FALSE COLOUR INFRARED IMAGING AS A TOOL FOR THE STUDY OF PIGMENTS USED IN CERAMICS FROM AREAS WITHIN THE MEDITERRANEAN BASIN

A. Alexopoulou[1], N. Liaros[2], D. Panagopoulou[1], A. Kaminari[1]

[1]Department of Conservation of Works of Art and Antiquities, TEI – A, Ag. Spiridonos 12, Egaleo 12210, Athens, Greece, e-mail: athfrt@teiath.gr
[2]Centre for the Study of Modern Pottery – G. Psaropoulos Foundation, Melidoni 4-6, Kerameikos 10553, Athens, Greece, e-mail: ex.machina2@yahoo.gr

The aim of this research

The aim of this research was the physicochemical study of the pigments and the construction technique used in post-Byzantine and contemporary ceramics decoration. The 23 shards analysed, from the collection of the Centre for the Study of Modern Pottery (G. Psaropoulos Foundation in Athens), are indicative of the ceramics that exist in Greece from the sixteenth-early twentieth century A.D. The shards represent the sgraffito ware of Greece and Italy during the sixteenth century as well as the artifacts from the pottery centres of Asia Minor (Iznik, Kütahya, Çanak Kale) and Majiolica ware from central and south Italy.

Introduction

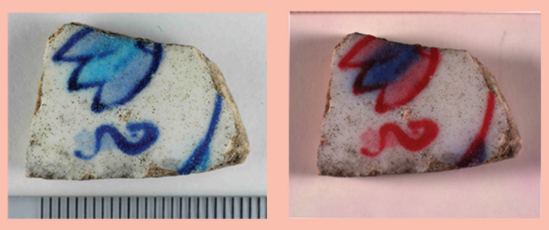
The pigments that can be used in a pottery glaze (as under and over glazed colours) are very few due to the high temperatures of firing. Generally. only a few metal oxides are useful as pigments. The colours that these oxides produce in pure form are also well known. For this reason little analytical research has been done on the colours of post - Byzantine and contemporary Mediterranean pottery. Accordingly, there is little knowledge of the specific techniques used in those ceramics and particularly the combination of various oxides, glazes and other materials used to create more sophisticated colours. It is known that yellows were usually produced from iron oxides, but analysis has shown antimony oxide in certain shards.

A new methodology

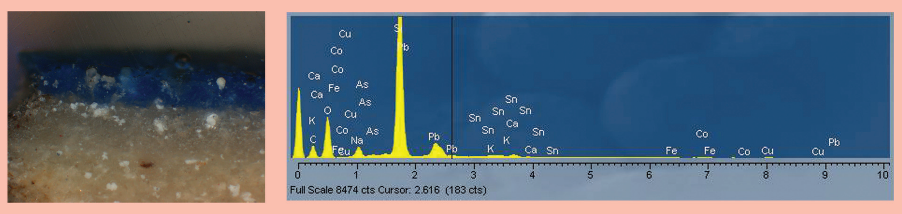
A new methodology, in the study of ceramics, was applied based on multispectral imaging system MU.S.I.S HS for the infrared false colour (FCIR) recording of the surface of the ceramic. The x, y, z tristimulus values, derived from initial R, G, B measurements, have been calculated according to CIE XYZ colour space functions, using the appropriate software, in order to have an initial assessment of the chemical composition of the pigments used. The internal layer structure was examined using cross-sections and SEM analysis, as necessary.

Experimental results

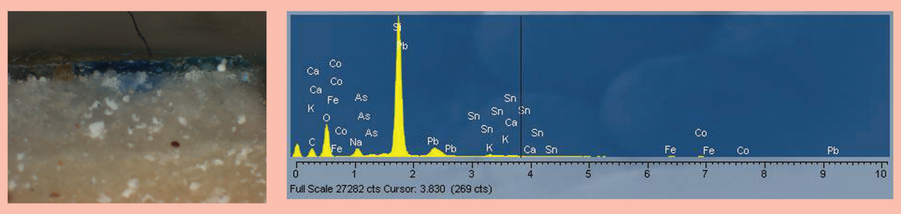
Copper oxides ''Green or Blue''?, depended on the environment.



Blue shades; the use of infrared to distinguish blues from Copper or Cobalt oxide.



OEKK20Δ41

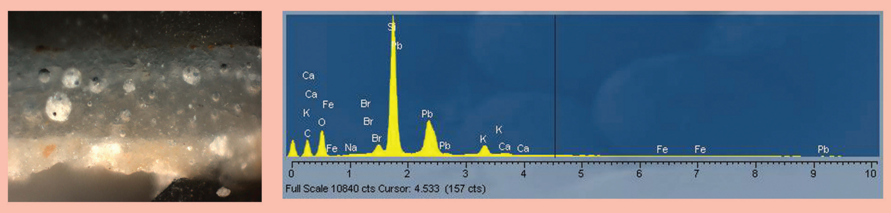


OEKK20Δ42

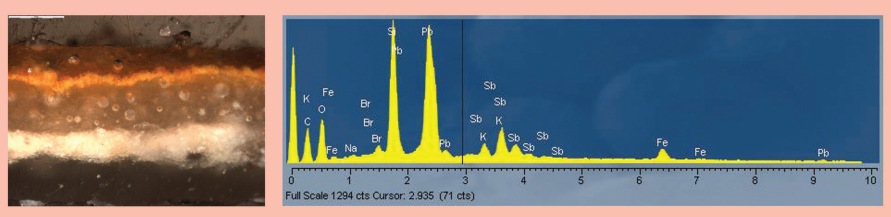
The results also showed that blue shades from an Iznik shard register as bright red false colours (characteristic of cobalt oxides) can be distinguished from blue-turquoise shades which are recorded as blue false colours, indicating copper oxides mixed with other oxides alkaline glaze.

Sophisticated combination of oxides in order to produce special colours.

Cobalt oxides; a powerful pigment.



OBKK8Δ21

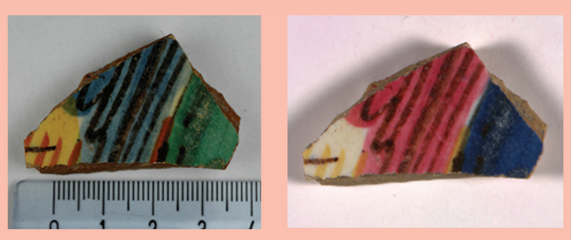


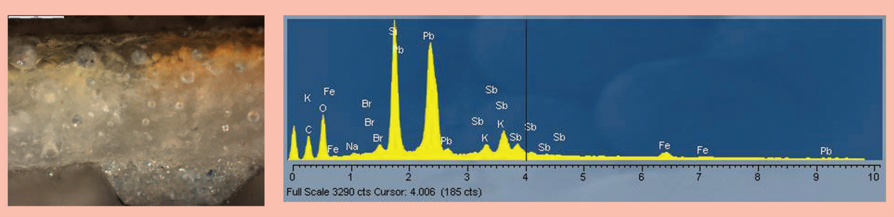
OBKK8Δ23

Cobalt oxide produces a characteristic blue, easily identified and confirmed through infrared. Although SEM analysis does not trace it at all. The reason for this is possibly that cobalt oxide is a ''powerful'' pigment ever very small quantities are enough to produce colour but too few to trace them through SEM.

Orange, can be produced from iron-rich slips, but analysis of an orange pigment on a c. sixteenth-century shard from Italy shows a combination of iron oxide with antimony oxide, a sophisticated technique to produce a bright orange colour.

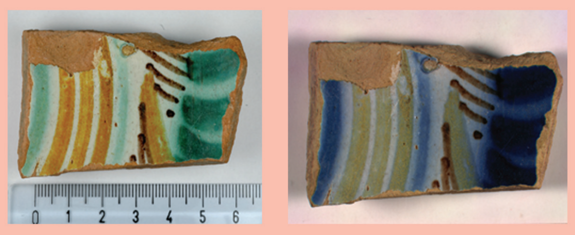
Yellow; from common iron or from rare antimony?





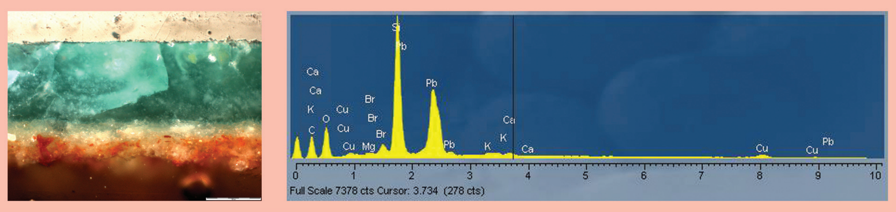
OBKK7Δ16

Yellow and yellow-orange colours were recorded as yellow-green false colour shades, characteristic of iron oxides; whereas the yellow tone coming from antimony oxide is transparent in the infrared. The used of a rarer element and a more sophisticated colour production indicates specialised ceramics manufacture and may be used to indentify pottery groups and find the connections and differences between them.



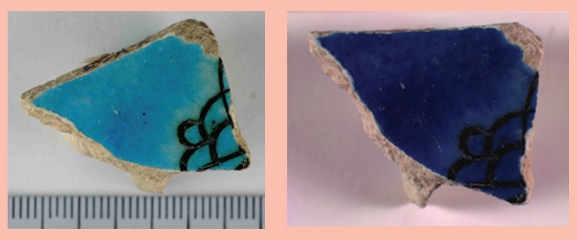
The diffusion of Copper oxides.

OBKK6Δ14

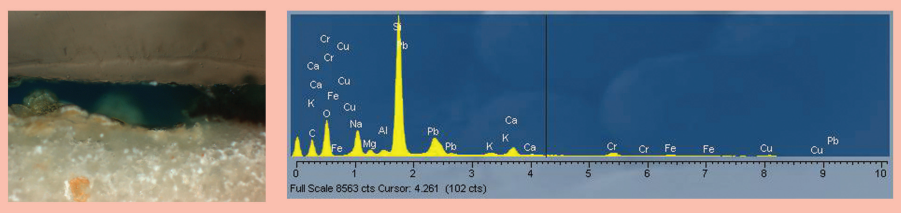


Copper oxides produce a bright green colour in lead glazes. Copper oxide has also great diffusion such as to colorize the whole glaze as shown at photo.

Use of Chromium pigments before Chromium discovery?



OZKK23Δ47



The analysis of the black pigment from a Kütahya or Persian 'black on blue' nineteenth-century shard revealed the used of chromium oxide with copper and iron oxides. Chromium as pigment was considered to be in use from the twentieth century and on; its presence here and on older ceramics requires reconsideration of old perceptions.

EXPERIMENTAL RESULTS OF COLOUR MEASUREMENTES AND SEM ANALYSIS

x	y	z	GROUP	SHARD'S CODE	SAMPLE'S CODE	TRUE COLOUR	FALSE COLOUR INFRARED	CHEMICAL ANALYSIS
0,26905545	0,273727564	0,457216989	A	KK1	Δ1	GREEN	BLUE	**Si, Pb**, Al, **Ca, Cu**
0,26741094	0,264601964	0,4679871	E	KK20	Δ41	TURQUOISE	BLUE	**Si, Pb, Sn, Ca, Fe, Co, Cu**
0,29592209	0,306837321	0,397240585	A	KK3	Δ6	GREEN	BLUE	**Si, Pb, Al, Ca, K, Cu, Fe, Mg**
0,29233034	0,3150546	0,392615062	A	KK4	Δ8	GREEN	BLUE	
0,28793264	0,304722054	0,407345305	A	KK5	Δ9	GREEN	BLUE	Si, Pb, Al, K, Ca, Mg, Fe, Cu
0,29171115	0,306633341	0,401655506	B	KK8	Δ19	GREEN	BLUE	**Si, Pb, K, Al, Ca, Fe, Cu, Na**
0,2933275	0,305058266	0,401614239	B	KK11	Δ28	GREEN	BLUE	
0,28256871	0,292205561	0,425225728	A	KK2	Δ5	GREEN	BLUE	
0,2839605	0,290686743	0,42535276	B	KK6	Δ14	GREEN	BLUE	**Si, Pb, Al, Ca, K, Mg, Cu**
0,27533085	0,285705151	0,438963999	B	KK9	Δ26	GREEN	BLUE	Si, Pb, Al, K, Fe, Nα, Cu
0,2825707	0,295137934	0,422291368	D	KK19		LIGH.GREEN	LIGH.BLUE	
0,24779799	0,230857728	0,521344279	Z	KK23	Δ48	GREENBLUE	BLUE	**Si, Na, Pb, Ca, K, Cu, Fe**
0,31425971	0,321506838	0,364233453	Z	KK23	Δ47	DARK BLUE	DAR.BLUE	**Si, Pb,** Na, **Ca,** Mg, **K,** Fe, **Cu,** Cr
0,31376228	0,33547874	0,350758984	D	KK19	Δ40	DAR.GREEN	DAR.BLUE	**Si, Pb, Al, K, Ca, Cu**
0,2740611	0,285517183	0,440421714	B	KK7	Δ17	GREEN	BLUE	**Si, Pb, K, Al, Ca, Nα, Fe, Cu**
0,3860176	0,317069548	0,296912853	B	KK7	Δ18	BLUE	RED	Si, Pb, As, Ca, Fe, Na, K
0,37334148	0,319344512	0,307314004	B	KK9	Δ24	LIGH.BLUE	PINK	
0,38284808	0,314826777	0,302325141	C	KK12		LIGH.BLUE	RED	
0,38886231	0,326459528	0,284678158	C	KK13	Δ30	BLUE	RED	**Si, Pb, K, Al, Nα,** Mg
0,35552987	0,320368712	0,32410142	B	KK8	Δ21	LIGH.BLUE	PINK	**Si, Pb, K, Al, Ca, Nα,** Fe
0,34948306	0,324393613	0,326123327	C	KK14	Δ32	LIGH.BLUE	PINK	**Si, Pb, Al, Ca, K,** Mg, Na
0,35911864	0,324630202	0,316251154	C	KK15		LIGH.BLUE	PINK	
0,41892588	0,322899094	0,258175023	C	KK16		LIGH.BLUE	RED	
0,44598556	0,324955404	0,229059035	E	KK20	Δ42	BLUE	RED	**Si, Pb, Na, K,** Sn, **Ca,** Fe, Co, As
0,44501163	0,324551556	0,230436818	Z	KK22	Δ44	BLUE	RED	**Si, Pb**, **Na, K, Ca**
0,37753178	0,327846205	0,294622014	E	KK21	Δ43	BLUE	RED	**Si, Pb, Na,** Sn, **Ca**, Fe, Co
0,36525362	0,319354006	0,315392372	E	KK20		LIGH.BLUE	PINK	
0,35376547	0,357024974	0,289209555	B	KK6	Δ13	BROWN	BROWN	Si, Pb, Br, Mg, Sn, Fe, Ca, Mn
0,32484542	0,33878979	0,336364791	B	KK8		BROWN	BROWN	
0,32958823	0,339683079	0,330728695	B	KK10		BROWN	BROWN	
0,39850059	0,360370411	0,241129003	C	KK14	Δ33	BROWN	BROWN	
0,39370132	0,362058149	0,24424053	C	KK15	Δ34	BROWN	BROWN	
0,39969543	0,355623067	0,244681503	C	KK16	Δ36	BROWN	BROWN	**Si, Pb, Al, Ca, K,** Mg
0,3944622	0,36290397	0,242633835	D	KK18	Δ39	BROWN	BROWN	
0,3949951	0,353243276	0,25176162	Z	KK22	Δ45	BROWN	BROWN	Si, Mg, Cl, Ca, K, Na
0,36257041	0,348752518	0,288677067	D	KK17	Δ38	BROWN	BROWN	**Si, Pb, Al, Mn, Ca**
0,36063093	0,336867761	0,302501308	B	KK7	Δ15	BROWN	BROWN	Si, Pb, Sb, K, Fe
0,35354032	0,365122326	0,281337356	A	KK5	Δ10	BROWN	OCHRE	**Si, Pb, Al, Fe,** K, **Mg,** Na
0,3426598	0,368668635	0,288671561	B	KK6	Δ12	YELL.OGHRE	LIGH.OCHRE	**Si, Pb, Al, Fe, Mg, Ti**
0,36507345	0,374923499	0,260003052	B	KK8	Δ23	DAR.OCHRE	LIGH.OCHRE	Si, Pb, K, Al, Ca, Nα, Fe
0,36137783	0,371916557	0,26670561	C	KK15		OCHRE	YELL.OCHRE	
0,36063046	0,36740088	0,271968659	D	KK17	Δ37	OCHRE	LIGH.OCHRE	
0,34117476	0,357860914	0,300964328	B	KK8	Δ22	OCHRE	YELL.OCHRE	
0,34221453	0,347998842	0,309786626	C	KK13	Δ31	OCHRE	LIGH.OCHRE	
0,34582198	0,353111357	0,301066664	Z	KK22	Δ46	OCHRE	LIGH.OCHRE	Si, Ca, K, Mg, Na, S, Cl, Fe
0,34876598	0,389804301	0,261429716	B	KK9	Δ25	OCHRE	LIGH.OCHRE	Si, Ca, Al, P, Fe, Mg, Pb, Nα, Cl, Ti, Mn
0,35426005	0,372104732	0,273635214	C	KK12	Δ29	OCHRE	LIGH.OCHRE	**Pb, Si, Al,** Nα, **Fe**
0,33336896	0,35251093	0,314120112	A	KK1	Δ3	OCHRE	YELLOW	
0,3524086	0,372211158	0,275380245	B	KK7	Δ16	OCHRE	YELLOW	**Si, Pb, Al, K, Ca,** Fe, Nα, **Mg**
0,34597265	0,367425912	0,286601441	A	KK3	Δ7	OCHRE	YELLOW	**Si, Al,** K, **Pb,** Na, **Ti, Fe (oxi Ca)**

The conclusion

The main aim has been to create a new methodology applied to the analysis of colours and glazes in pottery, by combining different non-destructive techniques to obtain better results. We have started to create a database of specific colours and the paraments that affect the final result. Further research is planned on a wider range of samples.