsek@ku.edu.tr

G. SIMSEK¹ & PH. COLOMBAN²

²SORBONNE Université,
MONARIS UMR 8233
(FROM NANOMOLECULE TO NANO-OBJECT:
REACTIVITY, INTERACTIONS & SPECTROSCOPIES),
Formerly LADIR UMR 7075 & LM2N UMR 7070
4 Place Jussieu, philippe.colomban@upmc.fr
75005, Paris, France

Aim



Although portable/handheld X-ray Fluorescence instruments are available from decades, the number of publications reporting on-site analysis of pottery remains very limited. Most of them have been focused on the paste composition and not the (glazed) décor, which is the most advanced part from the technological and aesthetical point of view.

Procedures

Ceramic approach

- Elemental characteristics of Flux (K, Na, Pb, Ca: feldspar, marl), clays (Al) and Si content; characteristic traces (Bi, Zr, REE)
- Impurities tracing the process (purification) and origin (Fe, Ti, Zr, REE)
- Characteristics of trace and second phases related to rare ores

Algorithmic approach

- Biplots & Ternary diagrams of major, minor and traces elements
- Principal Component Analysis
- Dendrograms built with selected/non selected data

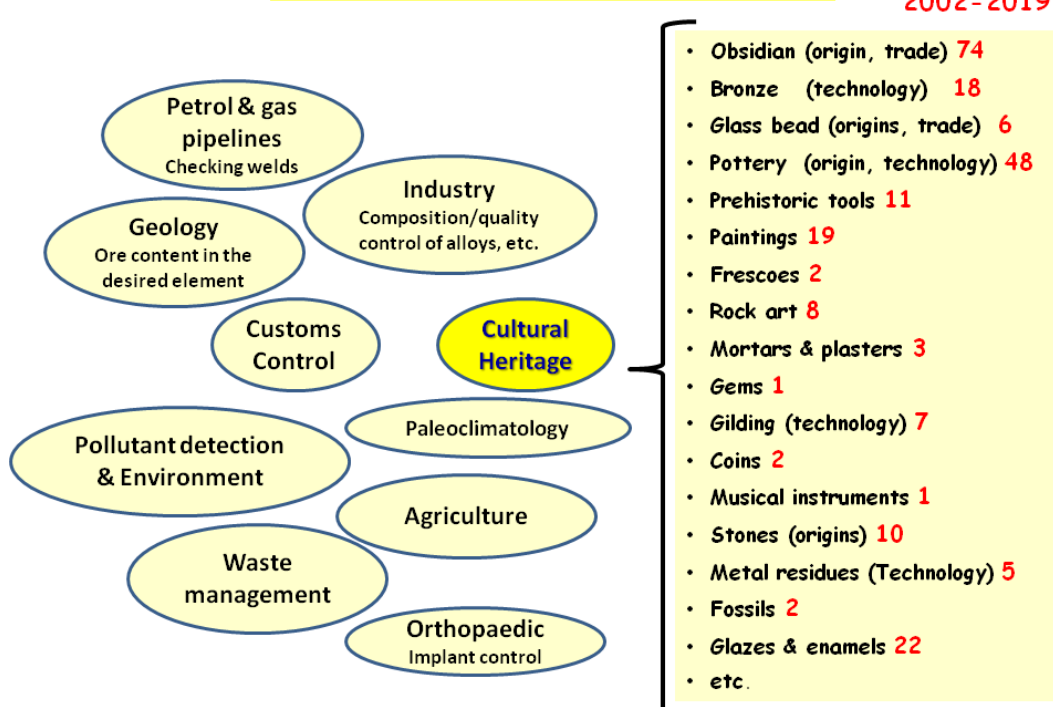
Advantages & Drawbacks

On-site analysis and selection of artefacts
Fast collection of data (a few minutes/spot) ⇔ higher number of objects, statistics ...
Many instruments available



Light elements and some traces not measured (B, C, O, N, Na)
Semi-quantitative (specific calibration)
Difficulty to determine the analyzed volume (variable depth)
Contact
Positioning and analyzed surface depend on object shape
Direct device emission: mainly directional
Secondary emission of the sample: all directions!
Depending on system / measuring conditions:
Different national legislation
Measurement configuration is important! (safety)

pXRF Application Areas



Examples of recent works: 2018-2019

| Research Material | First Author | Date | pXRF model | Complementary Instruments |
|----------------------|----------------------------|------|---|---------------------------------|
| Iznik Tile | Simsek, G. | 2019 | Hitachi X-Met8000 Expert | Not used |
| Soil | Ruano, S.M. | 2019 | Thermo Niton XL3T 792 | ICP-MS |
| Alluvium & Rock | Groover, K.D. | 2019 | ED-XRF DP-4000 Delta | WD-XRF |
| Soil | Kim, H.R. | 2019 | Olympus Innov-X | ICP-AES |
| Mine | Rincheval, M. | 2019 | Olympus Innov-X | WD-XRF |
| Nutrition | Fischer, S. | 2019 | Bruker Tracer Si | Organic analyzer, ICP-OES |
| Wall Paint | Ericson, B. | 2019 | Niton XL3T & Olympus Delta Classic Plus | AAS |
| Plant | Sapkota, Y. | 2019 | Bruker Tracer III-SD | ICP-MS |
| Soil | Chakraborty, S. | 2019 | Olympus DP 6000 | Not used |
| Soil | Rawal, A. | 2019 | Vanta | Not used |
| Obsidian | Ladefoged, T. N. | 2019 | Not documented | Not used |
| Mine | Simpson, M. P. | 2019 | Not documented | XRD, SEM |
| Soil | Ericson, B. | 2019 | Olympus Innov-X | Not used |
| Chinese Porcelain | Xu, W. P. | 2019 | Thermo Niton XL3T GOLDD+ | Not used |
| Teeth | Hammond, A. S. | 2019 | Bruker Tracer III | Not used |
| Sculpture | Fort, R. | 2019 | Thermo Niton XL3T GOLDD+ | Not used |
| Drill core (Mining) | Padilla, J.T. | 2019 | Olympus DP 4000 Delta | Not used |
| Mine | Duee, C. | 2019 | Thermo Niton XL3T 980 GOLDD | piR, XRD, Raman |
| Mine | Hollis, S. P. | 2019 | Olympus Innov-X | Not used |
| Mudbrick | Lorenzon, M. | 2019 | Olympus Innov-X | SEM-EDS |
| Fresco Paint | Khranchenikova, R. | 2019 | Bruker Tracer SI-Turbo | Not used |
| Soil | Rogan, G. | 2019 | Bruker Tracer III-SD | ICP-OES |
| Metal Brooch | Roxburgh, M. A. | 2019 | Thermo Niton XL3T GOLDD | Not used |
| Sediment | Rashid, H. | 2019 | Not documented | Isotope ratio mass spectrometer |
| Ceramics | Shahvi, G. | 2019 | Bruker Tracer III-V | EPMA, ICP-MS |
| Granite | Steiner, B. M. | 2019 | Olympus DP 6000 | ICP-MS |
| Sediment | Hines, B. R. | 2019 | Olympus Innov-X Delta | ICP-MS, fusion XRF |
| Soil | Xu, D. | 2019 | Thermo Niton | LIBS, vis-NIR, mid-IR |
| Soil | Ouyouou, J.N. | 2019 | Thermo Niton XL3T GOLDD+ | ICP-OES |
| Soil | Gutiérrez-Rodríguez, M. | 2019 | Thermo Niton XL3T 792 | SEM |
| Coin | Ortega-San-Martin, L. | 2019 | Bruker Tracer III-SD | AAS |
| Mine | Turner, O. | 2019 | Olympus Delta X | ICP-AES/MS |
| Lithology | Yarbrough, L. D. | 2019 | Bruker Tracer IV-SD | Not used |
| Pigments in ceramics | Obregon, C. L. | 2018 | Olympus DP 6000-CC | Not used |
| Polluted water | Zhou, S. | 2018 | Thermo Niton XL3T 950 | Lab. Type XRF |
| Soil | Caporale, A. G. | 2018 | Olympus Delta X | ICP-MS |
| Soil | Harvey, P. J. | 2018 | Olympus Innov-X | Not used |
| Carbonates | Sinnesael, M. | 2018 | Bruker Tracer IV | μ-XRF |
| Sediment | Kinney, M. | 2018 | Thermo Niton XL3T 792 | ICP-OES |
| Obsidian | Abadi, A. | 2018 | Thermo Niton XL3T 950-HE GOLDD+ | Not used |
| Obsidian | Frahm, E. | 2018 | Olympus Vanta M | Bench-top EDXRF, NAA |
| Ceramic | Nizolek, L. C. | 2018 | Olympus Innov-X Alpha | Not used |
| Mine | Cao, Y. H. | 2018 | Thermo Niton XL3T GOLDD+ | Bench-top SEM |
| Pottery | Scott, R. B. | 2018 | Bruker Tracer III SD | Lab type XRF, ICP-OES |
| Soil | Godinho, S. | 2018 | Bruker S1 Titan 600 LE | XRD |
| Mineral (quartz) | Dos Santos Teixeira, A. F. | 2018 | Bruker S1 Titan LE | Not used |
| Mineral | Desroches, D. | 2018 | Thermo Niton XL3T GOLDD+ | Lab type XRF |
| Mortar & Plaster | Tenconi, M. | 2018 | Thermo Niton XL3T GOLDD+ | SEM-EDS |
| Petroglyph | Macholdt, D. S. | 2018 | Thermo Niton XL3 | Not used |
| Soil | Harvey, P. J. | 2018 | Olympus Delta Premium | Not used |

Conclusions

Ethical rules of cultural heritage studies now limit destructive analyses as much as possible.

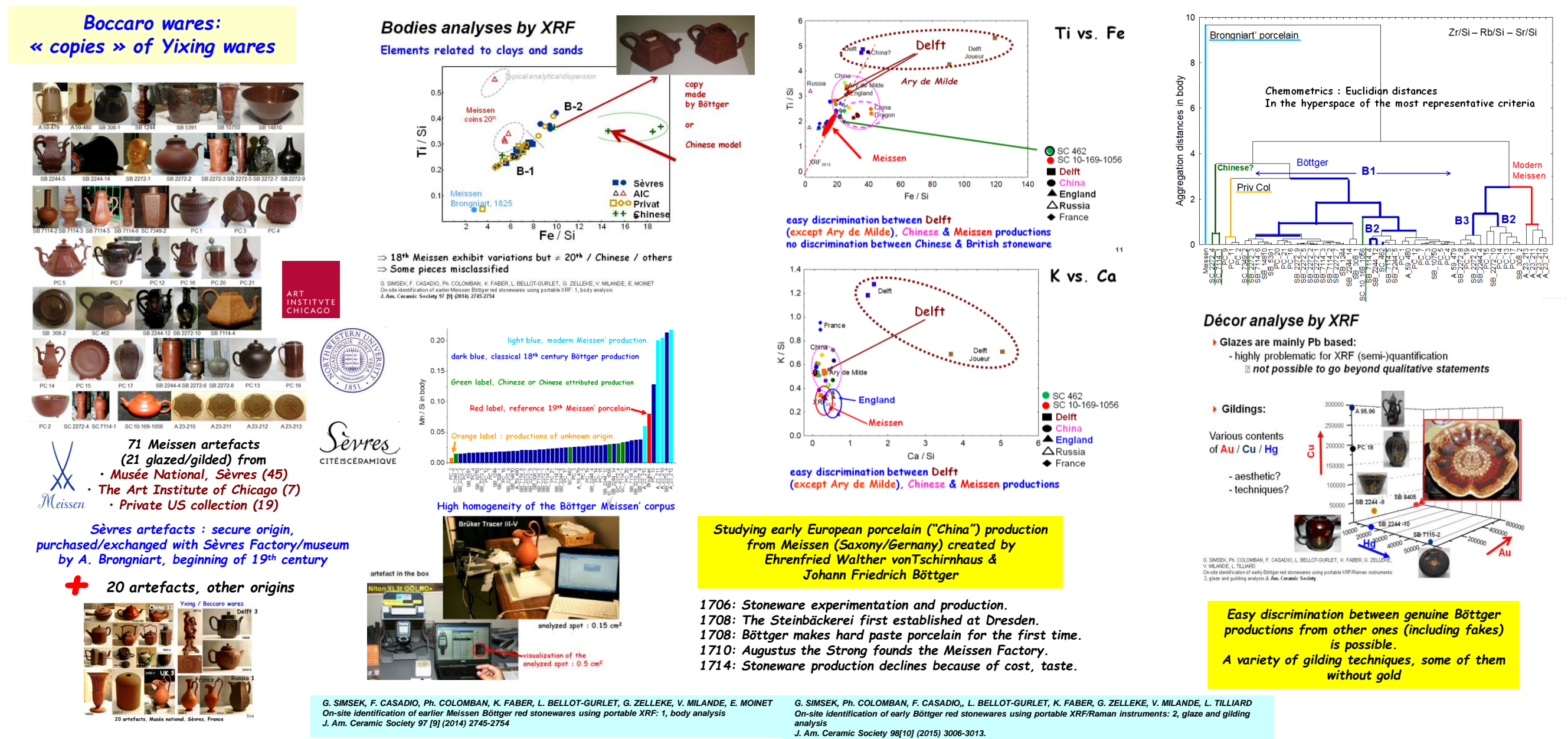
Therefore, the portable, non-destructive techniques, e.g. **pXRF**, **pRaman**, and **FORS** have become essential tools for the analyses of the objects in place or exclusive objects preserved in the secure rooms of museums or private collections.

Thus, a methodology must be created to make the analytical procedures more reliable when using portable instruments.

Representative case studies

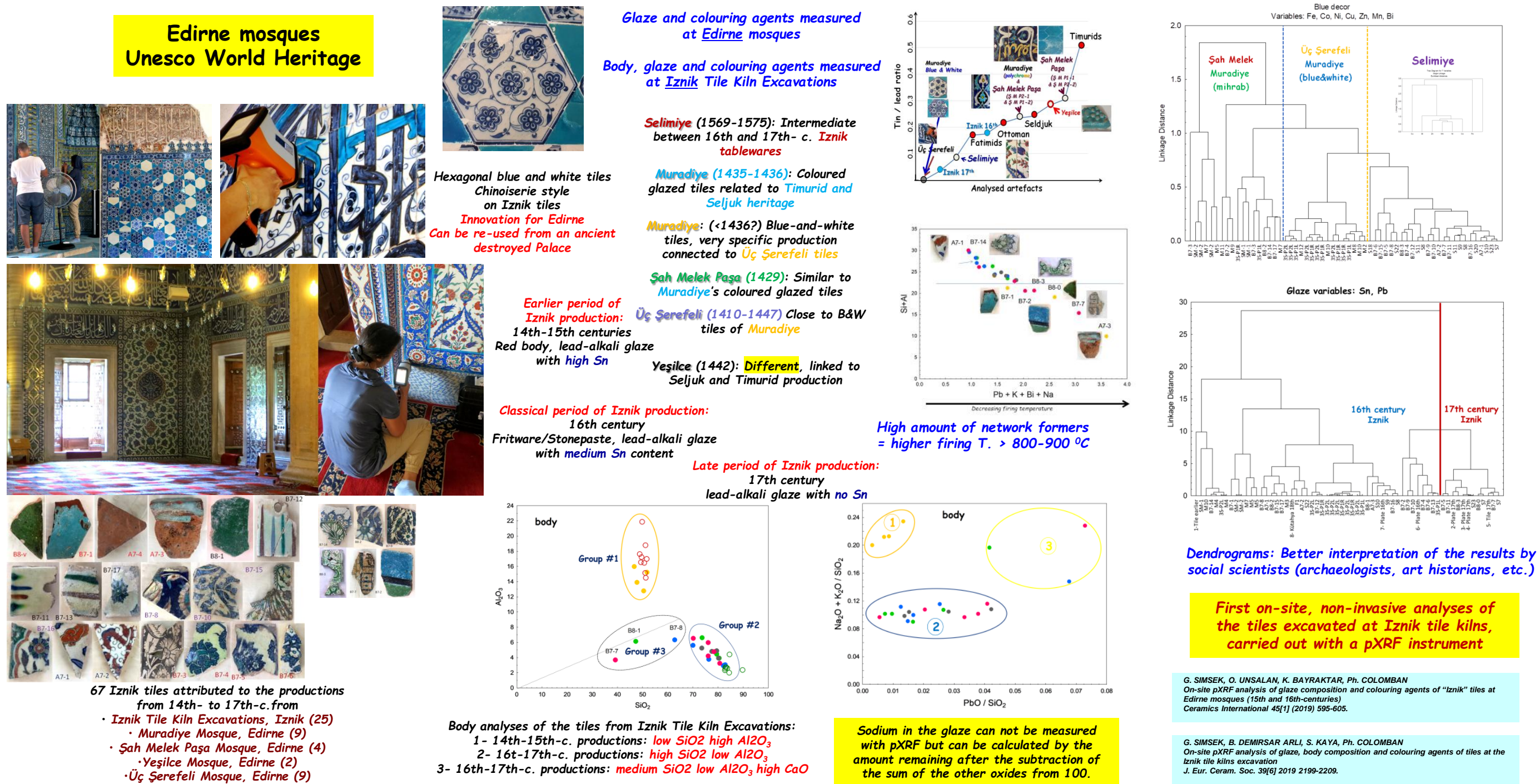
1) At the Museum storage rooms

Discrimination between genuine stonewares and fakes (Meissen, Delft, China, etc.)



2) On-site : building walls

Origin of Iznik tile technology - International Timurids style



3) Measurement at excavation site

Discrimination between Chinese (Yunan) and Vietnamese porcelains with similar decor

