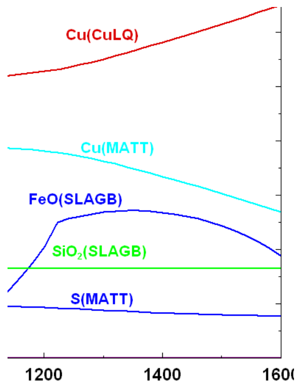
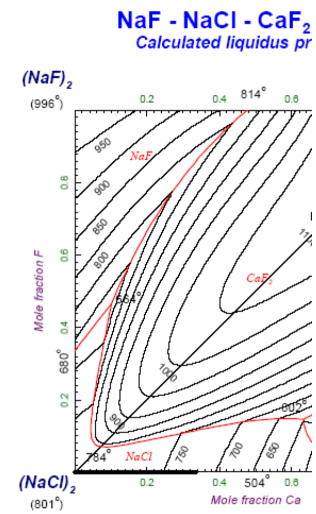
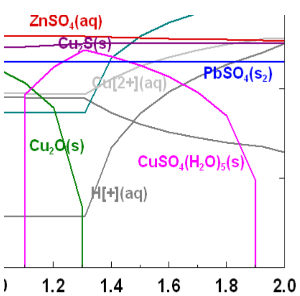


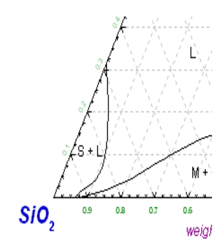


University-based Research Studies aided by FactSage Simulation Program

Bora Derin and Onuralp Yucel



Istanbul Technical University
Metallurgical and Materials Engineering Department
Maslak, Istanbul, 34469, Turkiye



GTT-Technologies 10^{th} Annual Workshop, June 4-6, 2008

Some Studies of Extractive Metallurgy Division

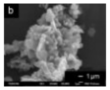
1. A Process Designed for The Ancient Copper Smelting Slags

2. Calcination Studies of West Anatolian Dolomite Ores

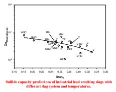
3. Magnesium Production via Pidgeon Process

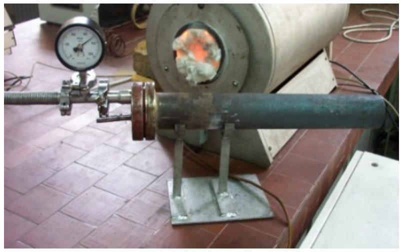
4. Self Propagating High Temperature Synthesis (SHS) Studies

5. Carbothermal Studies for Titanium diboride Synthesis



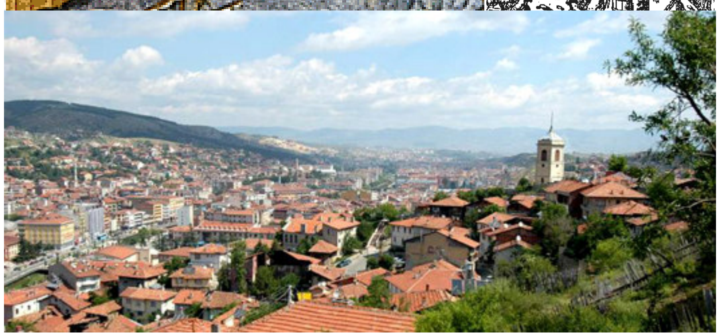
6. Modeling of Sulfide Capacities of Binary and Multicomponent Slags





A Process Designed for The Ancient Copper Smelting Slags

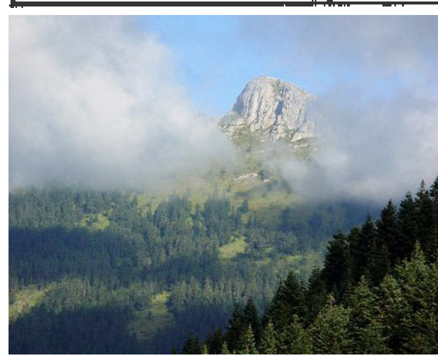


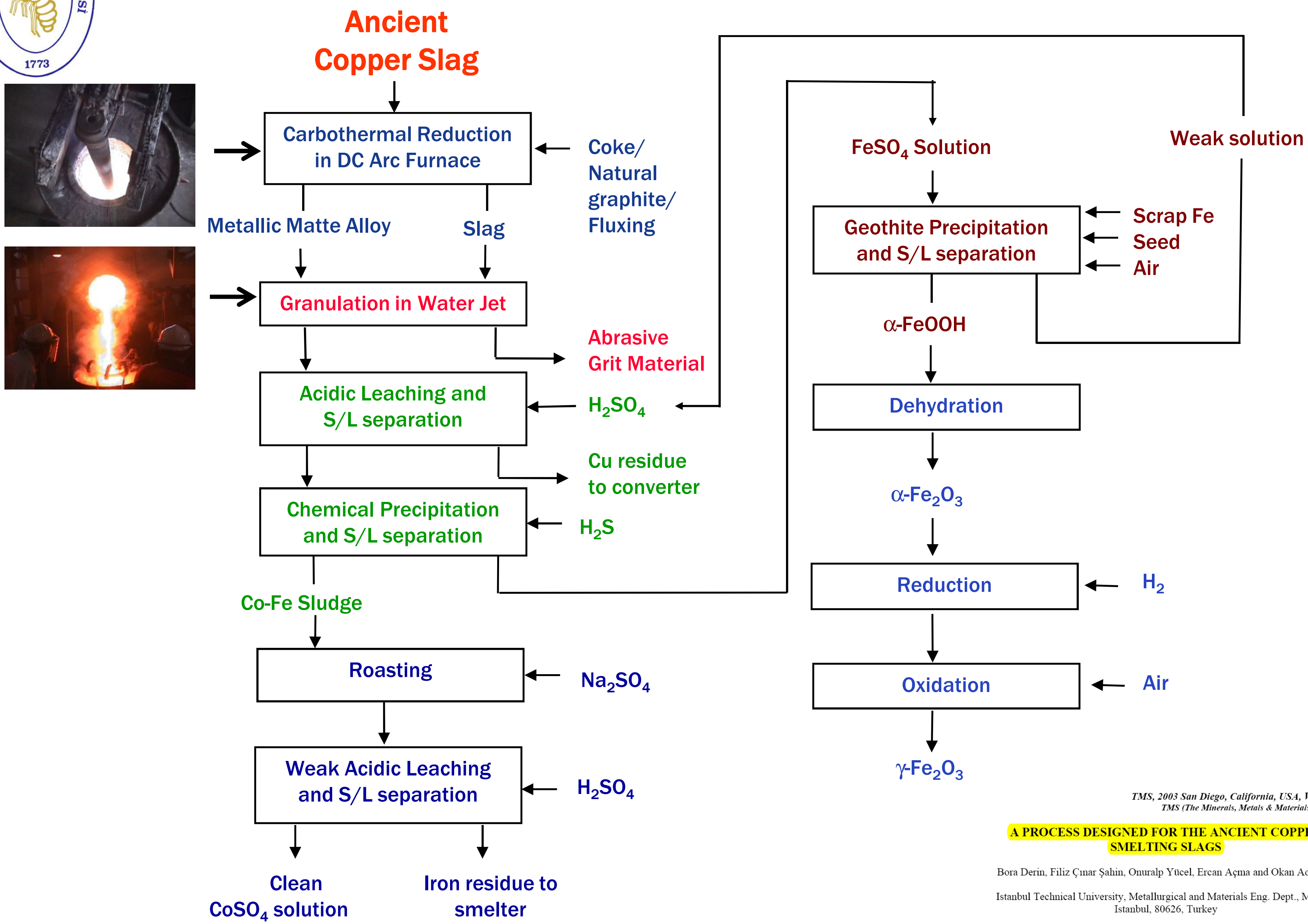


An approximate amount of **2 million tons** of copper smelting slag has been lying on the northern part of Turkiye-Kastamonu/Küre, dating back Genoese times (A.D. 958-1528).

Chemical composition of the ancient Küre copper slags

Components	Wt. %	Components	wt. %
Co	0.4	SiO_2	26.1
Cu	0.82	Al_2O_3	6.8
Zn	0.15	CaO	0.7
Fe	47.8	MgO	1.0
S	1.5	NiO	0.02



TMS, 2003 San Diego, California, USA, Vol:2, 471-482.
TMS (The Minerals, Metals & Materials Society) <2003>

A PROCESS DESIGNED FOR THE ANCIENT COPPER SMELTING SLAGS

Bora Derin, Filiz Çınar Şahin, Onuralp Yücel, Ercan Açma and Okan Addemir

Istanbul Technical University, Metallurgical and Materials Eng. Dept., Maslak, Istanbul, 80626, Turkey

EAF Studies for Ancient Copper Slags

- Different EAF crucibles for 25, 30 and 150 kg-weight samples of Küre slag with or without additives were charged into for reduction smelting.
- Coke as reducing material (78.5 % fixed carbon, 3.64 % volatile substances, and 17,6 % ash
- $CaCO_3$ and Al_2O_3 as fluxing additives
- Tap to tap time was selected as at most 50 min.
- At selected intervals, submerged type of Pt-PtRh10 thermocouple was introduced to the crucible to measure the temperature of the molten slag.
- In the taping stage, the metal and slag temperatures were also measured with an optical pyrometer.

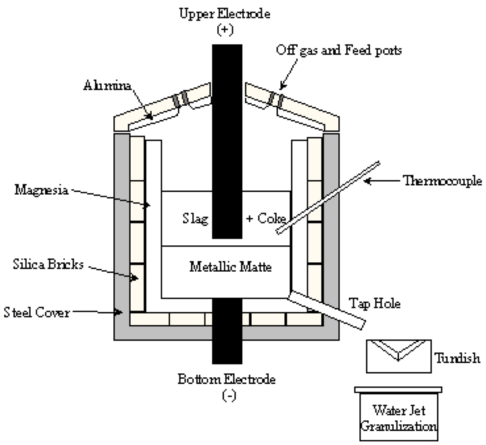
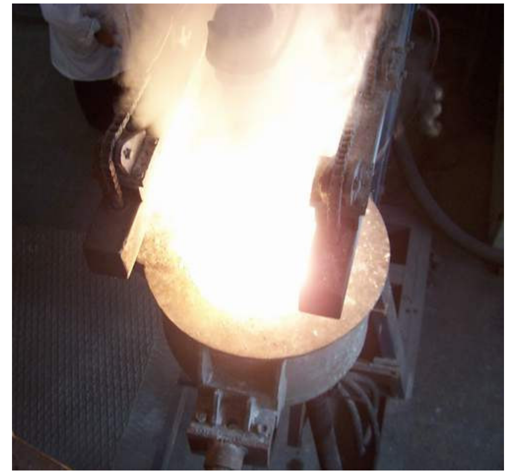
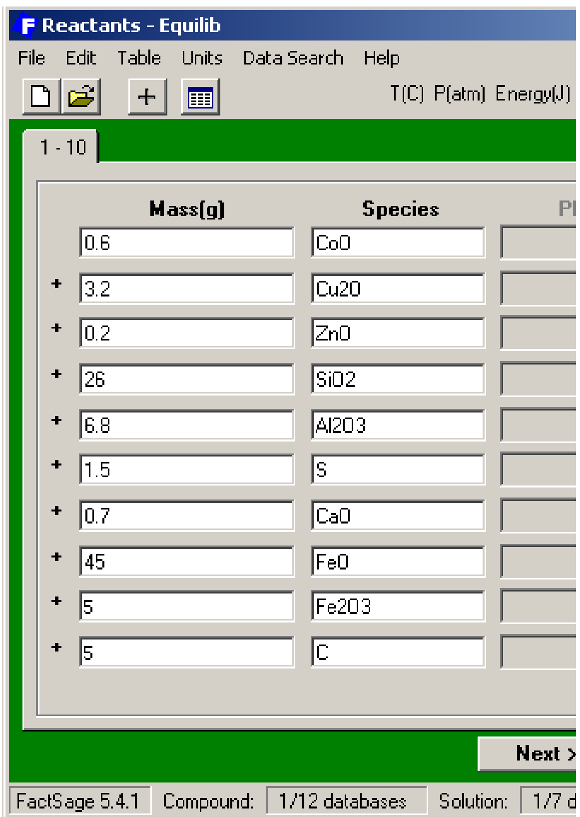


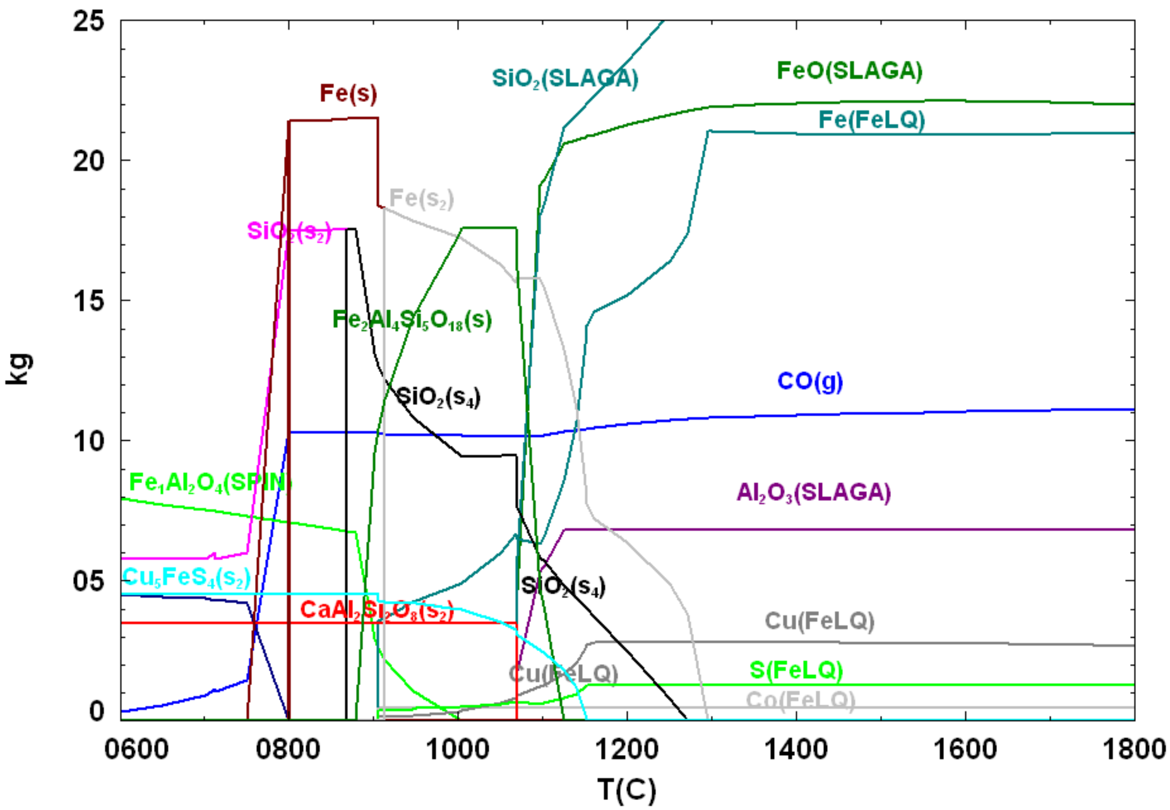
Table II. The chemical compositions and phases of metallic mattes for various reduction temperatures[8].

Granule No	Reduction Temp. (°C)	Chemical composition of metallic alloys, (%)				Phases identified by X-ray diffaction
		Co	Cu	S	C	
1	1380	2.38	3.51	3.1	0.21	Fe, Cu, Co, Cu_2S, FeS, Fe-C, $CuO_{0.75}Fe_{0.58}S_2$
2	1440	1.96	3.00	2.9	0.26	Same
3	1550	2.34	2.10	2.72	0.31	Fe, Cu, Co, FeS, Fe-C
4	1630	1.47	2.14	2.26	0.42	Same
5	1710	1.42	1.35	1.82	0.46	Same
6	1790	1.36	1.31	1.32	0.53	Same



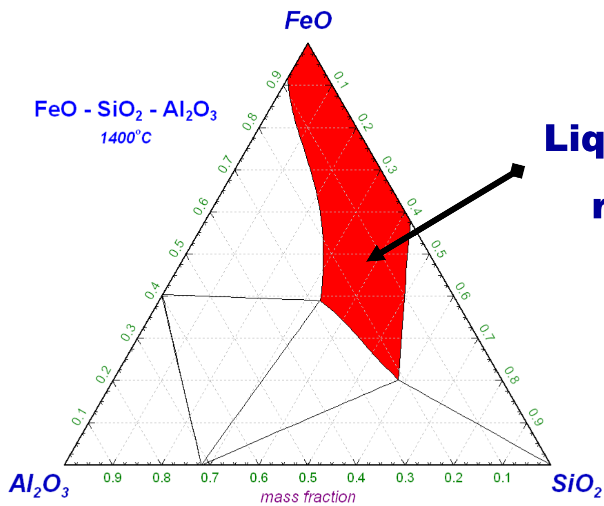
FactSage for reduction behaviour at different temperature



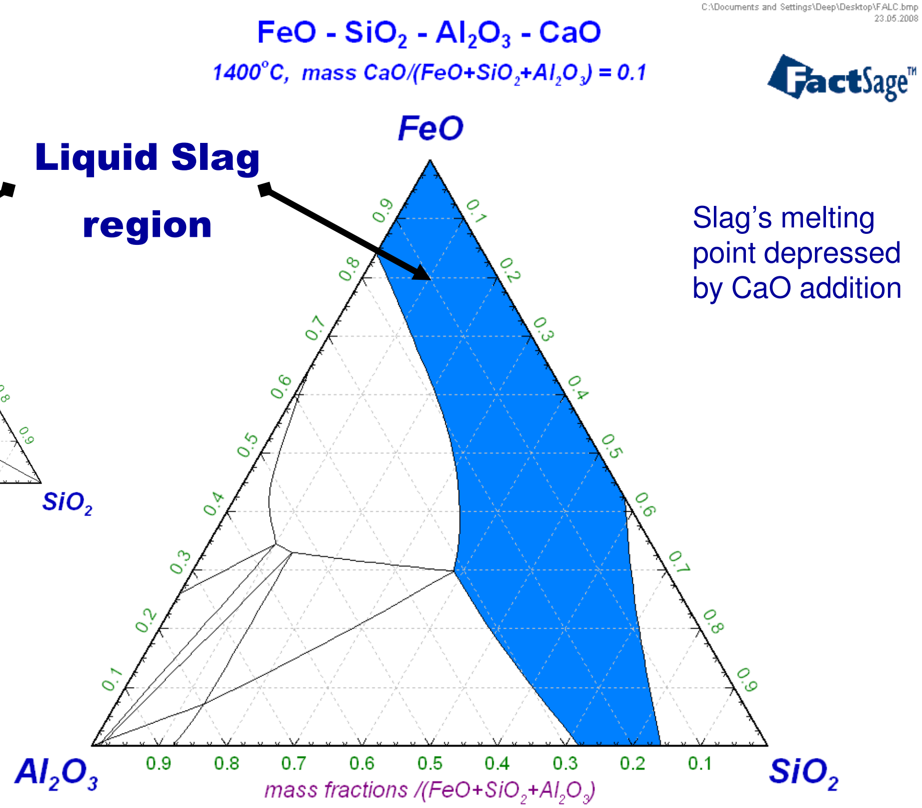


FactSage for Slag Optimization

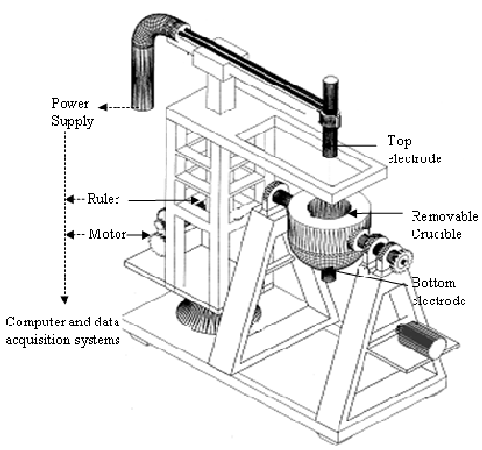
Effect of CaO in $FeO-SiO_2-Al_2O_3$ @ 1400 °C



Liquid Slag region



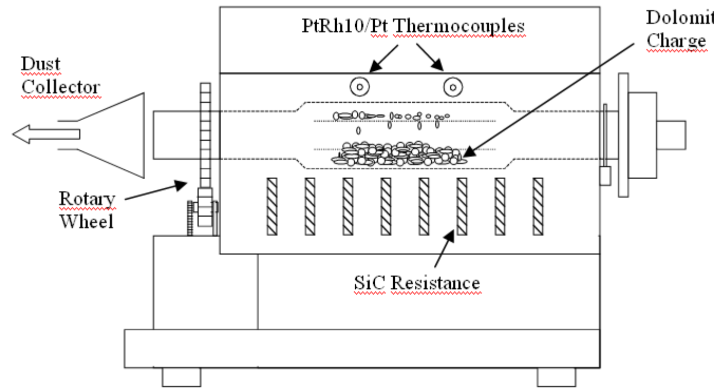
Slag's melting point depressed by CaO addition

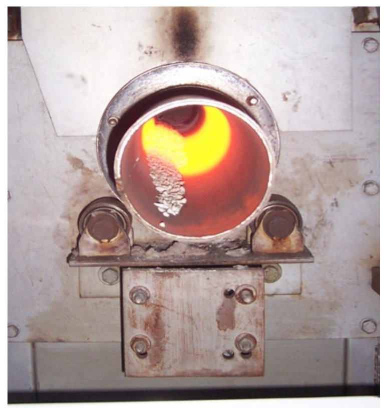


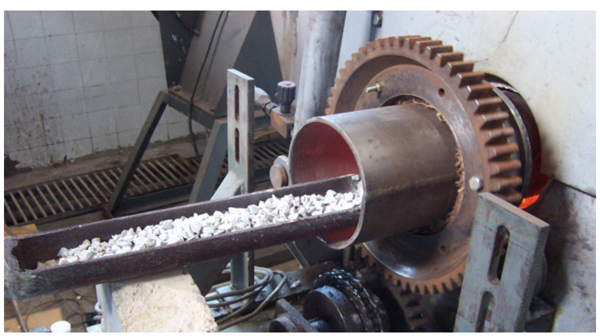
Calcination Studies of West Anatolian Dolomite Ores

Aim:
to prepare calcined dolomite for Mg production via Pidgeon process.

- **Dolomite (Mg,Ca)CO_3 (1000 g)**
- **Different temperatures (800-1100 °C)**
- **Different times (0-300 min)**







Samples of about 10 g each were extracted from the hot zone at different intervals.

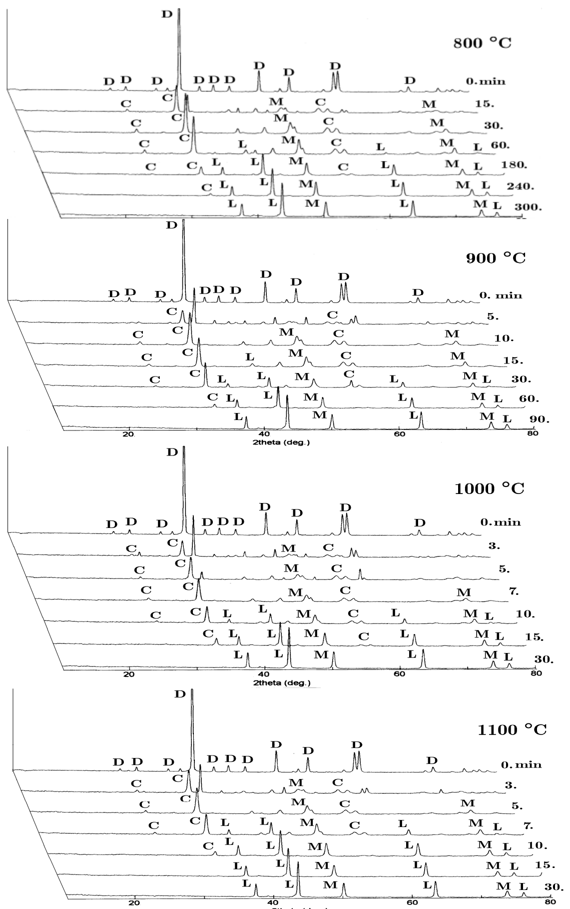
- **Ruhstrat rotary drum furnace (1400 °C max., ±5 °C)**
- **One or both end open stainless steel tubes**
- **Both end open ceramic tube**
- **Rotation rate: 2 rpm.**

COMPUTATIONAL SOLUTIONS IN METALLURGICAL PROCESSES

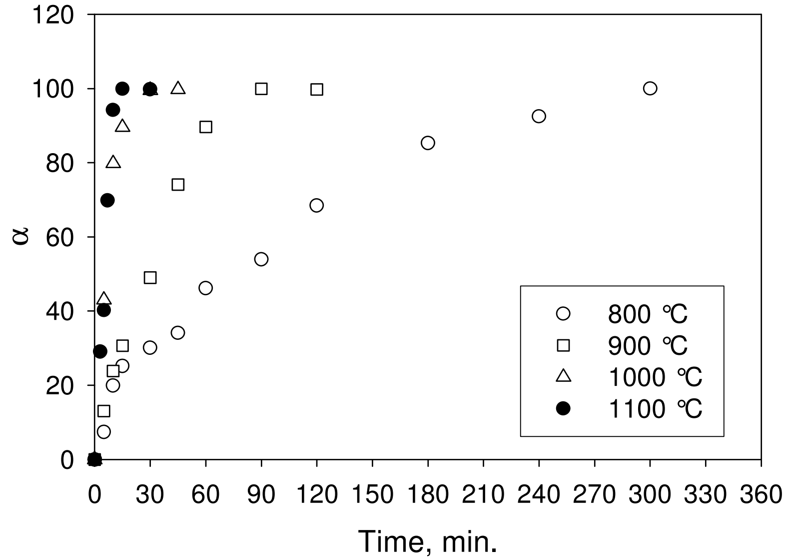
Bora Derin*, Onuralp Yücel*, Klaus Hack**

*Department of Metallurgical and Materials Engineering, Istanbul Technical University, Maslak, Istanbul, 34469, Turkiye
E-mail: bderin@itu.edu.tr, yucel@itu.edu.tr
**GTT-Technologies Kaiserstrasse 100 D-52134 Herzogenrath Germany
E-mail: kh@gtt-technologies.de

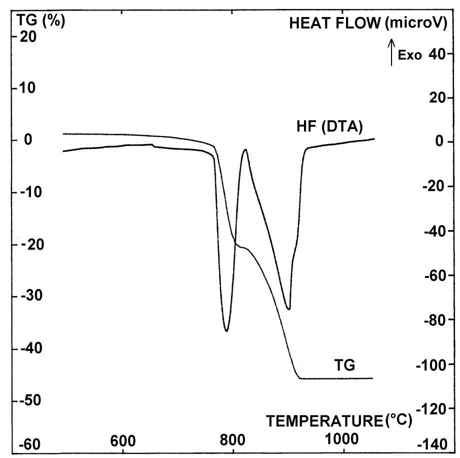
Case 2



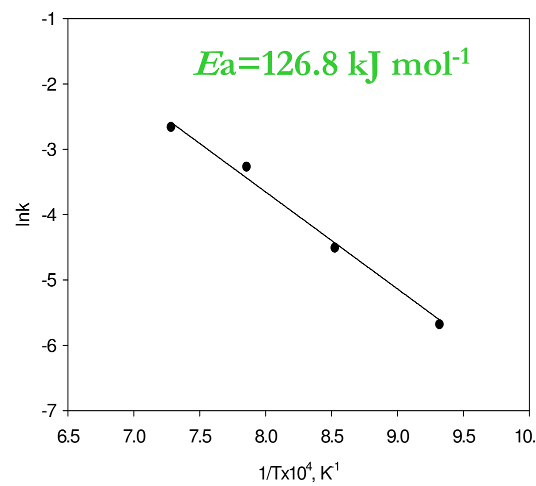
XRD patterns of samples at different time and temperatures
D=dolomite, M=MgO, C=$CaCO_3$, L=CaO.



Degree of dolomite calcination vs. time for different temperatures.



TG/DTA plot of dolomite decomposition in air atmosphere. (10 °C/min)



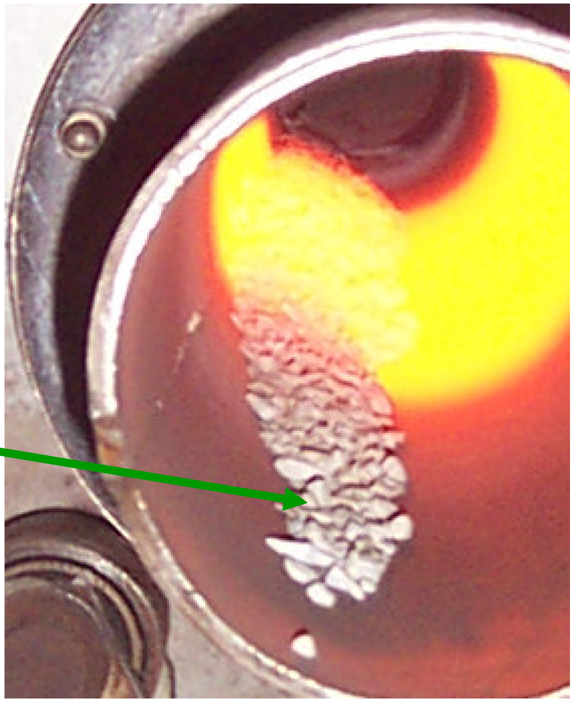
Arrhenius plot to determine the activation energy.

Chemical analysis of some calcined dolomite samples showed that

- **1000 - 1100 °C**
- **Interaction with Stainless Steel reaction tube**
- **Green particles on calcined dolomite grains**

Chromium 0.10 wt. %

Green Particles on calcined dolomite pebbles

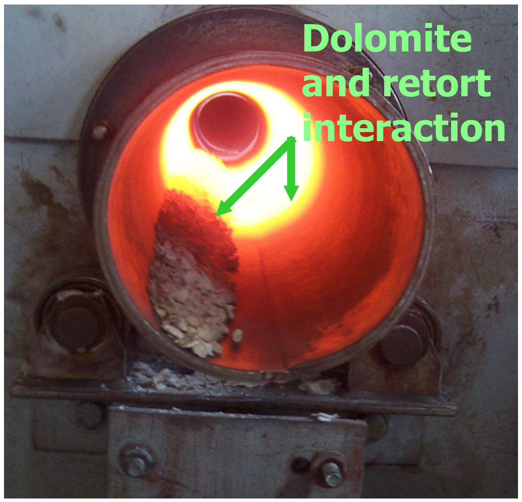


In order to collect these green particles for the characterization, some of samples withdrawn at different time and temperature were sieved for 30 min using a sieve shaker equipped with 106 μm screen.

Chemical analysis of the collected green sieved residue (<106μm)

Wt. %				
Cr	Fe	Ni	MgO	CaO
9.65	1.09	0.06	24.06	37.92

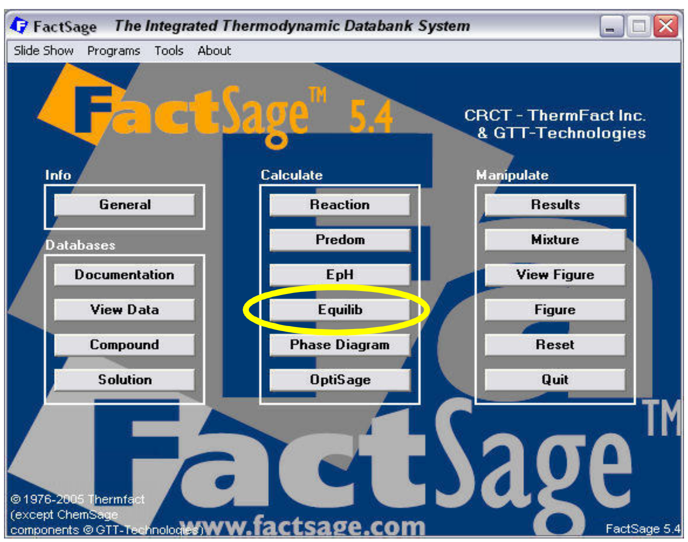
FactSage for simulation of interaction between stainless steel retort and dolomite

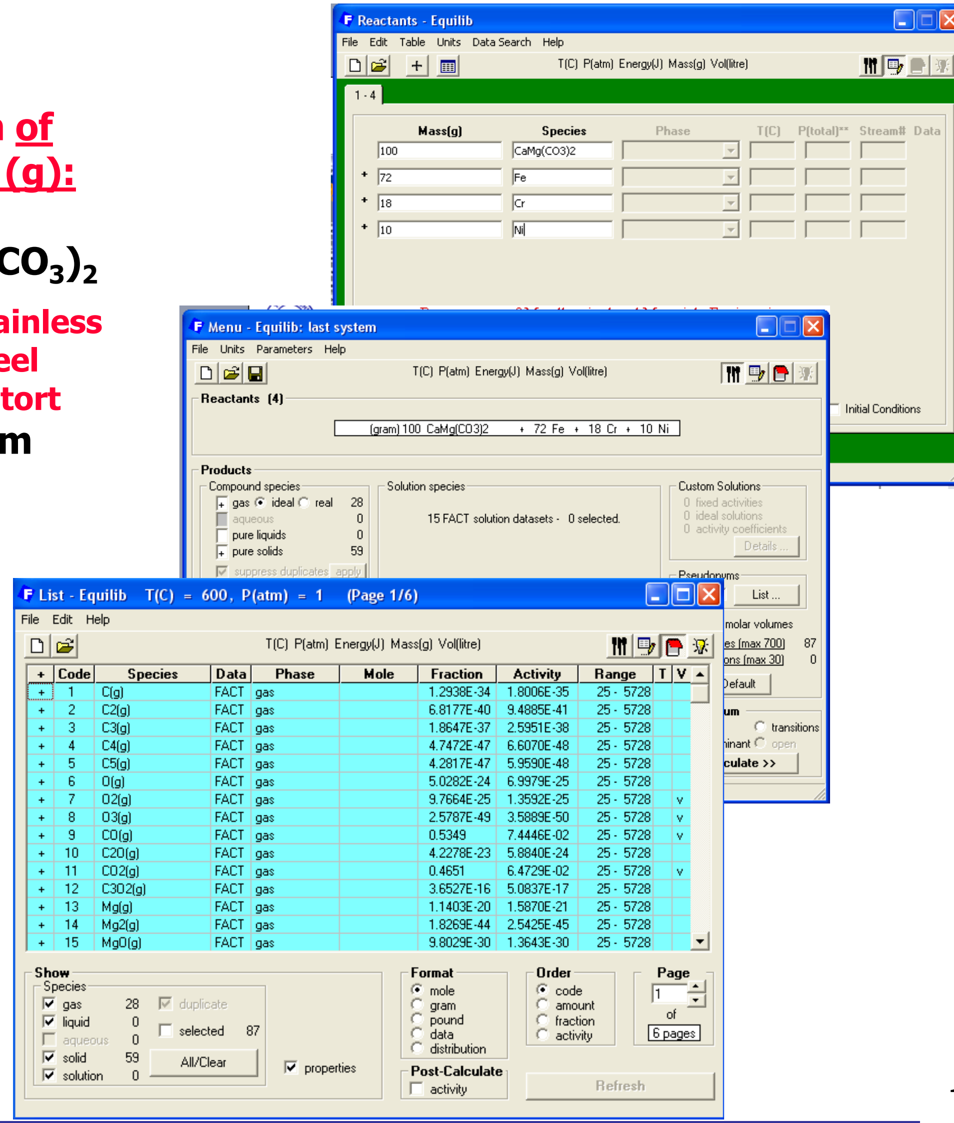


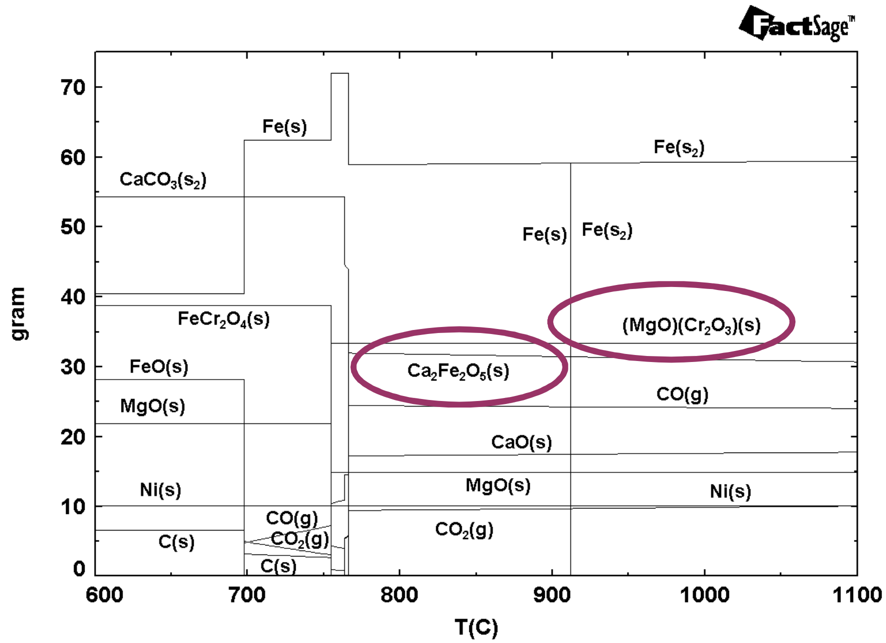
Initial composition of the system, (g):

- 100 $CaMg(CO_3)_2$
- 72 Fe
- 18 Cr
- 10 Ni
- under 1 atm

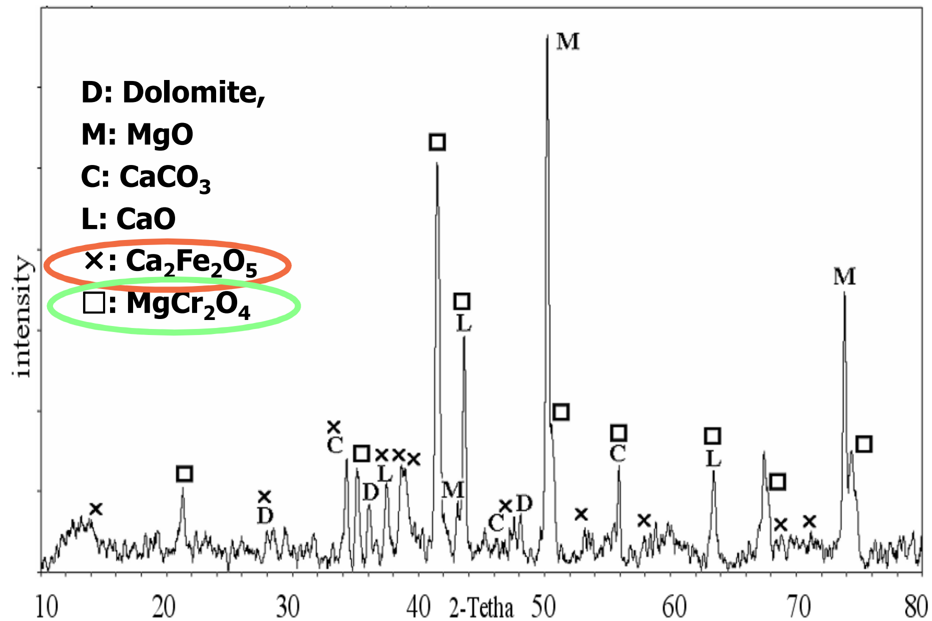
(72 Fe, 18 Cr, 10 Ni: Stainless Steel Retort)







Simulation result of interaction between stainless steel retort and dolomite



XRD pattern of sieved residue (<106 μm)

	ΔG @ 1100 °C (kJ)
$CaMg(CO_3)_2 = CaO + MgO + 2CO_{2(g)}$	- 139.956
$Cr_{(steel)} + 0.5MgO + 1.5CO_{2(g)} = 0.5MgCr_2O_4 + 1.5CO_{(g)}$	- 168.855
$Fe_{(steel)} + CaO + 1.5CO_{2(g)} = 0.5Ca_2Fe_2O_5 + 1.5CO_{(g)}$	- 22.779

No Nickel Oxidation

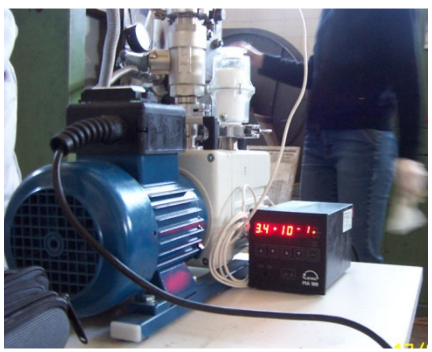
Magnesium Production via Pidgeon Process

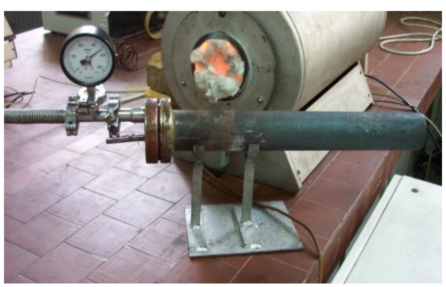
Aim:

Production of magnesium metal from Turkish calcined dolomite (43.20 % MgO and 47.46 % CaO) via the Pidgeon process was studied under the pressure of 1 mbar .

Lab. Scale

1 lt retort



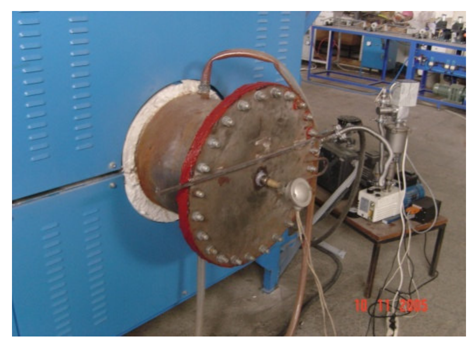


Semi-pilot Scale

11 lt retort

Pilot Scale

100 lt retort



FactSage for simulation of Mg reduction

Effect of reducing agents

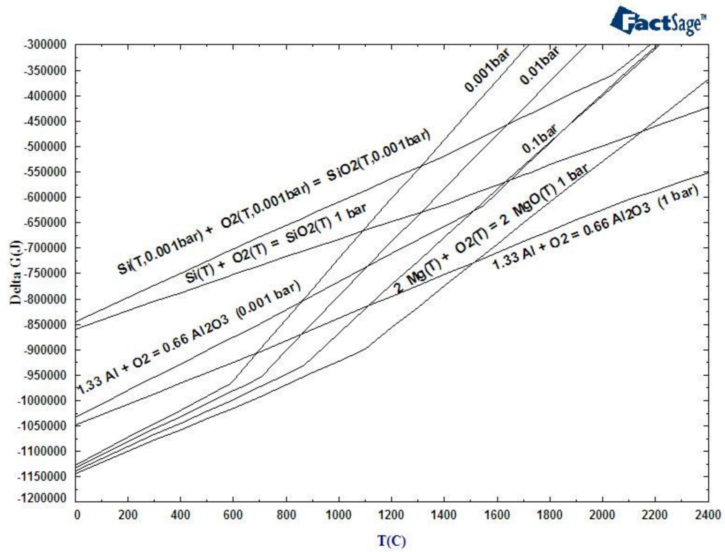
•FeSi •Al
•Si • Si-Al mixture

Effect of fluxing materials

•CaO •MgO •CaF_2

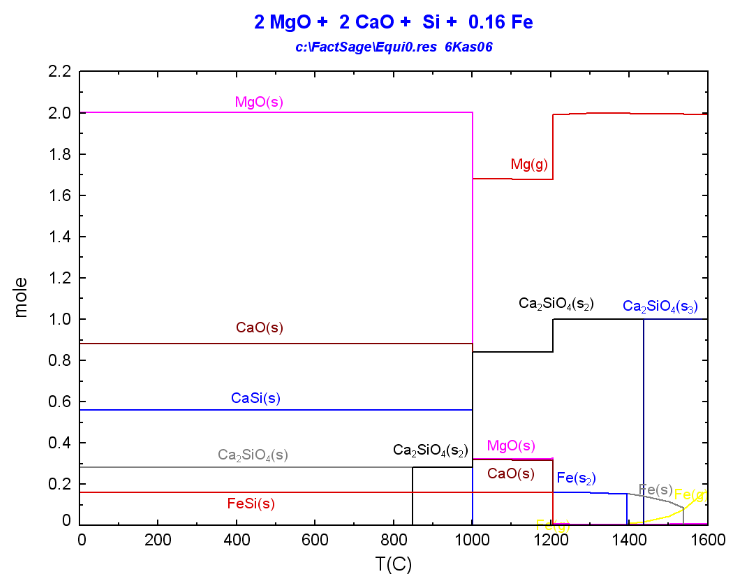
Effect of temperature

1100-1300 C



ΔG - T Diagram for different pressures

Fig. 6 a) Briquetted Charges b) Boat with Briquettes c) Reduction Retort and Furnace d) Vacuum Pomp e) Collected Magnesium f) Residue after an experiment



Magnesium production from Calcinad Dolomite using FeSi under 1 mbar.

Self Propagating High Temperature Synthesis (SHS) Studies

SHS

- Advanced ceramics,
- Intermetallics,
- Organic and inorganic compounds,
- Oxygen free single crystals
- Polymers

After initiation, reaction becomes self-sustaining and propagates in the reactant mixture.

A high amount of heat which is generated during the process accelerates the reaction rate and thus it makes the process highly productive and economically feasible for different production scales.

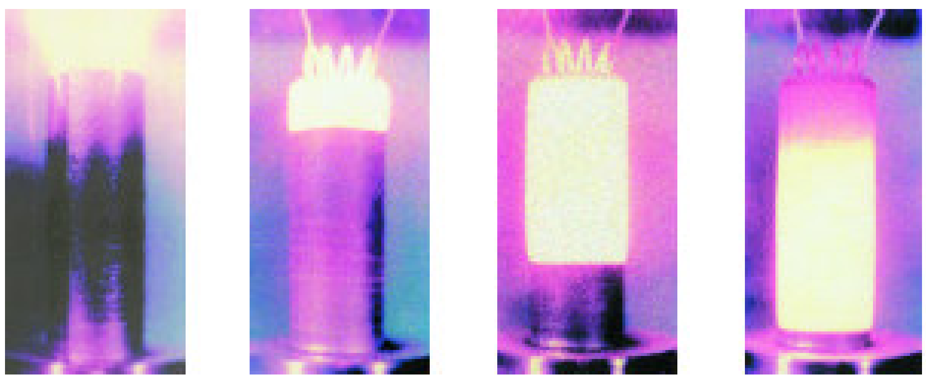
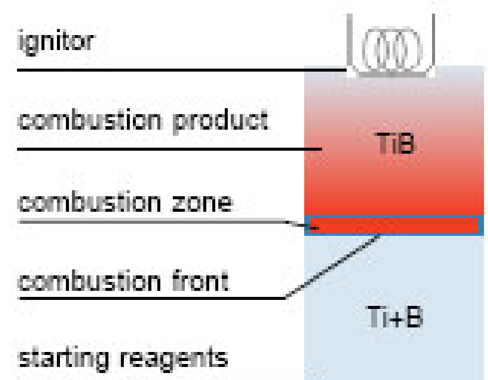


Photo of SHS process



Schematic of SHS process

TiB_2 Synthesis via SHS + HCl leaching

1

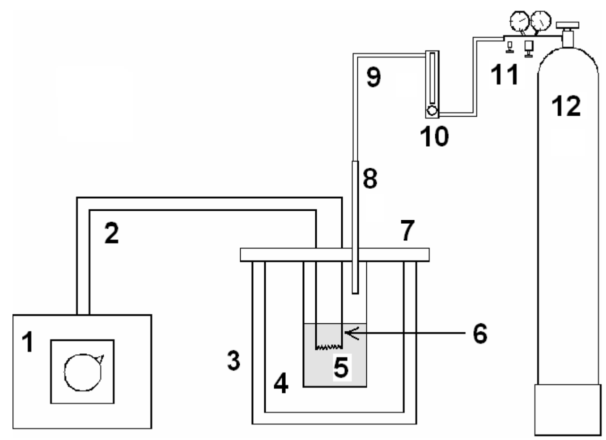
$TiO_2 + B_2O_3 + 5Mg = TiB_2 + 5MgO$

Different stoichiometric Mg (90-110%) and B_2O_3 (100 and 110%) additions were examined

Reaction Powders	Purity, wt %	Particle Size, µm
TiO_2	98.84	33 (mean)
Mg	99.95	< 150
H_3BO_3	99.50	-
B_2O_3	99.00	< 53

2

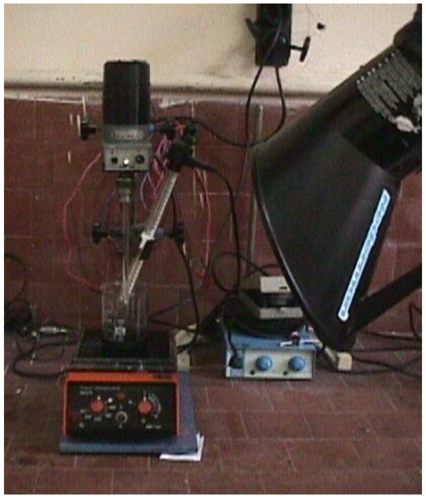
The SHS product = TiB_2+MgO



1. Power Supply, 2. Electricity Cable, 3. Crucible, 4. MgO lining, 5. SHS Mixture, 6. CrNi heating wire, 7. Steel Cover, 8. Argon gas inlet, 9. Gas hose, 10. Flowmeter, 11. Gas manometer, 12. Argon Gas

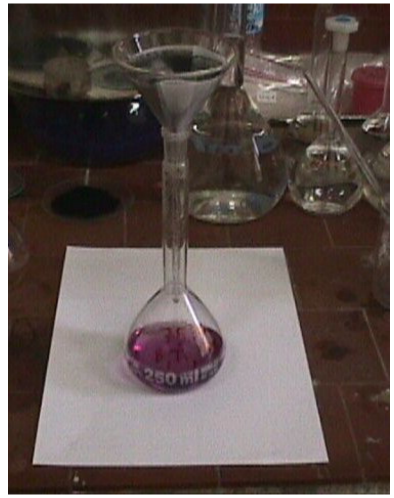
Leaching Step

3



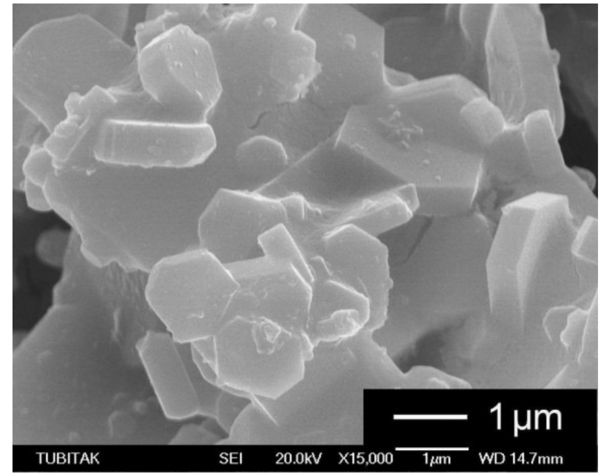
Filtering Step

4



TiB_2 product

5

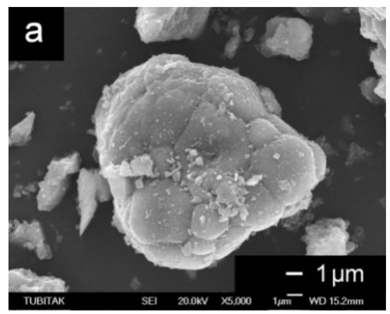


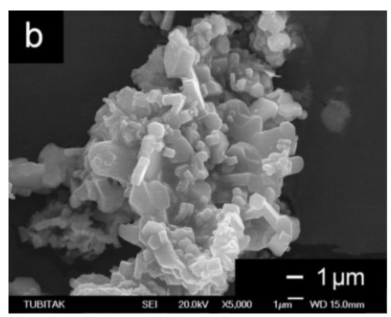
$MgO + 2HCl = Mg^{2+} + 2Cl^{-} + H_2O$

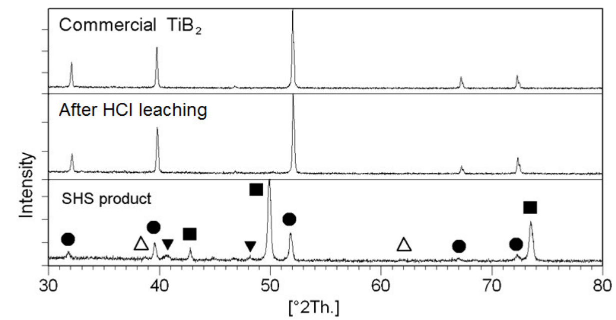
<u>In the leaching step,</u>

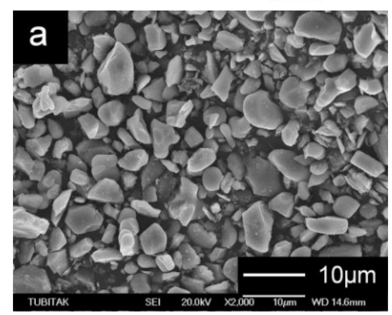
the SHS product was leached by HCl solution (0 - 9.25 M HCl)

- **1/5, 1/10, 1/20 S/L ratio,**
- **30 minutes,**
- **10 g of specimens.**
- **20 ℃**
- **400 rpm stirring rate,**



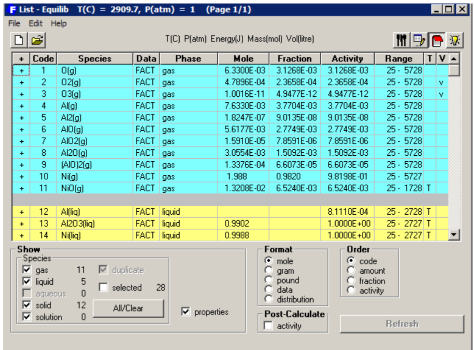






Commercial TiB_2

FactSage simulation for Adiabatic Temperature and SHS products

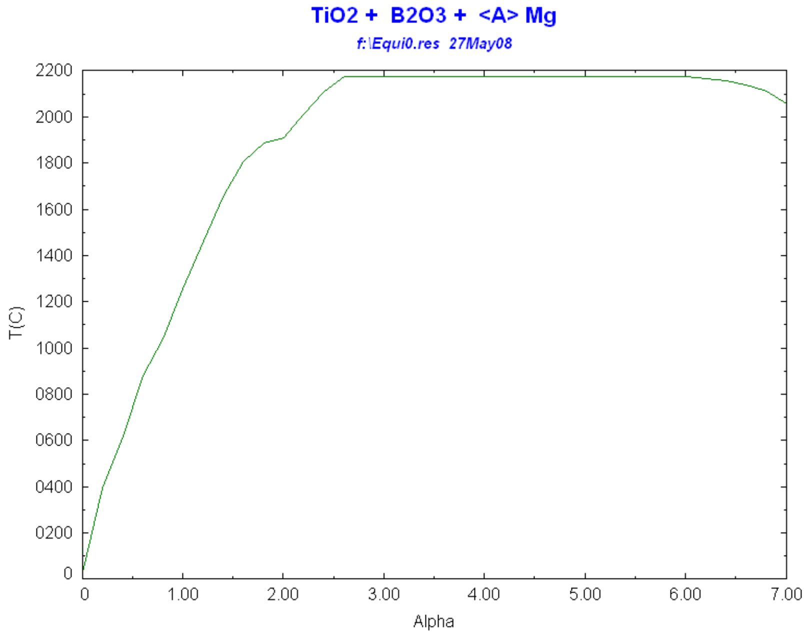


To estimate SHS reaction process

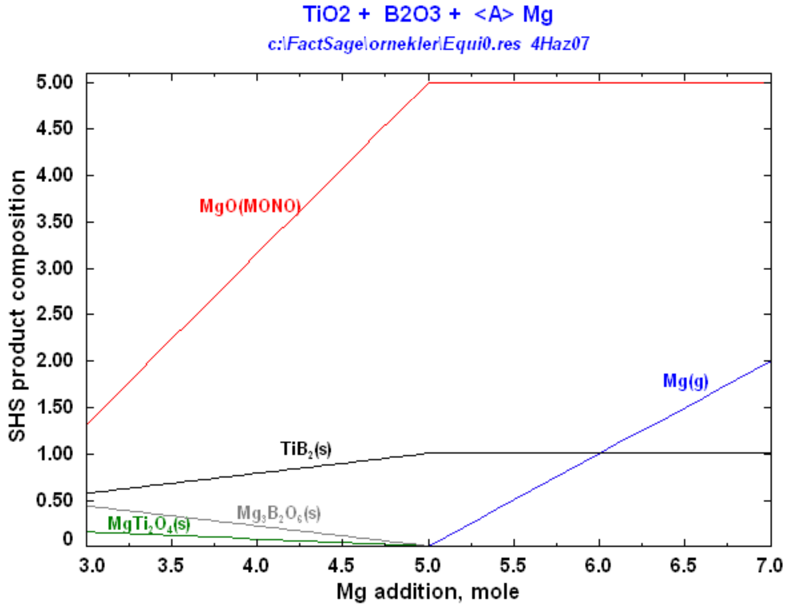
Adiabatic Temperature Calculations (T_{ad})

T_{ad} > 1527 ℃

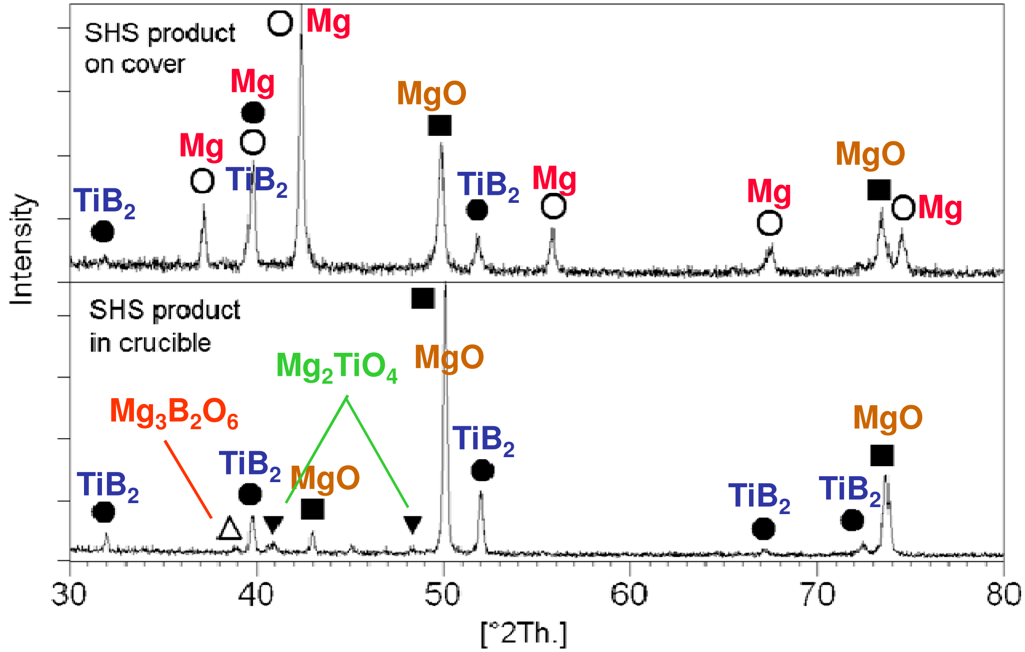
$TiO_2 + B_2O_3 + 5Mg$



Simulation of T_{ad} change with addition of Mg



Simulation of SHS products composition change with addition of Mg



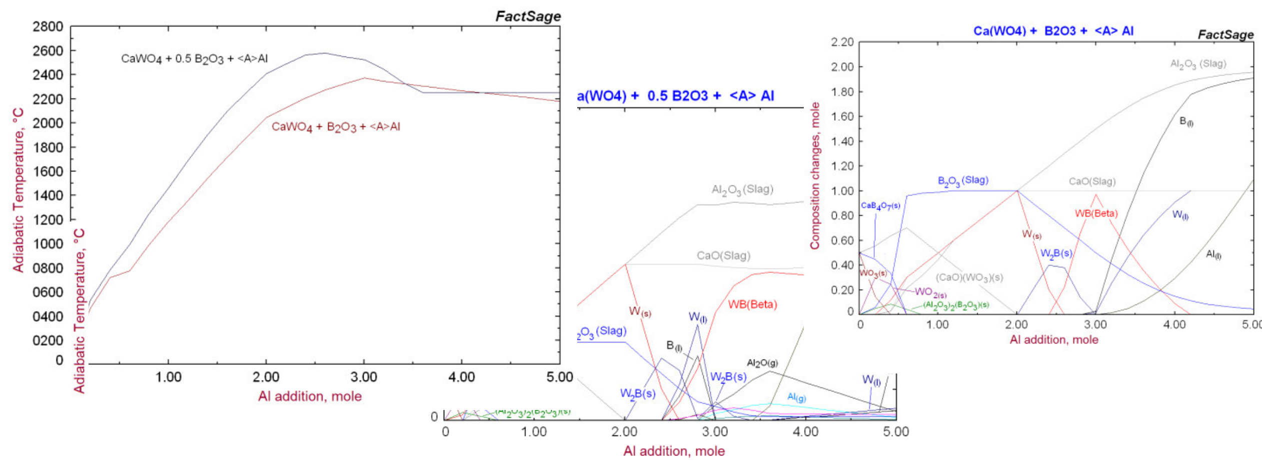
XRD analysis of the SHS products collected on the steel cover and remained in the crucible (100 % stoic. Mg and B_2O_3 additions) ●:TiB_2, ■:MgO, ○:Mg, △: $Mg_3B_2O_6$, ▼:Mg_2TiO_4

$B_2O_3 + 3MgO = 3MgO.B_2O_3$
$TiO_2 + 2MgO = 2MgO.TiO_2$

Minor phases

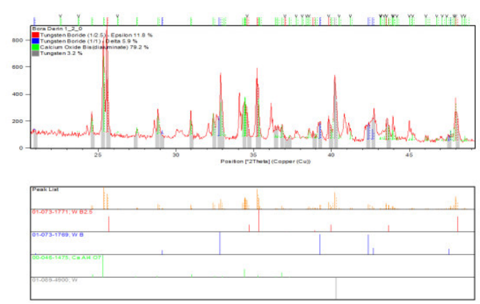
Tungsten boride synthesis via SHS method

$CaWO_4 + xB_2O_3 + yAl$

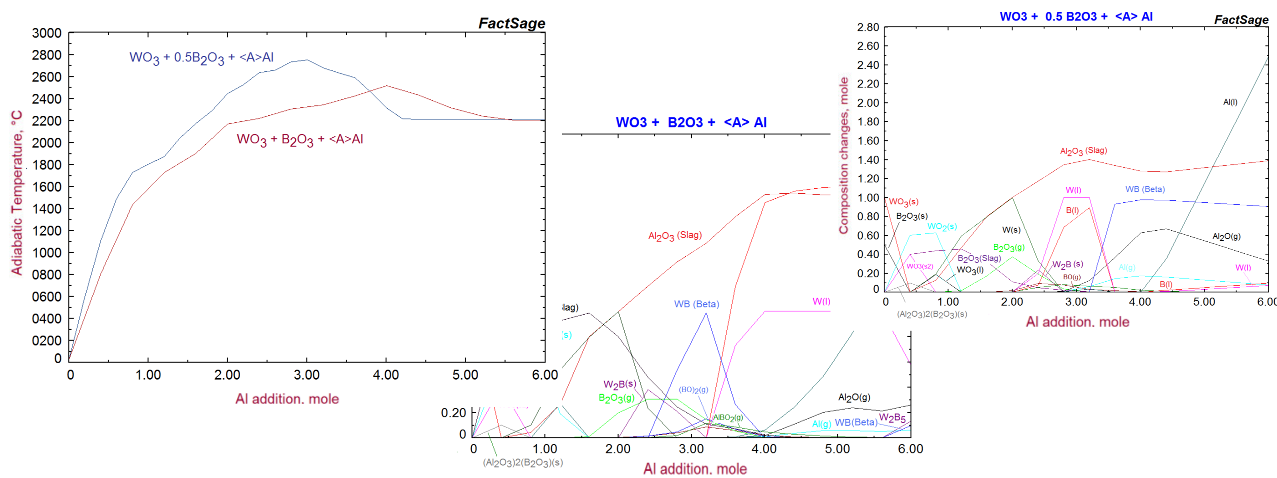


FactSage

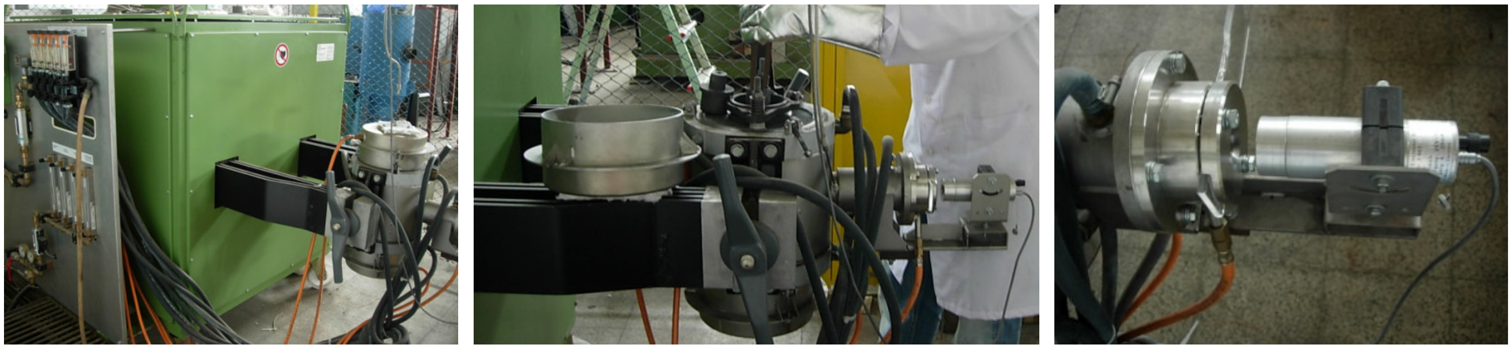
- **What is Tad?**
- **Which composition gives the best result?**



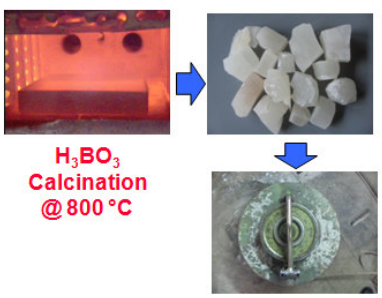
$WO_3 + xB_2O_3 + yAl$

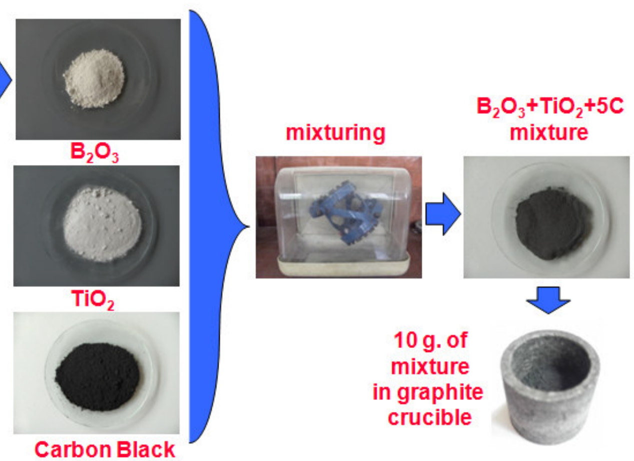


Carbothermal Studies for Titanium diboride Synthesis



High-Temperature Ruhstrat-Nernst Tammann tube furnace

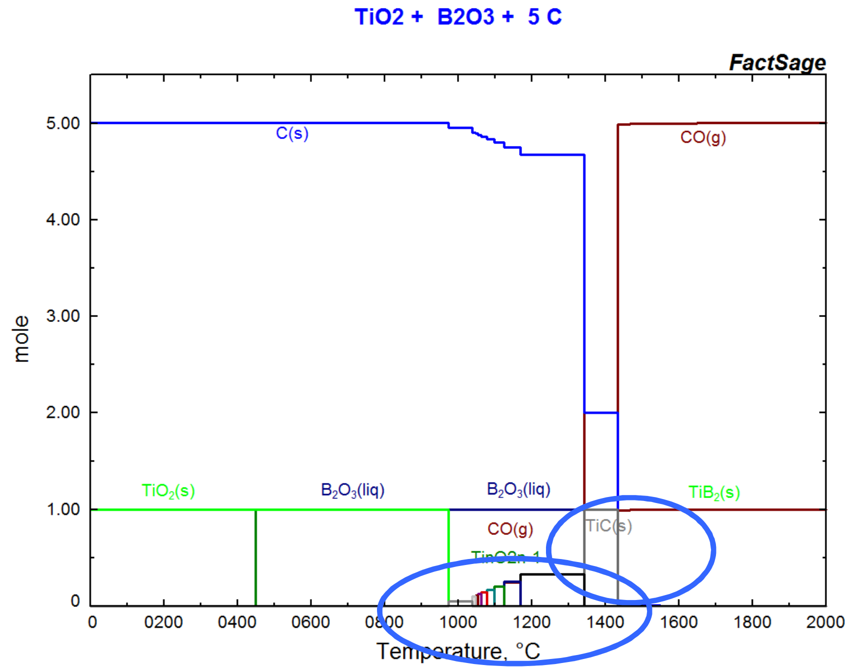


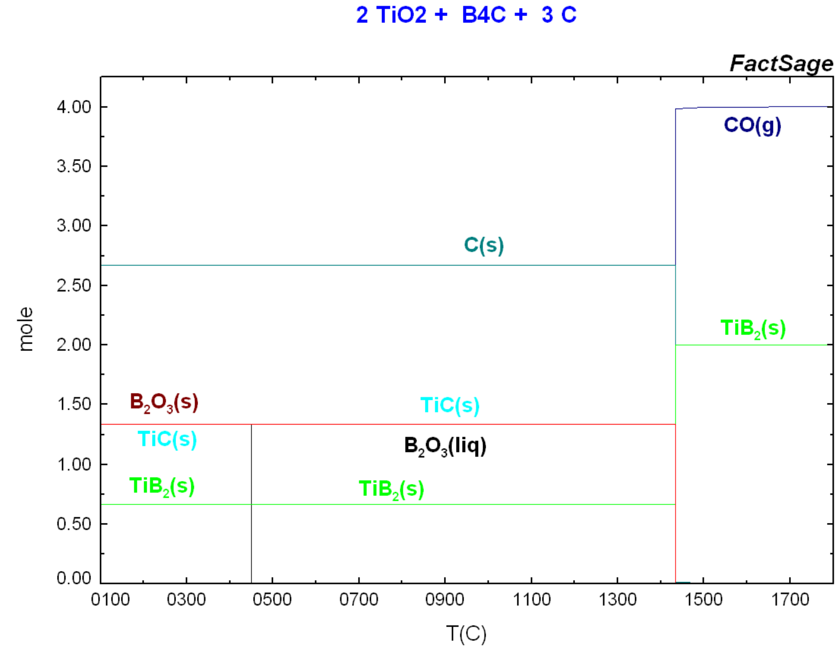


	Purity, wt %	Particle Size, µm
TiO_2	98.8	33 (mean)
C black	> 98	Elftex 125
B_2O_3	99.00	< 53

- Temperature (1400 - 1700 °C) and time (0 - 60 min.) were selected as experimental parameters.
- At the end of the experiments, the sample was left to soak in the crucible keeping flow of argon gas up to below 300 °C.
- The product was discharged, ground and sieved. The phase compositions of the product were examined by XRD

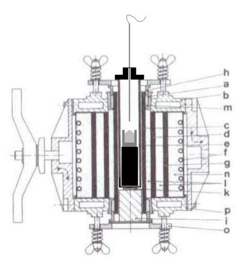
Factsage software calculation





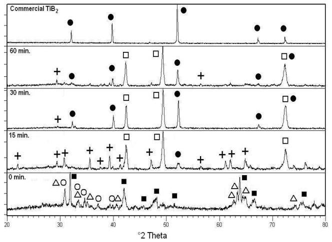
Many complex reactions occur until a complete TiB_2 formation, as in agreement with the literature.

Intermediate Phases are:
Magneli phases (Ti_nO_{2n-1}) and TiC



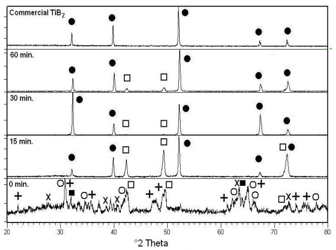
Case 5

1400 °C



Time	XRD Identified Phases
60 min	TiB_2, TiC, Ti_3O_5
30 min	TiB_2, TiC, Ti_3O_5
15 min	TiB_2, TiC, Ti_3O_5
0 min	TiO_2, Ti_6O_{11}, Ti_4O_7, Ti_3O_5, Ti_2O_3

1500 °C

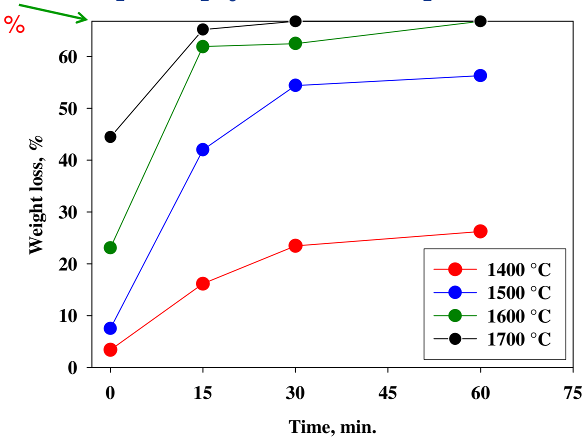


Time	XRD Identified Phases
60 min	TiB_2, TiC
30 min	TiB_2, TiC
15 min	TiB_2, TiC
0 min	TiO_2, Ti_3O_5, Ti_4O_7, TiC, Ti_2O_3, TiB_2

XRD analysis of a commercial TiB_2 and the experimental products obtained at different temperature and time.
(△ Ti_6O_{11}, ○ Ti_4O_7, + Ti_3O_5, × Ti_2O_3, ■ TiO_2, □ TiC, ● TiB_2)

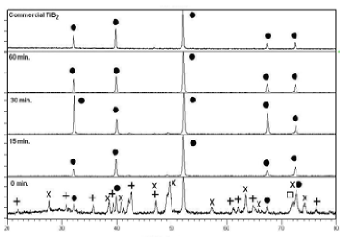
Teoritical value 66.8 %

$TiO_2(s) + B_2O_3(s) + 5C(s) = TiB_2(s) + 5CO(s)$

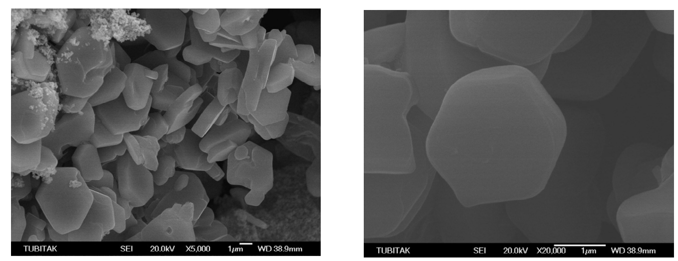


Mass loss of the experimental products after carbothermal synthesis at different temperature and time

1600 °C

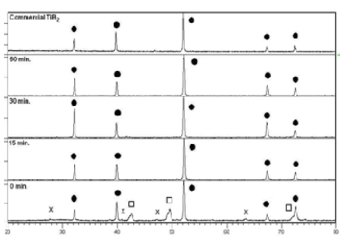


Time	XRD Identified Phases
60 min	TiB_2
30 min	TiB_2
15 min	TiB_2
0 min	Ti_2O_3, TiC, TiB_2, Ti_3O_5



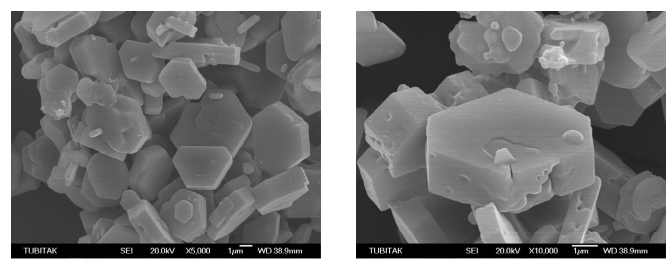
1600 °C 1-h

1700 °C



Time	XRD Identified Phases
60 min	TiB_2
30 min	TiB_2
15 min	TiB_2
0 min	Ti_2O_3, TiC, TiB_2

XRD analysis of a commercial TiB_2 and the experimental products obtained at different temperature and time.
(△ Ti_6O_{11}, ○ Ti_4O_7, + Ti_3O_5, × Ti_2O_3, ■ TiO_2, □ TiC, ● TiB_2)



1700 °C 1-h

Modeling of Sulfide Capacities of Binary and Multicomponent Slags

Sulfur is considered undesirable in steel because of the deleterious effect on the mechanical properties. So sulfur removal in the production stage is a necessary step in order to produce clean steel.

In copper, nickel and lead smelting, sulfur may also lead to metal losses in both forms entrained and chemical dissolution in the fayalite slags.

Sulfide Capacity is a measure of ability of a slag to remove sulfur from metal.

$$Cs = (\text{wt.}\%S)\left(\frac{PO_2}{PS_2}\right)^{1/2}$$

REDDY-BLANDER MODEL

The Reddy-Blander Model predicted that sulfide capacity can be calculated *a priori*, based on a simple solution model and on knowledge of the chemical and solution properties of sulfides and oxides.

<u>In Reddy-Blander Model, slag component is divided into two groups</u>

-"Acid" Components: SiO_2, $AlO_{1.5}$, TiO_2, $FeO_{1.5}$

-"Basic" Components: CaO, FeO, MgO, MnO, $NaO_{0.5}$, $CuO_{0.5}$

REDDY-BLANDER MODEL

Formulation of Equations for Binary Acid Melts ($0.33 \leq XSiO_2 < 1$)

$$Cs = 100 * Ws * K_M * a_{MO} * \frac{X_{SiO2}}{\overline{W}} \left(\frac{\Phi s}{a_{MS}} \right)$$

Formulation of Equations for Binary Basic Melts ($0 \leq XSiO_2 \leq 0.33$)

(Such as $CaO\text{-}SiO_2$, $MgO\text{-}SiO_2$)

$$Cs = 100 * Ws * K_M * a_{MO} \left[\frac{1 - 2X_{SiO2}}{\overline{W}} \right]$$

$$K_M = \left(\frac{P_{O2}}{P_{S2}} \right)^{1/2} \frac{a_{MS}}{a_{MO}}$$

$W_S =$ Molecular weight of sulfur

$\overline{W} =$ Average molecular weight of the solution

$a_{MO} =$ Activity of MO in the solution

Formulation of Equations for Multicomponent Slags

For a multicomponent system MO-NO-…-SiO_2, which contains only one acid component, such as $FeO\text{-}CaO\text{-}SiO_2$ system, Flood-Grjotheim approximation (electrically equivalent fractions) is applied.

$$\ln C_S = N_M \ln C_{S,M} + N_N \ln C_{S,N} + \ldots$$

Where

$$N_M = \left(\frac{X_{MO}}{X_{MO} + X_{NO} + \ldots} \right) \qquad N_N = \left(\frac{X_{NO}}{X_{MO} + X_{NO} + \ldots} \right)$$

$C_{S,M}$ and $C_{S,N}$ are sulfide capacities in the sulfide capacity of ternary MO-NO-….-SiO_2 system

For a multicomponent system containing more than one acid component such as MO-NO-…..-SiO_2-$AlO_{0.5}$-TiO_2 system

$XSiO_2 + XAlO_{0.5} + \ldots \leq 0.33$,

$$Cs = 100 * Ws * K_M * a_{MO} \left[\frac{1 - 2X_{SiO2} - 2X_{AlO0.5} - 2X_{TiO2}}{\overline{W}} \right]$$

$XSiO_2 + XAlO_{0.5} + \ldots \geq 0.33$,

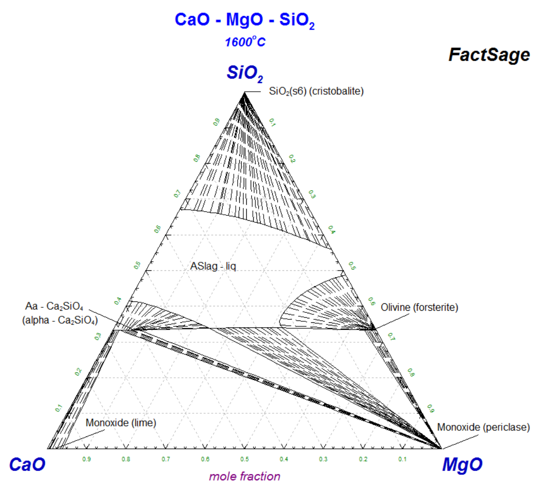
$$Cs = 100 * Ws * K_M * a_{MO} \left[\frac{X_{SiO2} + X_{AlO0.5} + X_{TiO2}}{\overline{W}} \right] \left(\frac{\phi_S}{a_{MS}} \right)$$

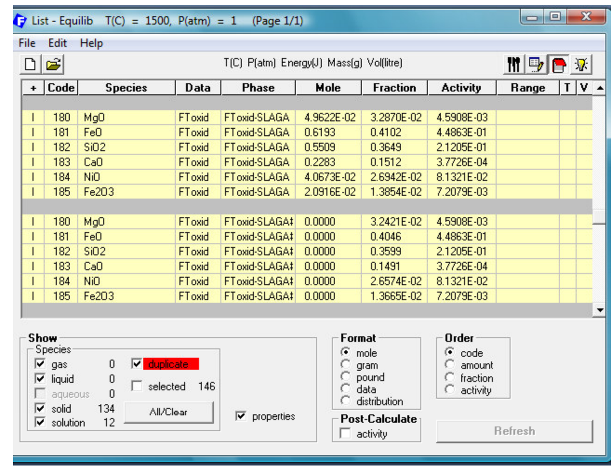
$$\ln C_s = \Sigma N_{MO} \ln C_{S,MO}$$

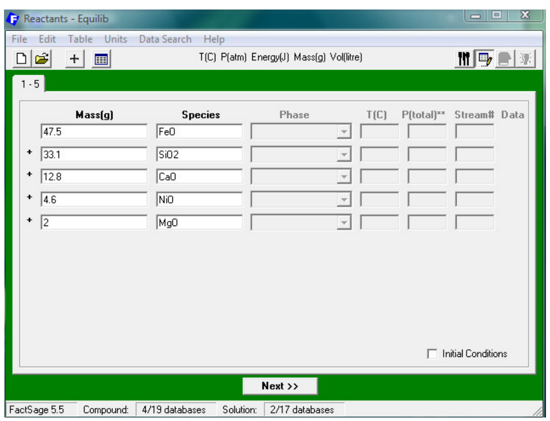
a_{MO} is the activity of MO in the MO-SiO_2-$AlO_{1.5}$-TiO_2 system

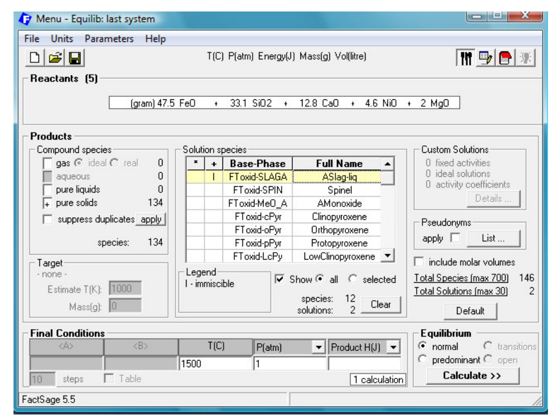
$\overline{W}$ is the is the average molecular weight of MO-SiO_2-$AlO_{1.5}$-TiO_2 system

FactSage for close approximations of activity values (a_{MeO}) in multi-component slags

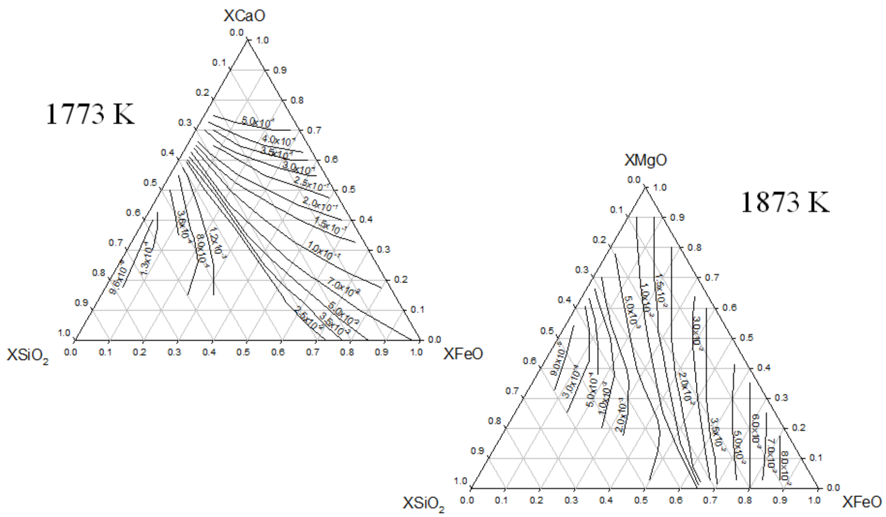




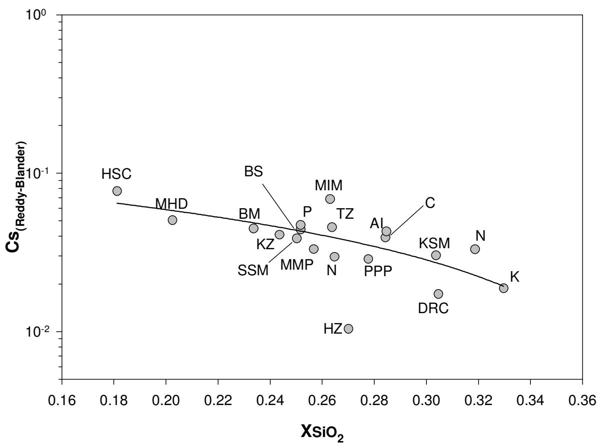




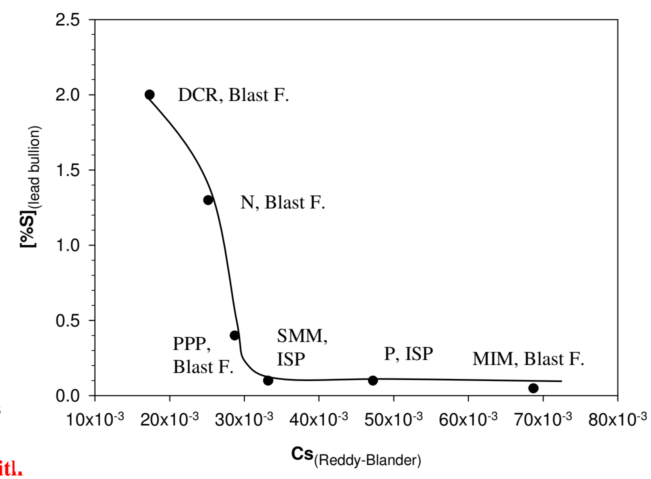
Predicted Iso-sulfide capacities of the ternary $FeO-CaO-SiO_2$ and $FeO-MgO-SiO_2$ slag systems



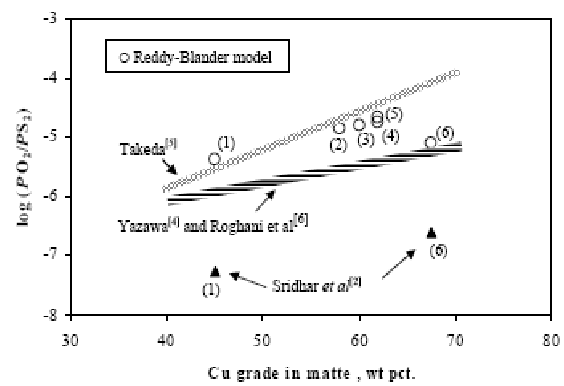
Initial	Company	Furnace Type	Slag Temp (°C)	Slag Composition (%)					Cs(R-B)
				PbO	ZnO	FeO	SiO_2	CaO	
MIM	Mount Isa Mines Ldt.	Blast	1225	2.8	17.3	22.8	21.0	24.5	$6.87x10^{-2}$
PPP	Pasminco Port Pirie	Blast	1200	2.8	19.9	32.0	22.0	14.0	$2.87x10^{-2}$
HSC	Hachinohe Smelting Co.	ISF	1300	1.1	8.7	36.0	12.3	17.5	$7.71x10^{-2}$
SMM	Sumitomo Metal Mining	ISF	1250	1.6	10.0	38.6	19.1	14.2	$3.32x10^{-2}$
KMS	Kamioka Mining&Smelting	Blast	1200	3.2	-	30.0	23.0	25.0	$3.03x10^{-2}$
TZ	Toho Zinc Co	Blast	1200	-	18.7	28.0	21.0	20.0	$4.56x10^{-2}$
HZ	Hindustan Zinc Ltd.	ISF	1000	1.6	11.2	35.0	20.0	15.0	$1.04x10^{-2}$
AI	Asarco Inc	Blast	1200	1.9	17.7	25.8	22.3	19.6	$3.92x10^{-2}$
DRC	Doe Run Company	Blast	1200	2.2	12.4	33.0	22.0	12.0	$1.73x10^{-2}$
MMP	Met-Mex Penolas	Blast	1150	1.4	14.9	31.4	19.9	20.5	$3.88x10^{-2}$
N	Noranda Inc.	Blast	1200	3.8	12.4	36.0	20.5	15.5	$2.97x10^{-2}$
BS	Berzelius Stolberg	QSL	1250	2.7	9.3	26.5	22.0	22.0	$4.42x10^{-2}$
BM	Boliden Mineral	Kaldo	1150	4.5	5.7	40.0	21.0	28.0	$4.48x10^{-2}$
MHD	MHD-M.I.M Huettenwerke	ISF	1300	1.0	9.2	40.5	13.8	12.5	$5.06x10^{-2}$
P	Portovesme srl	ISF	1300	1.1	8.7	40.0	20.0	18.0	$4.72x10^{-2}$
C	Cominco	Kivcet	1300	5.2	21.2	28.8	22.2	13.7	$4.29x10^{-2}$
K	Kazzinc	Kivcet	1300	1.3	18.0	28.8	26.8	15.6	$1.88x10^{-2}$
N	Nuova	Kivcet	1300	1.9	9.6	26.0	25.1	22.7	$3.31x10^{-2}$
KZ	Korea Zinc	QSL	1216	5.4	18.7	34.2	19.3	15	$4.09x10^{-2}$



Sulfide capacity predictions of industrial lead smelting slags with different slag system and temperatures.



The relationship between sulfur capacity of industrial slags and sulfur content of lead bullions.



Comparison of pressure ratios for the matte grades from different smelting plants: (1) INCO (2) Rio-Tinto (3) Tamano (4) Norddeutsche (5) Phelps (6) Outokumpu

Journal & Proceeding Papers

Thermochemical Calculations with FactSage

1. Derin B., Yucel O., Reddy R.G., “Modeling of Sulfide Capacities of Binary Titanate Slags” EPD Congress 2004, TMS Annual Meeting, March 14-18, (2004) North Carolina-USA, 155-160
2. Yucel O., Yigit S., Derin B., “Production of Magnesium Metal from Turkish Calcined Dolomite using Vacuum Silicothermic Reduction Method” Magnesium – Science, Technology and Applications, Materials Science Forum, Vols. 488-489 (2005) 39-42.
3. Onuralp Yücel , Selen Yiğit ve Bora Derin “Production of Magnesium Metal using Vacuum Sılıcothermıc Reductıon Method” Proceedings of the International Metallurgy and Materials Congress, (2005), Istanbul,.
4. “Bora Derin.,Onuralp Yucel, Ramana G. Reddy, “Sulfide Capacities of PbO-SiO2 and PbO-SiO2-AlO1.5 (Sat) Slags” Lead&Zinc 2005 Proceedings of the International Symposium on Lead and Zinc Processing, Kyoto, Japan, October 17-19, (2005) Vol II. pp: 1279-1287.
5. Derin B., Yucel O., Reddy R.G., “Predicting of Sulfide Capacities of Industrial Lead Smelting Slags” Sohn International Symposium on Advanced Processing of Metals and Materials: Principles, Technologies and Industrial Practice, August 27-31, 2006 Catamaran Resort. San Diego, California, USA
6. U. Demircan, B. Derin and O. Yücel. “ Effect of HCl concentration on TiB_2 separation from a self-propagating high-temperature synthesis (SHS) product” Materials Research Bulletin (2006)
7. B. Derin U. Demircan, T. Uzunoglu, and O. Yücel. “ Semi-Pilot Scale Calcination Study of Turkish Dolomite for Magnesium Production“ International Magnesium Conference, China, (2006)
8. Derin B, Demircan U, Uzunoğlu T, Yücel O, “Decomposition of Turkish Dolomite Using Semi-Pilot Scale Rotary Furnace” 13th Proceedings of the International Metallurgy and Materials Congress, (2006), Istanbul, Turkiye.
9. Derin B, Yucel O, Klaus Hack “Computational Solutions in Metallurgical Processes” 13th Proceedings of the International Metallurgy and Materials Congress, (2006), Istanbul, Turkiye
10. B. Derin, U. Demircan, O. Yucel, The Synthesis of TiB_2 Powder by a Self-Propagating High-Temperature Synthesis (SHS) and HCl Leaching Technique, Proceedings of the 10th International Conference of the European Ceramic Society, June 17 - 21, (2007), Berlin, 447 - 450.
11. B.Derin, M. Alkan and O. Yücel, "Effects of Charge Components on Ferromolybdenum Production by Aluminothermic Process" EuroMAT 2007, 10 – 13 September 2007, Nürnberg, Germany.
12. Filiz Sahin, Kutluhan Kurtoglu, Bora Derin, Onuralp Yücel. An Investigation of TiB2 Synthesis Using TiO2/B4C/C Powder Mixture, EPD Congress 2008 TMS Annual Meeting, March 9-13, (2008), New Orleans, USA, 355-360.
13. Bora Derin, Kutluhan Kurtoglu, Filiz Sahin, Onuralp Yücel. Titanium Diboride Synthesis by Carbothermal Reduction of TiO2 and B2O3, EPD Congress 2008 TMS Annual Meeting, March 9-13, (2008), New Orleans, USA, 379-383.
14. Derin B., Demircan U., Uzunoglu T., Yücel O,. “A Study on Thermal Decomposition of Dolomite from West Anatolia Region using semi-pilot Scale Rotary Furnace” The International Journal of Mineral Resources Engineering, Vol. 12, No.3 (2007) 205-214.

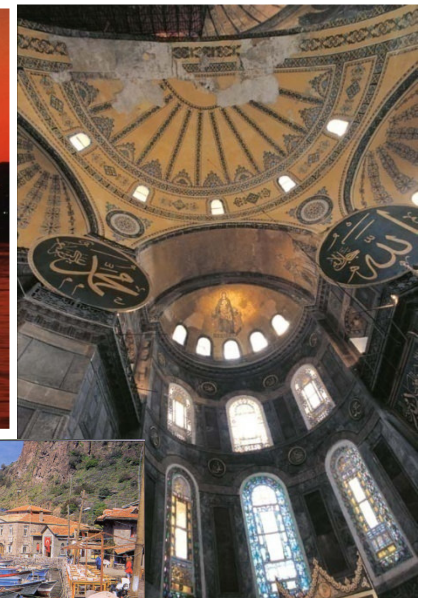
Workshop on Computational Thermochemistry in Istanbul

Conclusion

FactSage is an invaluable tool for our experimental/modeling studies since it helps us for understanding and optimizing the existing /new processes.

THANK YOU FOR YOUR ATTENTION




Bora Derin and Onuralp Yücel

Department of Metallurgical and Materials Engineering,
Istanbul Technical University, Maslak, Istanbul, 34469, Turkiye