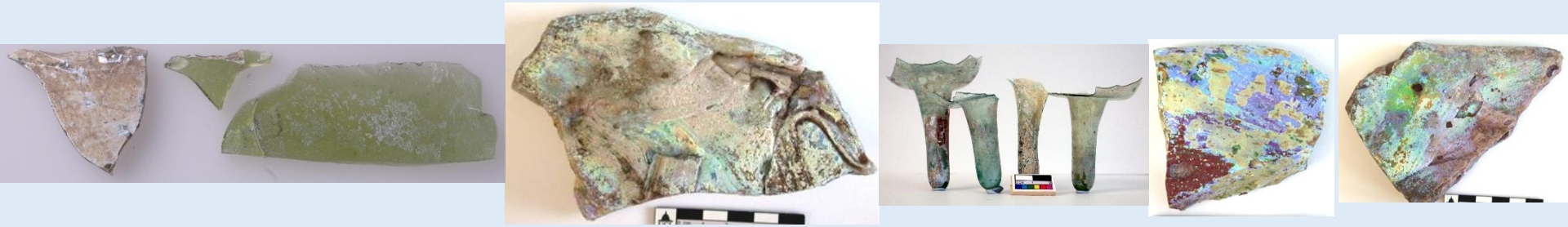
Studying Archaeological Glass Collection from the Petra Church

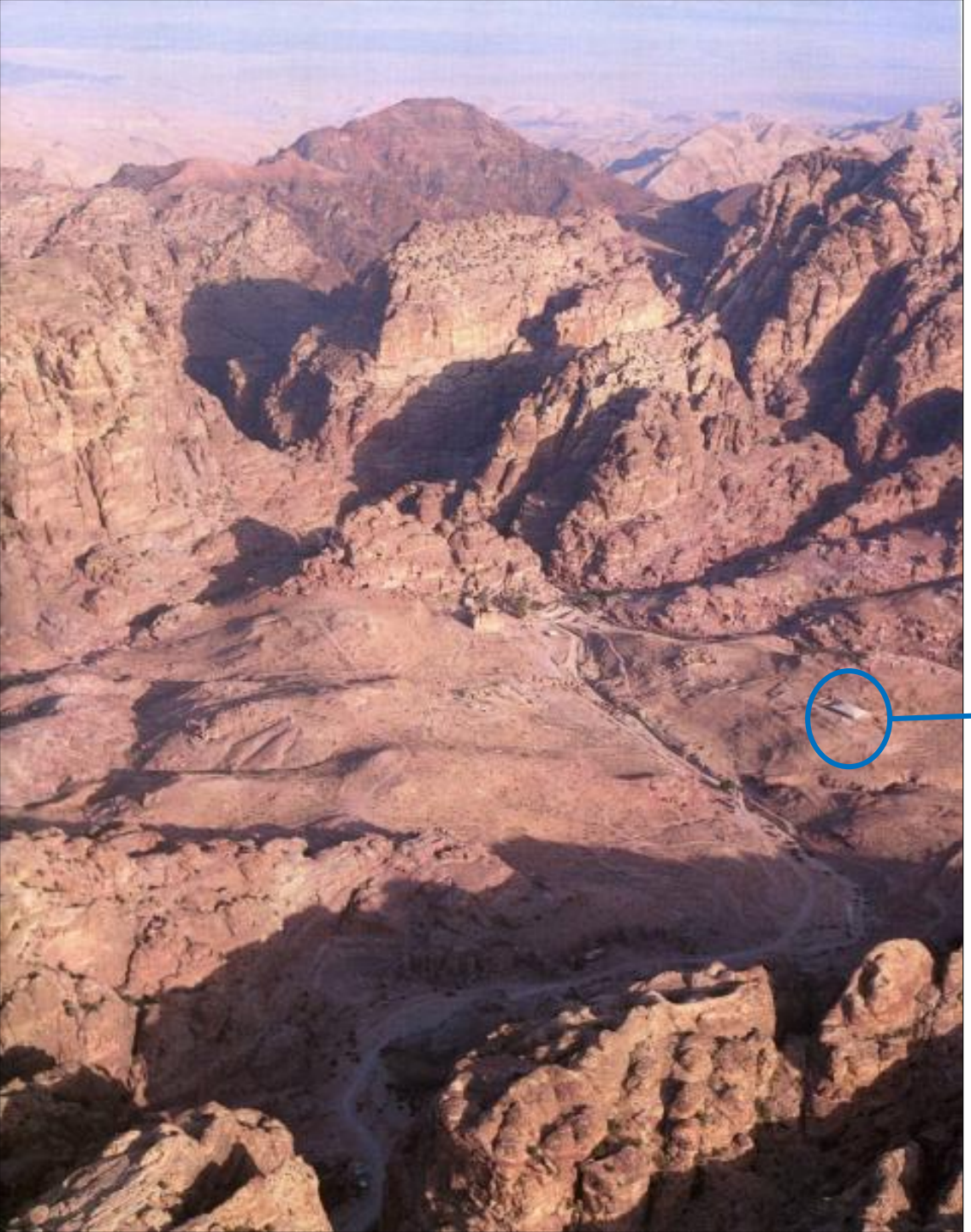


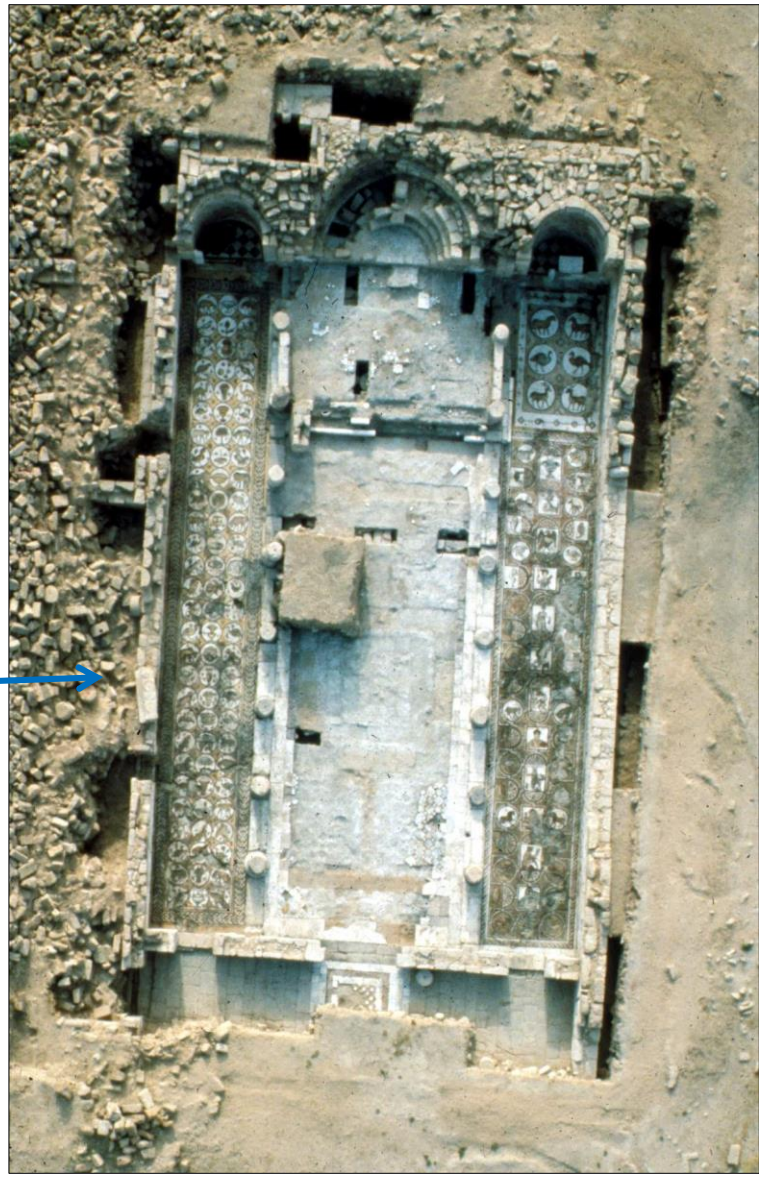
Fatma Marii

University of Jordan

SESAME Cultural Heritage Day

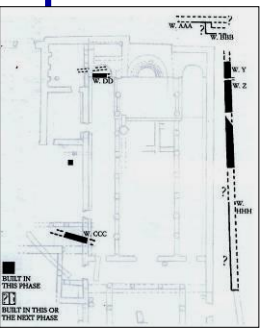
16/February/2022



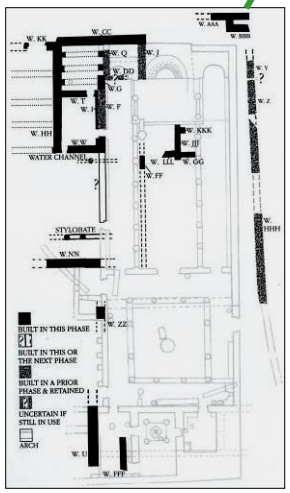


Nabatean Roman Byzantine Islamic

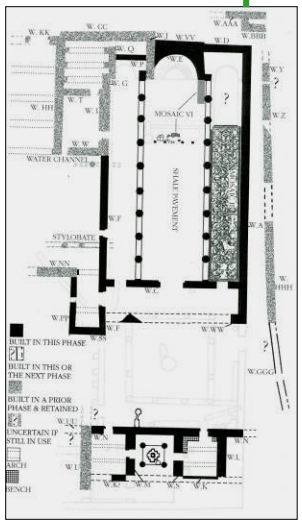
100 200 300 400 500 600 700 800 900 AD



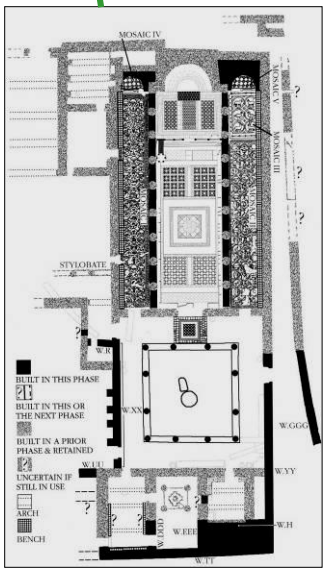
Phase I



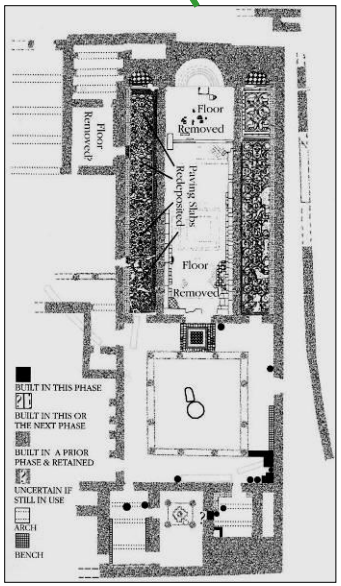
Phase III



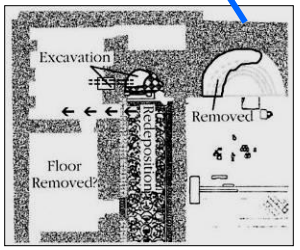
Phase IV



Phase V

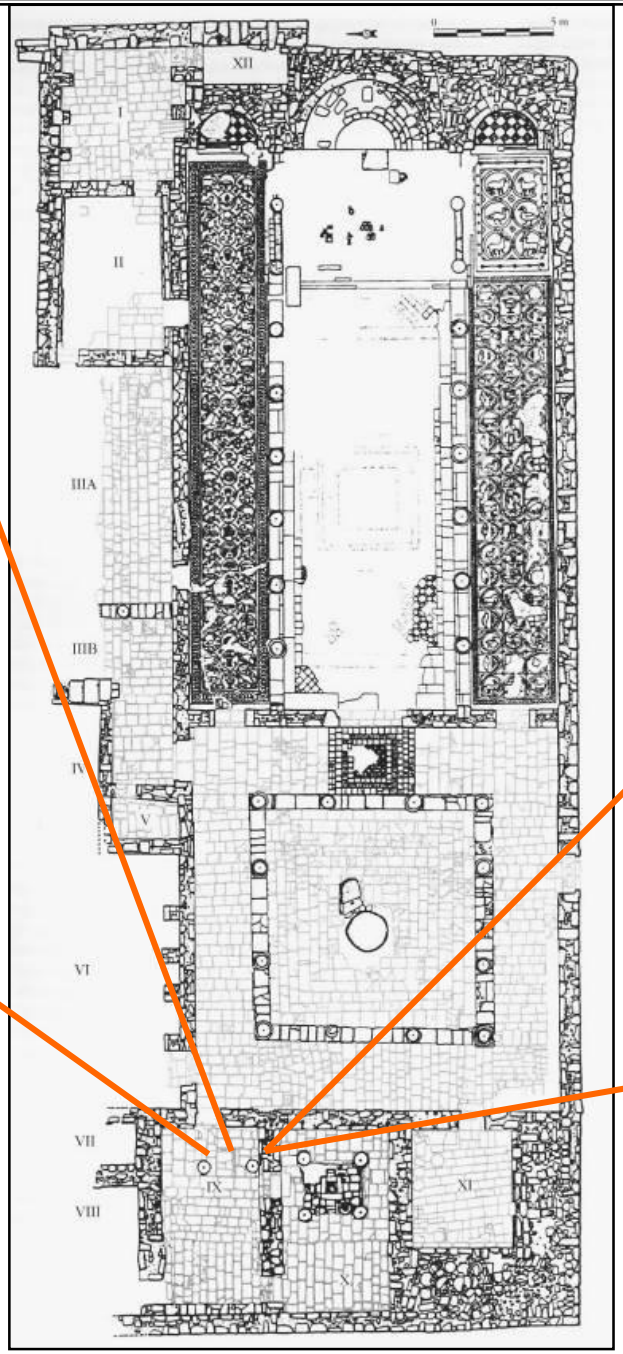


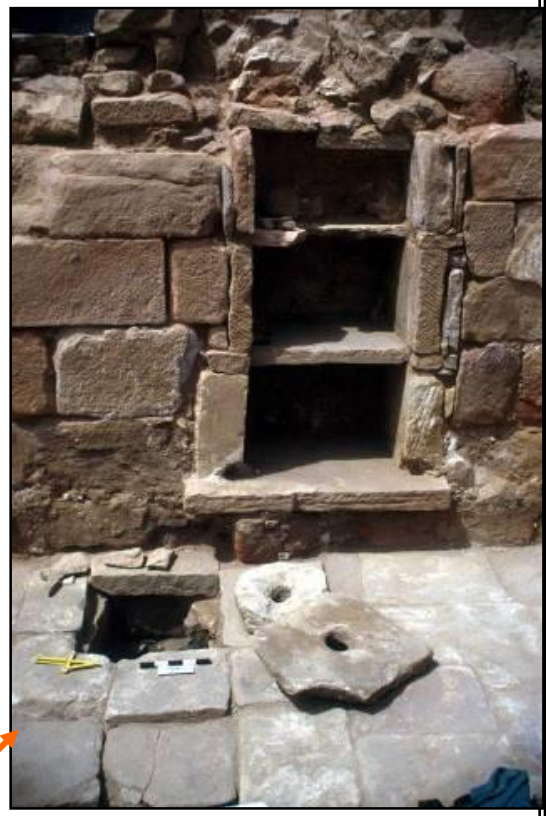
Phase IX



Phase XI

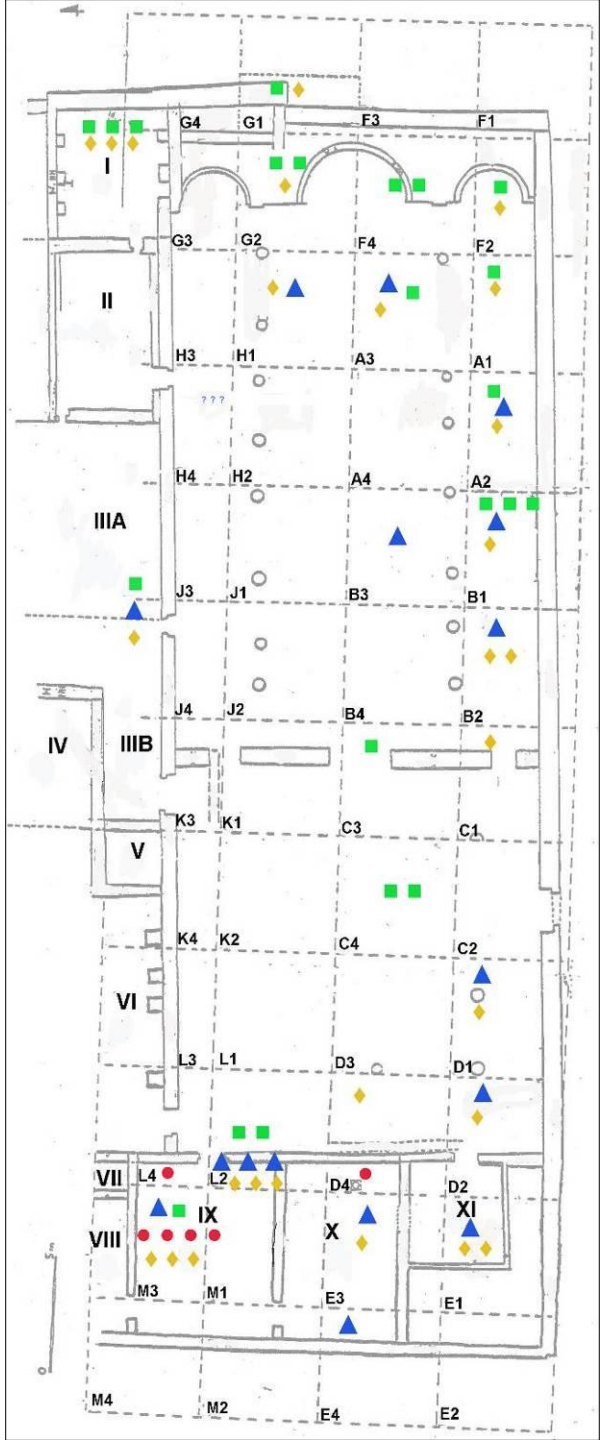
Archaeological Phases of Petra Church


XII
I
II
IIIA
IIIB
IV
V
VI
VII
VIII
IX
XI
X



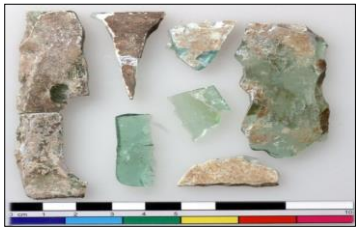
Distribution of the glass fragments

windows	101-500	■
	501-1000g	■ ■
	1001-5000g	■ ■ ■
lamps	100-500g	▲
	1001-5000g	▲ ▲ ▲
cakes	101-500g	●
	> 5000g	● ● ● ●
others	101-500g	♦
	501-1000g	♦ ♦
	1001-5000g	♦ ♦ ♦



Glass categories excavated from the Petra Church

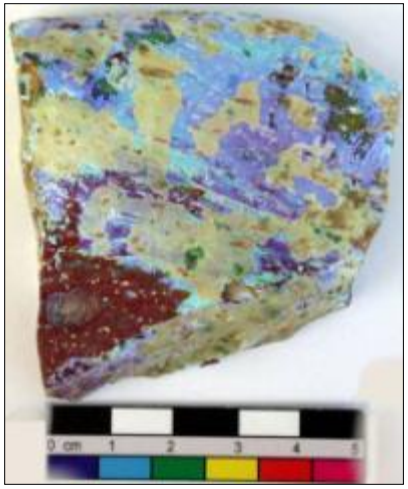
- Vessel and window-pane

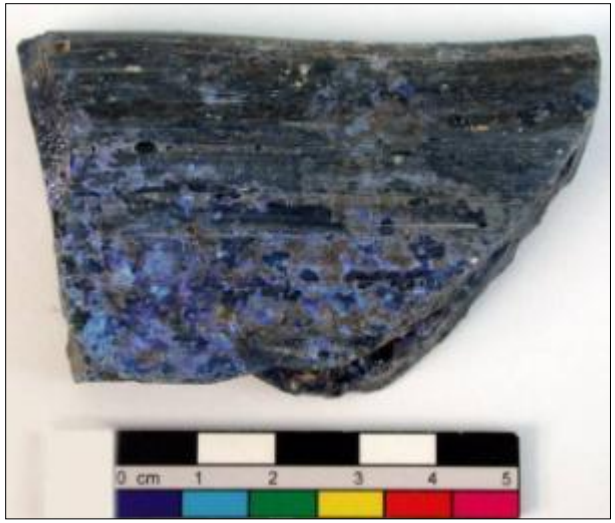


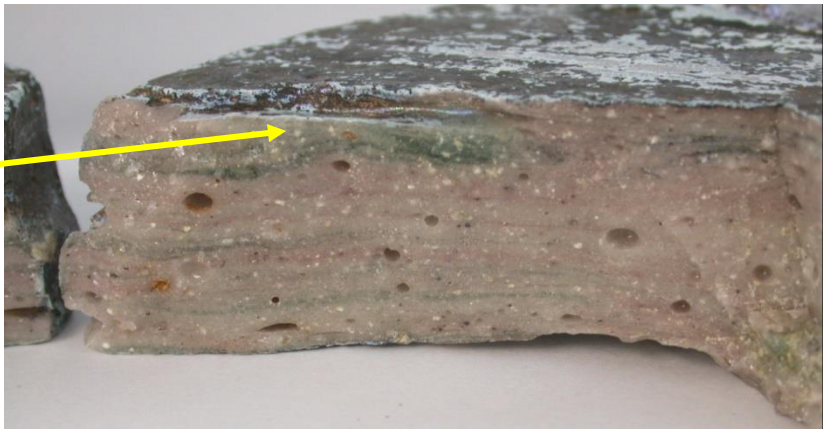
- Tesserae

- Glass cakes

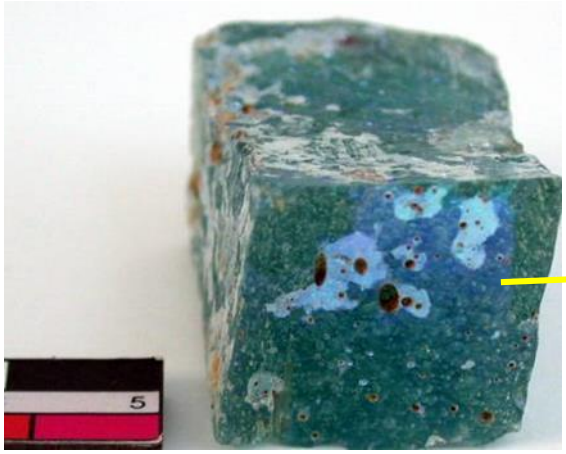
Glass Cakes

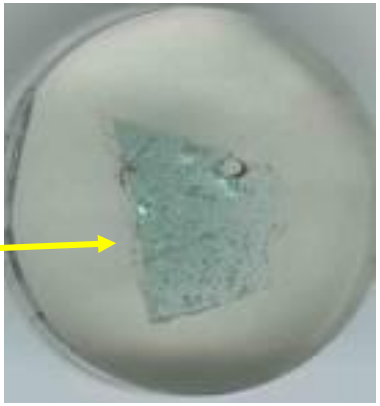






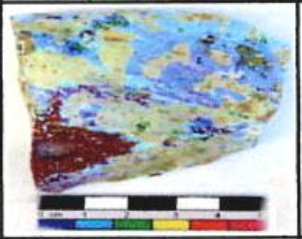
Heterogeneous Glass cakes





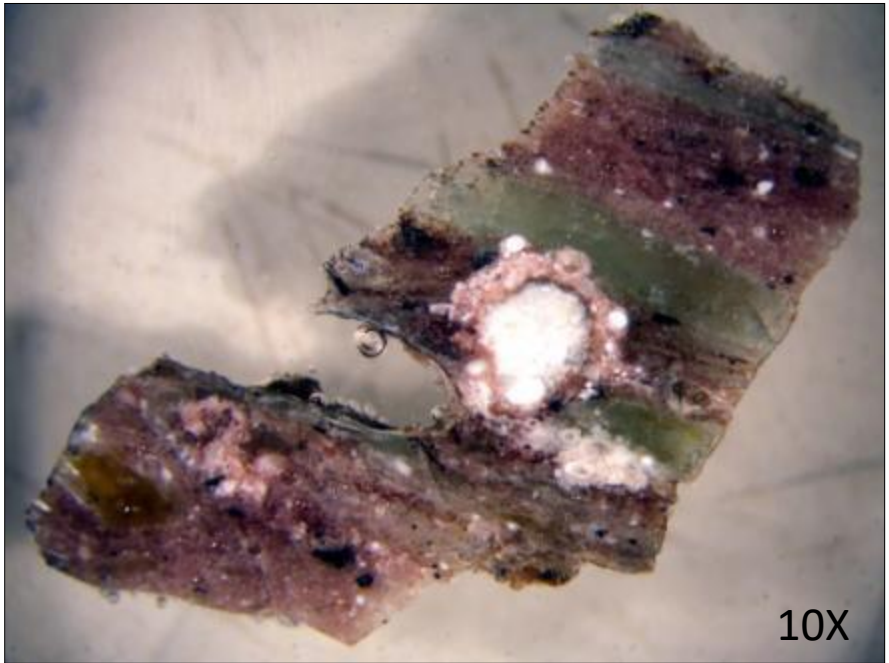
Homogeneous Glass cakes

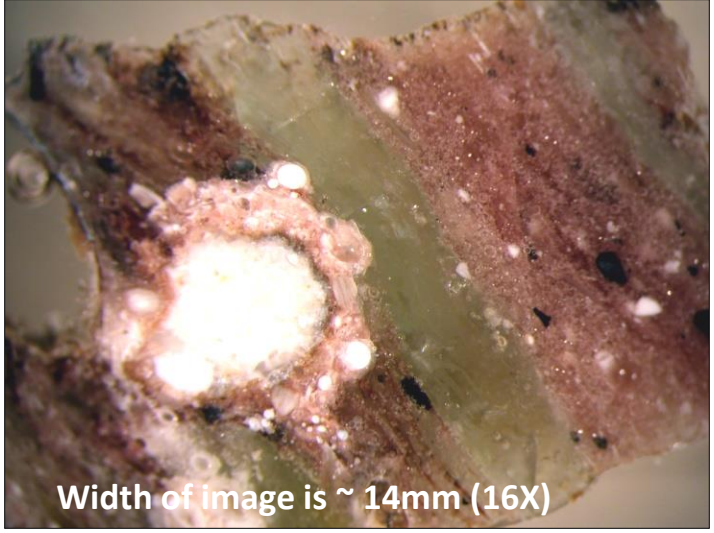
Catalogue of glass cakes

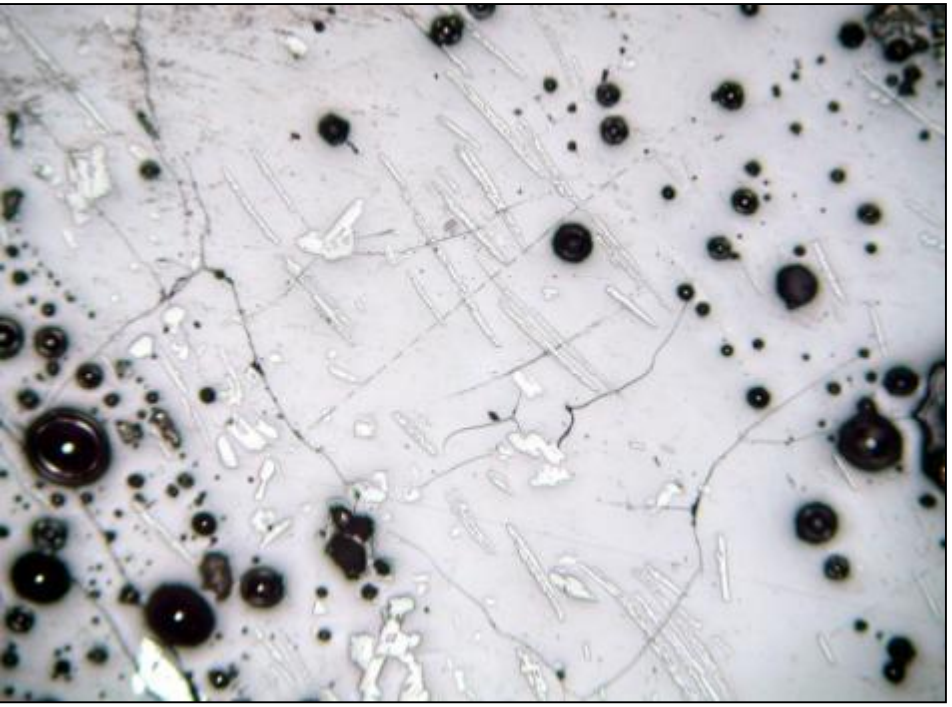
Serial Number	GLASS CAKE PHOTO	Site Number	MAXIMUM DIMENSIONS (mm)	WEIGHT (GRAM)	COLOUR (Munsel Colour Chart)	MOUNTED SAMPLE
# 011		PCP92-D4-19	100.48X60.20X20.73	225.30	5RP 2/2	
# 012		PCP96-M3-07	50.86X50.37X10.55	81.03	7.5R 3/8	
# 013		PCP96-M3-07	30.77X30.57X10.08	22.58	7.5R 3/8	
# 014		PCP96-M3-07	290.10X250.70X20.63	1710.20	5PB 8/2 (and) 10RP 7/4	
# 015		PCP96-M3-07	140.50X120.80X20.58	651.60	10RP 6/4 , 5G 5/2 (and) R-Y 8/10Y	

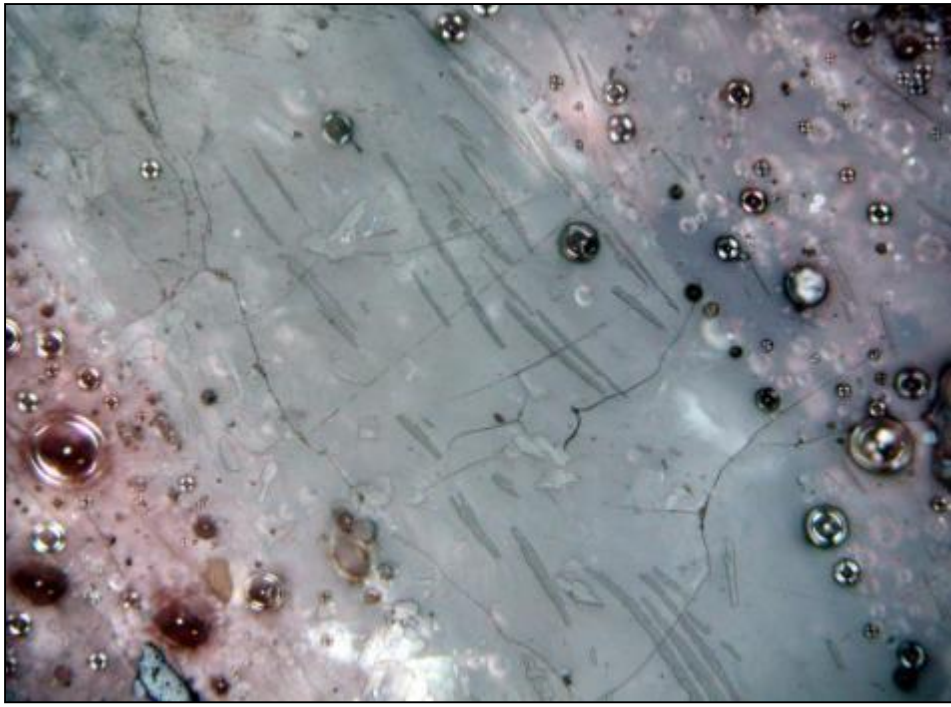
PCP glass cake - 004

Optical Stereomicroscopy



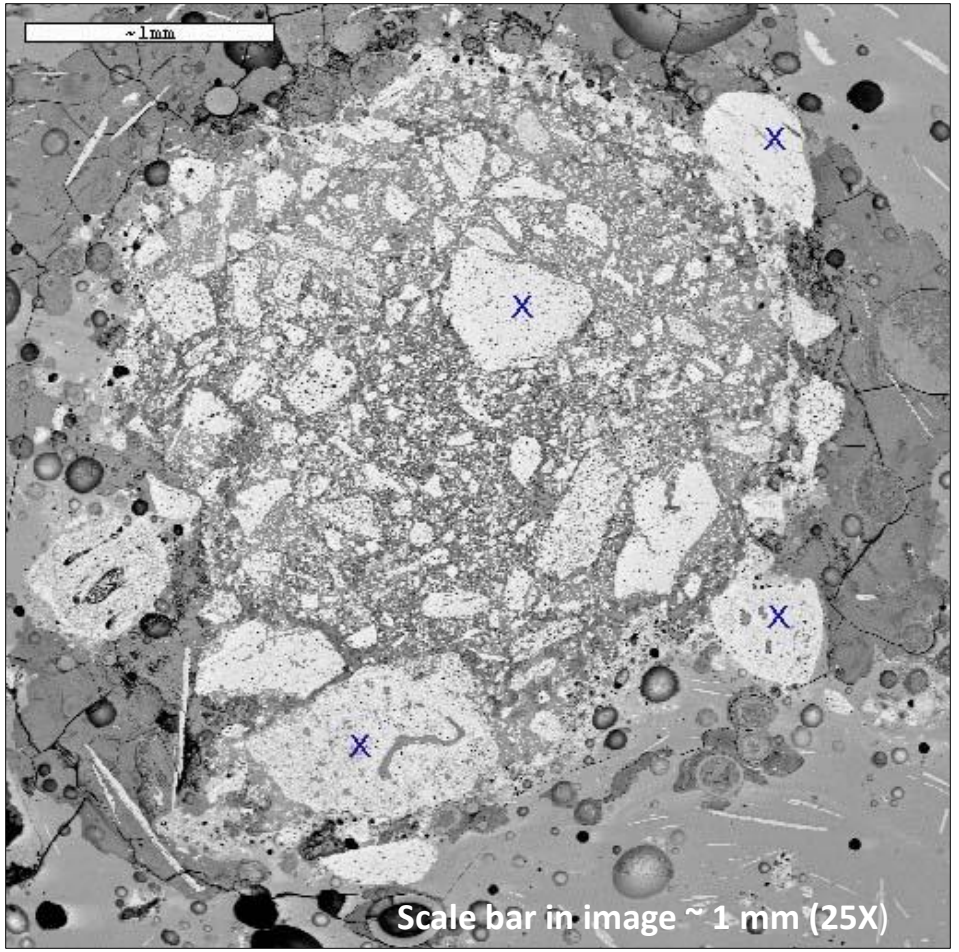






Glass cake 004, photomicrograph under XPL and PPL, both 50X.

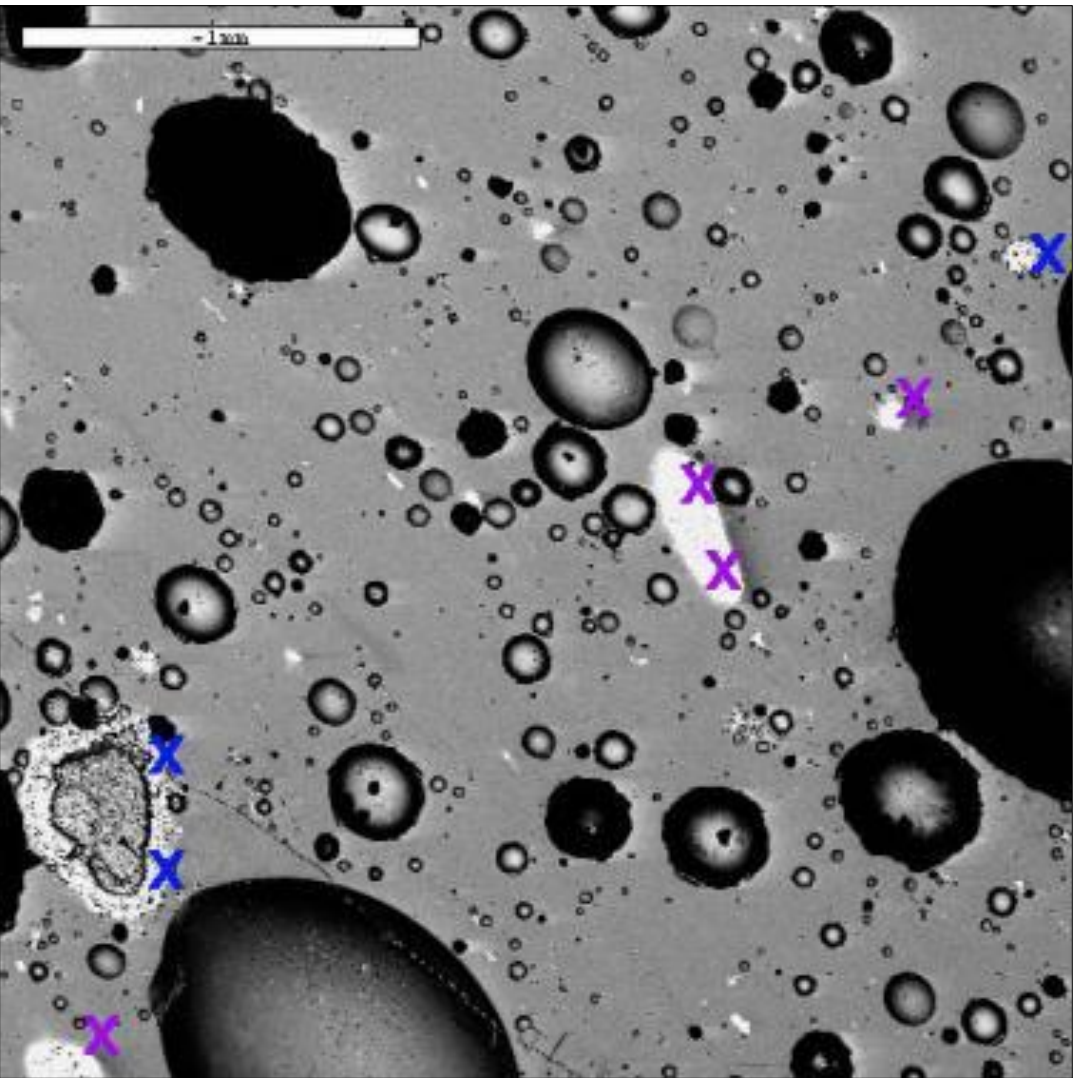
Scanning Electron Microscopy-Energy Dispersive Spectrometry

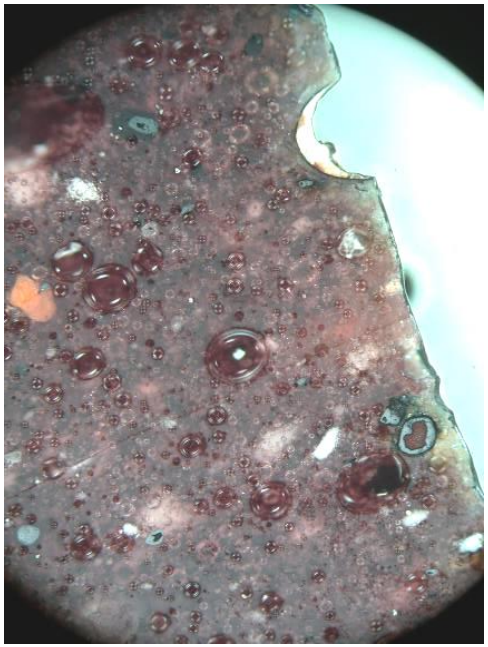


Calcium phosphate phase

PCP glass cake 008

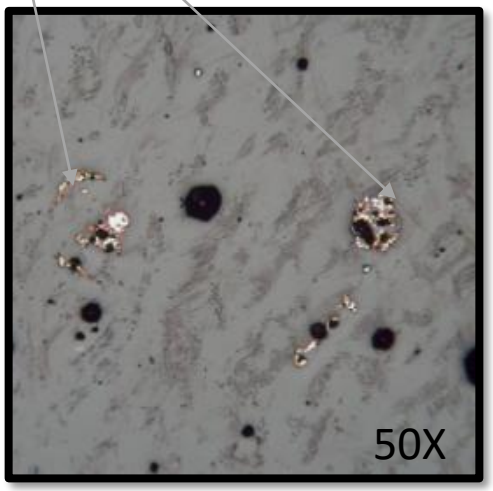
X Calcium phosphate (bone ash) and
X Manganese oxide (MnO) particles.

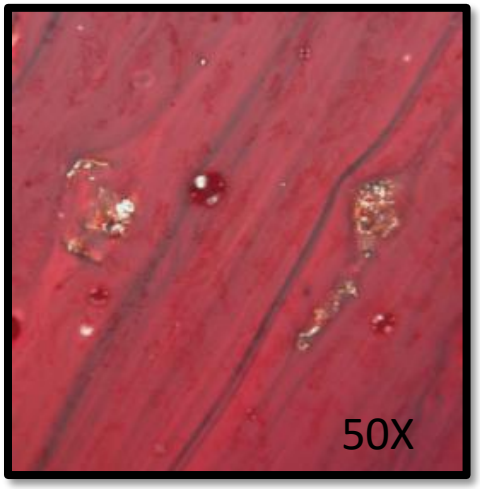




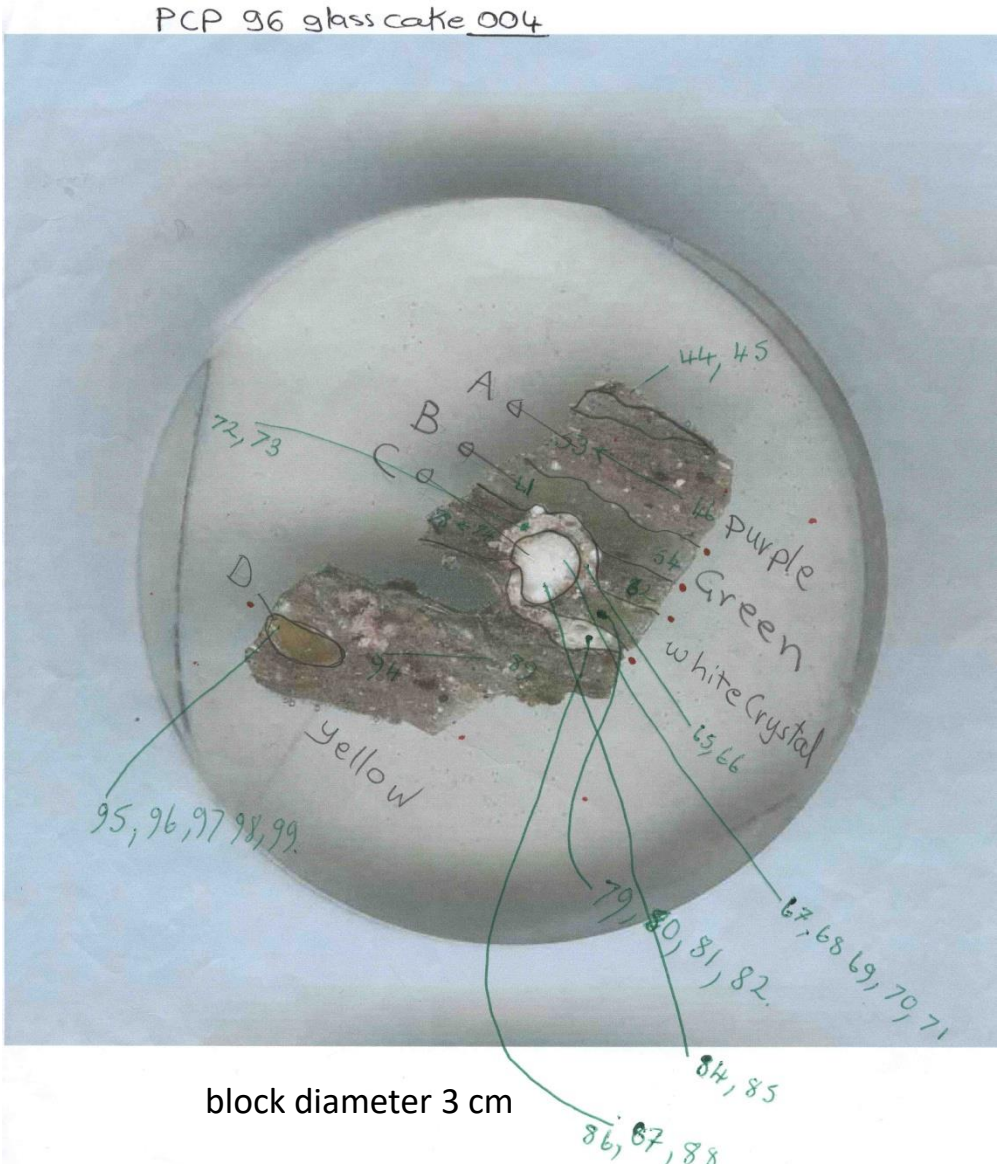
PCP glass cakes 013

Copper metal





Electron Probe Micro Analysis (EPMA)



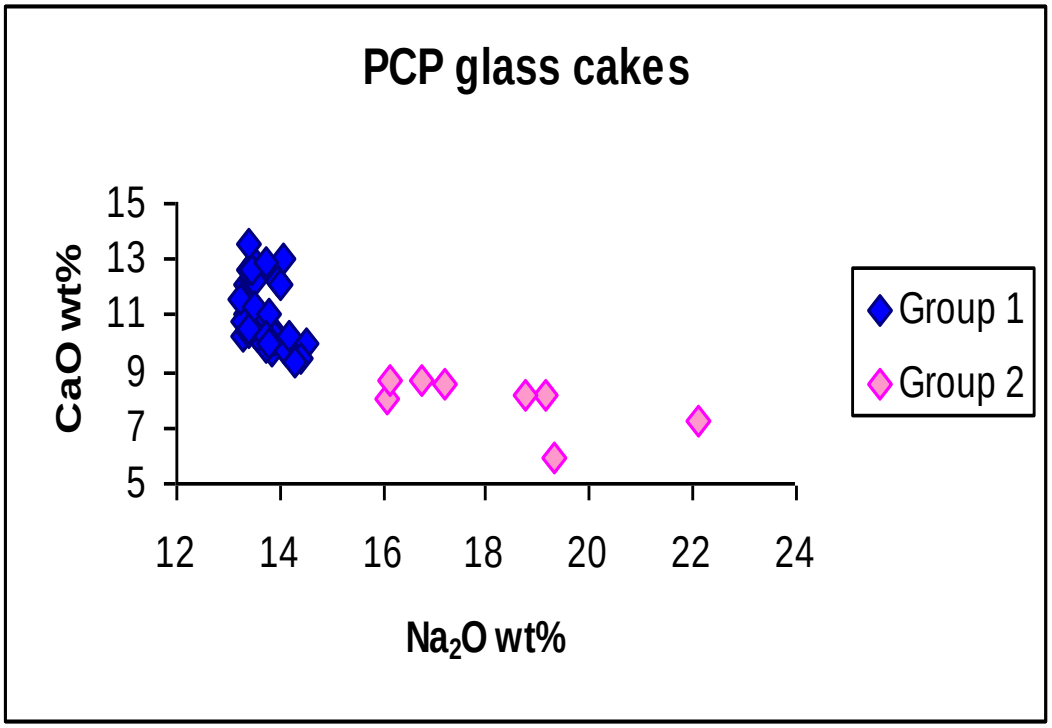
block diameter 3 cm

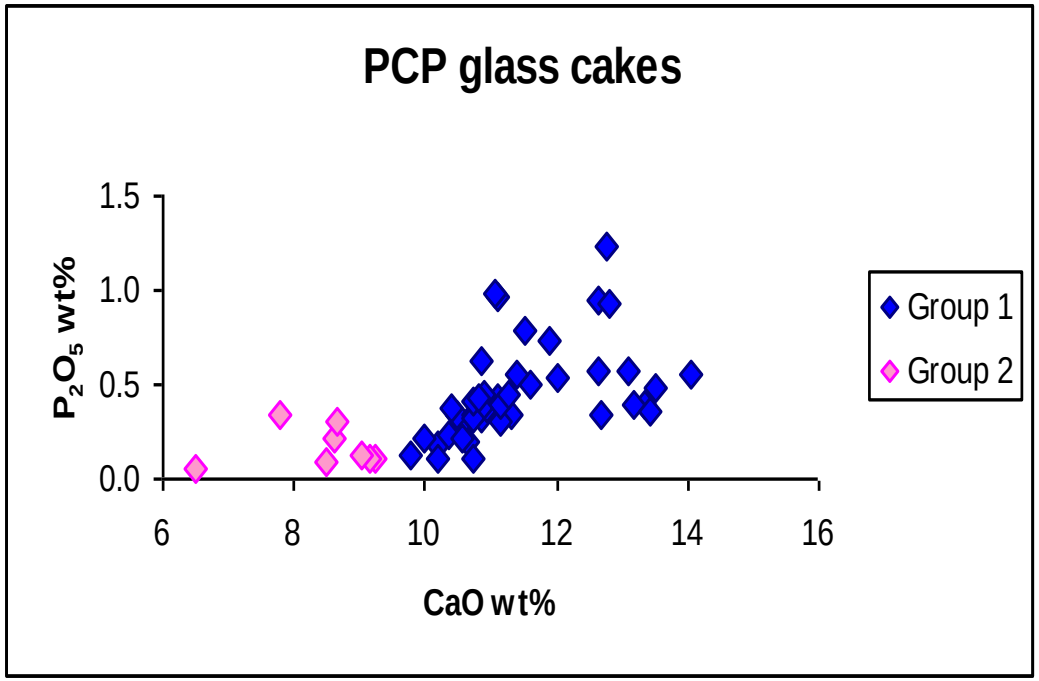
	PCP96-004	Elements	SiO2	Na2O	CaO	P2O5	K2O	MgO	Al2O3	Fe2O3	TiO2	MnO	Sb2O5	CuO	CoO	PbO	ZnO	SnO2	SO3	Cl	BaO	Cr2O3	As2O5	Total
	purple area																							
44	29/Jul/05	Wt. (%)	63.6	13.4	11.4	0.68	0.81	0.78	3.17	0.56	0.11	1.54	0.01	0.04	0.02	0.00	0.01	0.00	0.03	0.73	0.01	0.00	0.00	96.9
45	purple area	Wt. (%)	64.2	13.4	11.5	0.67	0.80	0.58	3.44	0.60	0.10	1.53	0.00	0.03	0.03	0.00	0.00	0.00	0.06	0.76	0.02	0.00	0.01	97.8
46	purple area	Wt. (%)	64.2	13.4	11.7	0.45	0.81	0.82	3.46	0.58	0.09	1.11	0.00	0.00	0.02	0.00	0.03	0.00	0.05	0.80	0.09	0.00	0.00	97.5
47	purple area	Wt. (%)	64.2	13.3	11.7	0.40	0.82	0.77	3.39	0.59	0.12	1.04	0.00	0.03	0.00	0.00	0.00	0.01	0.03	0.78	0.01	0.02	0.00	97.2
48	purple area	Wt. (%)	64.4	13.5	11.7	0.45	0.82	0.71	3.21	0.57	0.10	1.17	0.00	0.03	0.01	0.00	0.08	0.00	0.05	0.75	0.05	0.00	0.00	97.6
49	purple area	Wt. (%)	64.2	13.3	11.6	0.59	0.82	0.53	3.42	0.58	0.12	1.30	0.00	0.00	0.00	0.01	0.01	0.01	0.07	0.78	0.08	0.01	0.00	97.4
50	purple area	Wt. (%)	64.1	13.5	12.1	0.36	0.85	0.74	3.39	0.65	0.11	0.49	0.02	0.00	0.00	0.00	0.00	0.00	0.02	0.75	0.06	0.00	0.00	97.1
51	purple area	Wt. (%)	63.7	13.6	12.2	0.38	0.82	0.84	3.53	0.63	0.12	0.48	0.04	0.03	0.00	0.07	0.00	0.00	0.06	0.79	0.05	0.00	0.00	97.3
52	purple area	Wt. (%)	63.3	12.8	13.9	0.48	0.77	0.80	3.37	0.60	0.11	0.66	0.02	0.00	0.03	0.00	0.00	0.00	0.05	0.71	0.03	0.00	0.00	97.6
53	purple area	Wt. (%)	63.3	13.2	12.2	0.57	0.80	0.79	3.35	0.63	0.11	1.49	0.00	0.06	0.00	0.03	0.00	0.00	0.06	0.76	0.07	0.04	0.00	97.5
54	green area	Wt. (%)	62.2	13.8	13.0	0.47	0.71	1.12	3.74	0.78	0.15	0.64	0.00	0.08	0.00	0.17	0.00	0.02	0.01	0.72	0.02	0.00	0.00	97.6
55	green area	Wt. (%)	62.3	13.4	13.0	0.56	0.72	1.05	3.73	0.79	0.15	0.75	0.00	0.00	0.00	0.17	0.01	0.04	0.01	0.66	0.04	0.01	0.00	97.3
56	green area	Wt. (%)	62.7	14.0	12.9	0.21	0.67	1.11	3.80	0.81	0.13	0.16	0.00	0.00	0.02	0.03	0.00	0.00	0.02	0.78	0.05	0.02	0.00	97.5
57	green area	Wt. (%)	62.4	13.7	13.1	0.48	0.68	0.79	3.86	0.81	0.14	0.43	0.00	0.03	0.00	0.10	0.05	0.00	0.04	0.77	0.02	0.01	0.00	97.4
58	green area	Wt. (%)	62.8	13.5	12.5	0.58	0.79	0.96	3.68	0.75	0.12	1.14	0.00	0.01	0.03	0.10	0.00	0.01	0.01	0.73	0.07	0.04	0.00	97.8
59	green area	Wt. (%)	62.6	13.9	13.0	0.36	0.71	1.04	3.65	0.77	0.12	0.35	0.04	0.01	0.00	0.04	0.04	0.03	0.04	0.76	0.03	0.05	0.00	97.6
60	green area	Wt. (%)	62.6	13.5	12.8	0.63	0.69	0.98	3.60	0.79	0.13	0.84	0.00	0.07	0.00	0.14	0.00	0.00	0.06	0.69	0.03	0.00	0.00	97.5
61	green area	Wt. (%)	63.3	13.1	12.3	0.61	0.88	0.66	3.63	0.67	0.12	1.29	0.03	0.03	0.02	0.23	0.02	0.01	0.03	0.68	0.06	0.00	0.00	97.7
62	purple area	Wt. (%)	64.4	13.2	11.8	0.41	0.86	0.75	3.55	0.61	0.09	1.02	0.05	0.01	0.00	0.00	0.04	0.00	0.02	0.80	0.00	0.00	0.00	97.5
63	purple area	Wt. (%)	63.6	13.0	13.1	0.49	0.79	0.70	3.21	0.52	0.07	1.21	0.00	0.07	0.00	0.11	0.00	0.00	0.07	0.70	0.03	0.02	0.00	97.7
64	purple area	Wt. (%)	63.7	12.6	12.0	0.59	0.77	0.80	3.42	0.55	0.09	1.81	0.04	0.05	0.00	0.04	0.00	0.01	0.03	0.72	0.08	0.00	0.00	97.3
74	purple area	Wt. (%)	64.0	13.3	11.5	0.51	0.82	0.64	3.47	0.64	0.09	1.30	0.13	0.03	0.02	0.03	0.05	0.00	0.05	0.75	0.05	0.01	0.00	97.4
75	purple area	Wt. (%)	64.5	13.5	11.4	0.48	0.70	0.69	3.43	0.65	0.10	1.07	0.00	0.00	0.00	0.03	0.04	0.01	0.07	0.75	0.05	0.00	0.00	97.5
76	purple area	Wt. (%)	64.5	13.4	11.4	0.47	0.84	0.57	3.31	0.60	0.08	1.60	0.00	0.00	0.02	0.05	0.00	0.00	0.03	0.75	0.06	0.00	0.00	97.7
77	purple area	Wt. (%)	64.1	13.0	11.5	0.55	0.82	0.65	3.43	0.65	0.10	1.45	0.11	0.01	0.00	0.01	0.00	0.00	0.03	0.77	0.03	0.01	0.00	97.3
78	purple area	Wt. (%)	64.6	13.6	11.6	0.70	0.79	0.77	3.44	0.62	0.12	1.18	0.00	0.02	0.03	0.00	0.02	0.00	0.05	0.76	0.05	0.00	0.00	98.4
79	green area	Wt. (%)	63.6	13.1	11.9	0.35	0.78	0.85	3.62	0.71	0.11	0.33	0.02	0.05	0.02	0.07	0.00	0.00	0.07	0.81	0.09	0.03	0.00	96.5
80	green area	Wt. (%)	63.4	13.9	12.4	0.31	0.74	0.67	3.49	0.64	0.13	0.24	0.03	0.00	0.00	0.07	0.02	0.02	0.00	0.78	0.01	0.04	0.00	96.9
81	green area	Wt. (%)	62.7	12.3	15.7	0.34	0.68	0.75	3.23	0.59	0.08	0.33	0.00	0.01	0.02	0.03	0.02	0.01	0.02	0.64	0.05	0.02	0.00	97.4
82	green area	Wt. (%)	64.1	13.8	12.2	0.32	0.76	0.86	3.42	0.59	0.11	0.39	0.00	0.02	0.00	0.04	0.00	0.00	0.02	0.83	0.05	0.01	0.00	97.5
83	green area	Wt. (%)	64.0	13.8	11.9	0.37	0.76	0.81	3.36	0.61	0.10	0.47	0.00	0.03	0.00	0.03	0.00	0.00	0.07	0.70	0.04	0.02	0.00	97.0
89	purple area	Wt. (%)	64.1	13.3	12.1	0.46	0.72	0.77	3.44	0.65	0.11	0.60	0.02	0.00	0.00	0.05	0.00	0.00	0.04	0.76	0.02	0.00	0.00	97.2

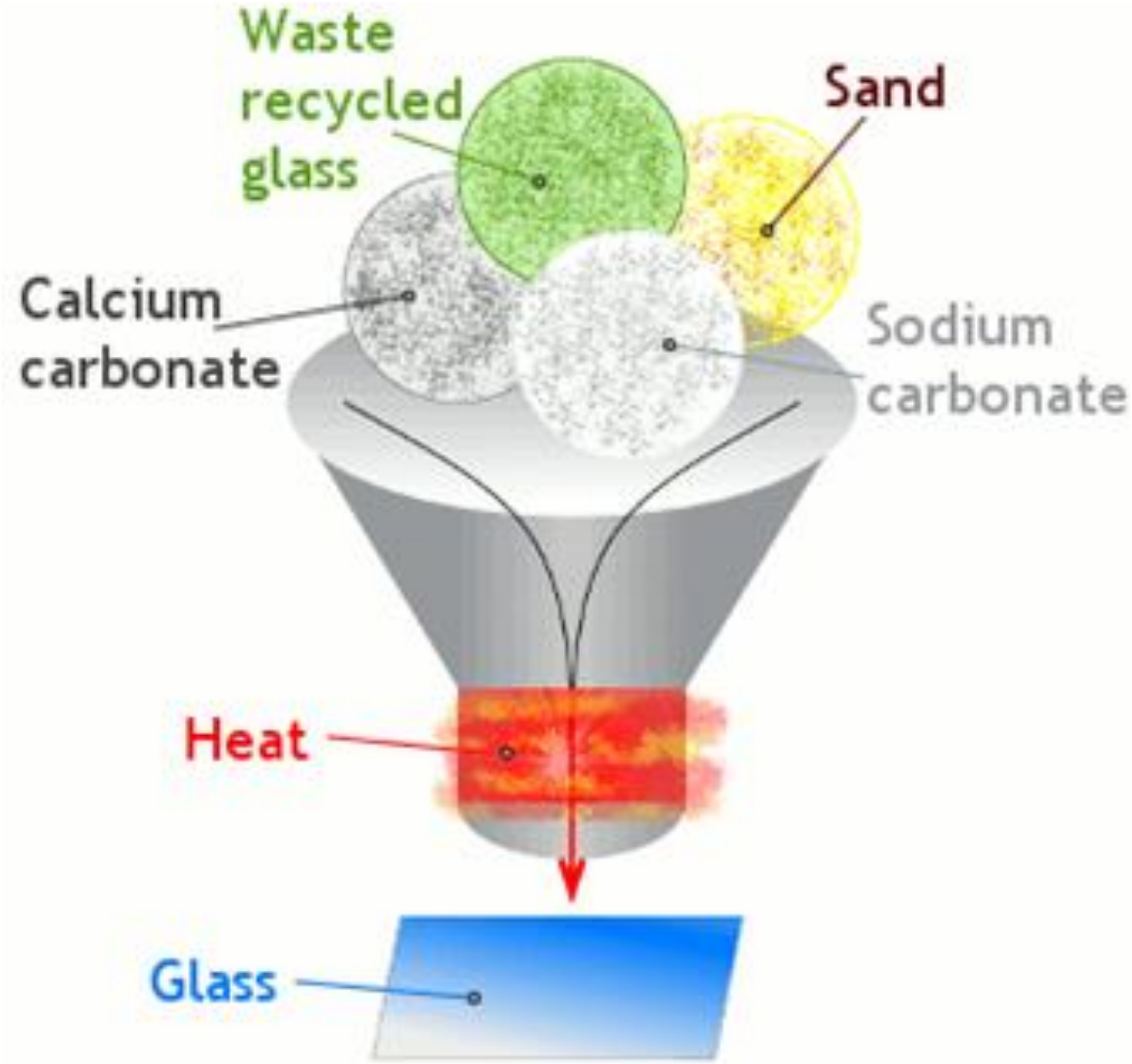
Petra Church glass cakes

glass cakes	SiO_2*	Na_2O*	CaO*	K_2O*	MgO*	Al_2O_3*	Fe_2O_3*	P_2O_5	TiO_2	MnO	SO_3	Cl
	wt%	wt%	wt%	wt%	wt%	wt%	wt%	wt%	wt%	wt%	wt%	wt%
Group 1	70.1	13.7	10.9	0.82	0.67	3.19	0.57	0.46	0.09	0.7	0.1	0.8
STDEV	1.14	0.31	1.09	0.11	0.08	0.16	0.11	0.25	0.0	0.4	0.0	0.1
Group 2	68.9	18.2	7.93	1.01	0.87	2.35	0.73	0.17	0.11	0.5	0.2	1.0
STDEV	2.15	2.06	0.91	0.31	0.45	0.49	0.33	0.11	0.0	0.5	0.1	0.2

Oxides with (*) are reduced and normalised to 100%


PCP glass cakes
CaO wt%
15
13
11
9
7
5
12
14
16
18
20
22
24
Na2O wt%
Group 1
Group 2


PCP glass cakes
P2O5 wt%
1.5
1.0
0.5
0.0
6
8
10
12
14
16
CaO wt%
Group 1
Group 2



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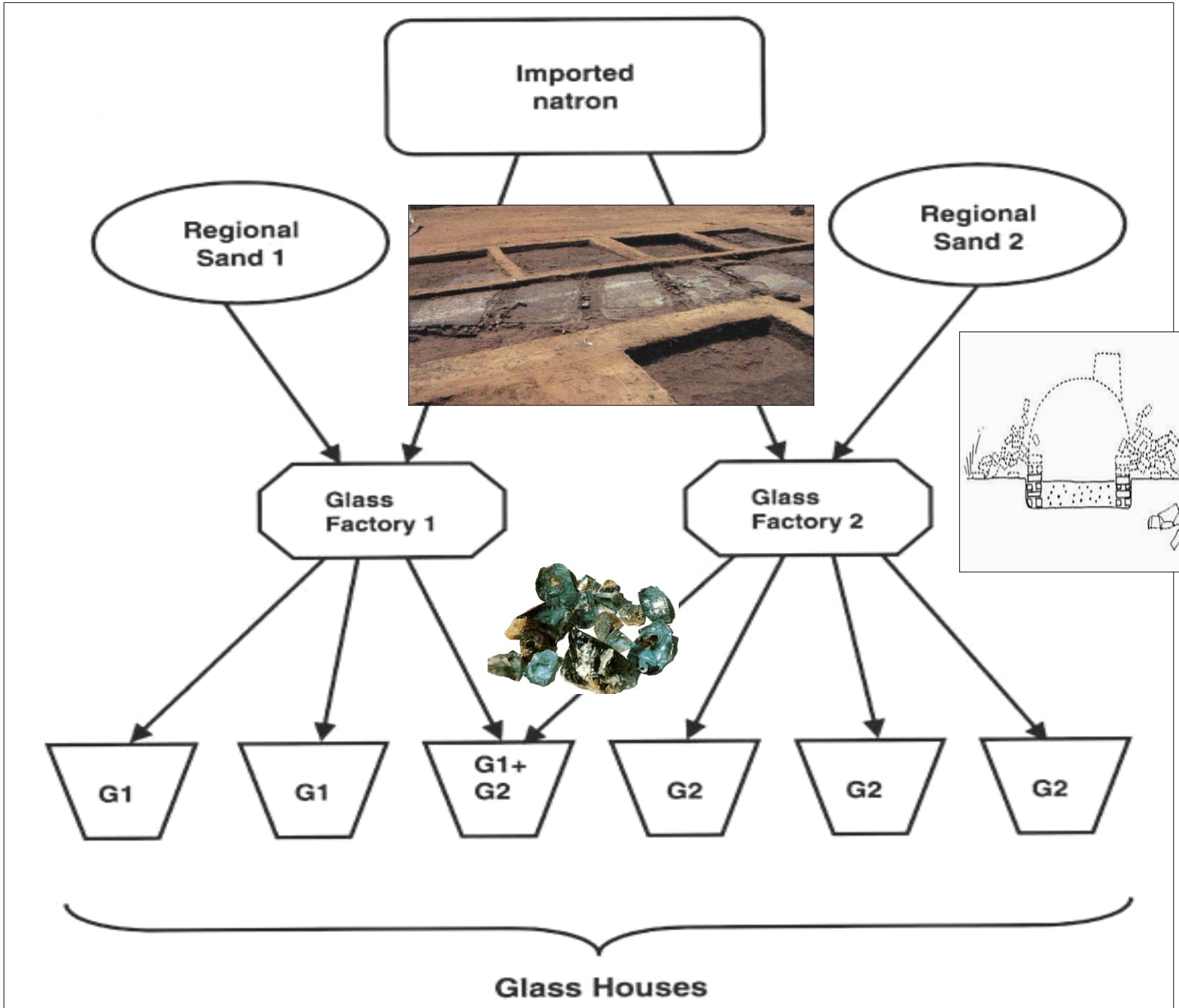

Imported natron
Regional Sand 1
Regional Sand 2
Glass Factory 1
Glass Factory 2
G1
G1
G1+ G2
G2
G2
G2
Glass Houses

Imported Natron

Sand 1 (Egypt)?

Sand 2 (Belus River)

cullet

Transparent supports gold

Transparent 2 Group

Cakes 2 Group

Transparent 1 Group

Tesserae

Recycling ?

blue

grey and purple

green and Yellow

Recycling ?

Cakes 1 Group

ROMAN

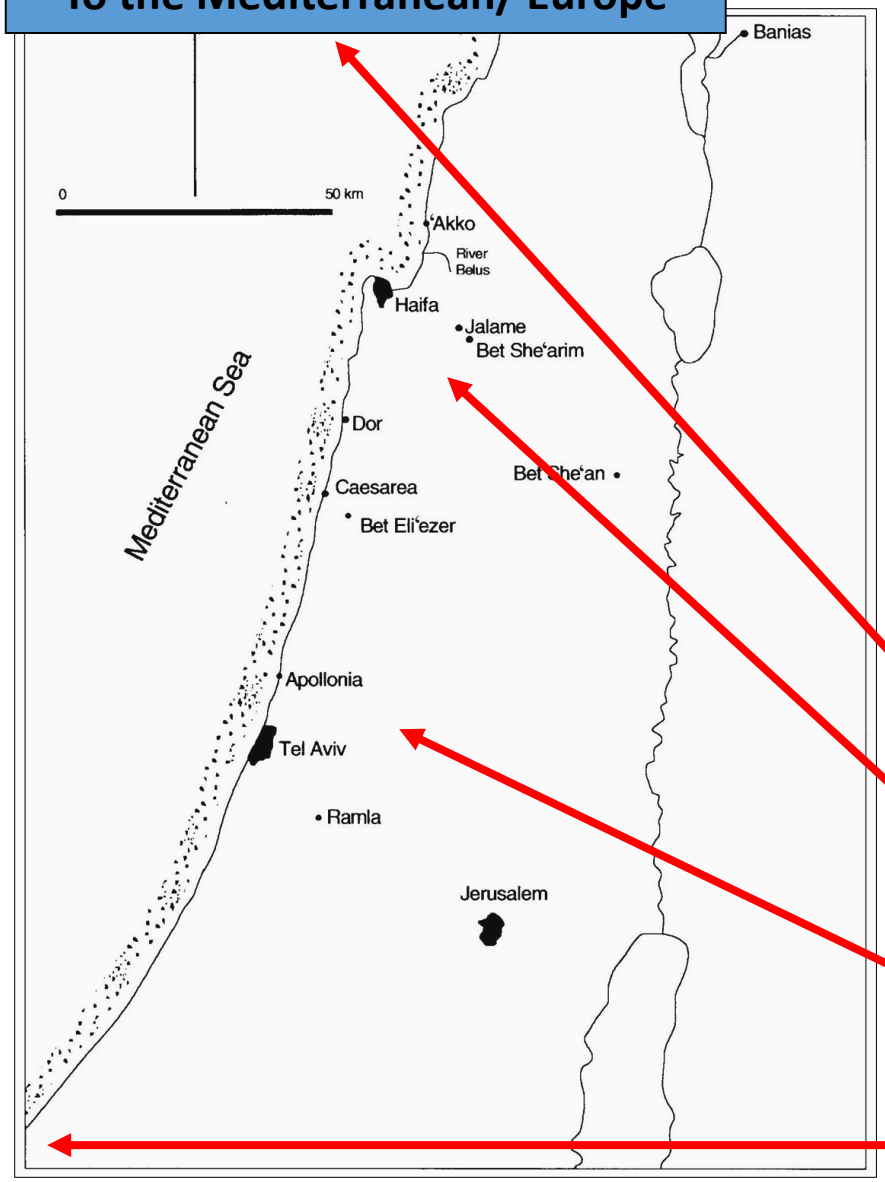
1st - 4th centuries AD

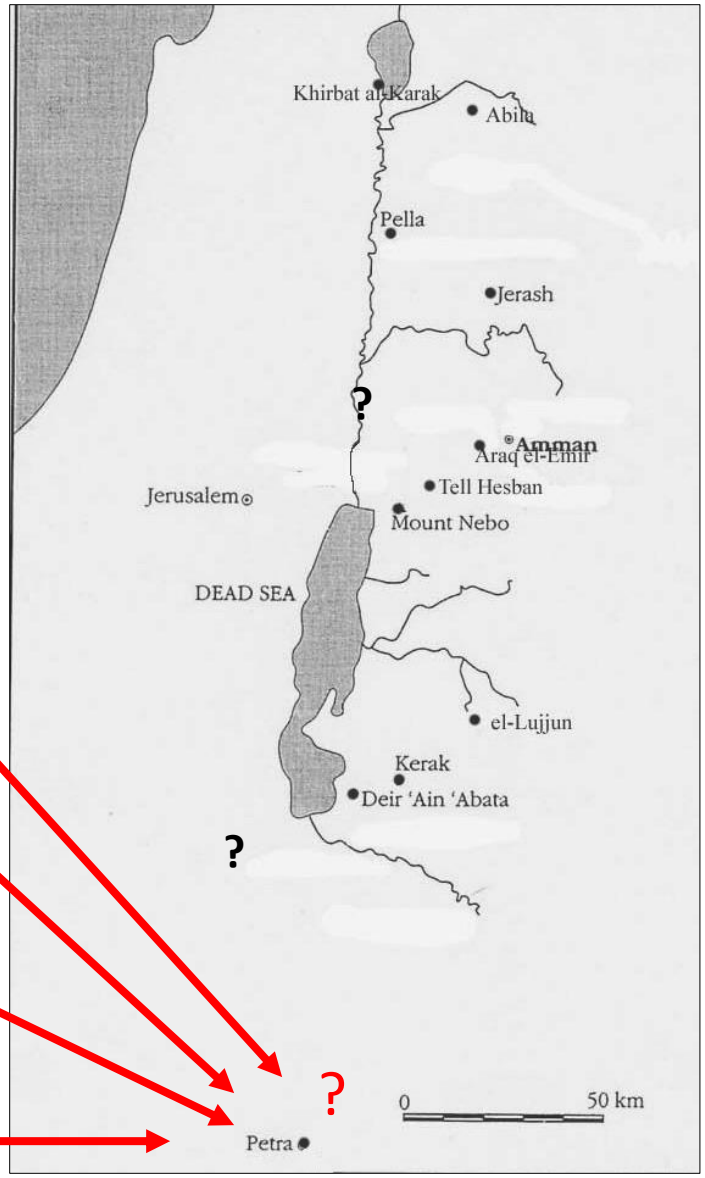
LEVANTINE I

5th – 6th centuries AD

Glass products trade routes

To the Mediterranean/ Europe





Conclusions

- Documentation of the glass cakes from Petra Church

- Identifying the chemical composition of these glass collections:
  - The producing and making of this collection
  - The possible trade routes
  - The Techniques of recycling broken glass artifacts

Celebrating the world of glass

On May 18, 2021, the United Nations General Assembly formally approved a resolution declaring the year **2022** as the **International Year of Glass** to celebrate the heritage and importance of this material in our lives.

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  - **Ian Freestone**

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Thank
You