Preliminary spectroscopic results on glass circulation in the Iron Age Mediterranean from the perspective of Central Italy: the INGOT-EL project

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The INGOT-EL project:

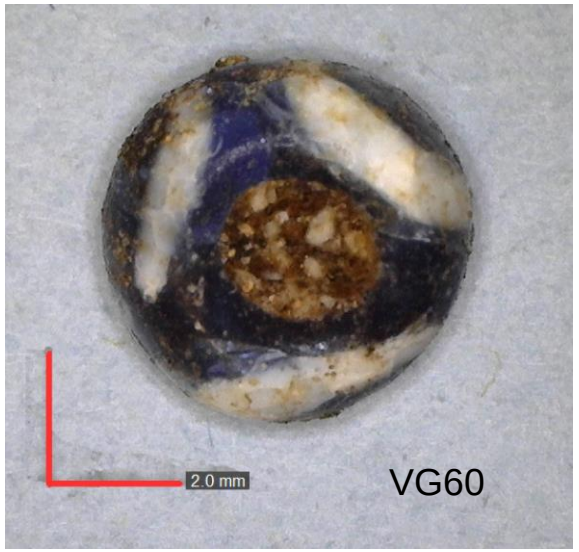
- 264 samples;
- 14 archaeological sites;
- 65 different graves;
- 10-5 centuries BCE;

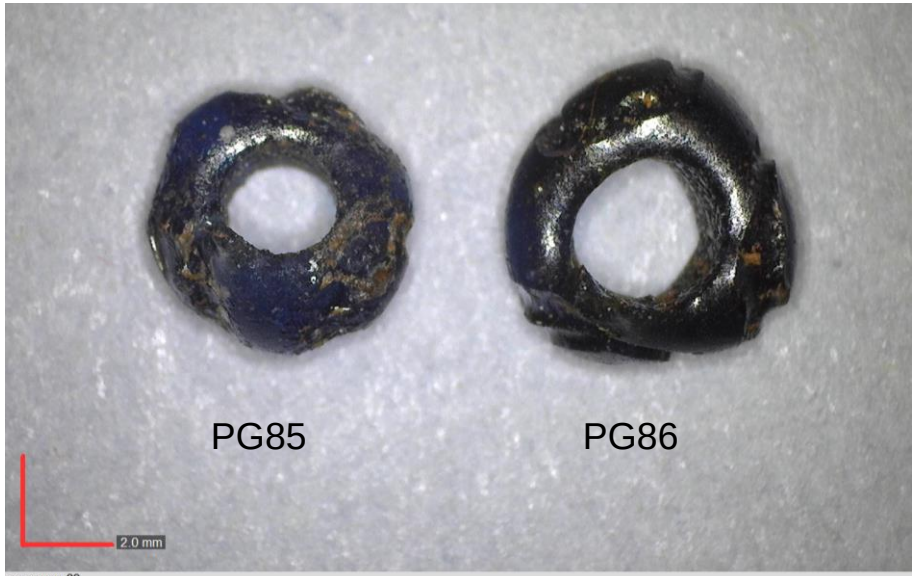
OBJECTIVES:
1. Establish cost-efficient, micro-invasive methodology for analyzing a large number of ancient glasses;
2. Give chemical characterization for glasses from Etruscan and Etruscanized sites;
3. Clarify the question of local glass production in Etruscan lands;
4. Reconstruct glass trade routes that were passing through the lands under Etruscan influence in the Iron Age.

Stage 1:	**Stage2:**	**Stage: 3**
Study of typology and context of glass objects. Photographic and microscopic imaging documentation	non-invasive archaeometric study of objects. XRF FORS	micro-invasive analyses. SEM-EDS Raman XRD LA-ICP-MS

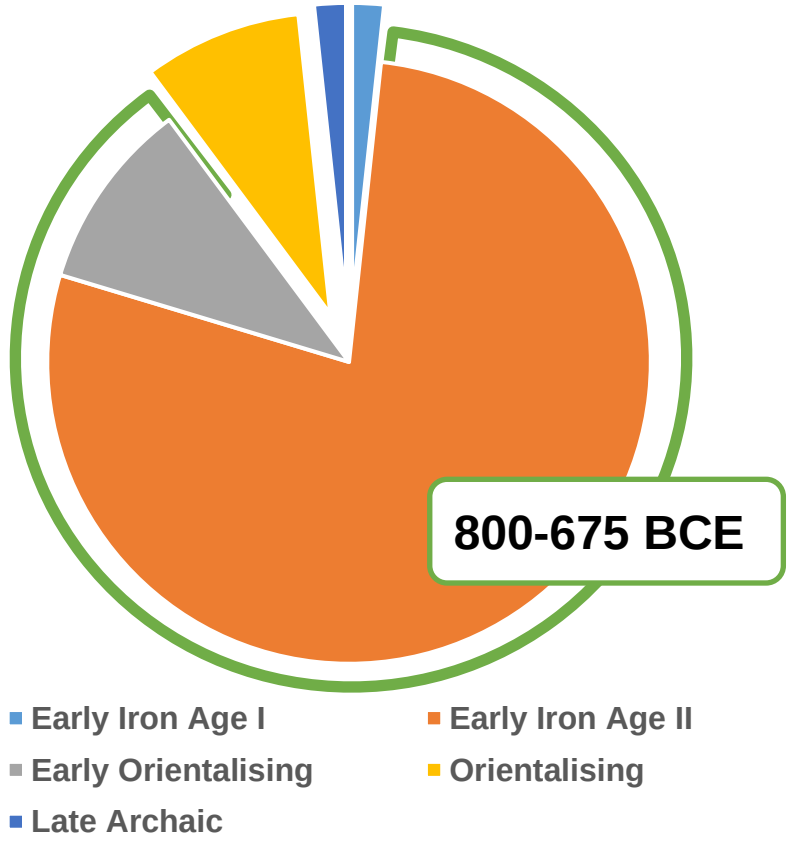
Archaeological sites:

Type of the beads:





Distribution in time:

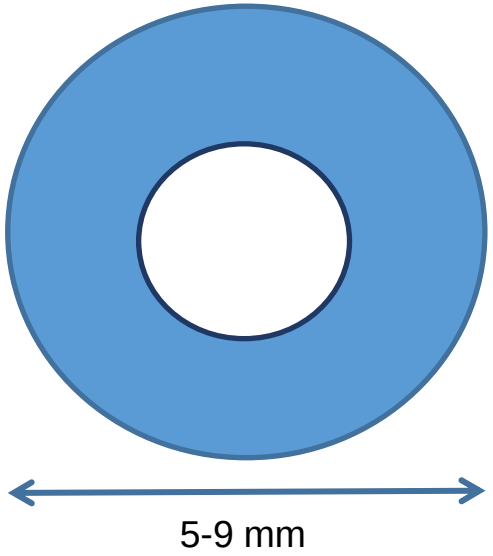


Description of the beads:

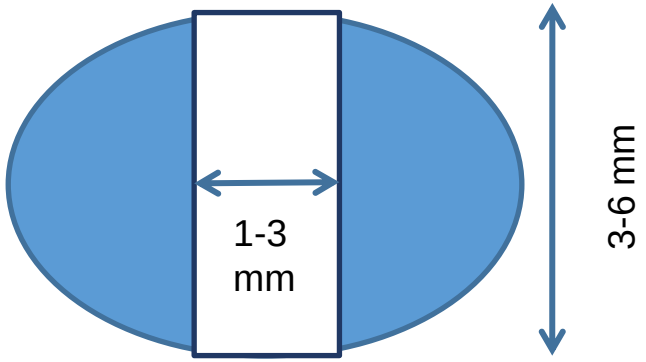
Colour, translucency and state of preservation vary slightly;

PG44-47;

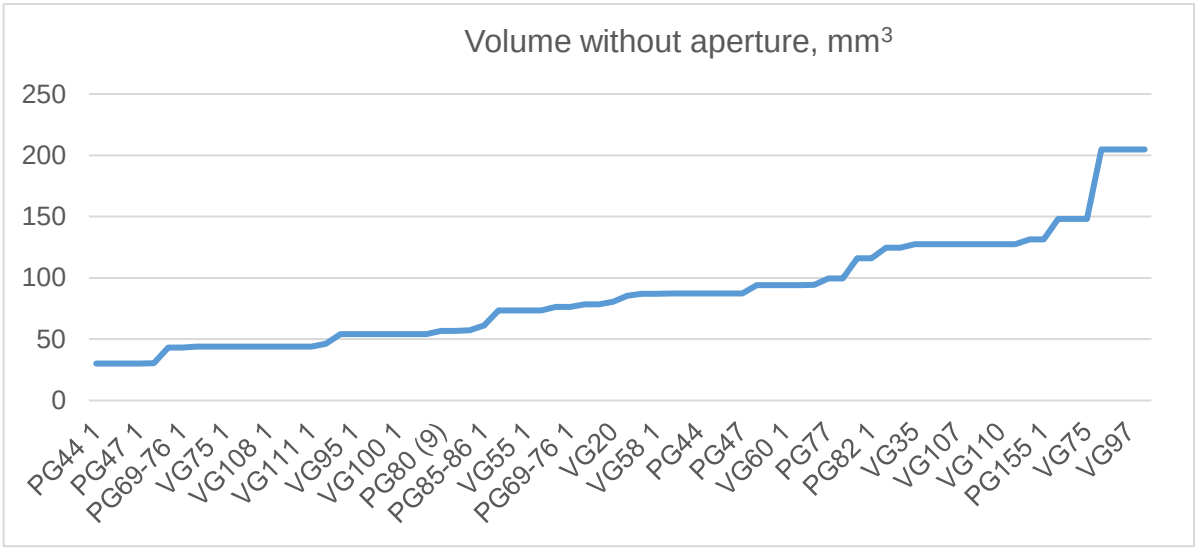
Usually 3 eyes, sometimes 2 (when the bead is small and the eyes are big);



Transversal section.



Longitudinal section.



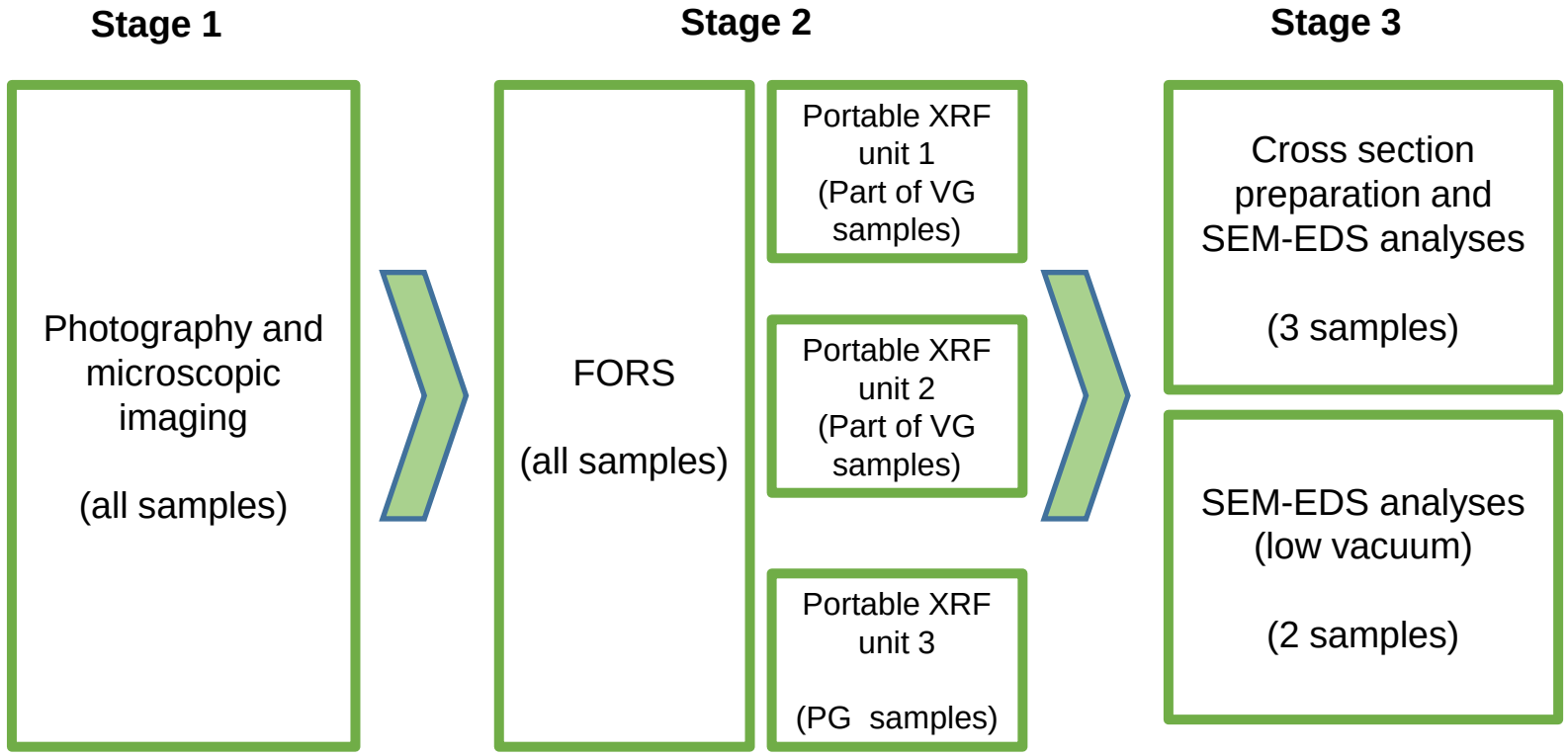
Questions:

- How were these beads made?
- Is there a single tradition in the production of these beads?
- Does different state of preservation coincide with a different composition?
- Where can be the place of production of these beads?

Beads from Capena, Early Iron Age II, Villa Giulia museum

Beads from Capena, Early Orientalising period, Museo delle Civita

Methods:



55 samples within this study;
most of the data are acquired within the museums;

Cross calibration of XRF data from 3 different units

Data acquisition → Creation of FP model for each XRF unit → Quantification (Application of the FP model and calibration using standards) → Correction of values using coefficients and QC of the data

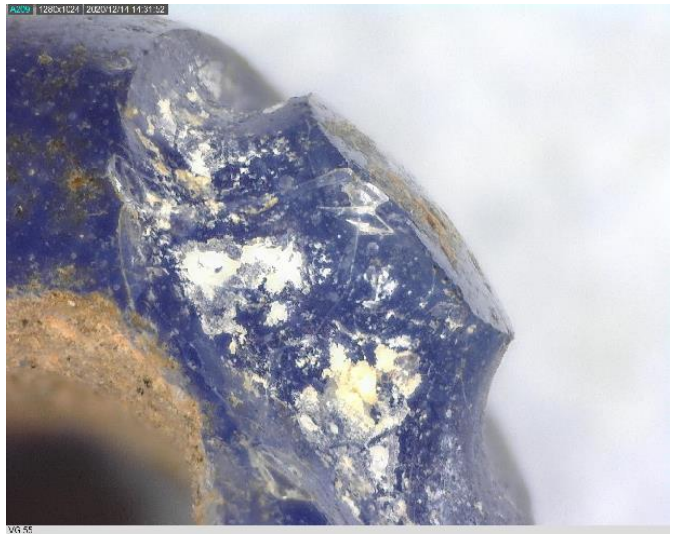
INFN (Frascati) units – analyses in Villa Giulia;

Arvedi laboratory unit – analyses in Museo delle Civita;

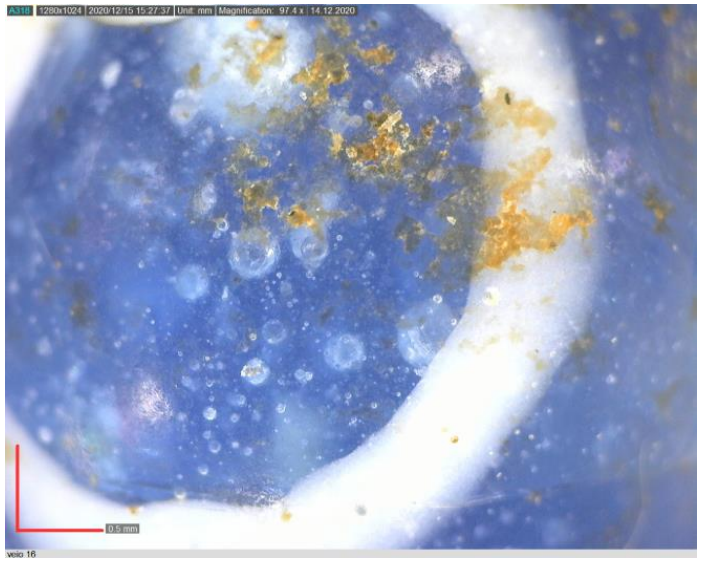
Main objective:

to be able to compare the data from different sources within the same frame of reference.

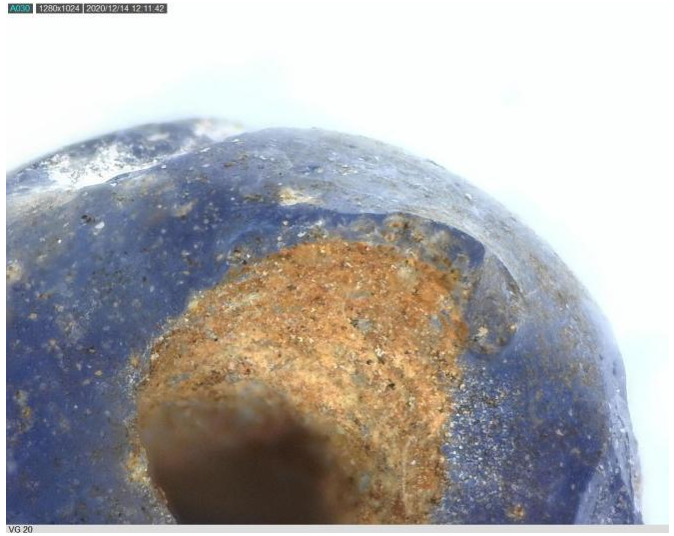
Forming technique: wound beads with inlaid coils



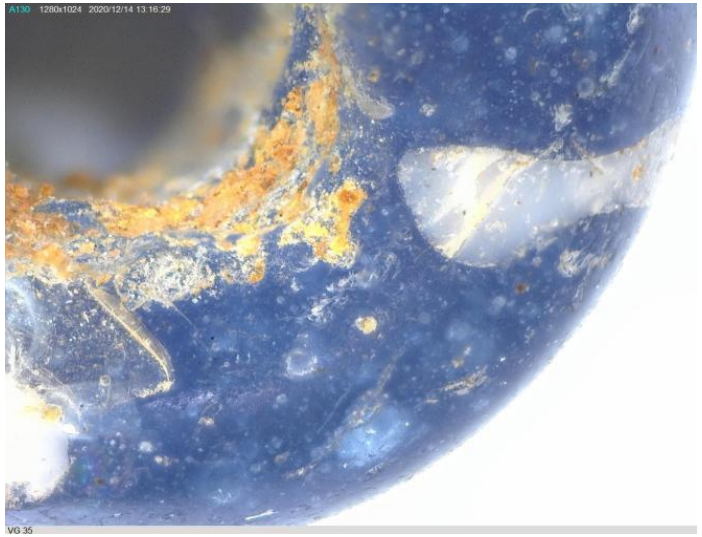
Groove of the detached coil; VG55.



Complete eye (inlaid coil); round bubbles; PG44.



Protrusion near the apex; VG20.



open end of the coil; round bubbles; VG35.

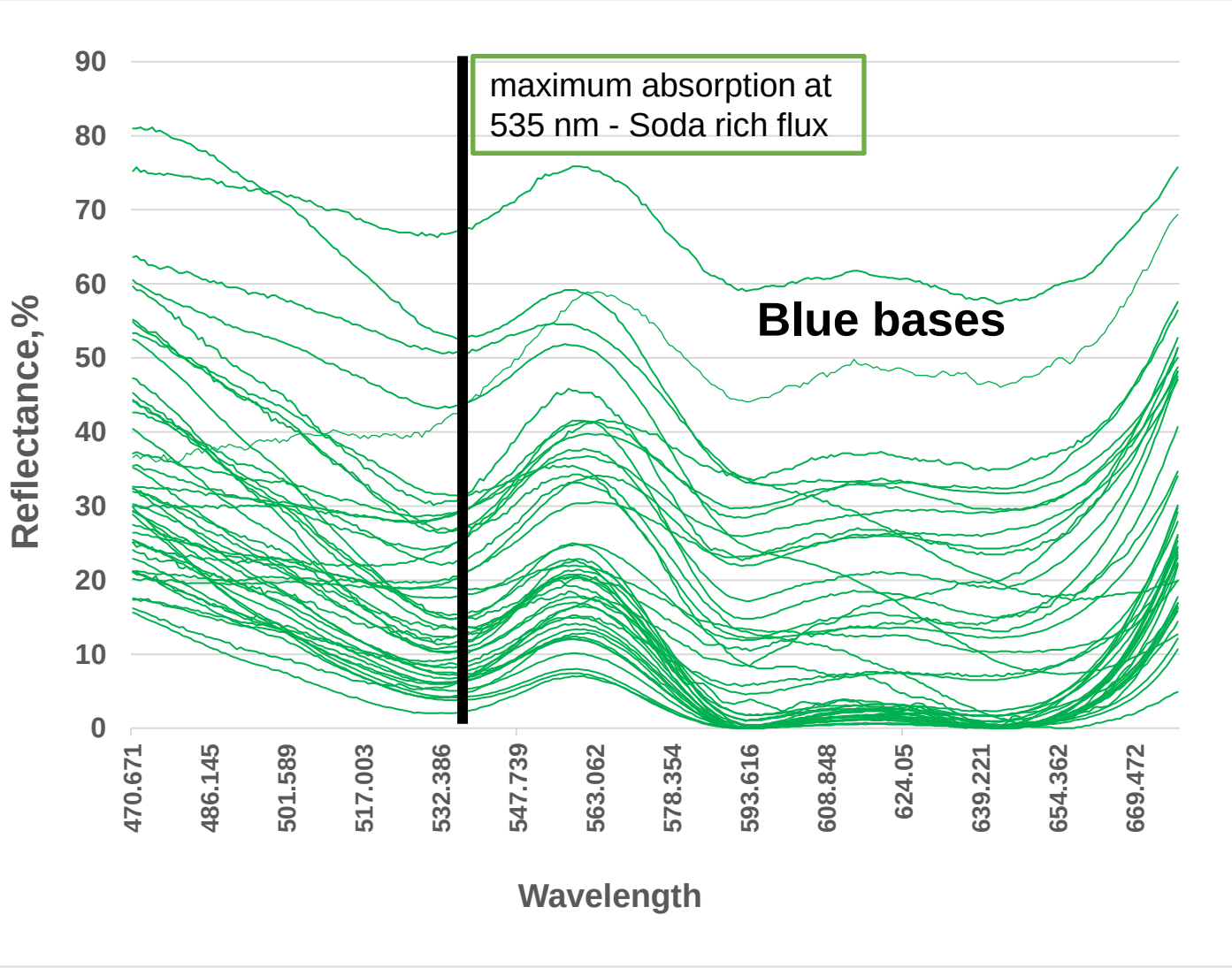
Major components: SEM-EDS analyses*

Cross sections PG110 (1), PG110 (2), PG139 demonstrate values of major components (coloured rectangles) that correspond to Soda-Lime-Silica glass.

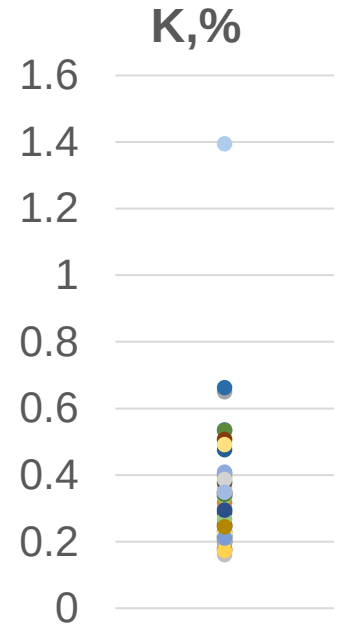
	Na_2O	MgO	Al_2O_3	SiO_2	SO_3	K_2O	CaO	TiO_2	MnO	FeO	CuO	Sb_2O_3
PG110_1_blue	17.50	0.74	0.85	70.63	0.38	0.53	4.70	0.11	1.25	0.40	1.67	N.D.
PG110_1_white	16.52	0.73	0.67	68.19	0.81	0.60	5.25	N.D.	N.D.	0.30	N.D.	6.24
PG110_2	19.23	3.30	6.24	64.89	0.58	0.12	3.58	0.17	0.34	0.89	N.D.	N.D.
PG139	18.62	2.62	6.21	66.60	0.85	N.D.	4.00	0.06	0.18	0.74	N.D.	N.D.

* Samples PG156 and VG109 were analysed in the environmental mode, due to the surface alteration the values of alkali elements are significantly different.

FORS data on flux:

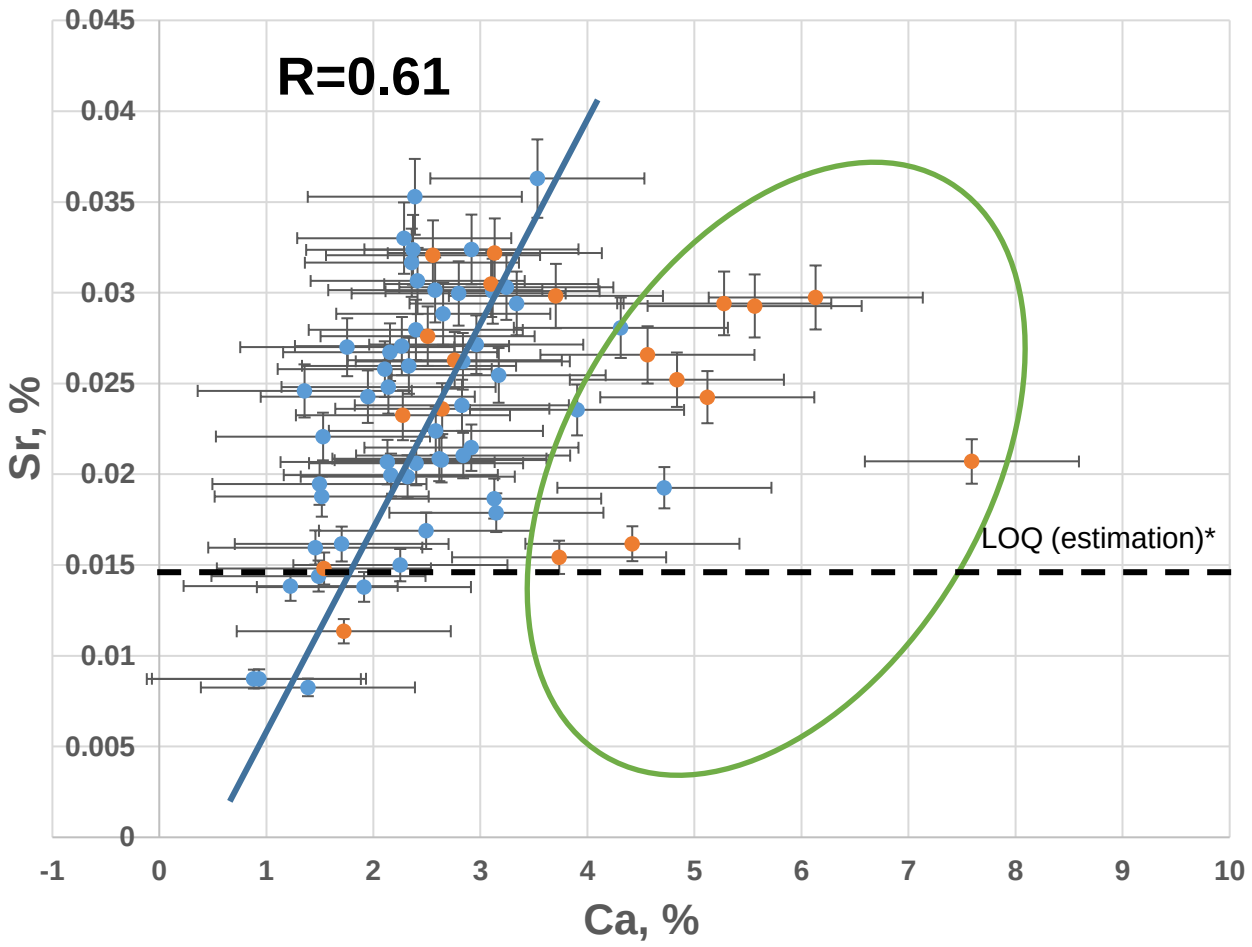


XRF data on flux:



*has to be taken with caution because of likely surface alteration (alkali leaching).

Network modifier



Blue bases; **White decorations**.

Ca values are comparable with IE soda lime glasses;

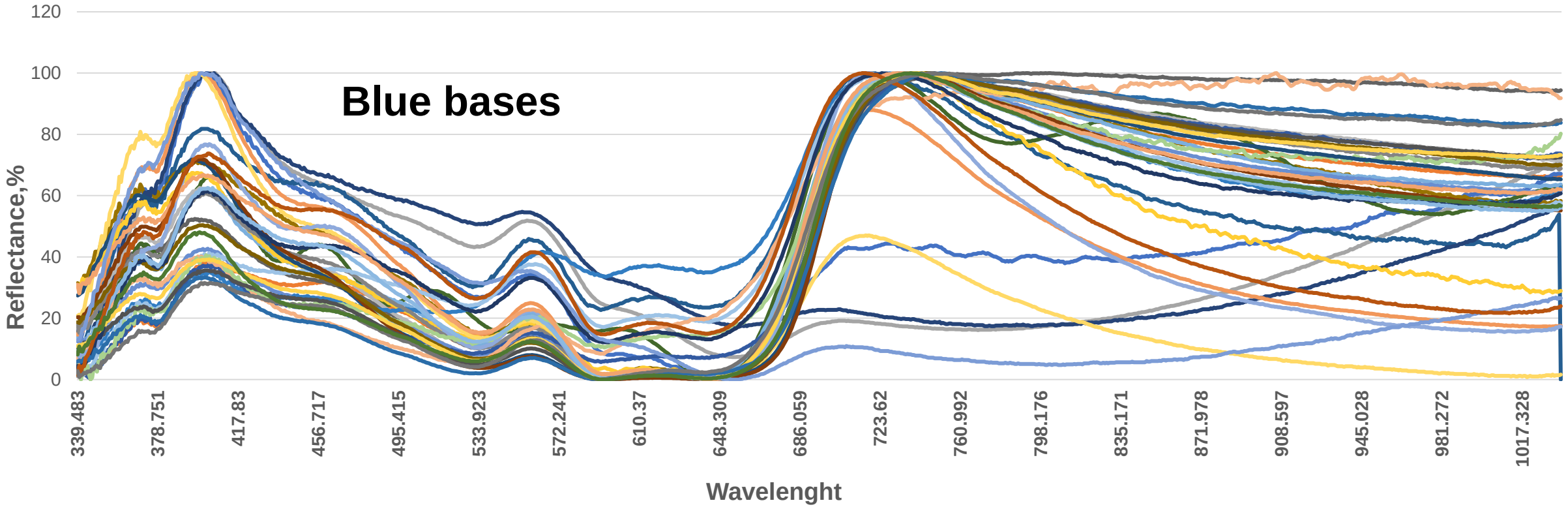
Additional Ca is detected in the white parts of beads (green ellipsis) - probable influence of the colorant addition;

SEM-EDS shows MgO values at – 2.62 - 3.3 % (for Co blue glasses);

Single source of modifier is suggested;

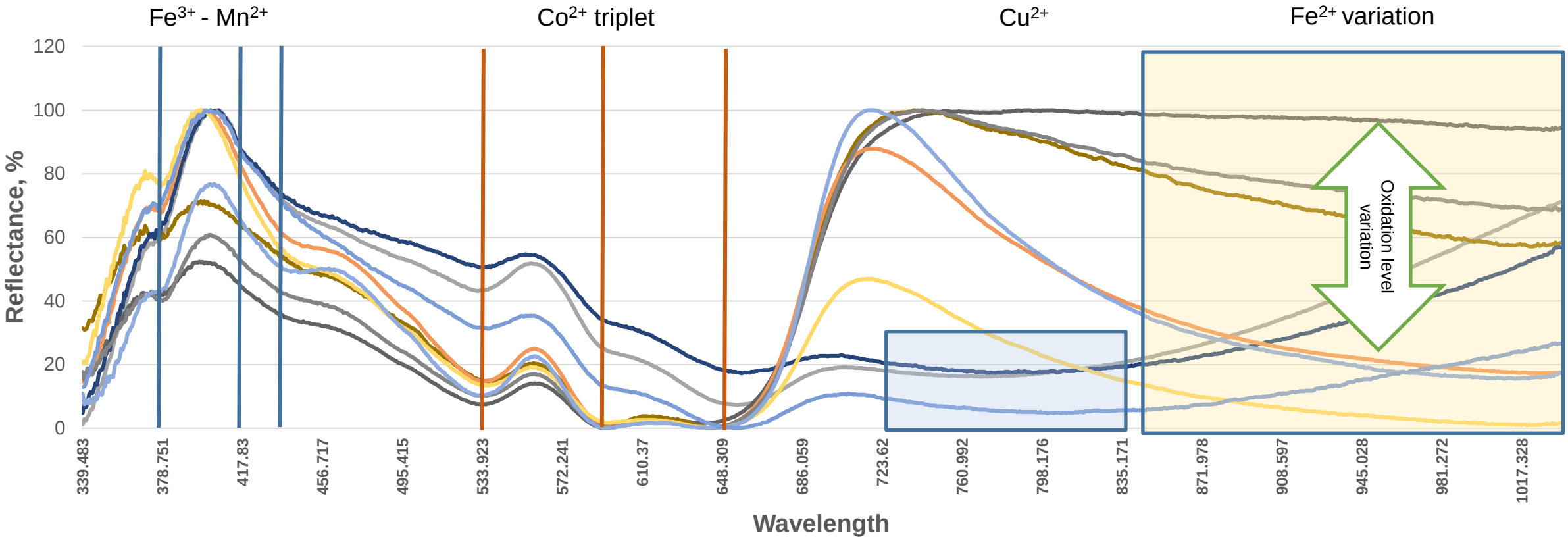
*Here and later LOQ is estimated as 10X detection limit based on data provided by the producer of ELIO XRF unit.

Colors (FORS)



Fe^{3+} - 375 nm;
Fe^{3+} - Mn^{2+} complex – 425, 440 nm;
Co^{2+} - 535, 600, 640 nm;
Cu^{2+} - 775-835 nm (broad band);
Fe^{2+} - NIR (broad band).

Colors (FORS)



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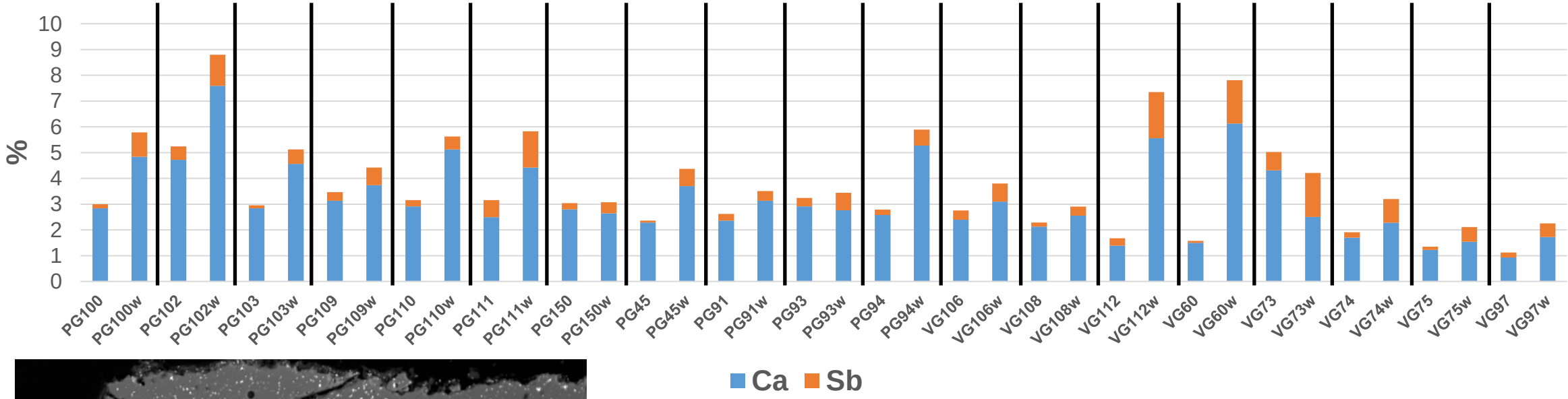
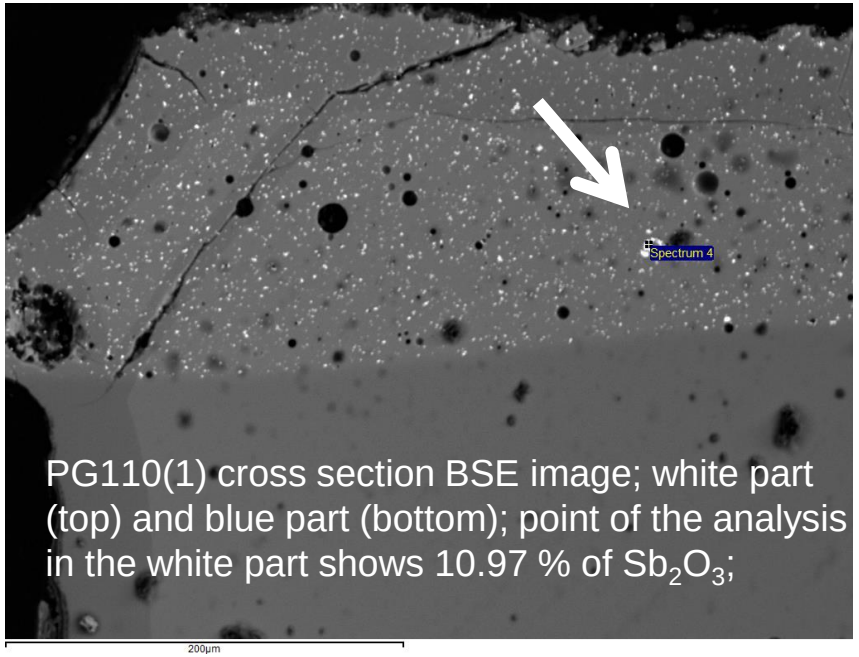
Fe^{2+} - NIR (broad band).

Colors (XRF; SEM-EDS)





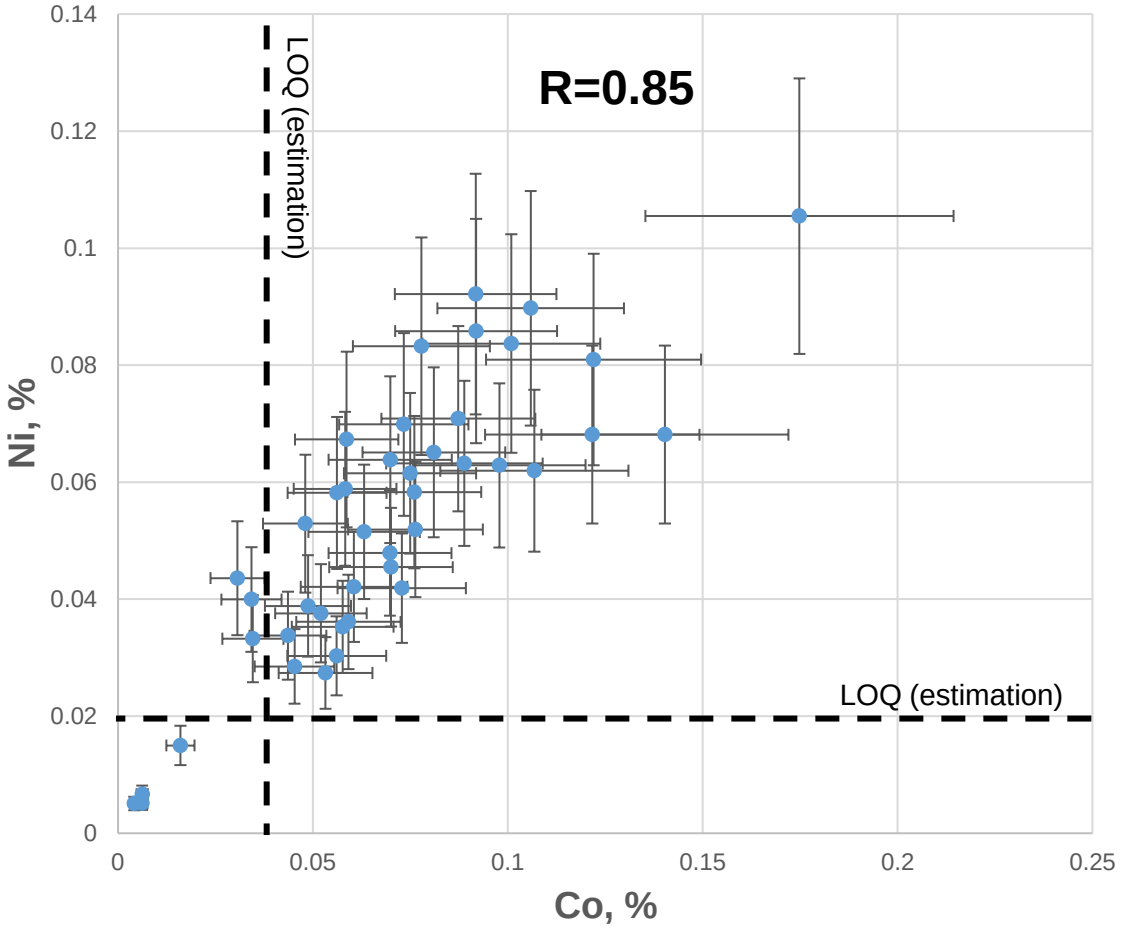
PG110(1) cross section BSE image; white part (top) and blue part (bottom); point of the analysis in the white part shows 10.97 % of Sb_2O_3;

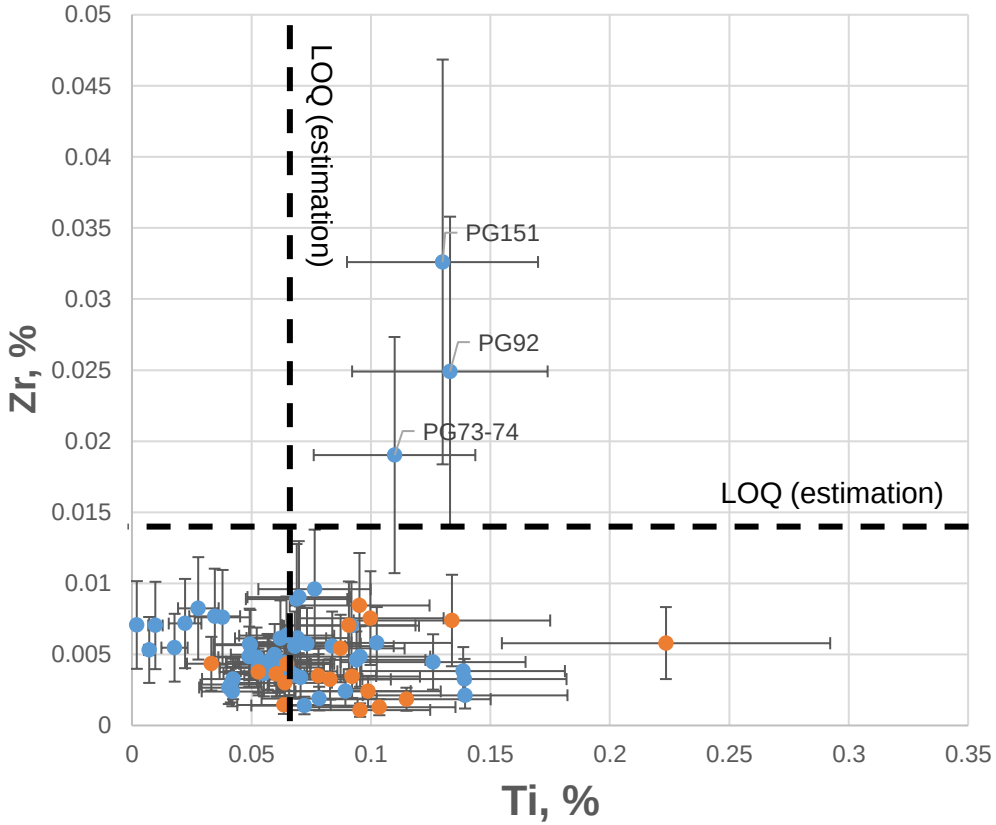
Significant increase of Sb in white decorations;

Abundance of Sb rich inclusions (SEM-EDS) increase of Ca values is noted;

Ca/Sb white = 5.2;
Ca/Sb blue = 11.7;
Ca white/ Ca blue = 1.69.

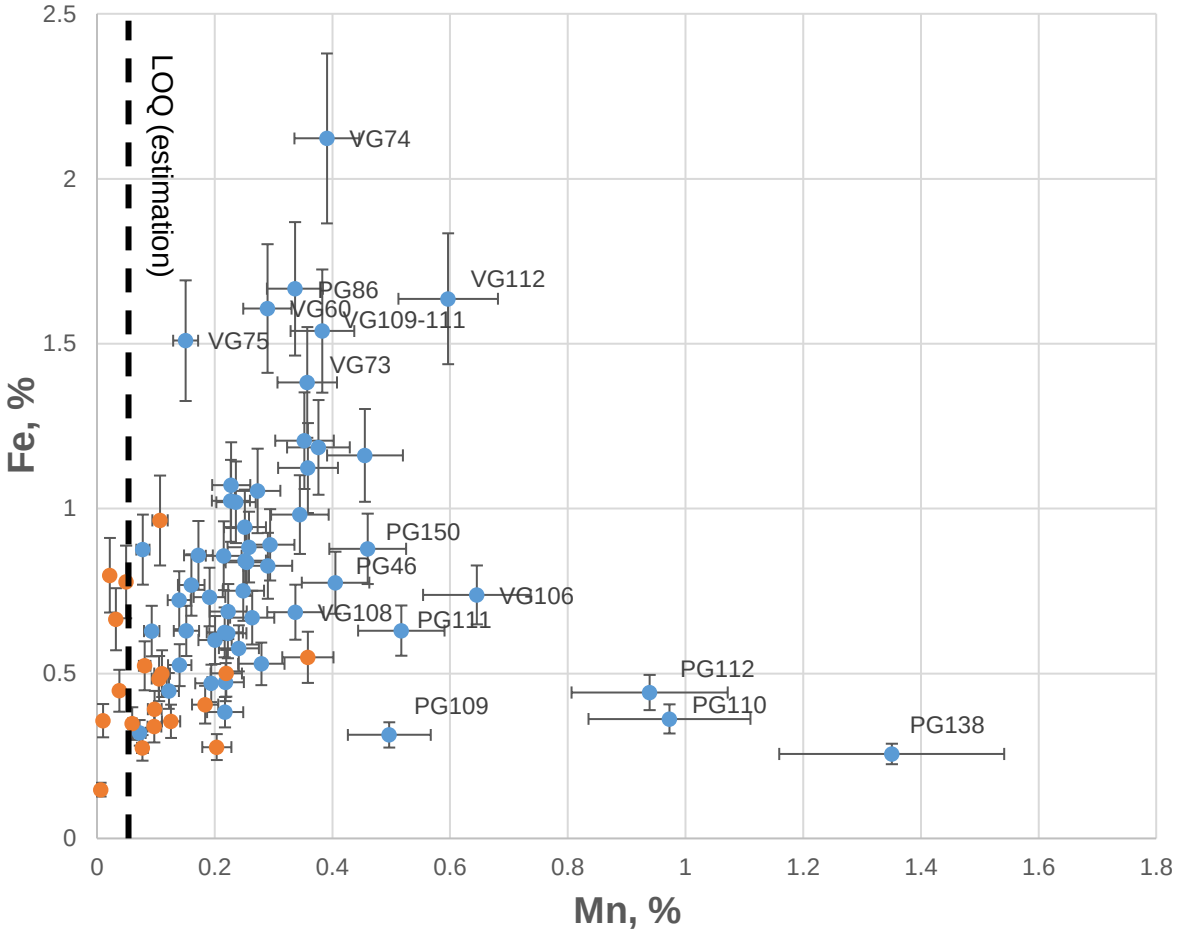
Suggestions of provenance

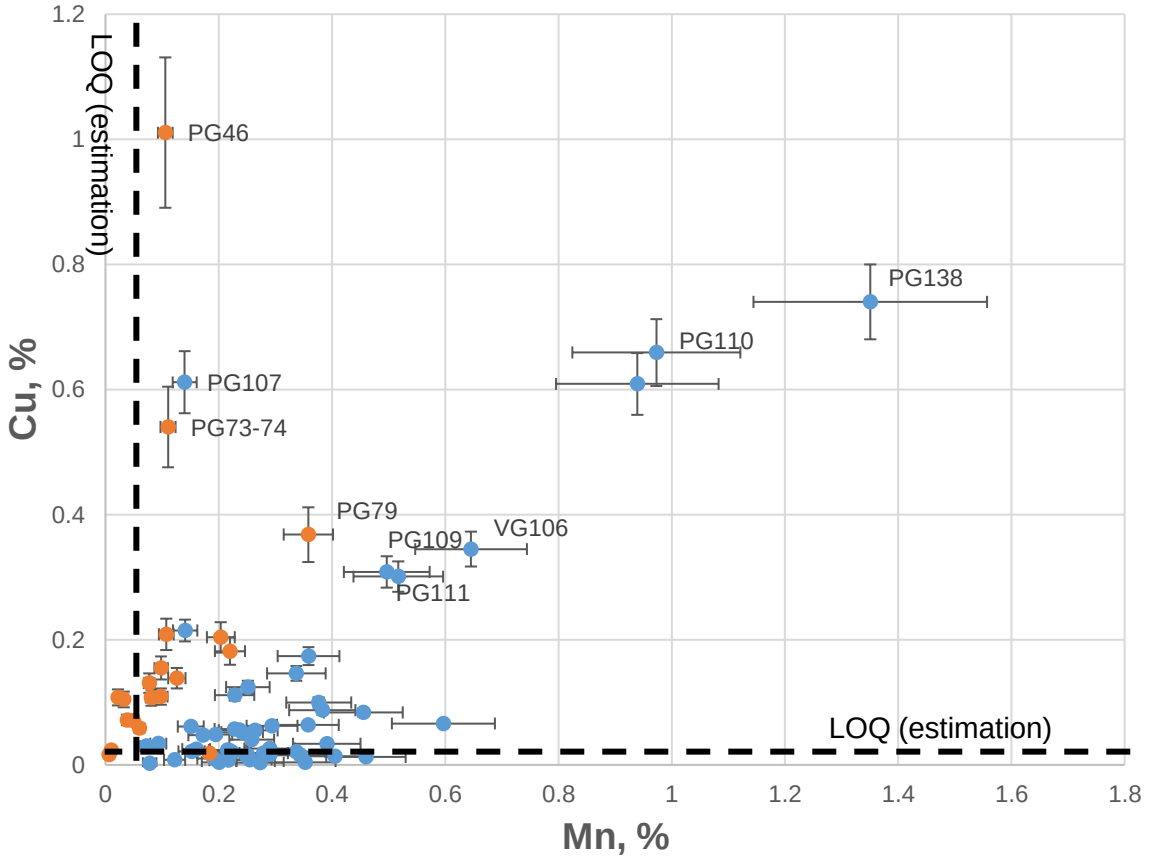




Blue bases; **White decorations**.

Co/Ni binary plot includes data of XRF Unit 1 and Unit 2 on blue bases (XRF Unit 3 values have great relative errors)





Blue bases; **White decorations**.

Instead of conclusion

Notes to keep in mind:

How these beads were made?

- Soda-lime-silica glass;
- Possible recycled glass use;
- Wound beads with coil eye decoration; Variety of sizes without one or several standards.

Where can the place of production of these beads be?

- Same place of production of raw glass is likely, some raw materials source is probably Egypt;
- Several outliers have to be kept in mind.

Is there a single tradition in the production of these beads?

- The colorants used are the same so is the aspiration to similar appearance (with exceptions);

Instead of conclusion

Future work:

- Refining of XRF data;
- Comparing with other groups of samples;
- Introducing new data of the stage 3 into discussion including LA-ICP-MS data;
- Cross validation of data;
- Checking the veracity of the preliminary conclusions.