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PRELIMINARY REPORT ON ANALYSIS OF THORIUM METAL

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#### PRELIMINARY REPORT ON ANALYSIS OF THORIUM METAL

#### Introduction

The analysis of thorium metal is of interest to many laboratories in both the producer and the consumer field.

As of this date, the methods and the results may vary to the extent of the number of laboratories doing the analysis. Some knowledge of the analysis must be had in order to establish confidence in the purity of the metal.

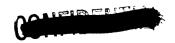
It is the purpose of this paper to list the several methods now employed with some correlation of the accuracy that may be expected in the results.

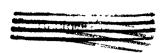
The specifications for the impurity content of the metal have been little changed in the past two years. The tentative specifications as supplied for the Materials Testing Reactor are as follows:

Element	ppm	Element	ppm
С	1000	Mg	Trace
0	500	Zn	Trace
N	100	Ce	15
Al	100	La	5
Fe	300	Nd	2
Ве	1000	DУ	0.05
U	5	Pr	0.4
Ca	Trace	Sm	0.1
N1	Trace	Y	0.05
Si	Trace	Gđ.	0.2

The above specification does not include all the elements that are probably present. Since a more complete analysis may be desired in the future, there has been additional work done on the determination of other elements.





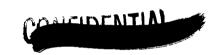




There has not been a great deal of correlation data obtained as yet on the ium samples. The metallurgical laboratory at Ames, Iowa, has made several lots of therium metal with great care to guard against contamination and segregation. Triplicate portions of the samples were taken and analyzed by both the Ames Laboratory and the New Brunswick Laboratory.

From a spectrographic standpoint and considering that many of the NSL values were visual estimations, the agreement in the results was quite satisfactory for the elements determined. There is insufficient data at this time for satisfactory comparison of chemical results.

In addition to the pure metals prepared, there have been several lots of impure metal on which both Ames and NBL have made analysis. Compilation of the data are shown in Tables I and II at the end of this report.







#### CHEMICAL PROCEDURES



#### Carbon

BMI - A combustion procedure for the determination of carbon is used at the Battelle Memorial Institute.

<u>NBL</u> - A combustion procedure similar to that used for the determination of carbon in uranium is used at NBL.

AMES - A report indicates difficulty is experienced in the determination of carbon in thorium by their combustion method.

#### Nitrogen

BMI - The Kjeldahl method for determination of nitrogen is used.

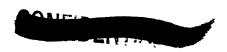
NBL - A micro-kjeldahl method similar to that used for nitrogen in uranium is used at NBL.

#### Oxygen

BMI - Oxygen is determined by a vacuum fusion technique. A thorium sample (0.2 - 0.5 gm) is dissolved in an outgassed tin bath (5-20 gms) contained in a graphite crucible. Using an operating temperature of 3200°F, the oxygen content of the specimen is extracted as carbon monoxide. Oxygen results are repeatable on duplicate specimens to ±5 to 10 percent of the obtained values.

NBL - Combined oxygen in thorium metal is determined by dissolving' the metal in oxygen free 6N HCl. The insoluble material is ignited, weighed, and reported as HCl insoluble.









#### HYDROGEN

BMI - The tin fusion method for hydrogen in thorium appears to give better results than does the vacuum fusion. This method consists of dissolving the sample in a large bath of tin (100 grms) contained in a carbon free furnace assembly. The operating temperature is 1000°C. The gas extraction is usually complete within 15 minutes. Practically all the gas evolved appears to be hydrogen.

<u>MBL</u> - Hydrogen has not been determined in any of the samples of thorium metal.

#### MANGANESE

<u>MBL</u> - The manganese is determined in a nitrate solution of the thorium metal by adding a weighed amount of potassium iodate, developing the color, and reading the transmittancy in a spectrophotometer.

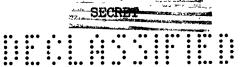
#### IRON

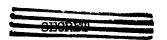
<u>NBL</u> - The iron in thorium metal is determined on the nitrate solution by a method similar to that used for uranium. Solutions of ortho-phenanth-roline and hydroxylamine hydrochloride are added, the pH adjusted and the transmittancy of the solution measured in a spectrophotometer.

#### URANIUM

AMES - The reclaimed thorium metal is analyzed for uranium by extracting the uranium with diethyl ether and then measuring the absorbency of the thiocyanate complex. This method seems to be good to ± 0.5 ppm of uranium in thorium.









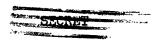
<u>NBL</u> - Thorium metal is converted to the nitrate, the uranium is extracted from the nitrate solution with TBP. The TBP is stripped by carbonate solution. After destruction of the carbonate, the uranium is determined polarographically.

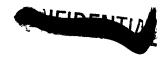
#### RARE EARTH

<u>NEL</u> - A 50 g. sample of metal is dissolved in nitric acid and the sample is evaporated to dryness. The dried sample, thorium nitrate, is treated with tributyl phosphate which extracts the bulk of the thorium nitrate. The aqueous layer, which is saturated with thorium nitrate also contains the rare earth nitrates, is diluted with water; the thorium is separated from the rare earth by repeated precipitations with hexamine solution (5,3). Finally the rare earths are precipitated with oxalic acid and the precipitate is collected and ignited to the oxide.

BMI - A 50 g. sample of metal is dissolved in nitric acid and the sample is evaporated to dryness. The dried sample, thorium nitrate, is dissolved in 2N nitric acid and treated with cellulose powder. The sample is repeatedly treated with ether-nitric acid (200-25) and the portion of the solution is passed through a prepared cellulose column. The column is then eluted with 2N nitric acid. The elute is evaporated to a small volume and the acidity is adjusted and a repeat of the above treatment with cellulose, ether-nitric acid, and the column passing is made.

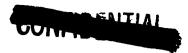
The elute from the second treatment is evaporated to dryness and any organic matter is decomposed by the addition of nitric acid.











#### SPECTROGRAPHIC PROCEDURE

Spectrographic procedures have been the methods generally employed for the detection of the metallic elements in the analysis of thorium samples.

Since the thorium spectrum is quite complex and the material is of a refractory nature there is no present procedure employing a direct examination for impurity content. Each laboratory engaged in the analysis of thorium metal has employed those procedures which they have generally found to be satisfactory for refractory materials.

#### AMES

The Ames procedure called for the simultaneous determination of Al, Fe, Mg, Ca, Si, B, Cd, Zn, and Be. The metal oxide is mixed with powdered flake graphite in the ratio 1:2 and compressed into 1/4 inch diameter conducting pellets by application of high pressure. These pellets are excited by means of a 60 cycle, 960 volt overdamped condenser discharge. Preliminary results indicate that all residual metallic impurities of interest except fractional parts per million quantities of boron, cadmium, and the rare earths can be determined in this manner.

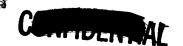
#### MBL

The spectrochemical procedure used for the analysis of thorium samples at the New Brunswick Laboratory follows identically the procedure for the analysis of uranium. This procedure is described in detail in report A-2907. This method can be used for the determination of Ag, Al, As, B, Bi, Ca, Cd, Co, Cr, Cu, Fe, Ge, In, Li, Ng, Nn, Mo, Na, Ni, P, Pb, Sb, Si, Sn, V and Zn.









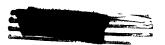
This is a carrier-distillation procedure using  $Ga_2O_3$  in the amount of 2% of the sample weight as the carrier. The sample mixture is excited in a 10 amp 250 V d.c. arc where the sample impurities distill from the sample into the arc stream. Estimations of the amount of impurity present are made by visually comparing the spectrum of the sample against the spectra of standards run under the same conditions. By standard densitometric procedures it is possible to make more precise determinations when desirable.

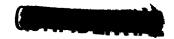
The spectrographic analysis of the rare earth concentrates is only a qualitative report at this time. Since rare earth concentrates as prepared from thorium samples are generally cerium-lanthanum mixtures, it is not felt that the samples would compare at all favorably with standards that are of a yttrium matrix. Work is progressing on development of a procedure for the analysis of Ce-La matrix.

#### BMI

The Battelle Memorial Institute uses a very similar procedure employing AgCl, instead of  $Ga_2O_3$  as the carrier additive.

In the BMI procedure for rare earths the resulting solution after the organic material decomposition is further treated by the addition of palladium solution for the internal standard and then adjusting the final volume with 1:1 nitric acid and so that 0.6 ml is equivalent to 10 g of thorium.









The solution is placed on counter electrodes in the excitation stand using a 3 mm gap spacing. Oxygen is passed through the atmosphere chamber surrounding the electrodes for 30 seconds before starting the spark. The samples are then excited in the high-voltage spark using 4/3 kva capacitance, 0.32 mh inductance and 45 second exposure. Densitometric measurements are made of the impurity lines.

#### REFERENCES

All results and procedures in the report were obtained from the following references.

The Technology of Thorium, BMI-76

The Determination of Rare Earths in Thorium, BMI-260

Semi-Annual Progress Report in Chemistry - April 1 - September 30, 1951, ISC-184

Quarterly Summary Research Report, Oct., Nov., and Dec. 1951, ISC-220 Communication, V. A. Fassel to H. R. Mullin, May 9, 1952.



# COMPARISON OF RESULTS FROM NEW BRUNSWICK LABORATORY AND AMES LABORATORY ON THORIUM METAL SAMPLES

#### TABLE I.

TRIPLICATE PORTIONS FROM SAME INGOT



	520A					520B				5200			
		NBL Chem	NBL Sp <b>ec</b>	AMES Chem	AMES Spec	NBL Chem	NBL Spec	AMES Ch <b>e</b> m	AMES Spec	NBL Chem	NBL Spec	AMES Chem	AMES Spec
	A1 Ag As		a15 a3 a5	16	12		a25 a3 < 5	11	12		< 10 a3 < 5	13	16
	В В <b>е</b>	•14	a0.3		< 0.5 80	.2	al		0.15 75	. 2	a0.2		0,20 <b>6</b> 0
	Bi C	<b>36</b> 0	< 1			<b>3</b> 50	< 1			<b>31</b> 0	< 1		
•	Ca. Cd		<b>a</b> 50		< 50 < .20	- ,	<b>al</b> 00		< 50 < 0.20		a 25	4	< 50 < 0.20
	Cb	••	n.d.			1/	n.d.			0	n.d.		
	Cl Cr Cu	11	4.4 < 5			16	< <b>5</b>			8	< 5 2.0		
	F Fe	< 100 47	<b>a</b> 50	46	55	< 100 <b>5</b> 0	a50	45	50	< 100 51	a50	42	40
	Li Mg Mn Mo N	< 2 149	< 1 a15 a3 5		< 20	< 2 148	< 1 a25 a3 2		< <b>2</b> 0	< 2 42	< 1 alo a3 < 2		< 20
	Na Ni Pb Si Sn		a10 a40 3.5 a80 a10		< 50		a10 a60 2.5 a50 a15		< 50		a10 a60 1.5 a50 a10		< <b>5</b> 0
	Ta W Zn Z <b>r</b>		n.d. n.d. n.d. 500	47	<b>2</b> 0		n.d. n.d. n.d. 200	36	< 10		n.d. n.d. n.d. 200	53	20
HC1	RE insol.	山 1.03%				63 1.18%			-	114 1.27%			

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		5 <b>21A</b>				521B				<b>521</b> 0				
		NBL Chem	NBL Spe <b>c</b>	Ames Chem	Ames Spec	NBL Ch <b>em</b>	NBL Spe <b>c</b>	Ames Chem	Ames Spec	NBL C <b>hem</b>	NBL Spec	Ames Chem	Ames Speo	
	Ag Al As		a0.5 a15 < 5	16	12		a0.5 a15 < 5	14	12		al al5 < 5	16	14	
	B Be		a0.5		0 <b>.2</b> 0 80	•14	82 <sup>-</sup>		0.25 100	•3	a0.5		0.25 105	
•••••	Bi C	<b>39</b> 0	< 1			410	< 1		- da	420	< 1		- 40	
	Ca Cd C1	10	<b>a7</b> 5		< 50 < 0.20	1և	a25		< 50 < 0.20	6	a 25		< 50 < 0.20	
	C <b>r</b> Cu		< 5 1,2				< 5 1.6				< 5 2 <sub>0</sub> 5			
	p Fe L1	< 100	<b>a</b> 50	Цо	65	< 100 50	a50	43	60	< 100 49	<b>a</b> 50 < 1	40	50	
	Mg Ma Mo	40	a20 a5 < 2		< 20	< 2	a20 a5 < 2		< 20	< 2	a20 a5 < 2		< 20	
•••••	n Na	60	a30			54	<b>a3</b> 0			56	<b>al</b> 0			
	N1 Pb S1 Sn		a30 a50 a30		< 50		a30 a100 a30 a20		< 50		a30 a50 a50		< 50	
	Zn		18	< 20	< 20		<b>2</b> 8	53	20		10	20	20	
. OP	Zr RE insol.	39 1 <b>.2</b> 9%	<b>Д</b> 00			41 1.21%	700			68 1.3%	<b>1</b> 400			

						, )					و صد	O.A.	
			548	A			54					.8c	
		NBL Chem	NBL Speo	AMES Chem	AMES Spec	NBL Chem	NBL Spe <b>o</b>	AMES Chem	AMES Spec	NBL Chem	NBL Spe <b>c</b>	AMES Chem	AMES Spe <b>c</b>
	Ag Al As B	۰2	a0.3 a10 < 5 a1	<b>2</b> 0	22 0.25 180			15	15 0.20 150			20	17 0.30 120
	B1 C Ca Cd Cl	5 <b>3</b> 0	< 1		< 50 <0.20				< 50 <0.20				< 50 <0.20
	Cr Cu F Fe Mg	<.01% 68	a10 2.4 a30 a50	<b>3</b> 6	55 < <b>2</b> 0			37	50 < 20			. 36	60 < 20
	Mn Mo N Ni Pb	< 2 49	a3 a3 a50 3.0										
	Si Sn Ti U	<1	a100 a8 a3		< 50				< 50				< 50
HC1	Zn Zr RE insol.	59 1.2%	13 a300	150	25			45	15			45	25

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## COMPARISON OF RESULTS FROM NEW BRUNSWICK LABORATORY AND AMES LABORATORY ON THORIUM METAL SAMPLES

TABLE II.

ROUTINE RECAST THORIUM METAL



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	NBL Chem	NBL Spec	Ames Chem	Ames Spec	NBL Chem	NBL Spec_	Ames Chem	Ames Spec
Ag Al As Au		al a20 <5		<b>a2</b> 5	an e e praegate con est est est	a0.5 a20 <5		<b>a</b> 30
В		al		-55		al		0.45
Ba Be Bi C	85∪	>500 <b>&lt;</b> 1	771	340		>500 <1	2720	375
Ca	050		770	<b>&lt;</b> 50	960		1130	<b>&lt;</b> 50
Cd Co Cr Cs		n.d. n.d. <b>al</b> 5		<b>&lt;</b> 0.20	- Cultural de la Principal de la Calanda de	n.d. n.d. al5		<0.20
Cu		<b>a</b> 50				<b>a</b> 50		
Fe Ge In K Li		alo n.d. n.d.			marina da de la composição de la composi	alO n.d. n.d.		
Mg Mn Mo N Na	<b>2</b> 40	a30 a5 n.d.	406	<b>&lt;2</b> 0	290	a5 a5 n.d.	437	<2∪
ni F Fo Rb Sb		a300 n.d. a5 n.d.				a100 n.d. a5 n.d.		
Si Sn		<b>al5</b> 0 <b>al</b>		<b>&lt;</b> 50		a80 <b>&lt;</b> 1		<b>&lt;</b> 50
V Zn		n.d. n.d.		<b>&lt;</b> 20	3	n.d. a30		<20





	NBL Chem	NBL. Spec	Ames Chem	Ames Spec	NBL Chem	NBL Spec	Ames Chem	Ames Spec
Ag Al As Au		a0.2 a2√ <5		<b>a2</b> 0		<b>a2</b> <b>a2</b> ∈ <b>&lt;</b> 5		
В		a0.5		0.30		<b>a</b> 10		
Ba Be Bi C	<b>7</b> 90	<b>&gt;</b> 500 n.d.	90 <b>0</b>	- 340	1000	>500 n.d.	7.700	
Ca	130		900	<b>&lt;</b> 50	1000		1120	
Cd Co Cr		n.d. n.d. al5		<0.2∪		n.d. n.d. a30		
Cs Cu		<b>a</b> 50				<b>a</b> 50		
Fe Ge In K Li		alo n.d. n.d.				alC n.d. n.d.		
Mg Mn Mo N Na	240	a5 a5 n.d.	427	<20	280	a30 <b>a</b> 5 n.d.	481	
Ni P Pb Rb		a200 n.d. a5			un distribution de description de la constant de la	a200 n.d. a5		
Sb		n.d.				n.d.		
Si Sn V		al00 <l n.d.</l 		<b>&lt;</b> 50		a100 <1 n.d.		
Zn		a20		<20		<b>82</b> 0		



	NBL Chem	NBL Spec	Ames Chem	Ames Spec	NBL Chem	MBL Spec	Ames Chem	Ames Spec
Ag Al As Au B		al a20 <5				a2 a20 <5		
Ba Be Bi C	<b>8</b> 40	>50 <b>0</b> al	1355		830	>500 <1	805	
Cd Co Cr Cs Cu		n.d. n.d. a30 a50				n.d. n.d. a30 a50		
Fe Ge In K Li		alo n.d. n.d.				al0 n.d. n.d.		
Mg Mn Mo N Na	320	a10 a5 n.d.	560		270	alO a5 n.d.	318	
Ni P Pb <b>R</b> b Sb		a300 n.d. a5 n.d.				a150 n.d. a5 n.d.		
Si Sn Y Zn		a100 a2 n.d. <20				al00 <1 n.d. <20		



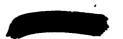
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Š	NBL Chem	NBL Spec	Ames Chem	Ames Spec	MBL Chem	NBL S <b>pe</b> c	Ames Chem	Ames Spec
Ag Aı As Au		a0.5 a15 <b>c</b> 5		<b>e</b> 25		a0.1 a15 <5		<b>a2</b> 5
В		<b>a</b> (5		<b>შ.3</b> 5		аЗ		0.30
Ba Be Bi	Elio.	<b>∢</b> i	Ch o	175	1.00	<b>&lt;</b> 1		145
C Ca	540		640	<b>&lt;</b> 50	480		595	<b>∢</b> 50
Cd Co C <b>r</b> Cs		n.d. n.d. al0		<≎.20		n.d. n.d. al0		<b>40.2</b> 0
Cu		alO		Treestable		<b>a</b> 10		
Fe Ce In K Li		al00 n.d. n.d.		<b>1</b> 40	enade morale a company of the compan	aloo n.d. n.d.		140
Mg Mn Mo N Na	1 <b>2</b> 4	a8 a3 n.d.	181	<b>≪2</b> 0	128	a3 a3 n.d.	172	<20
Ni P Pb Rb		a60 n.d. a5				a60 n.d. a5		
Sb		n.d.				n.d.		
Si Sn V		a30 a20 n.d.		<b>45</b> 0		<b>a300</b> <b>a1</b> 0 <b>n.d.</b>		<b>∠</b> 50
3n		n.d.		<20		n.d.		<20



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	NBL Chem	NBL Spec	Ames Chem	Ames Spe:	MBL Chem	NBL Spec	Ames Them	Amus Spec
Ag Al As Au		a0.3 a15 <5		<b>a</b> 25		20.3 250 <b>∢</b> 5		₹20
B B		<b>a</b> 3		6.36		ai		U 3
Ba Fe Bi C	<b>52</b> 0	<b>∢</b> 1		200	70 <b>0</b>	>2000 n.d.		31.0
Ca	76.0			<b>&lt;</b> 5℃				- J <b>o</b>
Cd Co Cr Cs		n.d. n.d. al0		<b>4</b> 0.2		n.d. n.d. al0		₹ .2
Cn		alO				alO		
Fe Ge In K Li		aloc n.d. n.d.		195		aloo n.d. n.d.		35
Mg Mn Mo N Na	112	a8 a3 n.d.		<5€	136	a5 a2 n.d.		∢20
Ni P Fb Rb		a60 n.d. a4			ne de la companya de	a30 n.d. a4		
Sb		n.d.				n.d.		
Si Sn V	Commission of the Commission o	u50 al0 n.d.		<b>∠</b> 50		a500 n.d. n.d.		a'/5
Zn		n.d.		<20		n.d.		₹50





	NBL Chem	IBL Spec	Ames Chem	Ames Spec	NBL Chem	HBL Spec	Ames Ohem	Ames Spec
Ag Al As Au		a0.5 a30 <5		<b>a2</b> 0		a0.3 a30 <5		a25
В		<b>a</b> 0.5		<0.2	ALLA DIVINITY CONTRACT	<b>a</b> 0.3		6.2
Ra Be Bi C	620	>2000 n.d.		245	660	>2000 n.d.		265
Ca	020			<50				<5○
Cd Co Cr		n.d. n.d. a <b>l</b> 0		<0.2	A STATE OF THE STA	n.d. n.d. al0		<€.2
Ca Cu		a10			and the state of t	alO		
Fe Ge In K Li		aloo n.d. n.d.		100		aloo n.d. n.d.		70
Mg Mn Mo N Na	127	a5 a2 n.d.		<b>∢2</b> ∪	166	aș a2 n.d.		<20
Ni P Pb Rb		a30 n.d. a2			Maria de la companio del la companio de la companio della companio	<b>a2</b> 0 n.d. a2		
<b>S</b> b		n.d.				n.d.		
Si Sn V		a100 n.d. n.d.		<b>∢</b> 50		a200 n.d. n.d.		<b>∢</b> 5⊆
Zn .		n.d.		₹20		n.d.		<50



	MBL Chem	NBL Spec	Ames Chem	Ames Spec	NBL Chem	NBL Spen	Ames Chem	Ames Spec
Ag Al As Au		a0.2 a10 <5				a0.1 a15 <5		
В		a0.5				a.		
Ba Be		3				7		
Bi C Ca	<b>62</b> 0	n.d.	775		530	<1	610	
Cd Co Cr		n.d. n.d. al5				n.d. n.d. al5		
Ca Cs		<b>a2</b> 0				a.15		
Fe Ge		`al06 n.d.				<b>a</b> 100 n.d.		
In		n.d.				n.d.		
K								
Li								
Mg	}	<b>al</b> 5				alO		
Mn		<b>a</b> 3				<b>a</b> 3 n.d.		
Mo N	150	n.d.	200		86	n.u.	<b>13</b> 5	
Na							•	
ni.		<b>a</b> 50				<b>a</b> 30		
P		n.d.		•		n.d.		
Pb		al4				a4		
Rb Sb		n.d.				n.d.		
Si		a500				a800		
Sn v		alC				n.d. n.d.		
V Zn		n.d. <20				n.d.		
	1	•			57			



11X-5 13

	NBL Chem	NBL Spec	Ames Ohem	Ames Spec	NBL Chem	NBL Spec	Ames Chem	Ames Spec
Ag Al As Au		a0.1 a10 <5		<b>e2</b> 0		aC.1 al5 <1		e.c.
В		e(.4		0.2		a0.3		C.25
Ba Be Bi C	560	n.d.		:65	660	n.đ.		250
Ca				<b>&lt;</b> 50				< 30
Cd Co Cr Cs		n.d. n.d. al5		<0.2		n.d. n.d. al5		∠0.2
Cu		<b>a2</b> 0				<b>a2</b> U		
Fe Ge In K Li		al 60 n.d. n.d.		60		al50 n.d. n.d.		65
Mg Mn Mo N Na	94	a15 a3 n.d.		<b>≲</b> 80 .	108	al5 a3 n.d.		. ≼ 2⊍
Ni P Fb Rb		<b>a</b> 30 n.d. a4				a30 n.d. a4		
Sb		n.d.			Andreas	n.d.		
Si Sn V		a800 a3 n.d.		< 50	Annual Programma Annual	al000 al n.d.		<b>a</b> 50
Zn		n.d.		<b>∠2</b> ∪		n.d.		€20



	NBL Chem	NBL Spec	Ames Chem	Ames Spec	NBL Chem	NBL Spec	Ames Chem	Ames Spec
Ag Al As Au		a0.1 a15 <5		<b>a2</b> 0		a0.1 a25 <5	,	n20
P.		al		0.45		a0.5		·>-3
Ba Be Bi C	6-0	n.d.		180	600	>2000 <1		. <b>2</b> 5
Ca				∠50				< 50
Cd Co Cr Cs		n.d. n.d. a25		<b>∠</b> ∪.2	en e	n.d. n.d. a20		<b>∢</b> 0.2
Cu		<b>a2</b> 0				alO		
Fe Ge In K Li		al50 n.d. n.d.		125		a200 n.d. n.d.		1 <b>2</b> 5
Mg Mn Mo N Na	176	a15 a3 n.d.		<b>&lt;2</b> 0	176	alO a3 n.d.		<b>₹</b> 20
Ni P Pb Rb		a50 n.d. a/4				a50 n.d. a2		
Sb		n.d.				n.d.		
51 <b>Sn</b> V		al000 n.d. n.d.		<b>a</b> 75		a1000 n.d. n.d.		<b>a5</b> %
Zn		25 ·		∠20		n.d.		€20





мх-627

	NBL Chem	NBL Spec	Ames Chem	Ames Spec	NBL Chem	NBL Spea	Ames Chem	Ames Spec
Ag Al As Au		a0.5 a20 <5		15		a0.2 a15 <b>८</b> 5		15
В		<b>a</b> 6.5		< ∪.2		a0.5		0.35
B <b>a</b> Be B <b>i</b> C	<b>56</b> 0	>2000 <1		<b>3</b> 60	580	>2000 <1		230
Ca				<b>&lt;</b> 50				650
Cd Co Cr Cs Cu	, , , , , , , , , , , , , , , , , , ,	n.d. n.d. a 0		<0.2		n.d. n.d. al0 al0		<0.2
Fe Ge In K Li		a200 n.d. n.d.		75		ai50 n.d. n.d.		100
Mg Mn Mo N Na	167	alo a2 n.d.		<b>∠</b> 20	104	al0 a2 n.d.		<b>∠2</b> ∪
Ni P Pb Rb		a40 n.d. a2				alı() n.d. a2		
Sb		n.d.				n.d.		
Si Sn V		al000 n.d. n.d.		<b>∠ 5</b> ○		al000 n.d. n.d.		<b>a</b> 50
Zn	1	n.d.		∠ 20		n.d.		< 20





	NBL Chem	IIBL Spec	Ames Chem	Ames Spec	NBL Chem	NBL Spec	Ames Chem	Ames Spec
A- Al As Au		a0.2 a15 <5		a15	And the second s	a0.1 a15 <5		1)
В		al		<b>&lt;</b> 0.2		al		0.25
Ba Be Bi C	600	>2000 <b>&lt;</b> 1		200	46c	>2000 <1		235
Ca	000			<b>4</b> 5	400			<b>&lt;</b> 50
Cd Co Cr Cs		n.d. n.d. alC		∠≎.2	Andreas de la companya del la companya de la companya del la companya de la compa	n.d. n.d. al0		<0.2
Cu		alO				alO		
Fe Ge In K Ii		a150 n.d. n.d.		65		a15 / n.d. n.d.		65
Mg Mn Mo N Na	102	al0 a2 n.d.		<b>∢</b> 20	122	a:0 a2 n.d.		< 20
N1 P Pb Rb		aliO n.d. a3				a40 n.d. a3		
Sb		n.d.				n.d.		
Si Sn V		alcco n.d. n.d.		<b>&lt;5</b> 6		al000 n.d. n.d.		<b>&lt;</b> 50
Zn		n.d.		<20		n.d.		<b>&lt;2</b> 0





MX-55.

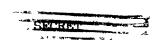
ACCUMON TO THE REAL PROPERTY OF THE REAL PROPERTY O	NBL Chem	NBL Spec	Ames Chem	Ames Spec	NBL Chem	NBL Spec	Ames Chem	Ames Spec
Ag Al As Au B		a0.2 a30 <5		al5 0.45		a0.5 a30 <b>&lt;</b> 5		
Ba Be Bi C	47C	>2000 n.d.		250 <b>&lt;</b> 50	8c <b>o</b>	>500 <b>&lt;</b> 1		
Od Cr Cs Cu		n.d. n.d. a20 a10		<b>4</b> 0.2		n.d. n.d. a15		
Fe Ge In K Li		a200 n.d. n.d.		125		al50 n.d. n.d.		
Mg Mn Mo N Na	154	al5 a3 n.d.		<b>≪2</b> ⊍	306	a5 a3 n.d.		
Ni P Pb Rb Sb		a80 n.d. a3 n.d.				a30 n.d. a10 n.d.		
Si Sn V Zn		al000 n.d. n.d. <2∂		a75		a2000 a2 n.d. n.d.		



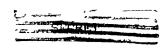


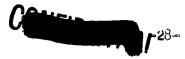
NX-758

	NBL Chem	IBL Spec	Ames Chem	Ames Spec	NBL Chem	NBI Spec	Ames Ch <b>e</b> m	Amas Spec
Ag Al As Au B		a0.1 a_0 <5 a2				al al5 5 al		
Ba Be Bi C Ca	450	>5.0 n.đ.			620	>5· 0 n.d.		
Cd Co C <b>r</b> Cs Cu		n.d. n.d. a5				n.d. n.d. a5 a15		
Fe Ge In K		a200 n.d. n.d.				a200 n.d. n.d.		
Li Mg Mn Mo N N	110	al0 a2 n.d.			<b>12</b> 0	al0 a2 n.d.		
Ni P Pb Rb		а40 n.d. a2				a40 n.d. a2		
Sb Si Sn V Zn	And the second s	n.d. a500 a2 n.d. n.d.				n.d. a200 a2 n.d. n.d.		









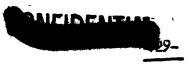
M:-762

	NBL Chem	NBL Spec	Ames Chem	Ames Spec	NBL Chem	MBL Spec	Ames Chem	Ames Spec
Ag Al As Au B		el al0 45 a2				a0.5 a15 <5 a2		
Ba Be Bi C Ca	510	>500 n.d.			500	>500 n.d.		
Cd Co Cr Cs Cu		n.d. n.d. a5 <b>a</b> 15				n.d. n.d. a5 a15		
Fe Ge In K		al50 n.d. n.d.				al50 n.d. n.d.		
Li Mg Mn Mo N Na	<b>23</b> 0	a5 a2 n.d.			160	al0 a2 n.d.		
ni P Pb Rb Sb		a20 n.d. a2 n.d.				a20 n.d. a2 n.d.		
Si Sn V Zn		<b>a500</b> <b>a2</b> <b>n.d.</b> 59				al000 a2 n.d. n.d.		









	NBL Chem	NBL Spec	Ames Chem	Ames Spec	NBL Chem	NB <b>L</b> Spec	Ames Chem	Ames Spec
	***************************************		,	<del></del>				
Ag	,	a0.5				a0.2		
A.		alu				<b>al</b> 0		
As		<b>4</b> 5				<b>&lt;</b> 5		
Au		<b></b> 7				-0.5		
В		al				<b>a</b> 0.5		
Ba								
Ве		>500				>500		
Bi		n.d.			H	n.d.		
C	5 <b>00</b>	221 221			540			
Ca	, , , ,							
					1			
Cd		n.d.				n.d.		
Co		n.d.				n.d.		
Cr		a5			H	<b>a</b> 5		
Cs								
Cu		<b>a</b> 15				ai0		
Fe		a200			II .	<b>a</b> 20 <b>0</b>		
Ge		n.d.			11	n.d.		
In		n.d.			11	n.d.		
K	l							
Li								
Mg	l	alO				<b>a</b> .8		
Mn	l	<b>a</b> 3				a2		
Mo		n.d.			1	n.d.		
n	120				121			
Na								
Ni		<b>a2</b> 0				<b>a3</b> 0		
P	İ	n.d.			1	n.d.		•
Pb	I	<b>a</b> 2				alt		
Rb	}	_			H	_		
Sb	I	n.d.				n.d.		
Si		a1500				<b>a</b> 800		
S1 Sn		e2				a2		
A N	1	n.d.			H	n.d.		
Zn		<10			H	n.d.		
71L	•	<b>**</b> **			ff.	24.4.		<b>\</b>



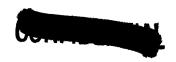




## MX-775

	NBL Chem	NBL Spec	Ames Chem	Ames Spec	NBL Chem	NBL Spec	Ames Chem	Ames Spec
Ag Al As Au B		a0.2 a10 <5				a0.4 a10 <5		
Ba Be Bi C	510	>500 n.d.			560	>500 n.d.		
Cd Co Cr <b>C</b> s Cu		n.d. n.d. a5 a10				n.d. n.d. a5 a10		
Fe Ge In K Li		a200 n.d. n.d.				a250 n.d. n.d.		
Me Mn Mo N	123	a8 a2 n.d.			133	a8 a3 n.d.		
N1 P Pb Rb Sb		a30 n.d. a2 n.d.				a30 n.d. a2 n.d.		
Si Sn V Zn		a1000 a2 n.d. n.d.				al000 a2 n.d. n.d.		





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