MINISTERY OF MINES
MYANMAR GEMS ENTERPRISE
NAPYITAW (18th March, 2016)

RAREST OF GEMS

DR KYAW THU
MACLE GEMS TRADE LABORATORY

How to Find

How to Know

Testing at Laboratory

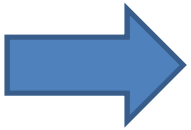
- Standard Gemmological Instruments
- Literature Review
- Website (www.mindat.org)

Unknown

Testing at International Laboratory

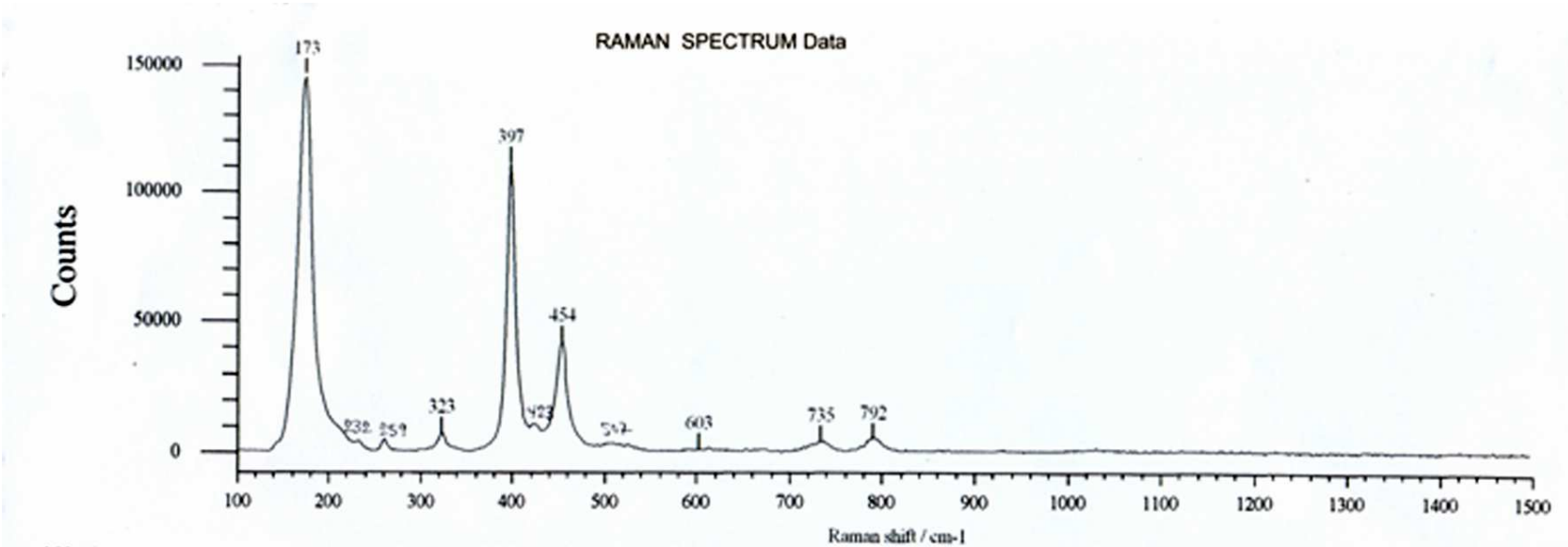
Sophisticated Methods at GIA and GIT

- Raman Spectroscopy
- LA-ICP-MS
- EDX-RF
- FTIR
- UV-VIS-NIR
- X-ray Diffraction Analysis



Unknown

RAMAN Spectrum (Table)



cquisition1
ıser: 514 nm notch
ectral range: 99.77 to 1,500.24
escription:

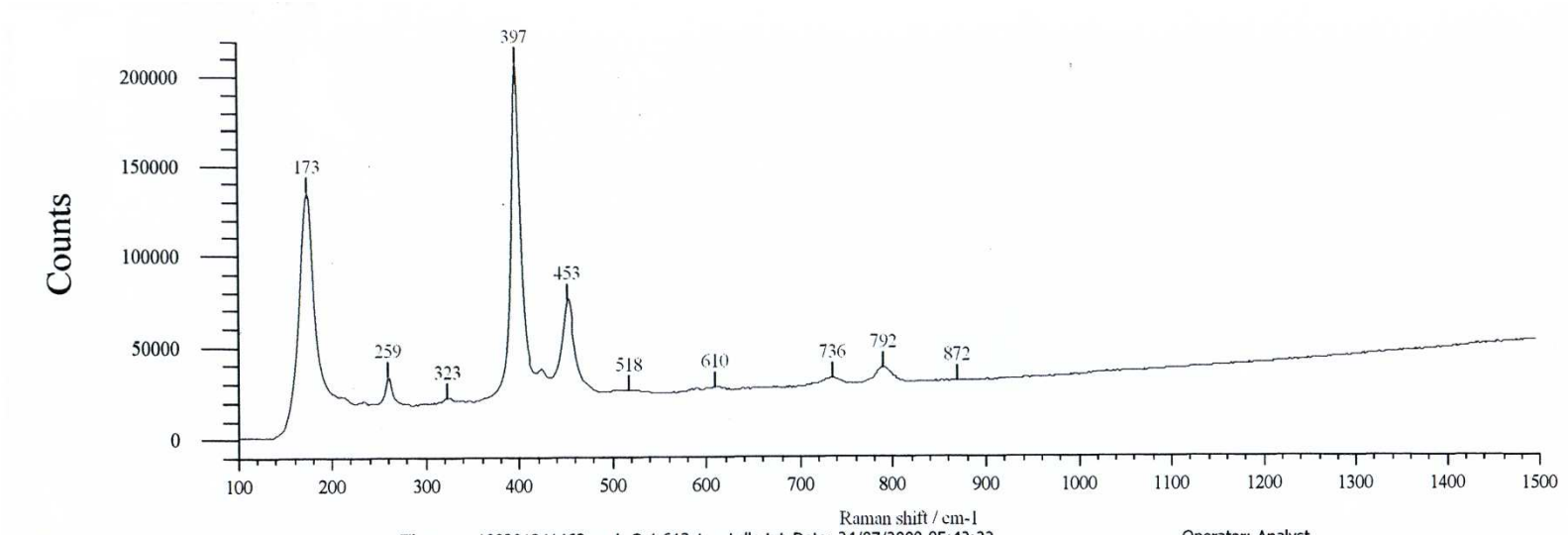
Filename: 100301341463 cush O 1.613cts.wxd
BeamPath: Grating
Acquisition time: 10

Date: 24/07/2009 05:42:32
Grating: 1800 l/mm (vis)
Accumulations: 10

Operator: Analyst
Focus mode: Confocal
Cosmic ray removal: False

Centre	Height	Peak no.	Width	Area	Absolute intensity	Low edge	High edge
173.119	147554	1	16.7132	3.35417e+006	147922	124.624	240.899
322.665	7064.43	2	8.96306	115052	7304.38	296.737	348.771
397.302	107473	3	9.32428	1.92957e+006	112976	357.414	427.97
453.582	36859.3	4	12.8137	1.15375e+006	42748.4	431.397	491.164
502.768	169.761	5	0.978064	39537.9	971.493	589.322	614.531
734.85	3732.56	6	20.0342	117923	4047.64	701.361	760.971
792.235	5083.12	7	18.7448	133421	5288.62	765.92	825.09

RAMAN Spectrum (Pavillion)



:quisition1

Filename: 100301341463 cush O 1.613cts_girdle.txt Date: 24/07/2009 05:42:32

Operator: Analyst

ıser: 514 nm notch
)ectral range: 99.77 to 1,500.24
escription:

BeamPath: Grating
Acquisition time: 10

Grating: 1800 l/mm (vis)
Accumulations: 10

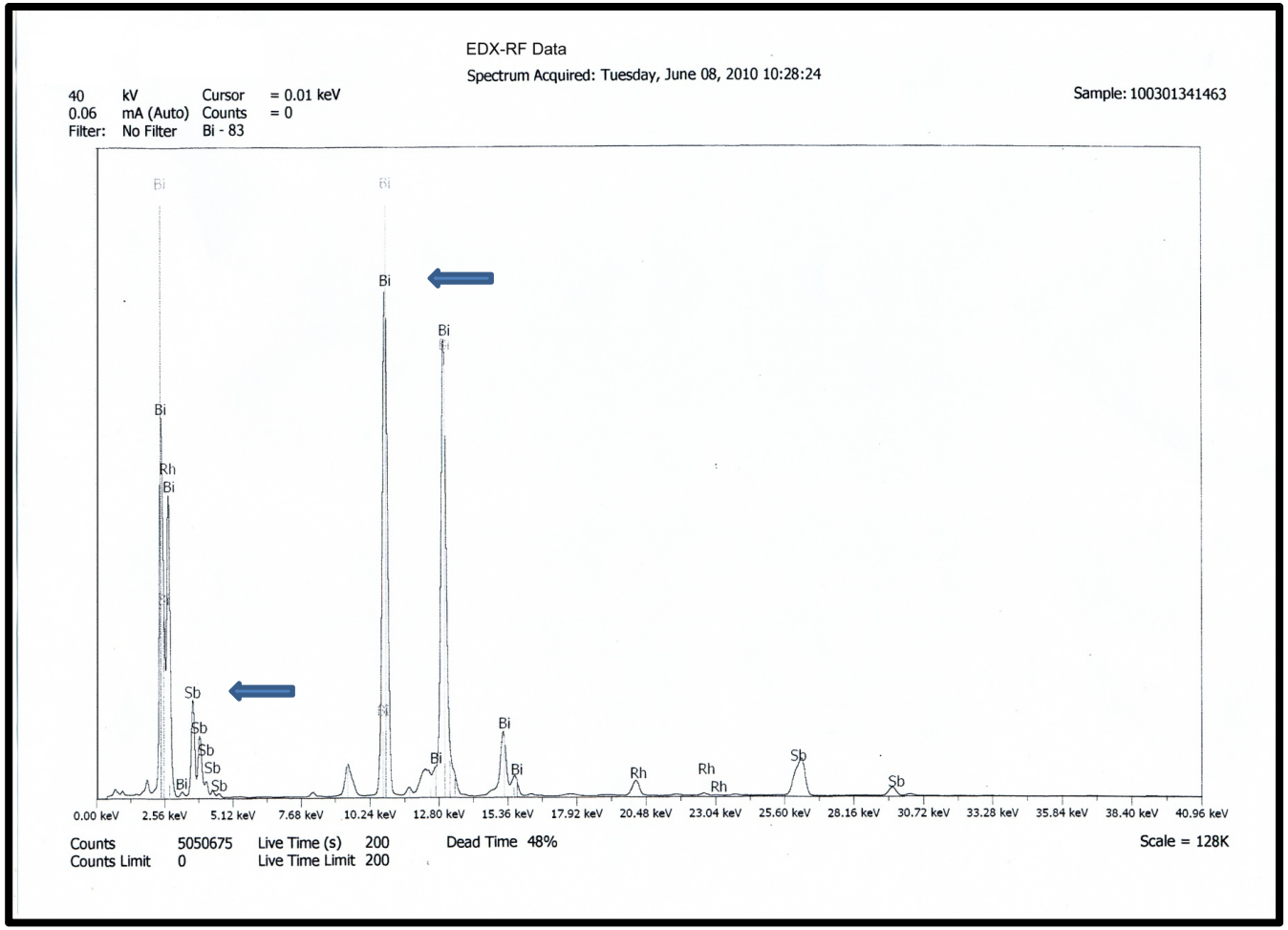
Focus mode: Confocal
Cosmic ray removal: False

Centre	Height	Peak no.	Width	Area	Absolute intensity	Low edge	High edge
173.421	127149	1	15.8243	4.93262e+006	136486	115.754	235.646
259.279	14905	2	7.35419	2.04242e+006	33513.7	239.148	289.776
322.797	2882.04	3	9.24716	2.00551e+006	22283.2	293.257	343.581
397.122	180812	4	9.36296	6.58576e+006	210432	347.041	427.97
453.389	46135.2	5	12.8409	4.38484e+006	76461.6	431.397	494.567
517.726	1037.57	6	28.6739	2.93039e+006	26014.5	497.969	555.598
610.15	1967.8	7	20.6852	3.99201e+006	27349.6	558.977	636.319
736.04	3948.56	8	19.9265	6.82683e+006	32411.8	639.667	760.971
792.129	8554.15	9	18.9666	3.99603e+006	37843.2	764.271	828.365
871.893	594.899	10	7.79507	3.30337e+006	30892.5	831.639	885.483

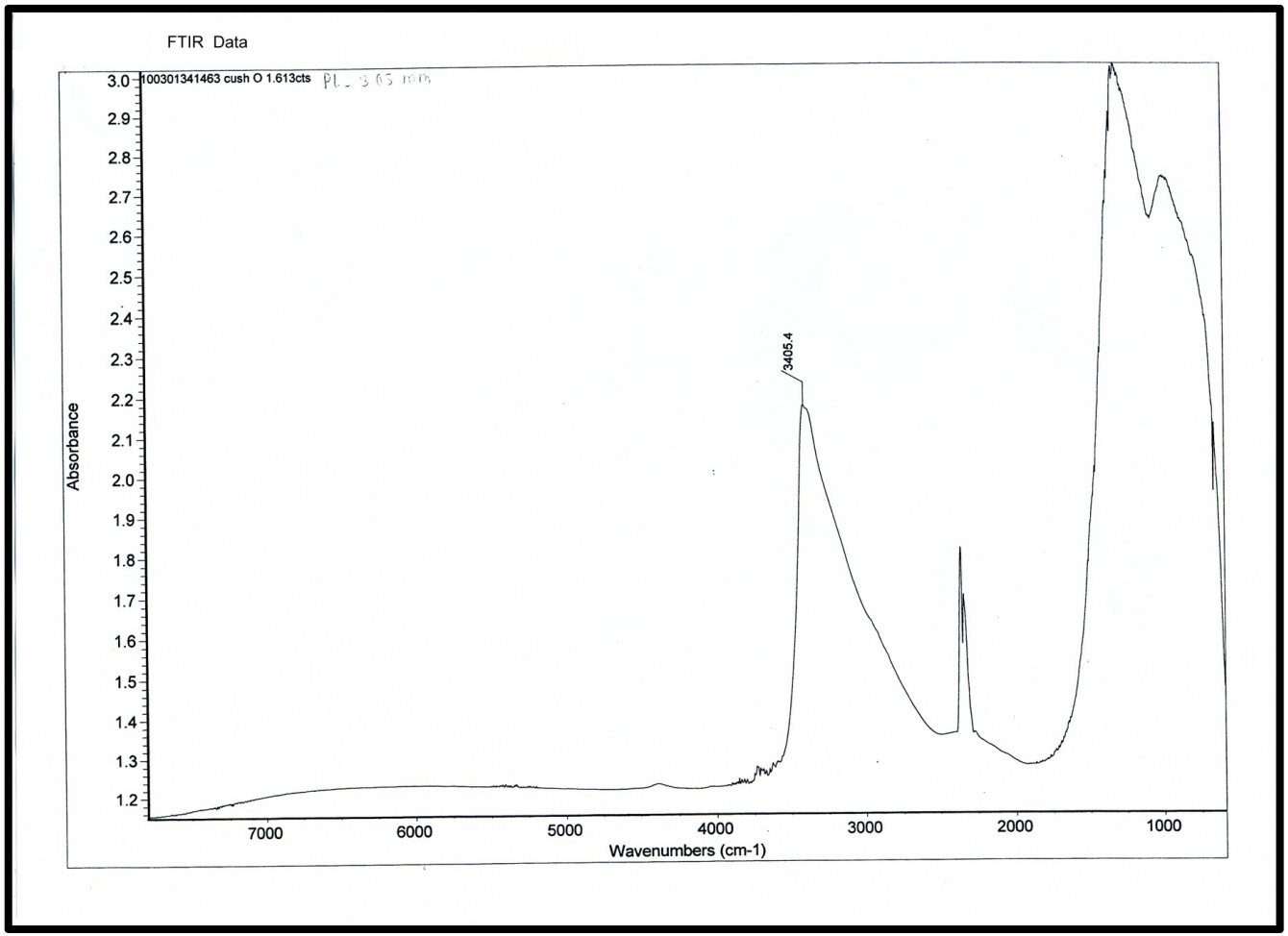
LA-ICP-MS Data

n % oxide	TiO_2	ZrO_2	Nb_2O_5	Sb_2O_3	HfO_2	Ta_2O_5	WO_3	Bi_2O_3	UO_2
SP1	0.09	0.01	0.05	41.93	0.01	0.75	0.09	57.00	0.03
SP2	0.09	0.01	0.04	42.1	0.01	0.68	0.09	56.95	0.03
SP3	0.09	0.01	0.04	45.8	0.01	0.58	0.09	53.34	0.03
SP4	0.09	0.01	0.04	46.83	0.01	0.63	0.09	52.25	0.03
SP5	0.09	0.01	0.05	45.46	0.01	0.68	0.09	53.58	0.03
Average	0.09	0.01	0.05	44.42	0.01	0.66	0.09	54.62	0.03
SD	0.00	0.00	0.00	2.26	0.00	0.06	0.00	2.20	0.00
%RSD	4.46	6.85	7.91	5.08	12.09	9.75	3.03	4.03	5.41

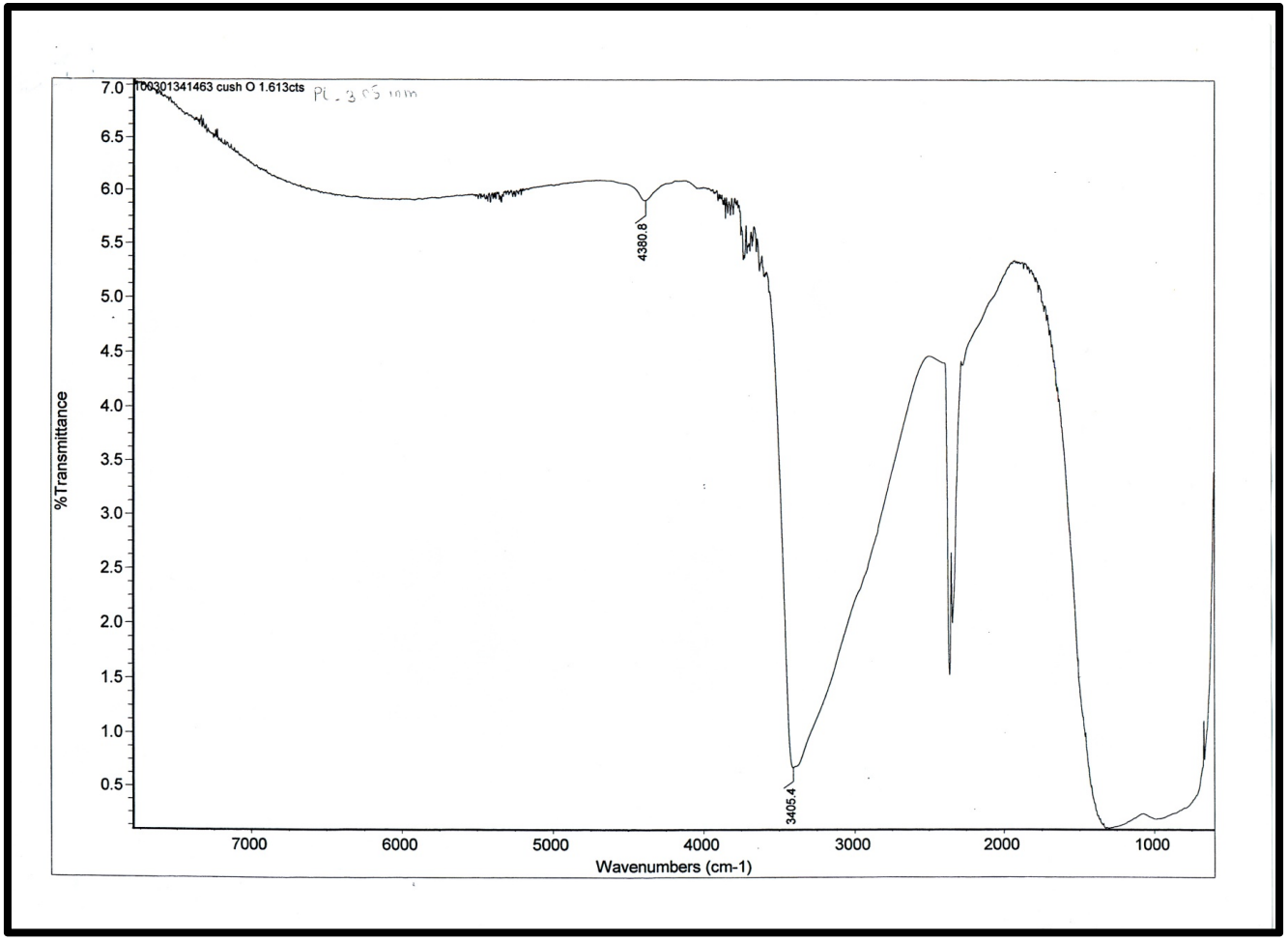
EDX-RF Data


EDX-RF Data
Spectrum Acquired: Tuesday, June 08, 2010 10:28:24
40 kV Cursor = 0.01 keV
0.06 mA (Auto) Counts = 0
Filter: No Filter Bi - 83
Sample: 100301341463
Bi
Rh
Sb
0.00 keV 2.56 keV 5.12 keV 7.68 keV 10.24 keV 12.80 keV 15.36 keV 17.92 keV 20.48 keV 23.04 keV 25.60 keV 28.16 keV 30.72 keV 33.28 keV 35.84 keV 38.40 keV 40.96 keV
Counts 5050675 Live Time (s) 200 Dead Time 48%
Counts Limit 0 Live Time Limit 200
Scale = 128K

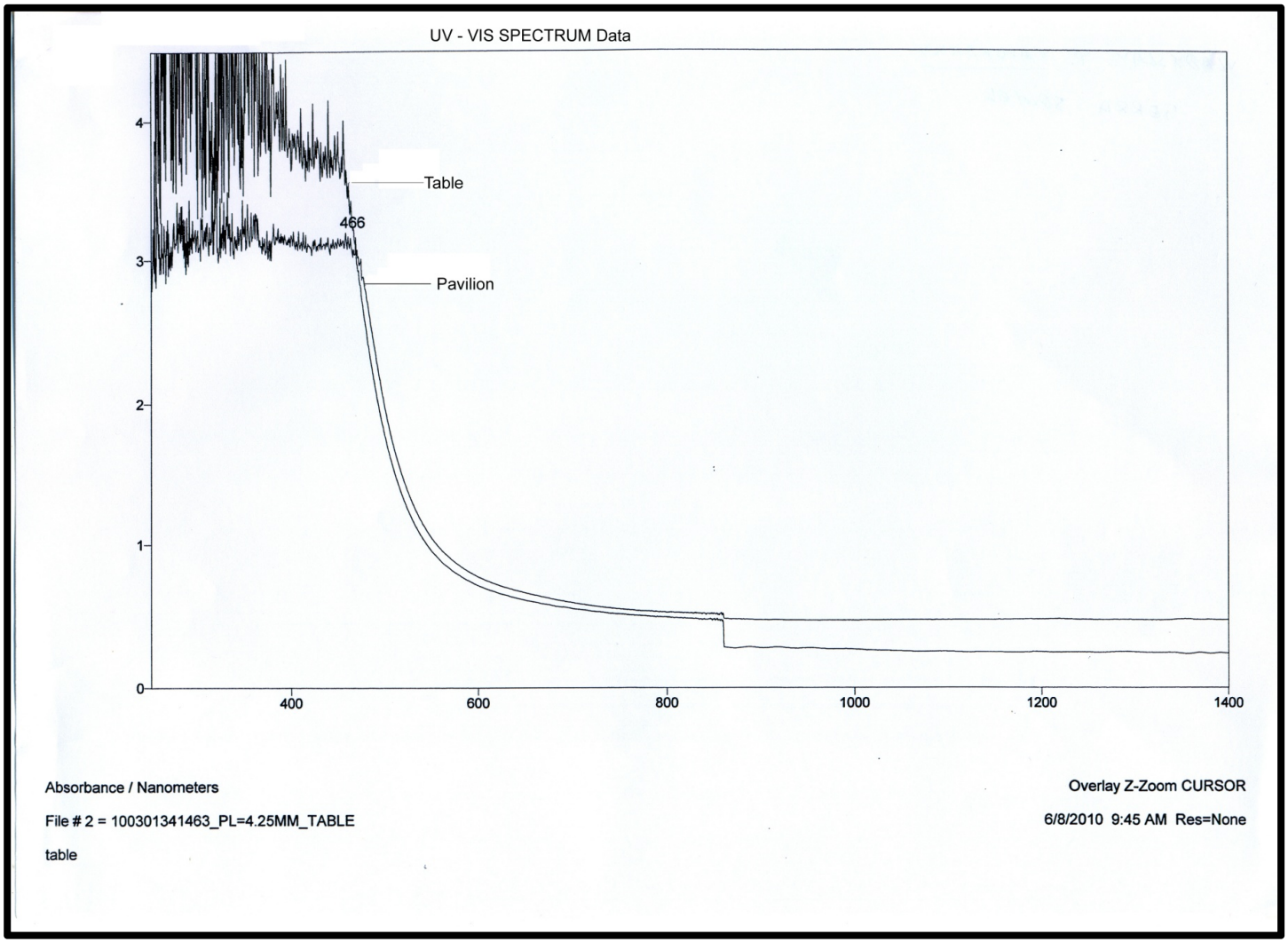
FTIR Data (Absorbance)



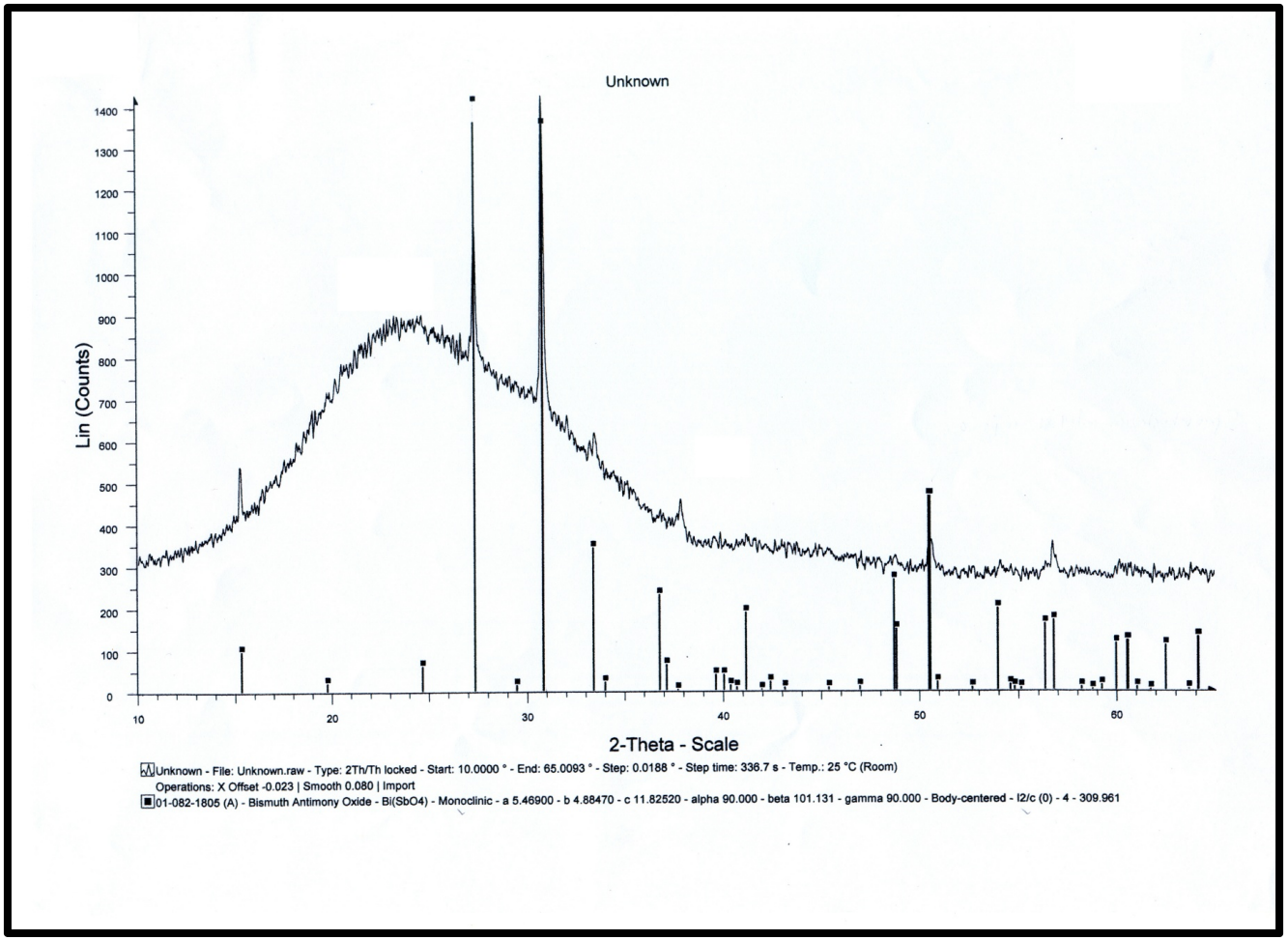
FTIR Data (Transmittance)



UV-VIS Spectrum



X-RD Data (GIT)

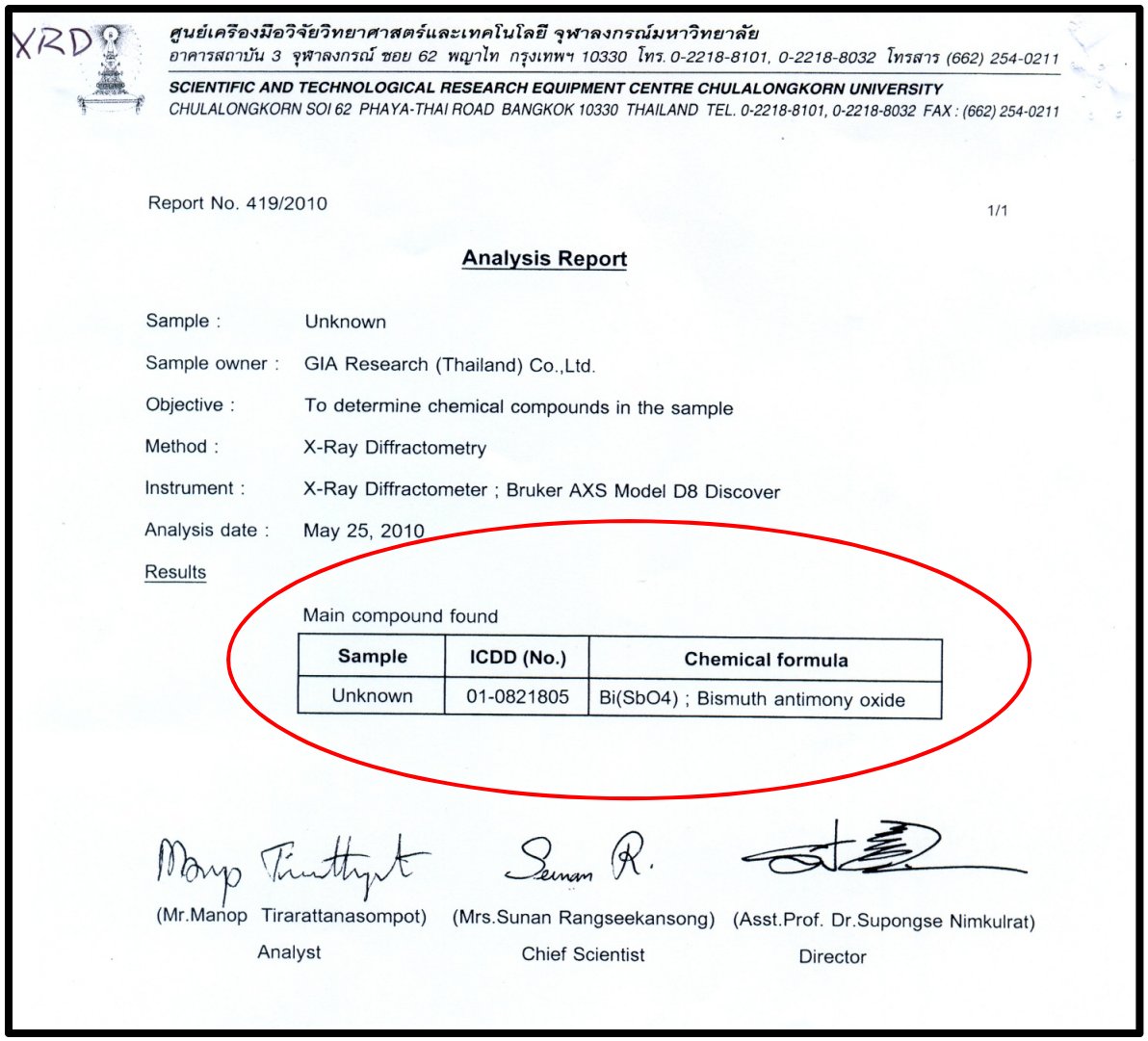

Unknown
Lin (Counts)
1400
1300
1200
1100
1000
900
800
700
600
500
400
300
200
100
0
10
20
30
40
50
60
2-Theta - Scale
Unknown - File: Unknown.raw - Type: 2Th/Th locked - Start: 10.0000 ° - End: 65.0093 ° - Step: 0.0188 ° - Step time: 338.7 s - Temp.: 25 °C (Room)
Operations: X Offset -0.023 | Smooth 0.080 | Import
01-082-1805 (A) - Bismuth Antimony Oxide - Bi(SbO4) - Monoclinic - a 5.46900 - b 4.88470 - c 11.82520 - alpha 90.000 - beta 101.131 - gamma 90.000 - Body-centered - I2/c (0) - 4 - 309.961

X-RD Data (GIT)

Date	: 25/5/2010		
Sample	: Unknown		
Instrument	: X-Ray Diffractometer ; Bruker AXS Model D8 Discover		
Condition	: Target	Cu	
	Voltage	40	kV
	Current	40	mA
	Angle	10-65	degree
	Increment	0.02	degree/step
	Scan speed	0.7	sec/step
	Detecter	VÅNTEC-1 Detector (Super Speed Detector)	
Operator	: Manop Tirarattanasompot		
Memo	:		

Angle 2-Theta °	d value Angstrom	Intensity Count	Intensity % %
15.2342	5.8113	541	37.8
27.3369	3.2598	1124	78.4
30.7925	2.9014	1433	100.0
33.2286	2.6940	602	42.0
33.4449	2.6771	620	43.2
36.8539	2.4369	433	30.2
37.8685	2.3739	458	32.0
48.7699	1.8657	324	22.6
50.5068	1.8056	345	24.1
50.5949	1.8026	361	25.2
54.0982	1.6939	310	21.6
56.4087	1.6299	308	21.5
56.7656	1.6205	356	24.9
60.2004	1.5359	311	21.7

X-RD Data (GIT)



XRD

ศูนย์เครื่องมือวิจัยวิทยาศาสตร์และเทคโนโลยี จุฬาลงกรณ์มหาวิทยาลัย
อาคารสถาบัน 3 จุฬาลงกรณ์ ซอย 62 พญาไท กรุงเทพฯ 10330 โทร. 0-2218-8101, 0-2218-8032 โทรสาร (662) 254-0211
SCIENTIFIC AND TECHNOLOGICAL RESEARCH EQUIPMENT CENTRE CHULALONGKORN UNIVERSITY
CHULALONGKORN SOI 62 PHAYA-THAI ROAD BANGKOK 10330 THAILAND TEL. 0-2218-8101, 0-2218-8032 FAX : (662) 254-0211

Report No. 419/2010

Analysis Report

Sample : Unknown

Sample owner : GIA Research (Thailand) Co.,Ltd.

Objective : To determine chemical compounds in the sample

Method : X-Ray Diffractometry

Instrument : X-Ray Diffractometer ; Bruker AXS Model D8 Discover

Analysis date : May 25, 2010

Results

Main compound found

Sample	ICDD (No.)	Chemical formula
Unknown	01-0821805	Bi(SbO4) ; Bismuth antimony oxide

(Mr.Manop Tirarattanasompot) Analyst

(Mrs.Sunan Rangseekansong) Chief Scientist

(Asst.Prof. Dr.Supongse Nimkulrat) Director

How to Approve

- According to Chemical Analysis
- Chemical Search on Mindat
- Mineral include Sb, Bi
- Aramayoite – $Ag(Sb,Bi)S_2$
- Bismuthian Stibiotantalite
- $(Sb,Bi)(Ta,Nb)O_4$
- Stibiobismuthinite
- $(Bi,Sb)_4S_7$

- According to X-RD
- Mineral Composition
- Bi (SbO_4)

IMA Approval

- California Institute of Technology
- Raman Spectroscopic Microanalyses
- Electron Microprobe Analyses
- Chemical Tests
- Crystallography Analyses at NHM, LA
- Single-crystal X-ray Diffraction Analyses
- Powder X-ray Diffraction Analyses

Chemical Data

JEOL 8200 electron microprobe (WDS mode, 15kV, 25 nA and focused beam at Caltech

Constituent	Mean	Range	SD	Standard
Bi_2O_3	50.64	50.34-50.96	0.22	$AgBiS_2$
Sb_2O_3	(50.10)	49.85-50.57	0.23	Sb_2S_3
Sb_2O_3*	6.90			
Sb_2O_5*	42.44			
Ta_2O_5	0.52	0.33-0.67	0.11	Ta metal
Total	100.50			

* Sb_2O_3 and Sb_2O_5 assignments based on the structure

Chemical Tests

- Un reactive in room temperature concentrated;
  - HCL
  - H_2SO_4
  - HNO_3

Crystallography; Isostructural with clinocervantite ($Sb^{3+}Sb^{5+}O_4$)

- Single-crystal X-ray data
- Monoclinic
- Space group: *I2/c*
- α = 5.4624(4) Å
- *b* = 4.88519 (17) Å
- *c* = 11.8520 (8) Å
- β = 101.195 (7)°
- *V* = 310.25 (3) Å3
- Z = 4

- Powder X-ray data
- Monoclinc
- Space group: *I2/c*
- α = 5.430(2) Å
- *b* = 4.854(2) Å
- *c* = 11.762(2) Å
- β = 101.271(7)°
- *V* = 304.03 (18) Å3
- Z = 4

Crystal Structure

Data collection and structure refinement details

Diffractometer	Rigaku R-Axis Rapid II
X-ray radiation / power	Mo$K\alpha$ (λ = 0.71075 Å)/50 kV, 40 mA
Temperature	293(2) K
Structural Formula	$(Bi^{3+}_{0.80}Sb^{3+}_{0.20})_{\Sigma 1.00}Sb^{5+}_{1.00}O_4$
Space group	*I*2/*c*
Unit cell dimensions	*a* = 5.4624(4) Å
	b = 4.88519(17) Å
	c = 11.8520(8) Å
	β = 101.195(7)°
V	310.25(3) Å^3
Z	4
Density (for above formula)	8.082 g cm^{-3}
Absorption coefficient	55.706 mm^{-1}
F(000)	638.7
Crystal size	30 × 30 × 30 µm
θ range	3.51 to 34.87°
Index ranges	$-8 \le h \le 7$, $-7 \le k \le 7$, $-18 \le l \le 19$
Refls collected / unique	3471 / 679; R_{int} = 0.045
Reflections with $F > 4\sigma(F)$	593
Completeness to θ = 25.01°	99.9%
Refinement method	Full-matrix least-squares on F^2
Parameters / restraints	32 / 0
GoF	1.083
Final *R* indices [$F_o > 4\sigma(F)$]	R_1 = 0.0269, wR_2 = 0.0536
R indices (all data)	R_1 = 0.0341, wR_2 = 0.0577
Extinction coefficient	0.0085(4)
Largest diff. peak / hole	+2.96 / –2.25 *e*/A^3

*$R_{int} = \Sigma|F_o^2\text{-}F_o^2(\text{mean})|/\Sigma[F_o^2]$. GoF = $S = \{\Sigma[w(F_o^2-F_c^2)^2]/(n-p)\}^{1/2}$. $R_1 = \Sigma||F_o|\text{-}|F_c||/\Sigma|F_o|$. $wR_2 = \{\Sigma[w(F_o^2-F_c^2)^2]/\Sigma[w(F_o^2)^2]\}^{1/2}$; $w = 1/[\sigma^2(F_o^2) + (aP)^2 + bP]$ where *a* is 0.0200, *b* is 0.8002 and *P* is $[2F_c^2 + \text{Max}(F_o^2,0)]/3$.

Fractional Coordinates, Occupancies and Atom Displacement Parameters (Å)

	x/*a*	*y*/*b*	*z*/*c*	U_{eq}	U^{11}	U^{22}	U^{33}	U^{23}	U^{13}	U^{12}
Bi*	0	0.51246(5)	0.25	0.00894(13)	0.0098(2)	0.00876(17)	0.00801(16)	0	0.00101(11)	0
Sb	0	0	0	0.00392(19)	0.0041(3)	0.0044(3)	0.0030(2)	0.00001(10)	-0.00001(16)	0.00019(10)
O1	0.1158(5)	-0.1576(6)	0.1541(2)	0.0096(7)	0.0107(18)	0.0121(14)	0.0056(14)	0.0028(10)	0.0006(12)	-0.0011(11)
O2	0.2383(6)	0.2965(5)	0.0610(2)	0.0095(7)	0.0092(15)	0.0086(13)	0.0108(14)	-0.0019(10)	0.0026(11)	-0.0047(11)

*Refined occupancy of Bi site is Bi/Sb: 0.802/0.198(6).

Selected Bond Lengths (Å)

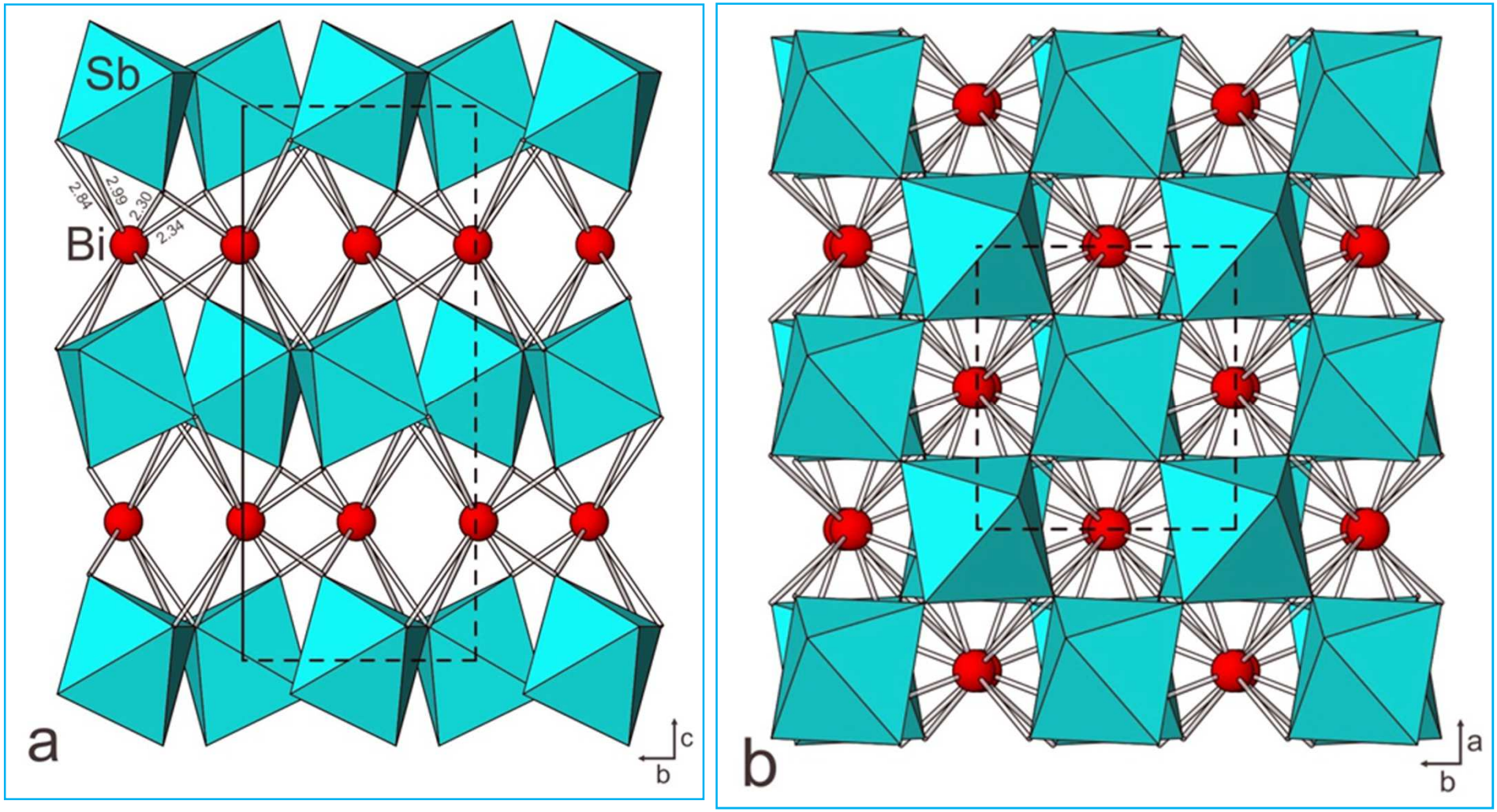
Bi–O1(×2)	2.137(3)	Sb–O1(×2)	1.970(3)
Bi–O1(×2)	2.296(3)	Sb–O2(×2)	1.988(3)
Bi–O2(×2)	2.845(3)	Sb–O2(×2)	1.989(3)
Bi–O2(×2)	2.993(3)	<Sb–O>	1.982
<Bi–O>	2.568		

Bond Valence Sums
Values are expressed in valence units

	O1	O2	Σ
Bi	0.52 ×2→ 0.71 ×2→	0.12 ×2→ 0.17 ×2→	3.04
Sb	0.86 ×2→	0.82 ×2→ 0.82 ×2→	5.00
Σ	2.09	1.93	

Bi3+ -O and Sb3+ -O bond valence parameters are from Krivovichev (2012) and Sb5+ -O are from Mills et. Al (2009)

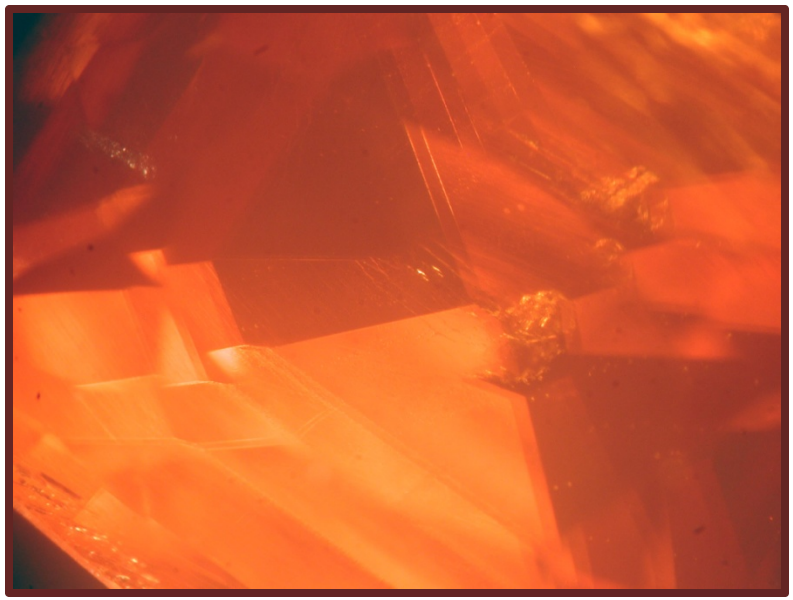
Crystal Structure

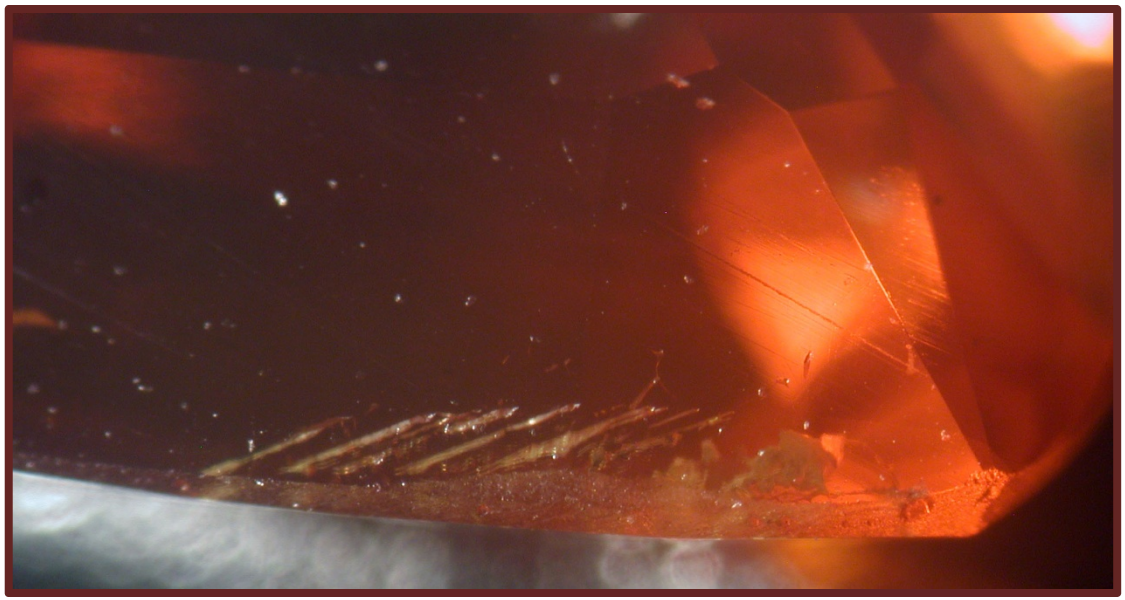


(a) Viewed along (100) (with Bi-O distances shown) and (b) viewed along (001)

IMA (CNMNC) APPROVED

- **IMA No. 2015-078 (11 November, 2105)**
- **KYAWTHUITE:** $Bi^{3+}Sb^{5+}O^{4}$





How to Cite

- Kampf, A.R.,Rossman, G.R and Ma, C. (2015) Kyawthuite, IMA 2015-078. CNMNC Newsletter No. 28, December 2015, page 1863; *Mineralogical Magazine*, 79, 1859-1864.
- www.mindat.org > min-46909
- www.rruff.info > mineral _name=Kyawthuite

THANKS YOU