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Scientific Analysis of Ancient Mural Pigments

(Focus on Mural Pigments at Daeungjeon Hall of Bongjeongsa Temple and
Ancient Tomb in Goadong)

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趙南哲

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(1)
(2)
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(1)
(2)
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(1)
(2)
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色土粉 水飛 泥彩 ([1]). 色岩石 岩彩
가 가

([2]).

1963 『

』

([3]). 1989 John Winter 『

』 1990 『 X

X , 3

([4~7]). 가

(2×2mm)

가 , 가 X

가 (

[8~11]).

(1)

鳳停寺 2 (682) 가 , (

55) 가 가 .

1962 .

1997 1 15

(가 399cm, 350cm)가

가

7가

(2)

(高靈古衙洞壁畫古墳, 165) 가

10

가 25m, 20m

가

4

X

(1)

X (Field X - ray fluorescence

analyzer : FXRF, Seiko Instruments Inc., SEA200)

50kV, 200 μ A 2mm Collimator

X (Energy Dispersive X - Ray Micro - Fluorescence Analyzer :

EDXRF, Kevex, OMICRON) 25kV

35kV, 0.25mA 0.04mA 300 μ m Collimator 가 勵

起

(2)

MCA(Multi Channel Analyzer) X
 (Micro - area X - ray diffraction system : MXRD, MAC Science, MXP18VA)
 X Target Cu , 30kV,
 100mA 100 μ m Collimator . 1000 ,
 (peak matching)

X
 (FXRF) ,
 X (EDXRF) X (MXRD)
 . 1 2 .
 (1) (1~3)



1.



2. 가



3. X

(Red Lead Pb O) (Cinnabar HgS), (Hematite Fe O)
 FXRF Pb Hg ,
 EDXRF Pb (Fig. 1, 2).
 MXRD (Pb O) (HgS)가
 (Fig. 3).

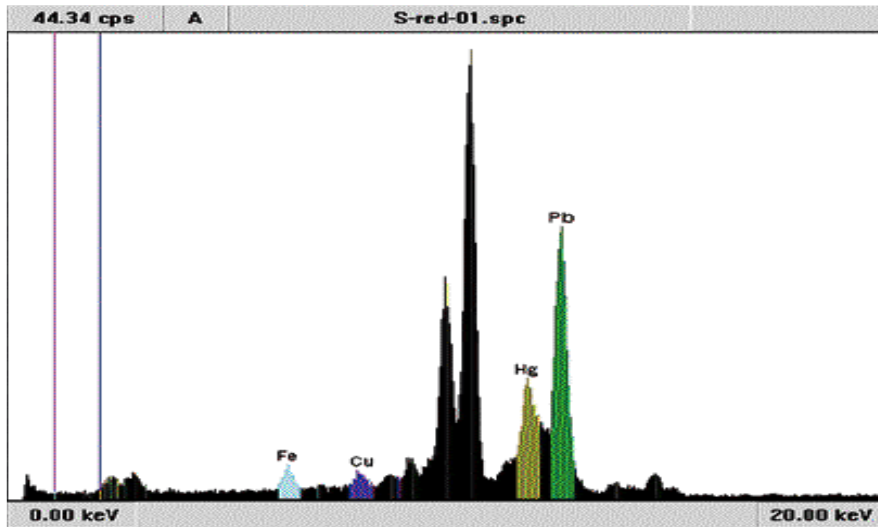


Fig. 1. FXRF : (Pb), (Hg)

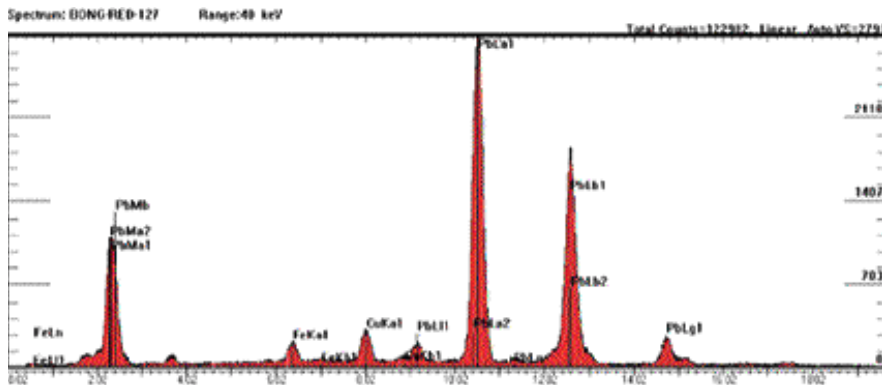


Fig. 2. EDXRF : (Pb)

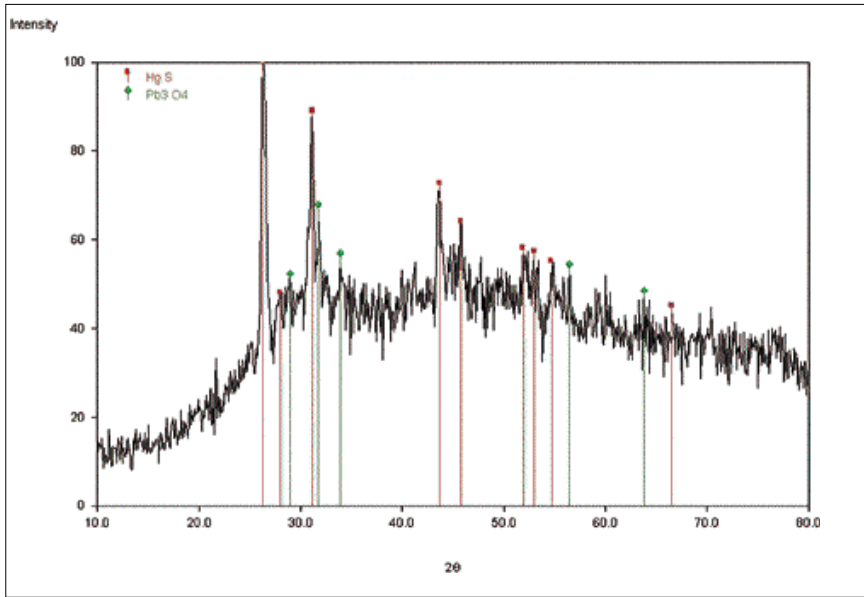


Fig. 3. MXRD : (HgS), (Pb O)

, (Calcite CaCO_3) . 7

(Titanium dioxide TiO_2) (Zinc oxide ZnO)
 ([12]).

, FXRF

Pb Fe가 (Fig. 4). MXRD
 [Lead Carbonate Hydroxide $\text{PbCO}_3 \cdot \text{Pb(OH)}_2$]

(Fig. 5). Fe

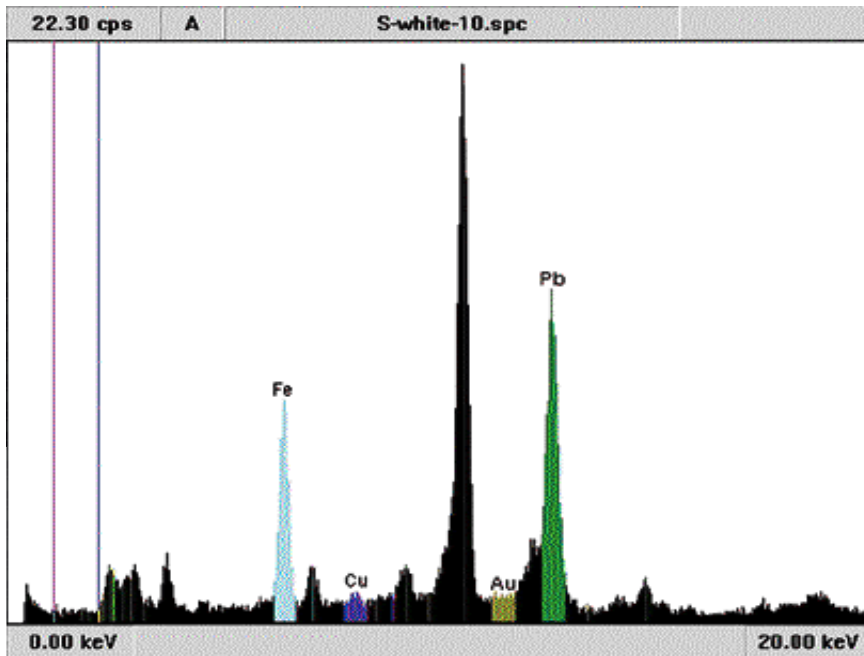


Fig. 4. FXRF : (Pb)

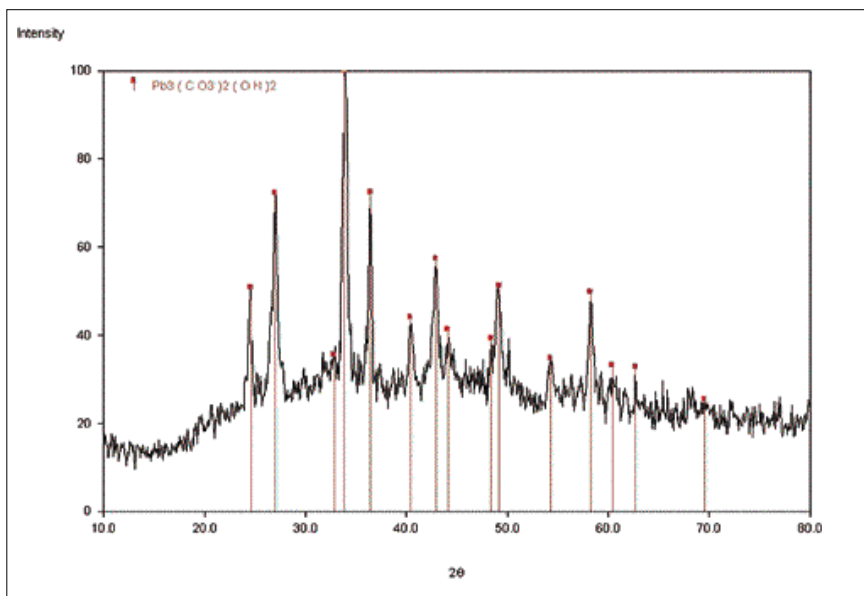


Fig. 5. MXRD : [PbCO · Pb(OH)]

Cu(OH)_2 or Atacamite $\text{CuCl} \cdot 3\text{Cu(OH)}_2$ [Paratacamite $\text{CuCl} \cdot \text{Cu(OH)}_2$]
 Cu(OH)_2 or Azulite $2\text{CuCO}_3 \cdot \text{Cu(OH)}_2$ [Malachite $\text{CuCO}_3 \cdot \text{Cu(OH)}_2$]
 $\text{K(Mg,Fe,Al)(Si,Al)}_6\text{O}_{10}(\text{OH})_2$ [Celadonite]

Cyanine green (Emerald green $\text{C}_2\text{H}_3\text{AsCuO}_6$)
 (Chrome green Cr_2O_3), Emerald green (As)

Emerald green

X-ray fluorescence (EDXRF) analysis of Cu (Fig. 6).
 EDXRF analysis of Fe, Cu, Si, K (Fig. 8). MXRD analysis of [Paratacamite $\text{CuCl} \cdot \text{Cu(OH)}_2$] and [Celadonite $\text{K(Mg,Fe,Al)(Si,Al)}_6\text{O}_{10}(\text{OH})_2$] (Fig. 7, 9).

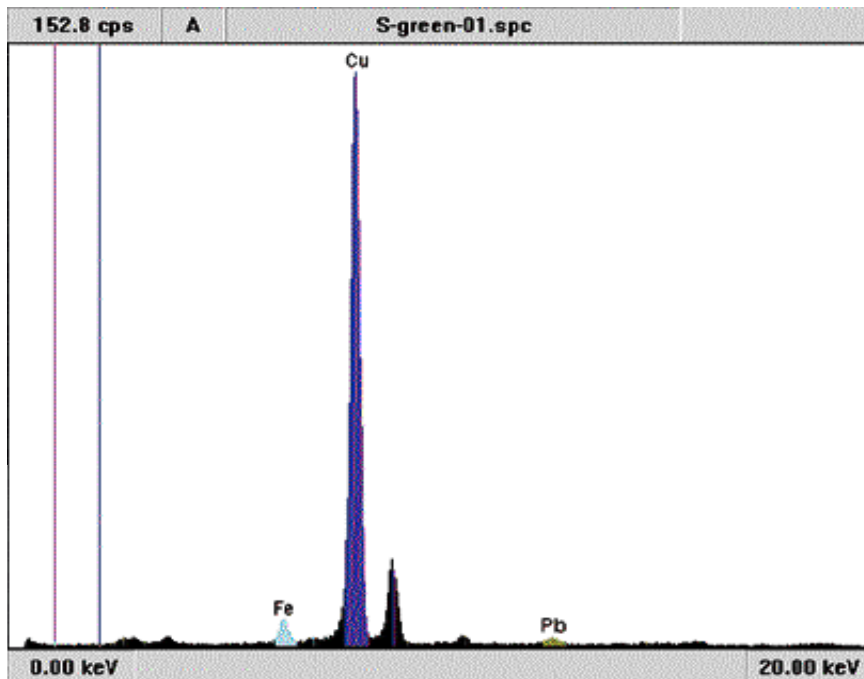


Fig. 6. EDXRF analysis of Cu ()

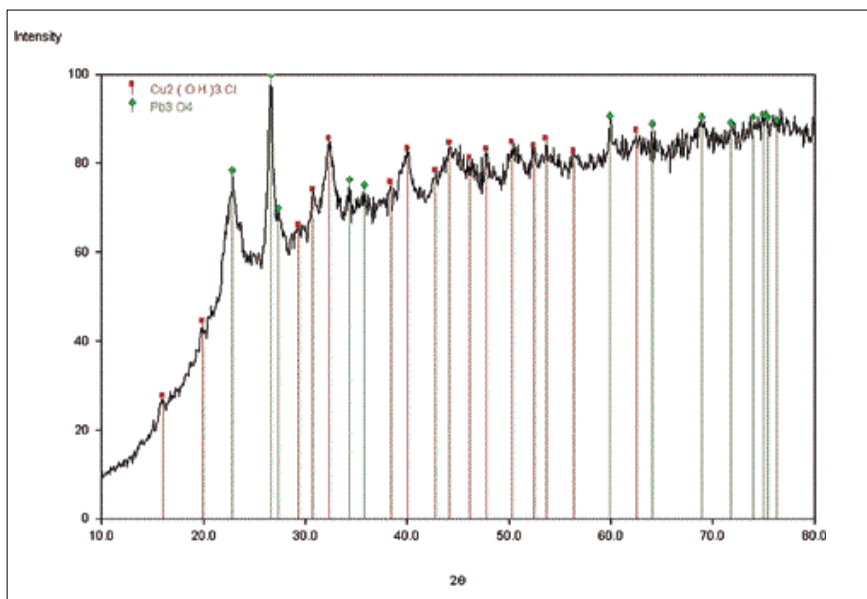


Fig. 7. MXRD : [CuCl·Cu(OH)]

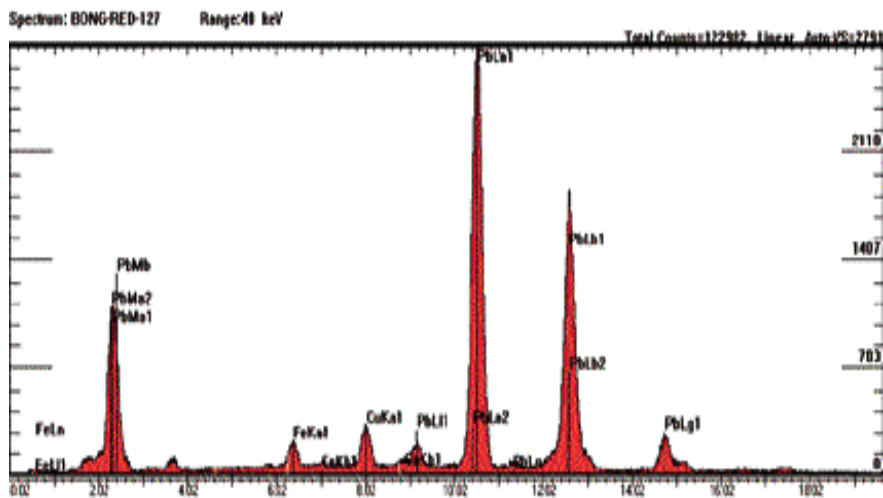


Fig. 8. FXRF : (Fe), (Si), (K), (Cu)

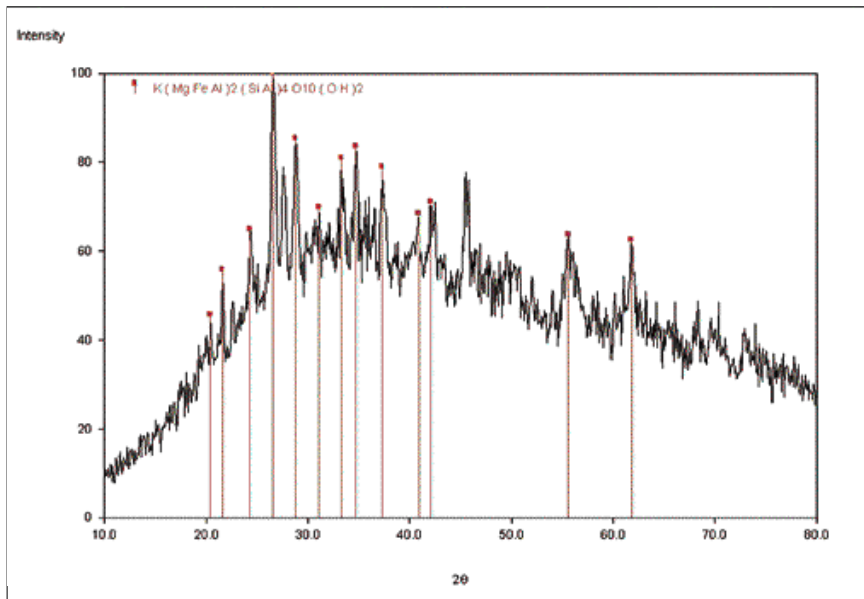


Fig. 9. MXRD : [K(Mg,Fe,Al)(Si,Al)O₁₀(OH)]

(松煙, 油煙) (Magnetite Fe O)
 ()
 FXRF Pb Fe
 Pb 가
 Pb , Fe
 (Fig. 10).
 Cu
 (Fig. 11).

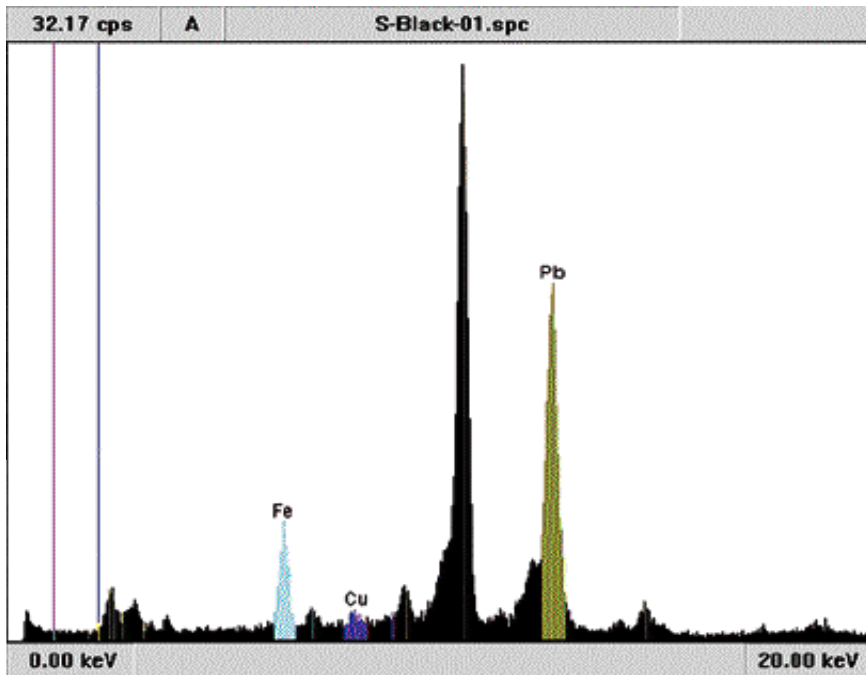


Fig. 10. FXRF : (Pb), (Fe)

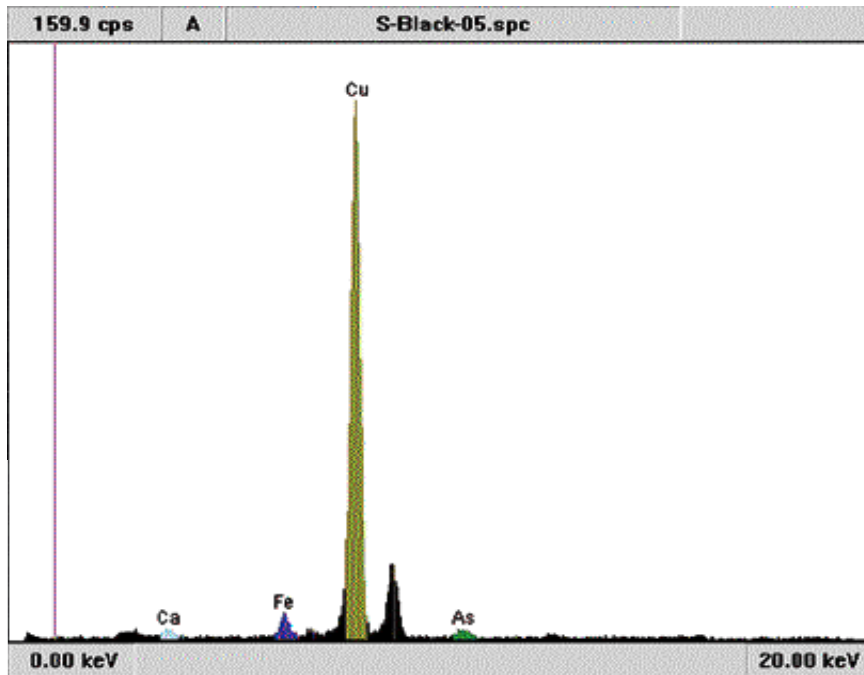


Fig. 11. : (Cu,)

Pb Au 가 가 FXRF
 Pb Au . Pb

(Fig. 12).

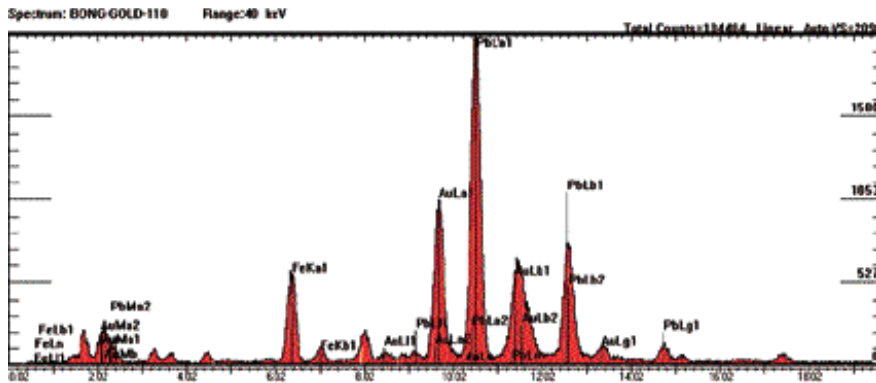


Fig. 12. EDXRF : Pb, Au

X , , 1
 Cu , Pb Hg ,
 Pb (Fig. 13~15).

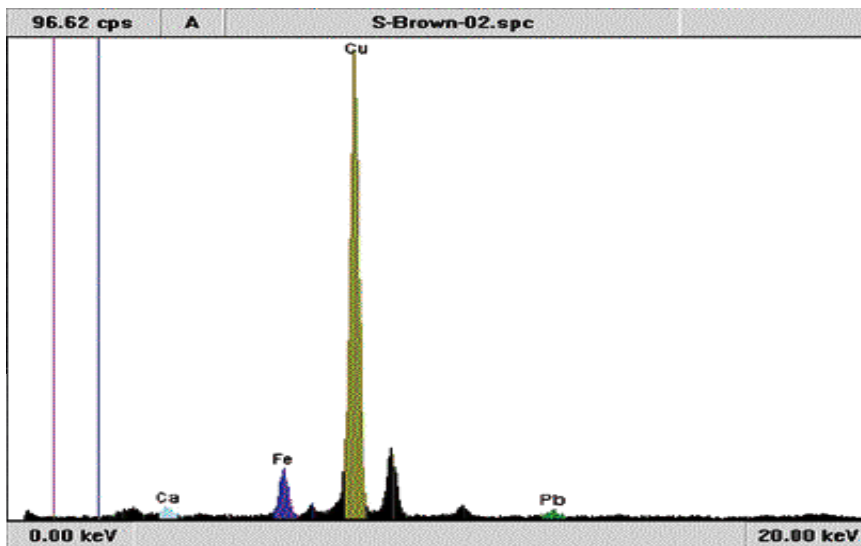


Fig. 13. FXRF : (Cu,)

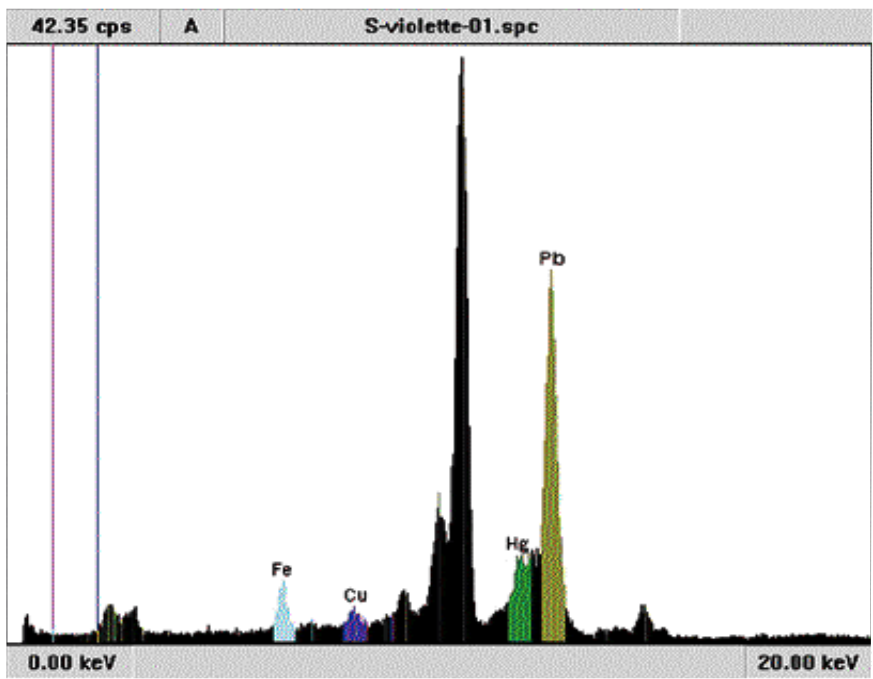


Fig. 14. FXRF : (Pb), (Hg)

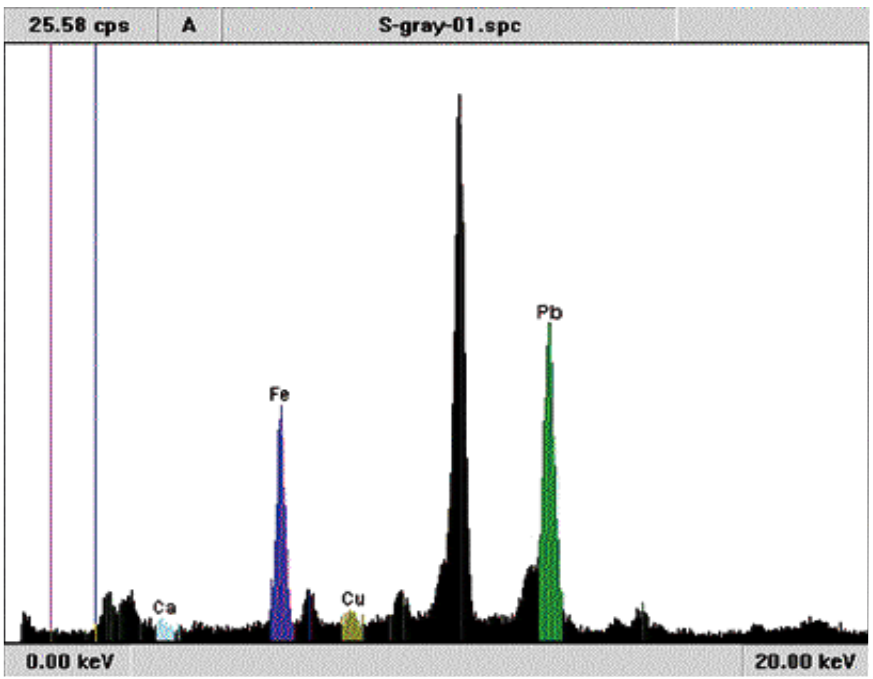


Fig. 15. FXRF : (Pb), (Fe)

1		가 ,	Pb, Hg	Red Lead(Pb O) Cinnabar(HgS)	Fig. 1~3
2		가	Pb, Fe	Lead Carbonate Hydroxide[PbCO · Pb(OH)]	Fig. 4, 5
3		가	Cu	Paratacamite [CuCl · Cu(OH)] Celadonite[K(Mg,Fe,Al) (Si,Al)O ₁₀ (OH)]	Fig. 6 - 9
4		가	Pb, Fe	(:)	Fig. 10, 11
			Cu		
5		가 , 가	Au, Pb		Fig. 12
6			Cu		Fig. 13
7			Pb, Hg		Fig. 14
8		가	Pb, Fe		Fig. 15

1.

(2)

(4~6)

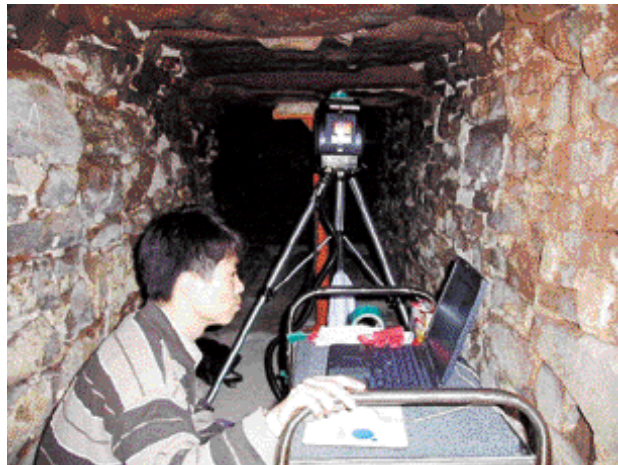


4.

()



5. ()



6. X

FXRF

Fig. 16

MXRD

Hg Fe
(Cinnabar HgS)

(Fig. 17).

18). MXRD

$O_{10}(OH)_2$

Fe가

(Fig. 18). Quartz Muscovite
(Fig. 19). Quartz Muscovite

Quartz(SiO_2)

Fe (Fig. 18)
Muscovite[$KAl_3(AlSi_3O_{10})(OH)_2$]
XRF

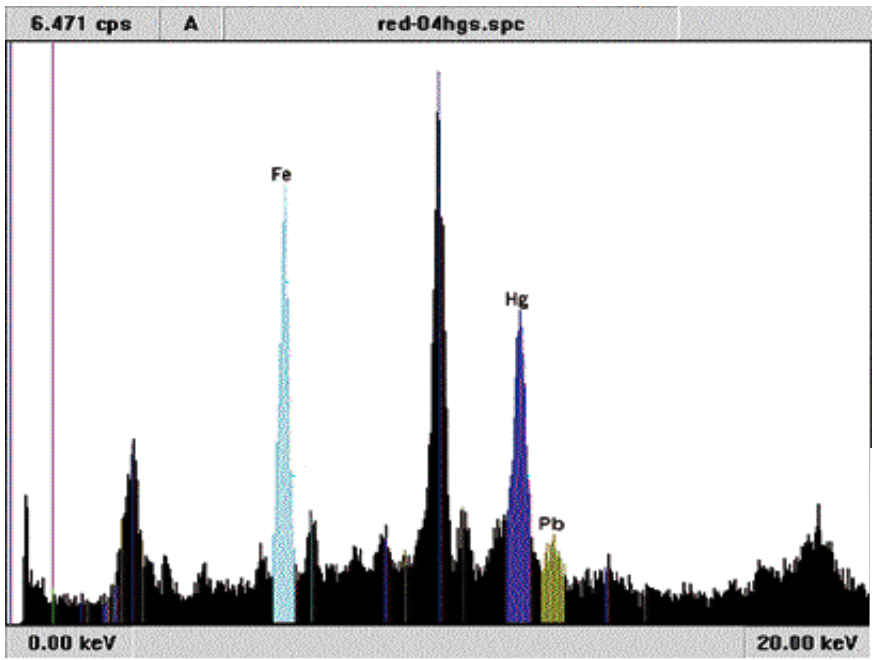


Fig. 16. FXRF : (Hg), (Fe)

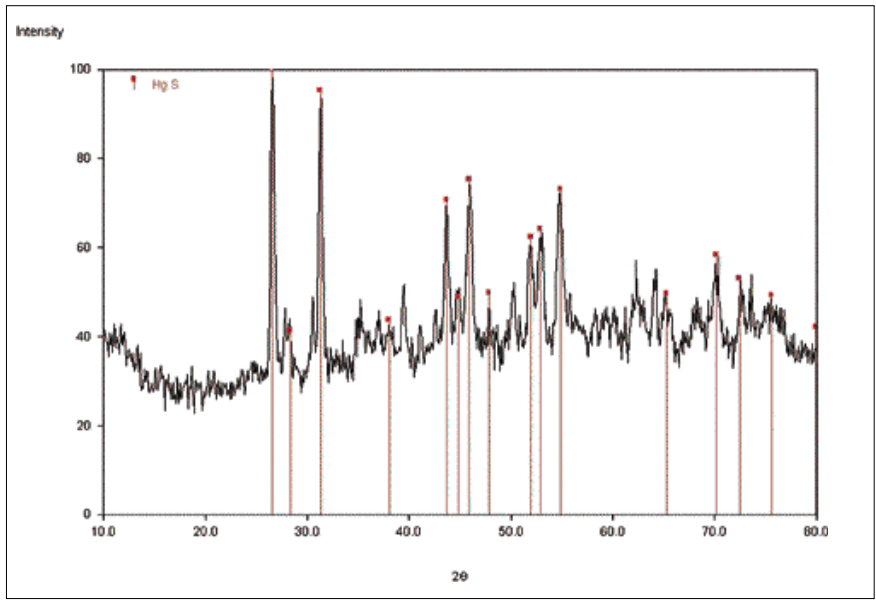


Fig. 17. MXRD : (HgS)

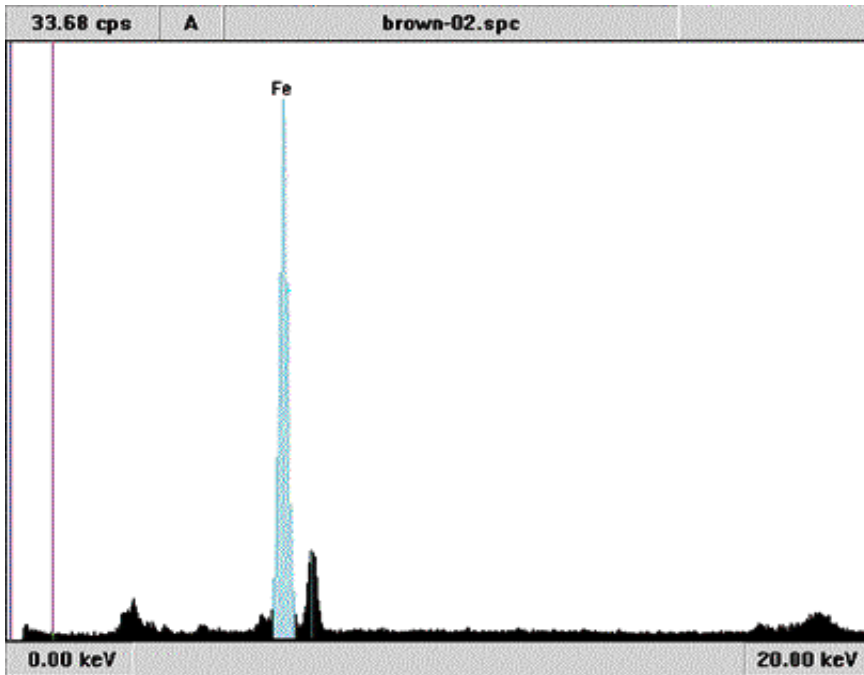


Fig. 18. FXRF : (Fe)

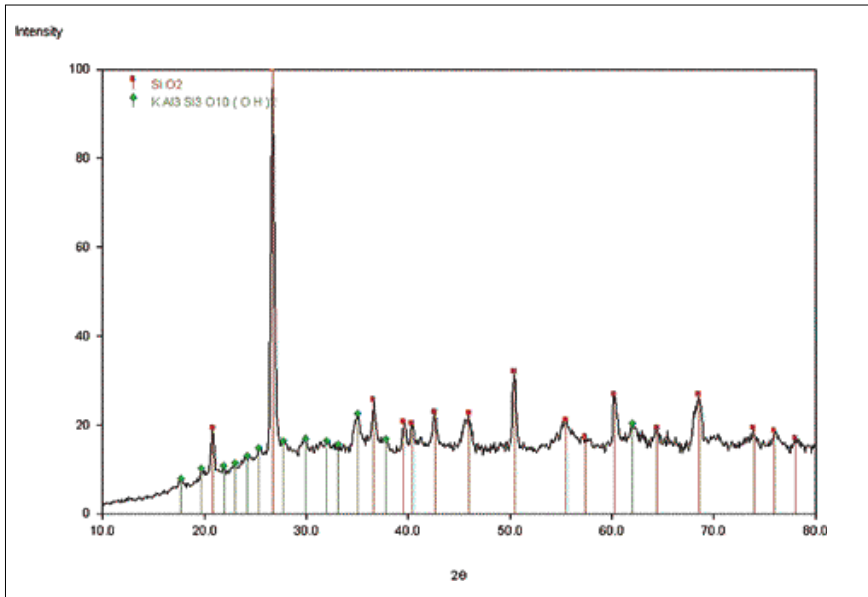


Fig. 19. MXRD : (Quartz, Muscovite)

(Fig. 20). 가 FXRF Pb ,
 Pb가 MXRD [PbCO · Pb(OH)] ,
 , MXRD (CaCO) Ca (Fig.
 21. 22). (5mm)

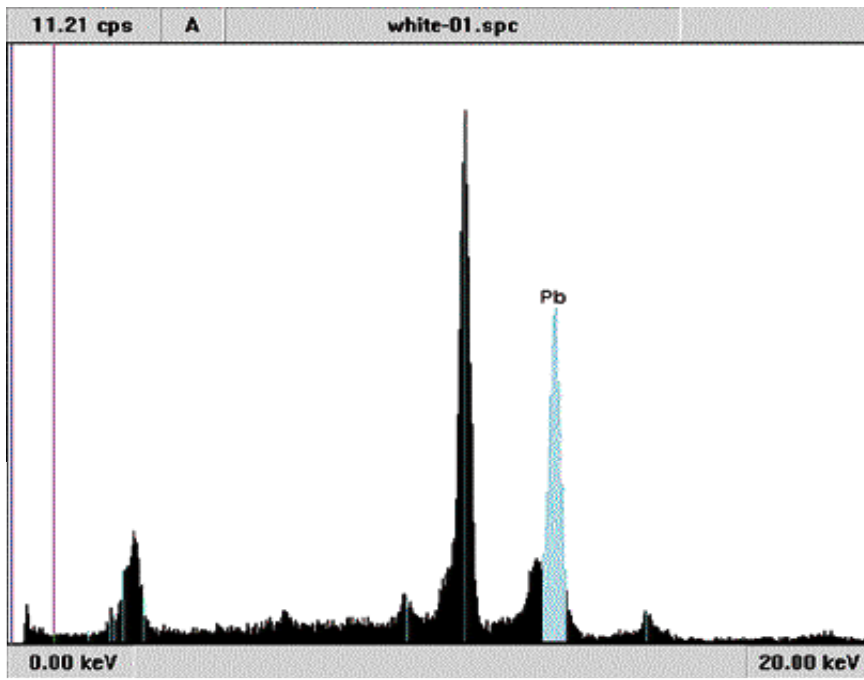


Fig 20. : (Pb)

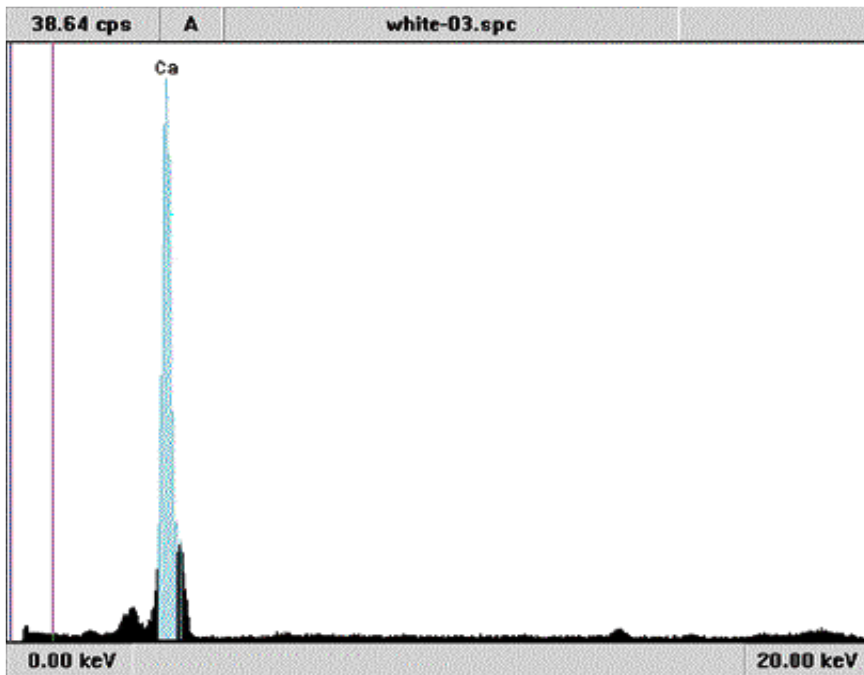


Fig. 21. : (Ca)

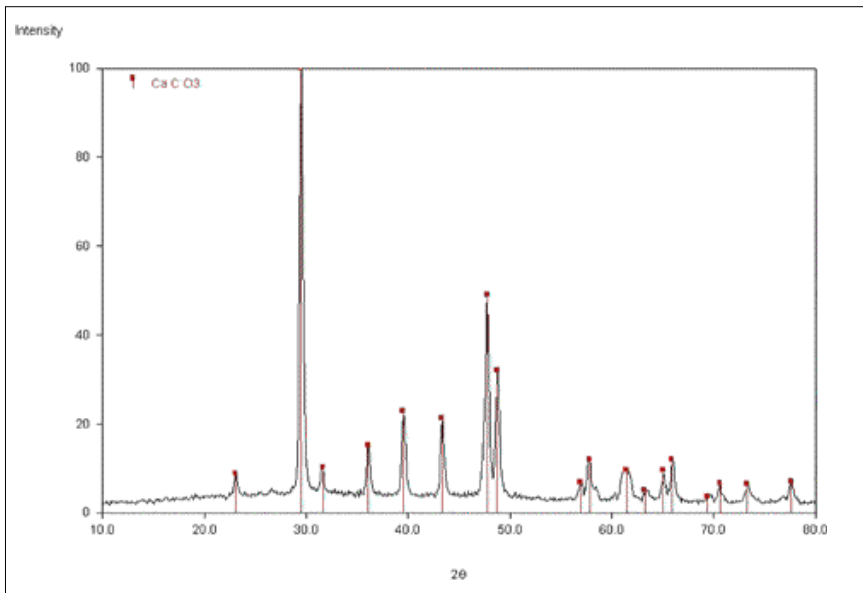


Fig. 22. MXRD : (CaCO)

(Fig. 23). 가 FXRF Cu
 MXRD .
 Cu가 [Paratacamite $\text{CuCl} \cdot \text{Cu}(\text{OH})$
 or Atacamite $\text{CuCl} \cdot 3\text{Cu}(\text{OH})$] [Malachite $\text{CuCO}_3 \cdot \text{Cu}(\text{OH})$ or
 Azulite $2\text{CuCO}_3 \cdot \text{Cu}(\text{OH})$] .

(Fig. 24). FXRF Fe
 , Fe

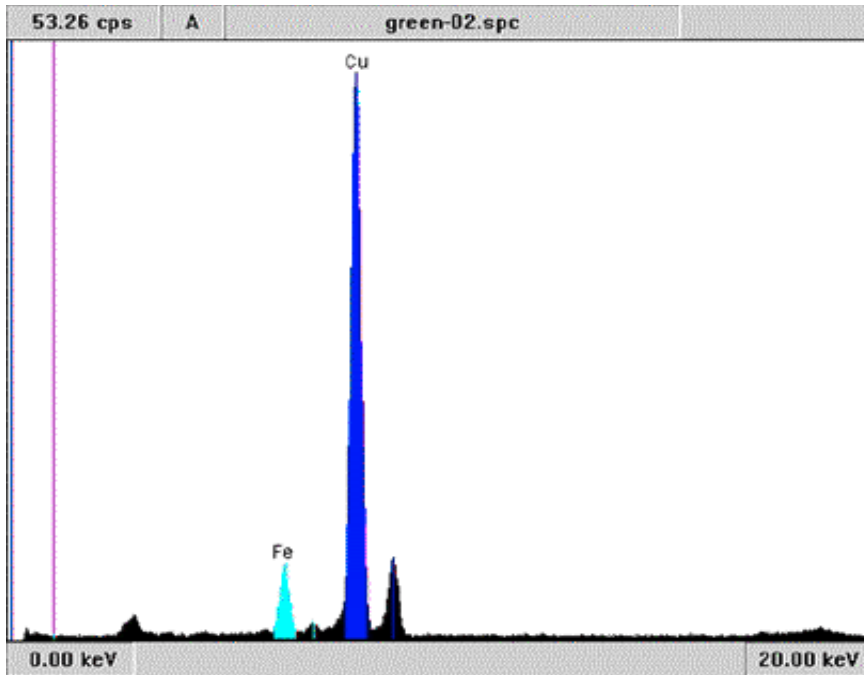


Fig. 23. : (Cu)

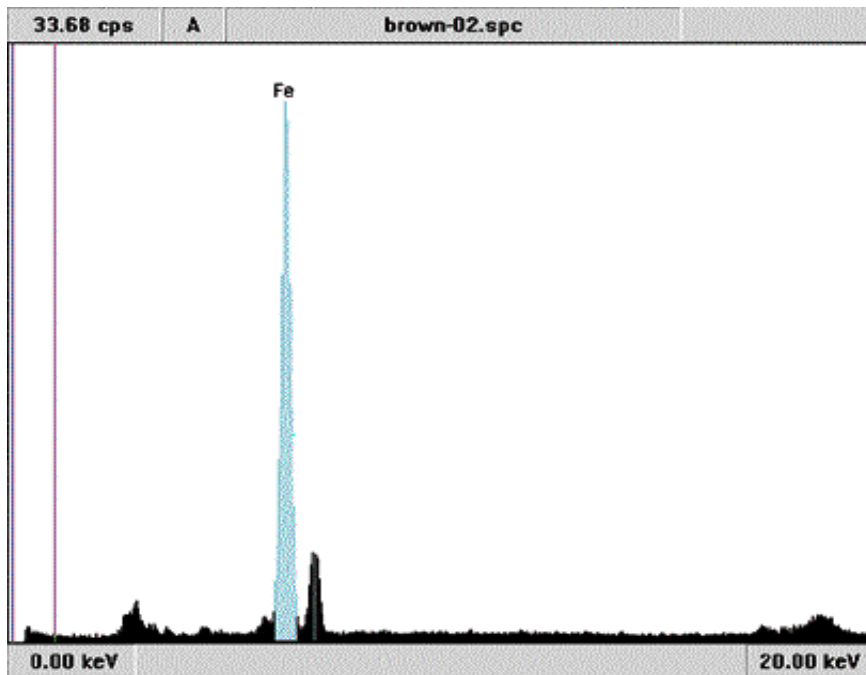


Fig. 24. : (Fe)

1			Hg	Cinnabar(HgS)	Fig. 16~19
			Fe	Quartz(SiO) Muscovite[KAl(AlSi ₃ O ₁₀)(OH)]	
2			Pb, Fe	Lead Carbonate Hydroxide [PbCO ₃ · Pb(OH) ₂]	Fig. 20~22
			Pb, Fe	Calcite(CaCO ₃)	
3			Cu		Fig. 23
7			Fe	()	Fig. 24

2.

(Cinnabar)
Hydroxide)
(Celadonite)

(Red Lead)

(Lead Carbonate
(Paratacamite or Atacamite)

가

가 , 6 가
()

가

가

< >

< >

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- [12],『』,『』,,1997,pp.106-137.

ABSTRACT

Scientific Analysis of Ancient Mural Pigments (Focus on Mural Pigments at Daeungjeon Hall of Bongjeongsa Temple and Ancient Tomb in Goadong)

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The composition analysis of mural pigments at Daeungjeon Hall of Bongjeongsa Temple (Treasure No. 55) and ancient tomb with mural pigments in Goadong (Historic site No. 165) were carried out by XRF and MXRD.

The analytical result showed that red pigments were Red Lead (PbO), Cinnabar (HgS) at Daeungjeon Hall of Bongjeongsa Temple and Cinnabar (HgS) in Goadong. The main composition identified in white pigments were Lead Carbonate Hydroxide [$\text{PbCO}_3 \cdot \text{Pb(OH)}_2$]. Green pigments were basic copper chloride [Paratacamite $\text{CuCl}_2 \cdot \text{Cu(OH)}_2$], celadonite [$\text{K(Mg,Fe,Al)}_3(\text{Si,Al)}_4\text{O}_{10}(\text{OH})_2$] at Daeungjeon Hall of Bongjeongsa Temple and were basic copper chloride or basic copper carbonate in Goadong. Therefore it proved that mural pigments painted in use the mineral materials.