FUNDAMENTALS OF FIRE ASSAYING
(An Introduction To *Slagmaster*)

BULLETIN 113084A

Text and Illustrations
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Published by AMERICAN SOCIETY FOR APPLIED TECHNOLOGY
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ACKNOWLEDGMENTS

As author of this Bulletin I wish to acknowledge my indebtedness to the host of previous authors who have researched and written upon the subject of fire assay. Without the multiplicity of their assay formulae and diverse comments, it would have taken a lifetime to collect the data which was incorporated in our computerized overview of the subject.

Among the most notable of such writings were the works of: T. K. Rose, C. H. Fulton, F. E. Beamish, E. H. Miller, S. W. Smith, and W. F. Hillebrand. Other authors must go unnamed, for I failed to make bibliographic comment on my notes.

An unsung hero of this Bulletin is Professor Jack Mason, Master of Fine Arts, Master of Science in Chemistry, and Master of Science in Geology. During my years at Findlay College, Jack contributed several thousand hours in one-to-one tutoring, and this author shall be forever in his debt.

Both time and expertise on the part of Joleen Russak, Michael Allen, and Sheila Lashley transformed this writing from scribbled notes to legible copy, and they are, rightfully, as much the author as I.

-- Walter C. Lashley
Silver City, New Mexico
January, 1985

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VisiCalc (R): Version 1.20; IBM Software; #6024004

ASAT
BULLETIN 113084A

INTRODUCTION

This bulletin is intended to familiarize the novice with, and to refresh the memory of the professional in, the art of fire assaying the noble metals.

In this writing, we will discuss only silver and gold. Even though the fire assay of the platinum group metals involves the same pyrometric chemistry, there are innovations for collecting the PGMs which are too numerous to be included in this publication.

We will be introducing into the flux formula one chemical (red iron or ferric oxide) which is not normally included in the fluxing of ores for assay, but which is always included in a smelting flux.

Moreover, ASAT's argument for the use of red lead oxide over litharge will be discussed.

We shall also describe how to determine the success or failure of the firing by examining the slag and the lead button which will have been produced.

LAYMAN'S TERMS

Wherever possible, we will use layman's terms, for this bulletin is designed as a tool to be used, rather than as a treatise to be argued over.

If technical references are employed, we shall define them as briefly as possible.

IT IS ASSUMED...

...that the reader already knows what the tools of the trade are. Therefore, we will not elaborate on their descriptions.

IN BRIEF

The object of fire assay is to oxidize and absorb into the slag all the unwanted base metals while completely digesting the rock-forming minerals. Simultaneously, droplets of lead are formed which, in turn, collect the noble metals and sink to the bottom of the melt to form the lead button.

Simple as the above statements sound, one must orchestrate these happenings upon a time/temperature sequence with reasonable accuracy. If the proper sequence does not transpire, the noble metals are left in the slag, and/or base metals are reduced to their metallic form and contaminate the lead button. Such contamination will result in losses during cupellation.

Therefore, the secret of a successful fire assay depends upon one's ability to combine dry chemical ingredients with an ore in such a manner that one produces a known slag which will fluidize at a known temperature.

DEFINITION OF SLAGS

Slag is the glassy end-product which has been produced during fusion. It is composed of a combination of elements involving three families of pyrometric behavior. Where R = Reagent (or element if you wish) and O = Oxygen, these families are identified as:

1) RO which is referred to as *basic oxygen* and comprises those elements that form primary oxides

with a single atom of oxygen. These include magnesium, calcium, barium, and strontium.

Most writings will also include lithium, sodium, potassium, and rubidium in this group, and, for the moment, we shall too. (The differences within these subgroups are defined on page 12 in this writing.)

Basic oxides melt at low temperatures and provide the eutectic fluxing which allows them to dissolve and combine with other elemental oxides.

2) R_2O_3 These are the *amphoteric compounds*. That is: they may act as either basic oxides or as acidic oxides (at the temperatures of fusion assay, they often remain refractory and merely thicken the melt).

They are comprised of the elements which form primary oxides using two atoms of an element and three atoms of oxygen.

The three most important members of this group are alumina (Al_2O_3), boron (B_2O_3), and Iron (Fe_2O_3).

3) RO_2 These are the *acidic oxides* often referred to as glass-formers. Silica, with one silicon atom and two oxygen atoms, is the most important. Titanium, tin, and zirconium dioxides only come into play when one is working with concentrates. As we are dealing here with raw ores, we will treat the entire family as though it were silica.

METALLURGICAL SCALE

Various ratios of combinations between the RO and RO_2 groups are referred to as the metallurgical scale.

When reviewing this scale, remember that the R in the RO portion may be sodium, potassium, calcium, etc.

For the simplification of understanding this scale, we will represent the acidic oxygen (RO_2) by silica alone (SiO_2), for it is the major rock-forming oxide as well as a common ingredient in the compounding of a flux.

<u>Subsilicate</u> =
$4RO*SiO_2$ = [$R_4\underline{O}_4$*Si $\underline{O}_2$]

This slag (irrespective of the compounds) has a ratio of two basic oxygens to each acidic oxygen (or 1:0.5).

<u>Monosilicate</u> =
$2RO*SiO_2$ = [$R_2\underline{O}_2$*Si $\underline{O}_2$]

As the name implies, the ratio of basic oxygens is equal to the acidic oxygens (1:1). This is, by far, the most important ratio to remember while reading this bulletin, for it is the slag that we will be trying to make in every instance.

<u>Sesquisilicate</u> =
$4RO*3SiO_2$ = [$R_4\underline{O}_4$*$Si_3\underline{O}_6$]

Sesqui means one and one-half. Therefore, the $RO:RO_2$ ratio is 4:6 (which reduces to 1:1.5).

<u>Bisilicate</u> =
$RO*SiO_2$ = [R $\underline{O}$*Si $\underline{O}_2$]

As the prefix *bi* suggests, the ratio of RO to RO_2 is 1:2.

There are, of course, <u>trisilicates</u> and on up the line; however, the fusion of bisilicates crowds the maximum firing temperatures used in normal assaying, and we can see no need to burden you with terms which do not pertain to the discussion.

REMEMBER:
<u>The slag is the constant</u>, and the fluxes are altered so that they and the ore will combine to produce the slag desired.

FLUXING INGREDIENTS

For the moment, we shall merely list the chemistry generally used in fluxing an ore along with the behavioral family to which it belongs.

BASIC OXIDES USED AS RO IN FLUXING FORMULAE:

Sodium Carbonate/anhydrous, Na_2CO_3
This is used in every flux formula.

Litharge, PbO
A form of lead oxide *normally* used in all fire assays.

Red Lead Oxide, Pb_3O_4
The form of lead oxide we *prefer* to use in our flux formulas.

Calcium Oxide (lime), CaO
Used as a high temperature flux which helps control the viscosity of the melt.

OXIDES SOMETIMES USED AS RO IN FLUXING FORMULAE:

Potassium Carbonate, K_2CO_3
Occasionally used in lieu of sodium carbonate, but *not* recommended.

Tartar (argol), $(CHOH*CO_2*H)_2$
An organic compound used when firing phosphate ores, or when assaying cupels. (It is also a reducing agent, like flour.)

Potassium Nitrate, KNO_3
This is an oxidant used to control the quantity of lead reduced when firing sulfide ores. (Its use should be *avoided* if possible, for it will slag some of the PGMs.)

NOTE: Do not use sodium or potassium bicarbonates, as substitutes for anhydrous sodium carbonate. Bicarbonates contain a hydrogen which is a reducing agent that would be released at the wrong time in the firing sequence.

AMPHOTERICS (R_2O_3) USED IN FLUXING FORMULAE:

Borax Glass, $Na_2O*B_2O_3*2H_2O$
The B_2O_3 is the actual amphoteric. However, sintering this compound to glass and grinding is easier to manipulate than powdered boric acid. It has been predetermined that pre-combining the diboron trioxide with sodium oxide will produce a basic oxide behavior at elevated temperatures.

Ferric Oxide, Fe_2O_3
If red iron oxide is less than 5% of the melt, it behaves as a very low temperature flux in the eutectic environment of a melt. This effect diminishes as the percentage rises. If the percentage exceeds 8, the excess is acting as a refractory.

ACIDIC OXIDE (RO_2) USED IN FLUXING FORMULAE:

Silica, SiO_2
There is only one RO_2 used, and that is *silica*.

CHEMICAL EVENTS DURING FUSION

The chemical events taking place during fusion are charted by their *theoretical* temperatures on page four (4). However, we wish to emphasize that these temperatures are approximate and will fluctuate according to the unique eutectics of each individual fusion.

TEMP. °C	VISIBLE COLOR	TEMP. °F	EVENT
30		86	SODIUM PEROXIDE (if used) begins oxidation
100		212	Surface water evaporates
190		374	Entrapped atmospheric water volatilizes
270		518	SODIUM BICARBONATE = CO_2 REDUCTION This would be an error
339		643	POTASSIUM NITRATE (if used) reacts w/SULFIDES

FUSION STARTS AT THIS POINT

TEMP. °C	VISIBLE COLOR	TEMP. °F	EVENT
339		643	Fusing point for LEAD OXIDES
340		644	Reduction of LITHARGE to LEAD by CO_2 starts if CHARCOAL is used
450		842	SILICA reacts w/POTASSIUM NITRATE (if present)
475	Lowest Visible Red	885	
482		900	Chemically combined water volatilizes
500		932	BORAX sinters to a viscous melt
500		932	RED LEAD OXIDE decomposes
530		986	When flour is used, the reduction of LEAD OXIDE to LEAD by CO_2 starts
530		986	POTASSIUM NITRATE oxidation finished
590		1094	BORAX reacts w/SILICA & remains viscous
590		1094	FERROUS SULFATE decomposes (if present)
650	Dark Red	1200	
655		1210	COPPER SULFATE decomposes (if present)
700		1292	The evolution of CO_2 stops
700		1292	SULFUR has combined w/SODA and/or volatilized

TEMP. °C	VISIBLE COLOR	TEMP °F	EVENT
700		1292	LITHARGE sinters & combines w/SILICA
704		1300	All water is gone
750	Cherry Red	1380	
800		1472	SODIUM CHLORIDE decomposes (Undesire-able due to the release of CHLORINE)
814		1497	GALENA changes to LEAD in the presence of SODIUM OXIDE and IRON
814		1497	SODIUM CARBONATE, in the presence of SULFIDES, forms SODIUM SULFATES if IRON is present
815	Bright Cherry Red	1500	
815		1500	SODIUM CARBONATE melts
855		1570	POTASSIUM CARBONATE fuses (if present)
888		1616	LITHARGE decomposes
900	Orange	1650	
920		1688	CALCIUM & SILICA begin to combine
954		1750	SILICA begins to combine w/ALUMINA
1010		1850	SILICA has combined w/ALUMINA
1018		1865	SODIUM SILICATES are melted
1030		1886	LEAD MONOSILICATE is fluid; BORAX now becomes an active flux & fluidizes the melt; & METAL globules settle to the bottom to form the button
			<u>MINIMUM FIRING TEMPERATURE</u>
1090	Yellow	2000	
1150		2102	Na,Fe,Ca MONOSILICATES are fluid
			<u>MAXIMUM FIRING TEMPERATURE (WHICH SHOULD BE NECESSARY)</u>
1200	Hi Yellow	2192	
1200		2192	FLUORSPAR may or may not have melted
1315		2400	FIRE BRICK melts

30 DEGREES CENTIGRADE
SODIUM PEROXIDE

[This reagent is seldom used.]

Sodium peroxide would melt and begin oxidizing at 30°C.

This is a very powerful oxidizing agent and is seldom used in fusion assay, for it will not only dissolve the crucible, but will also take the entire platinum family into molten solution.

100 DEGREES CENTIGRADE
FIRST WATER

There are three types of water involved in the ore. The first is the surface water that has been absorbed from the air or during the act of concentration. This will evaporate at 100°C.

190 DEGREES CENTIGRADE
SECOND WATER

Physically entrapped waters are released (violently). These are the waters locked in vugs, inclusions, and ionically between platelets and crystals. They evolve at 190°C.

270 DEGREES CENTIGRADE
SODIUM BICARBONATE

[Do not use this reagent.]

This reagent is seldom used, for it must divest itself of both hydrogen and carbon before becoming sodium oxide.

To start reduction before the act of oxidation begins would, in the opinion of the author, be an error. The unwanted base metals must first be oxidized and then combined with the fluxes to keep them from contaminating the lead button. Reduction would defeat this goal.

339 DEGREES CENTIGRADE
POTASSIUM NITRATE

Working with a self-reducing or (sulfides) makes it necessary to oxidize a controlled amount of these sulfides to produce the correct size of lead button.

For this purpose, potassium nitrate is the most successful oxidant, and the reaction should take place very early in the melt.

However, use KNO_3 only when necessary, for it has a tendency to slag the PGMs.

339 DEGREES CENTIGRADE
LEAD OXIDES

Both litharge and red lead oxide fuse into a thick, syrupy mass at the same temperature. This is a melt, and no real reaction has taken place as yet.

340 DEGREES CENTIGRADE
CHARCOAL, FLOUR, CORNMEAL, ETC.

Most carbon bearing materials smolder and char at this temperature. Carbon dioxide is created and evolves as a gas; however, it has little effect until higher temperatures are reached.

450 DEGREES CENTIGRADE
POTASSIUM NITRATE, IF PRESENT, reacts with silica to form potassium silicates.

475 DEGREES CENTIGRADE
THE LOWEST VISIBLE RED HEAT

482 DEGREES CENTIGRADE
THIRD WATER

Chemically combined waters of crystallization break their bonds and immediately become live steam.

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THIRD WATER

Chemically combined waters of crystallization break their bonds and immediately become live steam.

(continued from page 6)

This reaction may be very violent and push the melt over the rim of the crucible.

The stronger the bonds, the higher the temperature that will be needed to break them, and this reaction may transpire from 492°C. to 704°C.

Each molecule of steam will carry one atom of oxygen with it. This is detrimental to the fusion and must be compensated for (this is one of the reasons why we use red lead).

500 DEGREES CENTIGRADE
BORAX GLASS

Although the borax glass, itself, will not become chemically active until much higher temperatures are reached, it sinters to a viscous mass at this point and acts as a glue to hold the melt in suspension while the necessary reactions take place.

500 DEGREES CENTIGRADE
RED LEAD OXIDE

Red lead oxide decomposes, releasing its extra oxygen. In other words, Pb_3O_4 (red lead oxide) decomposes to PbO (litharge). This translates to one mole of free oxygen for each 3 moles of litharge remaining in the melt.

The excess free oxygen enhances the probability of a successful firing, for oxidation of the base metals must transpire before any litharge is converted to metallic lead, or the lead button will be contaminated with them.

These reactions are on a *nearest neighbor* basis, and carbon (converting to carbon dioxide) as well as water (becoming steam) are competing with the base metals for any free oxygen that is available.

Base metals collected in the lead (soon to appear in the melt) would no longer be oxidized, and they would contaminate the resultant button.

Should there be insufficient oxygen in the melt, minerals of <u>antimony</u>, <u>bismuth</u>, <u>cobalt</u>, <u>copper</u>, <u>iron</u>, <u>nickel</u>, <u>tellurium</u>, <u>and tin</u> would reduce to their metallic state. In the presence of a CN radical, <u>indium</u> and <u>thallium</u> will reduce as well.

530 DEGREES CENTIGRADE
METALLIC LEAD BEGINS TO FORM

Metallic lead begins to appear in the melt: (1) as a microscopic mist, and (2) increasing in size as droplets collect upon one another.

(In a thin and fluid melt, these droplets would sink to the bottom before the noble metals had been released from their gangue, and the firing would be a failure.)

530 DEGREES CENTIGRADE
POTASSIUM NITRATE, IF IT HAS BEEN USED,
exhausts its power to oxidize.

590 DEGREES CENTIGRADE
BORAX
reacts with silica and base metal oxides to form complex borosilicates which remain viscous.

590 DEGREES CENTIGRADE
FERROUS SULFATE, IF PRESENT,
would decompose at this temperature, forming ferrous oxide and surrendering its sulfur to the sodium in the flux.

650 DEGREES CENTIGRADE
VISIBLE DARK RED

655 DEGREES CENTIGRADE
COPPER SULFATE, IF PRESENT, decomposes.

/00 DEGREES CENTIGRADE
ALL CARBON PRESENT
has converted to carbon dioxide, and internal reduction stops.

700 DEGREES CENTIGRADE
ALL SULFATES AND/OR SULFIDES PRESENT
have decomposed, and the sulfur has either combined with sodium or volatilized. *That is if, and only if, the flux was properly compounded.* Should this not be the case, there would be a black, granular, semi-malleable, sulfide matte lying just above the lead button, and the firing would be a failure.

700 DEGREES CENTIGRADE
LITHARGE (PbO)
sinters and combines with silica ɔ form lead silicates.

704 DEGREES CENTIGRADE
ALL WATERS OF CRYSTALLIZATION
have been expelled, and the melt begins to settle in the crucible.

750 DEGREES CENTIGRADE
VISIBLE CHERRY RED

800 DEGREES CENTIGRADE
SODIUM CHLORIDE (SALT)

In many older flux formulae, salt was called for as a cap for assays. If it were used, it would decompose at this point.
WE STRONGLY RECOMMEND that salt <u>not be used in any fluxing formula</u>, for it will combine with any sulfides and volatilize gold -ɿd the PGMs. (There are several covery patents based upon this very principle.)

814 DEGREES CENTIGRADE
ALL GALENA PRESENT
will convert to lead at this temperature. *That is if, an[d] only if, there is enough iron oxide present to act as the exchange agent which transfers the sulfur from the galena to the sodium oxide, forming sodium silicate.*

<u>NOTE</u>: Galena is known to carry all of the noble metals, and, in our opinion, its direct reduction to metallic lead is important to the success of any fire assay.
It is our observation that slags which contain very high entrapped noble metal values are invariably those which also contain high potassium.
Apparently, the use of potassium nitrate to oxidize the sulfides and to nullify their reductive power may contribute to the slagging of the noble metal values.
For this reason, we have incorporated ferric oxide in our flux formulae to facilitate the reduction of galena and other sulfides.
WE RECOMMEND that you accept the larger lead button. Either scorify the excess lead off, or, better yet, use a larger cupel to absorb the excess lead.

815 DEGREES CENTIGRADE
VISIBLE BRIGHT CHERRY RED

815 DEGREES CENTIGRADE
ANY SODIUM CARBONATE,
which has not combined with other elements by eutectic effect, will melt at this temperature.

855 DEGREES CENTIGRADE
ANY POTASSIUM CARBONATE,
which has been substituted for sodium carbonate and which has not combined by eutectic effect, will fuse at this point.

888 DEGREES CENTIGRADE
TOTAL DECOMPOSITION OF LITHARGE

takes place, and the serious business of dissolving the rock-forming minerals commences.

REMEMBER: The mist of lead droplets is suspended in the melt, and it will collect the noble metals as they are released from their gangue.

900 DEGREES CENTIGRADE
VISIBLE ORANGE

920 DEGREES CENTIGRADE
CALCIUM AND SILICA

begin to combine.

954 DEGREES CENTIGRADE
ALUMINA AND SILICA

begin to combine.

1010 DEGREES CENTIGRADE
CALCIUM, ALUMINA, AND SILICA

have combined to form complex silicates.

1018 DEGREES CENTIGRADE
SODIUM SILICATES

As the sodium silicates reach their melting point, the flux begins to fluidize, and the droplets of lead begin their descent to the bottom of the crucible.

1030 DEGREES CENTIGRADE
LEAD MONOSILICATE

has become highly fluid, and *borax* changes from a refractory, thickening agent to a very active fluxing agent. With increased fluidity, the droplets of lead contact each other and the freed noble metals which have not already been collected. Then they rapidly descend to the bottom of the crucible.

Those members of the platinum group metals, which do not combine with lead, settle by gravity in accordance to their size, shape, and density. Whether they do or do not arrive at the button is a function of the fluidity of the slag.

<u>NOTE</u>: The word *slag* has appeared in the descriptive vocabulary. Usage of this word is now proper, for *slag* is the dross remaining when all possible reactions of digestion are completed and separation of the suspended lead has taken place. If the above has not taken place, then the crucible has been removed from the furnace prematurely, or the ore was not properly fluxed in the first place.

1090 DEGREES CENTIGRADE
VISIBLE YELLOW

1150 DEGREES CENTIGRADE
MONOSILICATES FLUIDIZE

Even the most stubborn combinations of <u>iron</u>, <u>sodium</u>, <u>and</u> <u>calcium</u> monosilicates <u>fluidize</u>. If the calculations are anywhere near correct, this should be the highest temperature needed for a successful assay.

1200 DEGREES CENTIGRADE
VISIBLE HI-YELLOW

1200 DEGREES CENTIGRADE
CALCIUM FLUORSPAR

Many fluxing formulas call for calcium fluorspar. We consider this to be an error, as it remains refractory until it reaches this temperature and has a tendency to retain small particles of lead and noble metals in the slag.

SLAGMASTER

Had Slagmaster been compiled in the era of pen and paper mathematics, it would have constituted a monumental feat.

As it is, the ability of the micro-processor to crunch numbers at lightning speed has allowed us to combine the theoretical principles of pyrometallurgy (as applied to assaying) with the pyrometrics of ceramics, and to introduce empirical observations which have resulted in the simplified work sheet found on page 12.

In reviewing hundreds of assay formulas from the past, we attempted to ascertain what rationale the *art* of assaying employed to arrive at flux variations for various host rock.

It was decided that the *art* is most probably based upon one's ability (either conscious or subconscious) to determine the composition of the sample to be assayed, including (but not limited to) the approximate content of silica, feldspars, calcium group minerals (as carbonates or oxides and not combined in feldspars), the sulfides and oxides of metals, and clay or clay-like minerals.

Specifically, the assayer must combine the ore and the fluxes in a manner which produces a *successful* slag. To paraphrase E. E. Bugbee (1940, *A textbook of fire assaying* [3rd ed.]: New York, John Wiley & Sons), a successful slag must meet the following criteria:

(1) Low temperature of formation.

(2) Pasty at formation temperature, to hold up the lead mist until the noble metals are liberated.

(3) Thin and fluid when hot, so that the lead may collect and settle.

(4) Must decompose the ore completely and have NO affinity for the noble metals.

(5) Should not attack the crucible (appreciably).

(6) Must have a low specific gravity when fluid, so that the lead and slag will separate into two phases.

(7) Must separate readily from the lead button when cold. (This indicates complete decomposition of the ore.)

(8) Should contain all of the impurities of the ore.

These same rules apply when compounding a successful glaze for useful and/or decorative pottery (excepting the comments about metallic lead and the collection of the noble metals).

Hence, our rationale was:

If we use the rules of ceramics to arrive at a glaze formula which matures at 1050°C and is composed of the chemistry of assay fluxing (including flour as a reducing agent), then all of Bugbee's rules will be satisfied.

Using the "what if" capacity of a spreadsheet program called *VisiCalc (R)*, we manipulated the lengthy formulae involving molecular weight, ceramic equivalents, and the empirical relationships necessary to design successful fluxes (glazes).

On page 12, the first four categories are based upon resolving the problem for each behavioral group at 100% (29.166g). You must furnish the estimated percentages and multiply by a single factor for each fluxing ingredient.

Group five is based upon the oxygen requirements for oxidizing base metal minerals (and nothing more). Once oxidized, they become RO chemistry in the flux.

MISCELLANEOUS NOTES

NOTICE: READ THIS BEFORE USING SLAGMASTER

I. Slagmaster is designed to work with *ORES* which contain up to 15% base metals (and/or noble metals) as their sulfides, sulfates, and/or oxides.

If you are wishing to fire *CONCENTRATES* with base metals exceeding this amount, please refer to ASAT Technical Aid #7.

- - - -

II. Your firing cycle and the amount of oxidation or reduction during the fusion will play a part in the size of the lead button which is recovered.

Therefore, if the buttons are consistantly smaller than 25 grams, you will need to add approximately 1/10 gram of flour for each additional gram of lead that the buttons lack.

- - - -

PHOTOCOPY PAGES 12 & 13 FOR YOUR WORKSHEET

We have stated that the RO group was actually divided into two groups which are considered separately. While calcium, magnesium, barium, and strontium compounds are represented on the worksheet (category B), lithium, sodium, potassium, and rubidium are noticeably absent, for they are, in reality, R_2O rather than RO. As such, they melt at very low temperatures. Therefore, their minerals are generally self-fluxing and may be ignored in our calculations.

To the best of your ability, (1) estimate the percentage of each of the five categories, (2) multiply the percent (as a whole number) times the factor given below each ingredient, (3) enter the answer in the space provided, and (4) total each column. Using these totals, fill in the blanks provided in *Your Flux Formula Is:*.

REMEMBER TO ADD the 38 grams of red lead oxide as noted below (+) on the worksheet. It is the lead which will provide the button, and if it is not present, there will be a serious error in the slag.

WORKSHEET FOR MONOSILICATE SLAGS INVOLVING ORES
WITH 15% OR LESS METALLICS

PERCENTAGE CALCULATIONS

1) Silica	QUARTZ	______	(A*)
2) Ca,Mg,Ba,Sr as	OXIDE or CO_3	______	(B*)
3) Feldspars	any TYPE (AVG.)	______	(C*)
4) Aluminas as	CLAY,TALC,ETC.	______	(D*)
5) METALS --	OXIDE,SULFIDE,-ATE	______	(E*)
TOTAL PERCENTAGE		______	

MULTIPLY EACH ROW BY *%:

	SODA	RED LEAD	SILICA	BORAX
A______	0.36 = ______	0.88 = ______	xxxx = ______	0.04 = ______
B______	0.46 = ______	0.78 = ______	0.10 = ______	0.10 = ______
C______	0.04 = ______	0.16 = ______	xxxx = 0.0	0.16 = ______
D______	0.39 = ______	0.39 = ______	0.16 = ______	xxxx = 0.0
E______	xxxx = 0.0	1.20 = ______	xxxx = 0.0	xxxx = 0.0
		(+) = 38.0		
TOTALS	______g	______g	______g	______g

MULTIPLY EACH ROW BY *%:

	LIME	IRON III	FLOUR
A______	0.13 = ______	0.19 = ______	0.048 = ______
B______	xxxx = 0.0	0.14 = ______	0.043 = ______
C______	xxxx = 0.0	xxxx = 0.0	0.030 = ______
D______	xxxx = 0.0	0.09 = ______	0.035 = ______
E______	xxxx = 0.0	xxxx = 0.0	xxxx = 0.0
TOTALS	______	______	______

PROJECT #__________ NAME____________________ DATE________

YOUR FLUX FORMULA IS:

ORE	29.16-1	
SODIUM CARBONATE	______	grams
RED LEAD or LITHARGE	______	grams
SILICA	______	grams
BORAX GLASS	______	grams
CALCIUM OXIDE (lime)	______	grams
RED IRON OXIDE	______	grams
POTASSIUM NITRATE	______	grams
OTHER	______	grams
FLOUR	______	grams
TOTAL CHARGE + ORE	______	grams

- -

INQUART (if any) = __________ mg GOLD
__________ mg SILVER

TOTAL INQUART __________ mg

- -

BUTTON WEIGHT __________ grams

TOTAL WEIGHT OF BEAD __________ mg

Minus GOLD (__________) mg = Oz Tr/TON __________

Equals SILVER __________ mg = Oz Tr/TON __________

- -

COMMENTS:______________________________

____

____

____

____

FIRE ASSAY PROCEDURES

ASAT's procedures are directed at accuracy, rather than at economics, and they will be more costly in both time and materials than standard commercial methods.

We assume that a valid representation of the ore to be assayed has been properly acquired, crushed, and split.

Sample Preparation

At least 150 grams of crushed materials should be pulverized to pass a #200 mesh sieve. Any flattened, metallic particles remaining upon the screen should be returned to the sample which passed through the screen.

Blend the sample well, and use either a microsplitter or, better yet, the checkerboard method to select the 29.16 grams (1 assay ton) which will be used in the assay.

Using the formulae derived from the Slagmaster worksheet, weigh out each designated ingredient.

Withhold a spoonful of borax glass, or silica, to clean the mortar and pestle.

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In the checkerboard method, the pulp is spread about 1/8 inch thick upon a flat, smooth surface, and a spatula is used to draw a checkerboard pattern of 1 inch squares.

Use the spatula to take a small quantity from each square. Be sure that each square is represented at least once and that the tip of the tool slides across the surface upon which the pulp resides.

For practical purposes, 29.2 grams is sufficiently accurate for assay ton.

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Place the fluxing components (but not the ore) in a large, plastic, freezer bag, inflate it, and shake it for at least 100 strokes.

Plastic bags are excellent, for you can see just how well the powdered materials are blending as you shake them.

Place the weighed sample of the ore and twice its volume of the blended fluxes in the mortar, and then grind them together.

REMEMBER: all the reactions which will transpire during the firing are dependent upon nearest neighbor effects, and intimate contact can be assured only if the ore is ground into a portion of the flux.

As red lead oxide is a bulky material, it will probably be necessary to use a 40 gram crucible rather than the traditional 30 gram crucible. However, we feel that this added cost is warranted.

Place approximately one-half of the flux from the plastic bag in the crucible, and carefully brush the contents of the mortar into the crucible as well.

Add the spoonful of borax, or silica (that you retained while weighing out the fluxes), to the mortar, and grind it with the pestle to clean these tools and to collect any particles of the sample which may have adhered to the walls of the mortar.

Brush the cleaning compound from the mortar into the crucible, and add the remainder of the fluxes from the mixing bag.

Plastic or stainless steel iced tea spoons (or long spatulas) are excellent tools with which to stir the powdered material in the crucible.

Blend the fluxes and sample in the crucible until the color is uniform throughout.

Firing Schedule

Place the crucible(s) in a preheated furnace at 900°C ±20°C [1562°F ±58°F], and maintain that temperature for 20 minutes.

At the end of 20 minutes, the internal temperature of the melt will approximate the chamber temperature, for melt temperature generally lags 15 to 20 minutes behind the air temperature in the furnace.

Adjust the furnace so as to arrive at 1150°C [2102°F] in 20 minutes, and then hold this temperature for another 20 minutes.

This 60 minute firing cycle allows 20 minutes for oxidation, 20 minutes for digestion, and 20 minutes to fluidize the slag.

Casting

Remove the crucible from the furnace with crucible tongs.

Swirl it 6 or 8 times with the same counterclockwise motion that you would use in panning gold.

Thump it gently on a fire brick or massive metal plate, and repeat the sequence of swirling and thumping one more time.

The slag should be about as fluid as 40-weight (or less) motor oil. Should it be as thick as honey, it must be returned to the furnace with the temperature increased to 1200°C [2192°F] for another 20 minutes.

Any lead spheres that may have clung to the wall have been dislodged and have settled to the bottom.

Now, the button may be cast in a conical steel (or mehanite) mold. This should be done with a smooth pouring motion and in such a manner that some of the slag has entered the mold before the lead does. This eliminates any tendency for the lead button to scald to the iron mold.

It is best to lay a piece of sheet metal over the mold while it cools, for the stress within the cooling slag can hurl glass-like splinters for some distance.

During this cooling process, one may often hear a pinging sound as the slag fractures, and it is best to wait until you can touch the iron mold with the bare hand before inverting it and allowing the cone to fall out.

First Examination

Examine the area where the lead button joins (joined) the slag.

If there is a *brittle*, semi-metallic to metallic layer, this is speiss (composed of arsenides and metals). Collect every bit of it, and see page 20 where we will explain how to salvage the assay by proper scorification of this material.

Should there be a layer of *semi-malleable*, black, spongy material lying above the button, this is a matte composed of undigested sulfides. In this event, throw the assay away and recalculate a new fluxing formula using a larger percentage figure for category number 5 (metals as sulfides, sulfates, and/or oxides).

Neither of the above circumstances should exist if your estimation of all five categories in the Slagmaster formulae was correct.

So we will assume that you are ready to part the button from the slag. In most instances, they will have parted on their own. If they have not, a sharp rap with a hammer on the point of the button will suffice to separate them.

Cleaning The Button

It is best to tap the bulk of the slag free from the button with a steel rod before hammering it upon a steel block.

During the act of hammering the button into a square you will probably drive some of the slag into the lead. If this is only a small amount (2 or 3 milligrams), no harm is done. In fact, it will enhance the cupellation which is to follow.

Hammering the button into a square is a tradition, not a necessity. The object is to reshape the button so that it may be picked up easily and firmly ith the tongs.

We should note that when PGMs are involved the button is never hammered. However, PGMs are not the topic of this Bulletin, so we will not press the issue at this time.

Second Examination

Lead assay buttons should be a homogeneous lead grey in color and highly malleable. If during the cleaning you should note areas of contrasting metallic colors, or any areas of brittleness when hammering the button, this is evidence of contamination.

It is advisable to place the button under running water and then expose it to the air. If it rapidly darkens, this would indicate the presence of thallium.

Should thallium be present, the ore must be treated as a problem ore (this will be covered in a future Bulletin).

All other contaminants may be removed by scorification, which is explained on page 20.

Cupellation

Until recently, one could fire in any commercial cupel with confidence that the greatest error which could occur, even with a gross error in temperature, was 4.5 percent of the noble metals recovered.

However, we have recently discovered that this is no longer the fact, and a previously allowable 200°C error can create a loss of 73 percent of the noble metals in the lead button.

Therefore, WE STRONGLY SUGGEST that you follow the cupellation temperature schedule very closely so as to avoid these losses.

Preheat the cupellation chamber to approximately 1000°C [1832°F]. This will allow the fire brick to accumulate heat and facilitate the temperature regulation during the remainder of the firing.

Because bone ash cupels will absorb their weight in lead oxides, the weight of the lead button determines the size of cupel to be used.

As a general rule, it is best to use a cupel weighing approximately twice that of the lead button. By following this rule, there is little danger of the litharge (PbO) penetrating the mass and migrating into the floor of the muffle.

Cupels should be placed in the furnace either prior to turning it on, or at least 12 to 15 minutes before they are to be used. This will allow any accumulated moisture to be driven off.

Opening the door of the furnace allows the temperature to drop rapidly, and the buttons may be placed in their respective cupels at about 850°C [1562°F].

The excess heat retained in the cupel will melt the button rapidly, and a black scum will appear on the surface. This is an oxide of lead and will vanish as soon as the door is closed.

Uncovering is the term used to describe the disappearance of the oxide scum, and it is best to check the cupels within a minute or so to be sure that this has transpired. If it has not, a sliver of wood dropped upon the molten surface will accomplish the feat.

Close the furnace, and adjust the heat (to maintain 700°C [1292°F]) and the draft (to admit a flow of air through the chamber).

Lead turns to lead oxide (litharge) and is absorbed by the cupel at 770°C [1418°F]. *Do not* let the chamber temperature worry you, for the heat generated by the oxidation of the lead to lead oxide will contribute from 70°C to 135°C to the molten metal. That is: the molten metal will be hotter than the chamber in which it resides.

This (700°C) temperature should be maintained for the first 30 minutes of the cupellation and then slowly increased to 830°C [1526°F] over the next 30 minutes, and 910°C [1670°F] for the final 5 to 10 minutes. (The average 35 gram button takes 45 minutes to cupel.)

Again, the temperature of the bead will exceed that of the chamber. At the very end, however, it is the heat of surfusion rather than oxidation which creates this phenomenon.

We assume the reader is familiar with the weighing and parting of the prill (noble metal bead) and will direct the remainder of this Bulletin to evaluating the slag.

EVALUATING THE SLAG

As we stated earlier, the object of Slagmaster is to formulate a monosilicate slag based upon eyeball estimates of the five basic categories of pyrometric behavior.

When making these estimates, the *least* detrimental error would be to underestimate the silica content. Conversely, the *most* detrimental error would be to underestimate the calcium and/or clay content.

Most flux formulae will contain enough iron to mask the colors of other metal oxides. However, the opacifiers (titanium, zirconium, and tin) will alter a transparent slag to an opaque slag. Moreover, antimony, selenium, and zinc will contribute a smokey-grey, translucency to an otherwise transparent slag.

For the sake of brevity, we will describe several slags so that you will have a yardstick against which to measure your results.

Vitreous is a term describing the surface texture of the broken slag and does not relate to transparency or opacity. Visually, it looks like broken glass.

Vitreous Yellow-Green Slags are lead/sodium silicates and span the entire range from the monosilicate which is fluid at 1020°C

to the bisilicate which fluidizes at 1030°C.

Vitreous Light-Yellow and Transparent Slags

are lead silicates with the monosilicate fluidizing at 1030°C and the bisilicate becoming fluid at 1050°C.

Vitreous Black Slags

are of two types: either a monosilicate composed of sodium/lead/iron (fluid at 1030°C) or a sodium/iron bisilicate (fluid at 1070°C).

You will note that the last temperature listed (1070°C) is within 30°C of our 1100°C target, and all of the slags are vitreous.

Any undigested materials or entrapped lead spheres will stick out like a sore thumb.

If any undigested particles are present, this would indicate that the firing cycle was not quite long enough.

Mixture of Stoney-White and Transparent to Colorless Vitreous Crystalline Slags

are sodium monosilicates which fluidize at 1070°C and indicate a shortage of lead oxide. (Use a hand lens to carefully examine this one for undigested particles and/or entrapped lead beads.)

Stoney-White Crystalline Slags

are a homogenous, stoney-white and crumble into almost geometric pieces. At this point, a gross error has occurred, and you have a sodium bisilicate slag (fluid 1090°C). We suggest that you recalculate your formula and that you discard this button.

Stoney-Black Slags
(very fluid when poured)

are sodium/iron silicates which fluidize at 1070°C and should present no problems.

Stoney-Light-Yellow Slags

are sodium/lead/calcium monosilicates, and they crowd the target temperature by fluidizing at 1080°C. This indicates that you have misjudged the calcium group minerals, and it would be best to alter the percentages in the Slagmaster formula and fire again.

Resinous Black Slags

are iron/lead monosilicates fluidizing at 1100°C. Even though they appear reasonably fluid when poured, they are often deceptive, and we would suggest that you increase category #5 and decrease categories #1 and/or #2 on your Slagmaster worksheet.

Any Color & Syrupy

Although there are both monosilicate and bisilicate formulae which exceed 1100°C, they will be apparent by a thickening of the slag, which indicates that the calcium group minerals exceed the estimated percentages, and you should recalculate the Slagmaster formula.

You may have overlooked some easily missed mineral, such as barite or fluorite.

THE FOLLOWING IS A SUMMARY FOR QUICK REFERENCE

Color	*Pour*	*Comment*
V Y-G	*Very Fluid*	*Excellent*
V Lt-Y/Tr	*Very Fluid*	*Excellent*
V Blk	*Very Fluid*	*Excellent*
St-Wht/ Tr-Col Xtal	*Fluid*	*See pg. 18*
St-Wht Xtal	*Fluid*	*See pg. 18*
St-Blk	*Very Fluid*	*Excellent*
St-Lt-Y	*Fluid*	*See pg. 18*
Res.Blk	*Fluid*	*See pg. 18*
Any Color	*Syrupy*	*See pg. 18*

(V=Vitreous; Y=Yellow; G=Green; Lt=Light; Tr=Transparent; Blk=Black; St=Stoney; Wht=White; Col=Colorless; Xtal=Crystalline; Res.=Resinous)

FIRE ASSAYING SLAGS

Refiring the slag is usually necessary only if beaded metals (lead) still show in the dross, or if one is firing PGMs.

However, one may wish to refire the slag to confirm the thoroughness of the primary firing.

In any event, the method of assaying the slag is as follows:

1) Crush and pulverize the slag to minus #80 sieve size, and place it in a 30 gram crucible along with 38 grams of *litharge* (PbO) and 3 grams of flour.

2) Blend the material until the color is uniform throughout, and refire, using the same 60 minute firing cycle as before.

(We are simply replacing the litharge for a new cloud of lead mist, within the melt, which will result in a 25 gram to 35 gram button.)

Gold recovered in this second button indicates that the ore contains microcrystalline gold encapsulated in a rather refractory mineral, or that you have misjudged the calcium and clay factors of the ore by several fold.

This would allow the melt to become fluid at a temperature lower than the final digestion temperature of the minerals in the ore.

Thus, the lead would have settled *before* the values were freed from the gangue.

To remedy this problem, review the calcium group components and clayey constituents of the Slagmaster formula; make such adjustments as may be required; and, in any case, add a powdered silver inquart (from 4 to 10 times the anticipated gold to be recovered).

Record the inquart on the worksheet (page 13) so that it may be deducted from the bead weight.

Powdered metallic silver is the best inquart. Second best would be finely ground silver nitrate (one milligram of silver takes 1.575 milligrams of silver nitrate). Silver chloride (one milligram of silver to 1.328 milligrams of silver chloride) may be used; however, it does introduce chlorine into the melt and, therefore, should be your last choice.

SPOTTING CONTAMINATION IN THE LEAD BUTTON

Not all of the impurities which may contaminate the lead are easily recognized by observing the button. Fortunately, some potential problems may be spotted prior to cupellation and avoided by scorification (see pages 20 & 21).

At the temperatures we specified for the fusion assay, the possibility of PbO remaining in the lead is slight.

Therefore, if the button shows signs of brittleness (cracks when being hammered), you should suspect the presence of arsenic, zinc, antimony, or sulfur (silver and/or gold in excess of 30% will also make a button brittle).

Iron and copper tend to make the button hard and difficult to flatten during hammering.

Blotches of discolored metallic sometimes occur and always signal the need to scorify the button.

These are generally caused by exsolution where the metal(s) involved do not alloy with lead and, therefore, have a tendency to gather with clumps upon the surface of (and within) the cooling lead.

Thallium may be determined by wetting the lead button and exposing it to the air for a few minutes. If it is present, the button will blacken. (Scorify the button in a flow of moist air.)

Should the button have a very dark surface and a graphitic black owder rub off on your hands, the problem is moly (molybdenum). Once again, scorify the button.

There is one problem which may be spotted only by looking at the used crucible. If the walls above the melt are covered with a bubbly foam gloss, vanadium pentoxide was in the ore, and you must scorify the lead.

SPOTTING CONTAMINATION AFTER CUPELLATION

In this case, the observations are *ex post facto*, for you have suffered a loss of noble metals and must refire the assay.

However, the second assay should be successful, for you will know that the problem exists and will scorify the button prior to cupellation.

If the area around the bead (in he cold cupel) is brown with concentric rings of yellow and blackish-green, the impurity is bismuth.

If the bead is seated in a circle of black to dirty-green, copper is the culprit.

Discolored scoria (cinders) on the sides of the cupel signals tin, arsenic, zinc, cadmium, iron, and/or manganese.

If the cupel is checkered and cracked, antimony was present.

Tellurium will remain (in part) with the gold and discolor it, whereas selenium, thallium, vanadium, and molybdenum will cause losses without leaving a trace.

LOSSES DUE TO IMPURITIES IN THE LEAD BUTTON

In 1911, Charles H. Fulton and associates studied the losses in cupellation and included them in a publication titled simply, *Assay Manual*. Their figures agree with other, more recent studies. The simplicity with which their data is presented fits our context, and we submit the following paraphrase of that writing.

Influence of Impurities (upon cupellation losses)

Button size = 25 grams of lead
Impurity = 1 gram per button

Silver inquart = 4 milligrams (4 oz Troy/ton of ore)

Gold inquart = 1 milligram (1 oz Troy/ton of ore)

Impurity	Loss of Gold (%)	Loss of Silver (%)
Tin	2.0	13.9
Arsenic	3.9	16.3
Antimony	5.3	13.3
Zinc	9.3	17.6
Cadmium	3.5	13.1
Iron	4.0	16.6
Manganese	13.6	24.3
Molybdenum	11.0	26.2
Vanadium	7.7	21.7
Copper	10.0	32.6
Bismuth	21.8	27.9
Thallium	23.1	34.4
Tellurium	55.8	67.9
Selenium	54.1	64.5

Standard losses of gold and silver in pure lead buttons during cupellation usually average 0.01 milligrams of gold and 0.1 milligrams of silver.

The figures you have just read should convince you that if there is evidence of impurity in the button, a second assay accompanied by scorification is worth the time, effort, and money involved.

SCORIFICATION

Scorification is carried out in a shallow fire clay dish in which the lead button and a small amount of flux(es) is placed.

These shallow dishes vary in size and capacity as follows:

Diameter		Cubic Centimeters
1.5 inch	holds	15
2.0 inch	holds	25
2.5 inch	holds	37
3.5 inch	holds	100

The author prefers to use the 3.5 inch dish, for it gives a larger exposed area during the oxidation period of the scorification.

If the button weighs 35 grams or more, place it in the dish and add the flux (as defined below). If the button weighs less than 35 grams, add enough test lead (999 pure) to equal this weight.

SCORIFICATION FLUXES

For iron, molybdenum, vanadium, and manganese, add 5 to 8 grams of borax glass.

For tin and/or copper, add a 1:1 mixture of borax glass and silica (5 to 8 grams).

For all of the remaining impurities, we suggest 3 grams of borax glass, 2 grams of silica, and 2 grams of red lead oxide.

For scorifying a *speiss*, weigh the speiss (which you salvaged from the fusion) and add 6 times its weight in red lead oxide (NOT litharge) plus 5 grams of borax glass.

FIRING SCHEDULE

Place the scorifying dish in a preheated furnace and fire at 1000°C to 1100°C for 20 to 30 minutes, or until the eye closes.

The term *eye* is applied to the circle of molten metal in the center of the dish which is formed by the surface tension of the lead drawing the center of the metal toward a spherical shape.

This allows the fluxes to form a ring around the lead. Impurities surfacing within the molten metal oxidize upon contact with the air and are collected in the flux.

Lead is slowly volatilized (and absorbed into the flux), and the button shrinks in size until the slag covers it completely. At this point, the eye has closed.

When the eye has closed, remove the dish from the furnace, for if it is allowed to continue in the absence of free oxygen, the noble metals may oxidize and combine with the flux (if the impurities are already consumed).

There is a protective order of oxidation involved (which means that iron will oxidize before zinc and zinc before lead, etc.).

The portion of this order which is known for sure is: iron, zinc, lead, nickle, copper, platinum, silver, and gold.

The unsure part of this sequence is as follows: antimony, arsenic, carbon, bismuth, tellurium, selenium, and sulfur.

However, the manner in which the two sequences fit together is uncertain.

After removal from the furnace, the contents of the dish should be poured into a conical mold.

If the slag adheres to the lead and leaves a film of metal on the slag, more lead should be added and a second scorification run.

If there is evidence of large quantities of impurities, the scorifying dish should be painted with a thin coat of (wet) red iron oxide. This will lessen the attack upon the silica in the clay dish.

Examine the new button with the same care used to examine the fusion button. If it still shows signs of impurities, rescorify it.

(If the scorification dish is undamaged, it may be used again.)

BUYING OUR ODDBALL SUPPLIES

Red Lead Oxide

If you purchase Pb_3O_4 from a chemical supply house, you will pay a small fortune for it. If you purchase from a *ceramic supply house*, however, it is as cheap as litharge.

[The red lead ASAT uses is manufactured by Hammond Lead Products Inc., Hammond, Indiana, and must be purchased in large quantities.]

If there are no ceramic supply houses in your area, try Ceramic King, 3300 Girard N.E., Albuquerque, NM 81107.

[Be sure to fire a test blank on any lead oxide, for it may (or may not) be contaminated with silver. For instance: our current supply carries 0.001 milligrams of silver per 100 grams of Pb_3O_4.]

Red Iron Oxide

Don't let this one throw you, for the Fe_2O_3 used in the construction trade to dye concrete pink is good enough. It may be purchased at any *construction material or masonry supply store*.

Soda Ash, Silica, & Borax Glass

May be acquired from a number of advertised sources. However, if you purchase in 100 pound lots from an *industrial supply house*, the savings will be considerable.

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AFTERTHOUGHT

Most persons will make the error of estimating a quartz/silicate vein material as being 100% silica.

Having viewed thousands of spectrographic films, the author may assure you that this is not the fact. (Besides, pure SiO_2 would be water glass clear.)

The average composition that we suggest you use when you encounter such material is:

Silica	[Balance less metallics]
Ca Group	8.0
Feldspars	5.0
Alumina	5.0
Metallics	[Your estimate]

Walt

Walt

50% or greater clayey materials

YOUR FLUX FORMULA IS:	29.16-1 AT
SODIUM CARBONATE (ANHYD)....	33.49 grams
RED LEAD or LITHARGE.......	115.56 grams
SILICA...................	3.01 grams
BORAX GLASS..............	3.67 grams
CALCIUM OXIDE (LIME).......	9.28 grams
RED IRON OXIDE...........	15.37 grams
POTASSIUM NITRATE.........	0.00 grams
OTHER....................	0.00 grams
FLOUR....................	4.24 grams

25 to 50% clayey materials

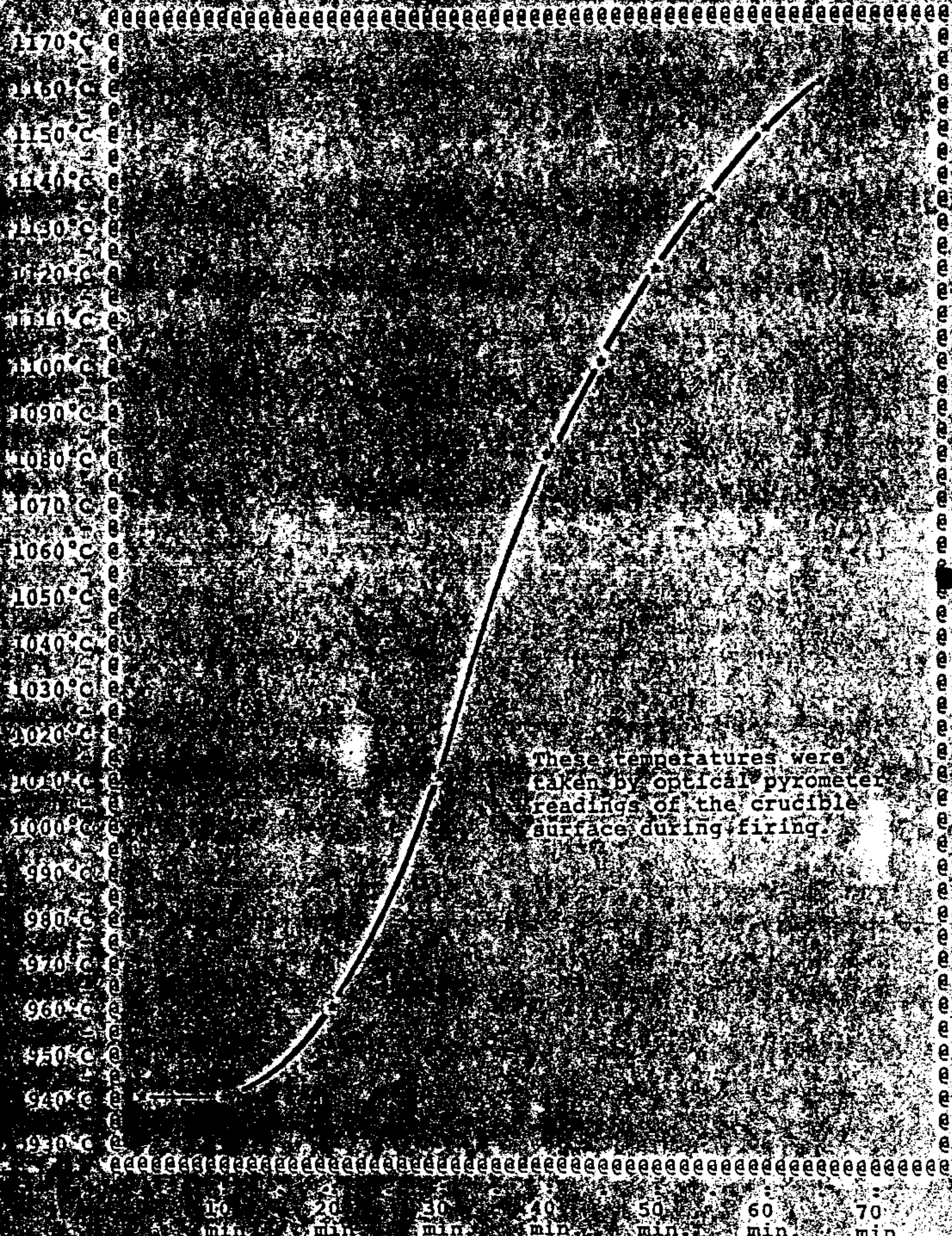
YOUR FLUX FORMULA IS:	29.16-1 AT
SODIUM CARBONATE (ANHYD)....	29.91 grams
RED LEAD or LITHARGE.......	100.53 grams
SILICA...................	5.06 grams
BORAX GLASS..............	5.60 grams
CALCIUM OXIDE (LIME).......	5.33 grams
RED IRON OXIDE...........	11.43 grams
POTASSIUM NITRATE.........	0.00 grams
OTHER....................	0.00 grams
FLOUR....................	3.84 grams

Up to 25% clayey materials

YOUR FLUX FORMULA IS:	29.16-1 AT
SODIUM CARBONATE (ANHYD)....	33.13 grams
RED LEAD or LITHARGE.......	115.46 grams
SILICA...................	2.00 grams
BORAX GLASS..............	4.67 grams
CALCIUM OXIDE (LIME).......	9.82 grams
RED IRON OXIDE...........	15.76 grams
POTASSIUM NITRATE.........	0.00 grams
OTHER....................	0.00 grams
FLOUR....................	4.38 grams

RATE OF TEMPERATURE RISE DURING FIRE ASSAY

Before loading 45 min. warm-up (1070°C).



to the bisilicate which fluidizes at 1030°C.

Vitreous Light-Yellow and Transparent Slags

are lead silicates with the monosilicate fluidizing at 1030°C and the bisilicate becoming fluid at 1050°C.

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are of two types:
either a monosilicate composed of sodium/lead/iron (fluid at 1030°C) or a sodium/iron bisilicate (fluid at 1070°C).

You will note that the last temperature listed (1070°C) is within 30°C of our 1100°C target, and all of the slags are vitreous.

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are sodium monosilicates which fluidize at 1070°C and indicate a shortage of lead oxide. (Use a hand lens to carefully examine this one for undigested particles and/or entrapped lead beads.)

Stoney-White Crystalline Slags

are a homogenous, stoney-white and crumble into almost geometric pieces. At this point, a gross error has occurred, and you have a sodium bisilicate slag (fluid 1090°C). We suggest that you recalculate your formula and that you discard this button.

Stoney-Black Slags

(very fluid when poured)

are sodium/iron silicates which fluidize at 1070°C and should present no problems.

Stoney-Light-Yellow Slags

are sodium/lead/calcium monosilicates, and they crowd the target temperature by fluidizing at 1080°C. This indicates that you have misjudged the calcium group minerals, and it would be best to alter the percentages in the Slagmaster formula and fire again.

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V Lt-Y/Tr	*Very Fluid*	*Excellent*
V Blk	*Very Fluid*	*Excellent*
St-Wht/ Tr-Col Xtal	*Fluid*	*See pg. 18*
St-Wht Xtal	*Fluid*	*See pg. 18*
St-Blk	*Very Fluid*	*Excellent*
St-Lt-Y	*Fluid*	*See pg. 18*
Res.Blk	*Fluid*	*See pg. 18*
Any Color	*Syrupy*	*See pg. 18*

(V=Vitreous; Y=Yellow; G=Green; Lt=Light; Tr=Transparent; Blk=Black; St=Stoney; Wht=White; Col=Colorless; Xtal=Crystalline; Res.=Resinous)

PHOTOCOPY PAGES 12 & 13 FOR YOUR WORKSHEET

We have stated that the RO group was actually divided into two groups h h are considered separately. While calcium, magnesium, barium, and t. ntium compounds are represented on the worksheet (category B), ithium, sodium, potassium, and rubidium are noticeably absent, for hey are, in reality, R_2O rather than RO. As such, they melt at very ow temperatures. Therefore, their minerals are generally self-fluxing nd may be ignored in our calculations.

To the best of your ability, (1) estimate the percentage of each of he five categories, (2) multiply the percent (as a whole number) times he factor given below each ingredient, (3) enter the answer in the pace provided, and (4) total each column. Using these totals, fill in he blanks provided in *Your Flux Formula Is:*.

REMEMBER TO ADD the 38 grams of red lead oxide as noted below (+) on he worksheet. It is the lead which will provide the button, and if it s not present, there will be a serious error in the slag.

WORKSHEET FOR MONOSILICATE SLAGS INVOLVING ORES
WITH 15% OR LESS METALLICS

PERCENTAGE CALCULATIONS

.) Silica	QUARTZ	______	(A*)
!) Ca,Mg,Ba,Sr as	OXIDE or CO_3	______	(B*)
) Feldspars	any TYPE (AVG.)	______	(C*)
) luminas as	CLAY,TALC,ETC.	______	(D*)
) ETALS --	OXIDE,SULFIDE,-ATE	______	(E*)
TOTAL PERCENTAGE		______	

IULTIPLY ACH ROW 3Y *%:	SODA	RED LEAD	SILICA	BORAX
______	0.36 = ______	0.88 = ______	xxxx = ______	0.04 = ______
______	0.46 = ______	0.78 = ______	0.10 = ______	0.10 = ______
______	0.04 = ______	0.16 = ______	xxxx = 0.0	0.16 = ______
______	0.39 = ______	0.39 = ______	0.16 = ______	xxxx = 0.0
______	xxxx = 0.0	1.20 = ______	xxxx = 0.0	xxxx = 0.0
		(+) = 38.0		
OTALS	______g	______g	______g	______g

IULTIPLY ACH ROW 3Y *%:	LIME	IRON III	FLOUR
______	0.13 = ______	0.19 = ______	0.048 = ______
______	xxxx = 0.0	0.14 = ______	0.043 = ______
______	xxxx = 0.0	xxxx = 0.0	0.030 = ______
______	xxxx = 0.0	0.09 = ______	0.035 = ______
______	xxxx = 0.0	xxxx = 0.0	xxxx = 0.0
O...LS	______	______	______

PHOTOCOPY PAGES 12 & 13 FOR YOUR WORKSHEET

We have stated that the RO group was actually divided into two groups h are considered separately. While calcium, magnesium, barium, and ontium compounds are represented on the worksheet (category B), ithium, sodium, potassium, and rubidium are noticeably absent, for ey are, in reality, R_2O rather than RO. As such, they melt at very w temperatures. Therefore, their minerals are generally self-fluxing d may be ignored in our calculations.

To the best of your ability, (1) estimate the percentage of each of he five categories, (2) multiply the percent (as a whole number) times he factor given below each ingredient, (3) enter the answer in the pace provided, and (4) total each column. Using these totals, fill in he blanks provided in *Your Flux Formula Is:*.

REMEMBER TO ADD the 38 grams of red lead oxide as noted below (+) on he worksheet. It is the lead which will provide the button, and if it s not present, there will be a serious error in the slag.

WORKSHEET FOR MONOSILICATE SLAGS INVOLVING ORES WITH 15% OR LESS METALLICS

PERCENTAGE CALCULATIONS

}	Silica	QUARTZ	______	(A*)
)	Ca,Mg,Ba,Sr as	OXIDE or CO_3	______	(B*)
)	Feldspars	any TYPE (AVG.)	______	(C*)
)	Aluminas as	CLAY,TALC,ETC.	______	(D*)
)	ETALS --	OXIDE,SULFIDE,-ATE	______	(E*)
	TOTAL PERCENTAGE		______	

- -

ULTIPLY ACH ROW Y *%:	SODA	RED LEAD	SILICA	BORAX
______	0.36 = ______	0.88 = ______	xxxx = ______	0.04 = ______
______	0.46 = ______	0.78 = ______	0.10 = ______	0.10 = ______
______	0.04 = ______	0.16 = ______	xxxx = 0.0	0.16 = ______
______	0.39 = ______	0.39 = ______	0.16 = ______	xxxx = 0.0
______	xxxx = 0.0	1.20 = ______	xxxx = 0.0	xxxx = 0.0
		(+) = 38.0		
OTALS	______g	______g	______g	______g

- -

ULTIPLY ACH ROW Y *%:	LIME	IRON III	FLOUR
______	0.13 = ______	0.19 = ______	0.048 = ______
______	xxxx = 0.0	0.14 = ______	0.043 = ______
______	xxxx = 0.0	xxxx = 0.0	0.030 = ______
______	xxxx = 0.0	0.09 = ______	0.035 = ______
______	xxxx = 0.0	xxxx = 0.0	xxxx = 0.0
C LS	______	______	______

TECHNICAL AIDE: #9
Flux Formulae

PRECALCULATED FLUX FORMULAE BY ROCK TYPE

Introduction

The following precalculated fluxing formulae are the results of many hundreds of man hours of labor.

During the development of "Slagmaster" (ASAT's computerized method of arriving at a balanced monosilicate slag for any ore), our staff spent many hours in library research as well as laboratory experimentation. As a consequence, the "rock type" chemistry that we used for the individual formulations is the average of numerous chemical descriptions of each rock type.

You do not have to be an expert to use this tech aid for if you can determine the general family into which a rock falls, the formula will be close enough to do a good job. If, however, you can pick the proper name (or its nearest mineralogical relative), the firing should be nearly perfect.

We would suggest that you acquire Bulletin 113084A, Fundamentals of Fire Assaying (an introduction to Slagmaster) and Technical Aide #10, Increasing the Noble Metals From Fire Assay, before using these formulae.

Using the Table of Contents

Our table of contents, on the following page, is divided into three categories: concentrates (formulae 1 - 2), igneous rock types (3 - 34), and sedimentary rock types (35 - 45).

There will be two formulae, per page, which are listed by a number along the left margin, (we are using no actual page number in the conventional sense), as well as by name in the center column.

You will note that each rock type, in each category, is listed along the right margin in the order of diminishing silica content so that the user may employ this factor, if and when needed.

TABLE OF CONTENTS FOR FLUXES BY ROCK TYPE

No 1

FOR OXIDE CONCENTRATES

	Percent
Silica QUARTZ ETC.	7.00
Ca,Mg,Ba,Sr as OXIDE or CO3	0.00
Feldspars any TYPE (AVG.)	85.00
Aluminas as CLAY,TALC, ETC.	5.00
METALS** OXIDE,SULFIDE,-ATE	3.00
TOTAL %	100.00

YOUR FLUX FORMULA IS: ORE	5.84-0.2 AT	[ ]
FELDSPAR (YOUR CHOICE)----	23.33-0.8 AT	[ ]
SODIUM CARBONATE (ANHYD)---	8.00 grams	[ ]
RED LEAD or LITHARGE-------	63.00 grams	[ ]
SILICA ------------------	1.00 grams	[ ]
BORAX GLASS----------------	14.00 grams	[ ]
CALCIUM OXIDE (LIME)-------	1.00 grams	[ ]
RED IRON OXIDE-------------	2.00 grams	[ ]
POTASSIUM NITRATE ---------	0.00 grams	( )
OTHER ------------------	0.00 grams	( )
FLOUR ------------------	3.06 grams	[ ]
TOTAL CHARGE +ORE	121.00 g	
Flux charge only	115.16 g	

No 2

FOR SULFIDE CONCENTRATES

	Percent
Silica QUARTZ ETC.	0.00
Ca,Mg,Ba,Sr as OXIDE or CO3	0.00
Feldspars any TYPE (AVG.)	85.00
Aluminas as CLAY,TALC, ETC.	0.00
METALS** OXIDE,SULFIDE,-ATE	15.00
TOTAL %	100.00

YOUR FLUX FORMULA IS: ORE	5.84-0.2 AT	[ ]
FELDSPAR (YOUR CHOICE)----	23.33-0.8 AT	[ ]
SODIUM CARBONATE (ANHYD)---	3.40 grams	[ ]
RED LEAD or LITHARGE-------	69.62 grams	[ ]
SILICA ------------------	0.00 grams	[ ]
BORAX GLASS----------------	13.60 grams	[ ]
CALCIUM OXIDE (LIME)-------	0.00 grams	[ ]
RED IRON OXIDE-------------	7.00 grams	[ ]
POTASSIUM NITRATE ---------	0.00 grams	( )
OTHER ------------------	0.00 grams	( )
FLOUR ------------------	2.55 grams	[ ]
TOTAL CHARGE +ORE	125.34 g	
Flux charge only	119.50 gr	

No 3

ALKALI GRANITE

FOR MONOSILICATE SLAGS INVOLVING ORES WITH 15% OR LESS METALICS

	Percent
Silica QUARTZ ETC.	74.00
Ca,Mg,Ba,Sr as OXIDE or CO3	1.00
Feldspars any TYPE (AVG.)	23.00
Aluminas as CLAY,TALC, ETC.	0.00
METALS** OXIDE,SULFIDE,-ATE	2.00
TOTAL %	100.00

YOUR FLUX FORMULA IS:	29.16-1 AT	[ ]	14.58-1/2 AT
SODIUM CARBONATE (ANHYD)---	28.02 grams	[ ]	14.01
RED LEAD or LITHARGE-------	109.98 grams	[ ]	54.99
SILICA ------------------	0.10 grams	[ ]	0.05
BORAX GLASS----------------	6.74 grams	[ ]	3.37
CALCIUM OXIDE (LIME)-------	9.62 grams	[ ]	4.81
RED IRON OXIDE-------------	14.20 grams	[ ]	7.10
POTASSIUM NITRATE ---------	0.00 grams	( )	0.00
OTHER ------------------	0.00 grams	( )	0.00
FLOUR ------------------	4.29 grams	[ ]	2.14
TOTAL CHARGE +ORE	202.11 g		101.05
Flux charge only	172.95 gr		86.47

No 4

RHYOLITE

FOR MONOSILICATE SLAGS INVOLVING ORES WITH 15% OR LESS METALICS

	Percent
Silica QUARTZ ETC.	73.00
Ca,Mg,Ba,Sr as OXIDE or CO3	1.60
Feldspars any TYPE (AVG.)	24.00
Aluminas as CLAY,TALC, ETC.	0.00
METALS** OXIDE,SULFIDE,-ATE	1.40
TOTAL %	100.00

YOUR FLUX FORMULA IS:	29.16-1 AT	[ ]	14.58-1/2 AT
SODIUM CARBONATE (ANHYD)---	27.98 grams	[ ]	13.99
RED LEAD or LITHARGE-------	109.01 grams	[ ]	54.50
SILICA ------------------	0.16 grams	[ ]	0.08
BORAX GLASS----------------	6.92 grams	[ ]	3.46
CALCIUM OXIDE (LIME)-------	9.49 grams	[ ]	4.75
RED IRON OXIDE-------------	14.09 grams	[ ]	7.05
POTASSIUM NITRATE ---------	0.00 grams	( )	0.00
OTHER ------------------	0.00 grams	( )	0.00
FLOUR ------------------	4.29 grams	[ ]	2.15
TOTAL CHARGE +ORE	201.10 g		100.55
Flux charge only	171.94 gr		85.97

No 5

CALC ALKALI GRANITE

FOR MONOSILICATE SLAGS INVOLVING ORES WITH 15% OR LESS METALICS

	Percent
Silica QUARTZ ETC.	72.50
Ca,Mg,Ba,Sr as OXIDE or CO3	1.90
Feldspars any TYPE (AVG.)	23.00
Aluminas as CLAY,TALC, ETC.	0.00
METALS** OXIDE,SULFIDE,-ATE	2.60
TOTAL %	100.00

YOUR FLUX FORMULA IS:	29.16-1 AT	[ ]	14.58-1/2 AT
SODIUM CARBONATE (ANHYD)---	27.89 grams	[ ]	13.95
RED LEAD or LITHARGE-------	110.09 grams	[ ]	55.04
SILICA ------------------	0.19 grams	[ ]	0.10
BORAX GLASS----------------	6.77 grams	[ ]	3.39
CALCIUM OXIDE (LIME)-------	9.43 grams	[ ]	4.71
RED IRON OXIDE-------------	14.04 grams	[ ]	7.02
POTASSIUM NITRATE ---------	0.00 grams	( )	0.00
OTHER ------------------	0.00 grams	( )	0.00
FLOUR ------------------	4.25 grams	[ ]	2.13
TOTAL CHARGE +ORE	201.82 g		100.91
Flux charge only	172.66 gr		86.33

No 6

SODACLASE GRANITE

FOR MONOSILICATE SLAGS INVOLVING ORES WITH 15% OR LESS METALICS

	Percent
Silica QUARTZ ETC.	71.70
Ca,Mg,Ba,Sr as OXIDE or CO3	1.50
Feldspars any TYPE (AVG.)	23.50
Aluminas as CLAY,TALC, ETC.	0.00
METALS** OXIDE,SULFIDE,-ATE	3.30
TOTAL %	100.00

YOUR FLUX FORMULA IS:	29.16-1 AT	[ ]	14.58-1/2 AT
SODIUM CARBONATE (ANHYD)---	27.44 grams	[ ]	13.72
RED LEAD or LITHARGE-------	109.99 grams	[ ]	55.00
SILICA ------------------	0.15 grams	[ ]	0.08
BORAX GLASS----------------	6.78 grams	[ ]	3.39
CALCIUM OXIDE (LIME)-------	9.32 grams	[ ]	4.66
RED IRON OXIDE-------------	13.83 grams	[ ]	6.92
POTASSIUM NITRATE ---------	0.00 grams	( )	0.00
OTHER ------------------	0.00 grams	( )	0.00
FLOUR ------------------	4.21 grams	[ ]	2.11
TOTAL CHARGE +ORE	200.89 g		100.44
Flux charge only	171.73 gr		85.86

No 7

QUARTZ DIORITE

FOR MONOSILICATE SLAGS INVOLVING ORES WITH 15% OR LESS METALICS

	Percent
Silica QUARTZ ETC.	66.80
Ca,Mg,Ba,Sr as OXIDE or CO3	6.60
Feldspars any TYPE (AVG.)	21.80
Aluminas as CLAY,TALC, ETC.	4.80
METALS** OXIDE,SULFIDE,-ATE	0.00
TOTAL %	100.00

YOUR FLUX FORMULA IS:	29.16-1 AT	[ ]	14.58-1/2 AT
SODIUM CARBONATE (ANHYD)---	29.83 grams	[ ]	14.91
RED LEAD or LITHARGE-------	107.29 grams	[ ]	53.65
SILICA ------------------	1.43 grams	[ ]	0.71
BORAX GLASS----------------	6.82 grams	[ ]	3.41
CALCIUM OXIDE (LIME)-------	8.68 grams	[ ]	4.34
RED IRON OXIDE-------------	14.05 grams	[ ]	7.02
POTASSIUM NITRATE ---------	0.00 grams	( )	0.00
OTHER ------------------	0.00 grams	( )	0.00
FLOUR ------------------	4.31 grams	[ ]	2.16
TOTAL CHARGE +ORE	201.57 g		100.79
Flux charge only	172.41 gr		86.21

No 8

GRANODIORITE

FOR MONOSILICATE SLAGS INVOLVING ORES WITH 15% OR LESS METALICS

	Percent
Silica QUARTZ ETC.	66.60
Ca,Mg,Ba,Sr as OXIDE or CO3	5.40
Feldspars any TYPE (AVG.)	23.70
Aluminas as CLAY,TALC, ETC.	0.00
METALS** OXIDE,SULFIDE,-ATE	4.30
TOTAL %	100.00

YOUR FLUX FORMULA IS:	29.16-1 AT	[ ]	14.58-1/2 AT
SODIUM CARBONATE (ANHYD)---	27.41 grams	[ ]	13.70
RED LEAD or LITHARGE-------	109.78 grams	[ ]	54.89
SILICA ------------------	0.54 grams	[ ]	0.27
BORAX GLASS----------------	7.00 grams	[ ]	3.50
CALCIUM OXIDE (LIME)-------	8.66 grams	[ ]	4.33
RED IRON OXIDE-------------	13.41 grams	[ ]	6.71
POTASSIUM NITRATE ---------	0.00 grams	( )	0.00
OTHER ------------------	0.00 grams	( )	0.00
FLOUR ------------------	4.14 grams	[ ]	2.07
TOTAL CHARGE +ORE	200.09 g		100.04
Flux charge only	170.93 gr		85.46

No 9

TONALITE

FOR MONOSILICATE SLAGS INVOLVING ORES WITH 15% OR LESS METALICS

	Percent
Silica QUARTZ ETC.	66.60
Ca,Mg,Ba,Sr as OXIDE or CO3	6.70
Feldspars any TYPE (AVG.)	22.40
Aluminas as CLAY,TALC, ETC.	0.00
METALS** OXIDE,SULFIDE,-ATE	4.30
TOTAL %	100.00

YOUR FLUX FORMULA IS:	29.16-1 AT	[ ]	14.58-1/2 AT
SODIUM CARBONATE (ANHYD)---	27.95 grams	[ ]	13.98
RED LEAD or LITHARGE-------	110.58 grams	[ ]	55.29
SILICA ------------------	0.67 grams	[ ]	0.34
BORAX GLASS----------------	6.92 grams	[ ]	3.46
CALCIUM OXIDE (LIME)-------	8.66 grams	[ ]	4.33
RED IRON OXIDE-------------	13.59 grams	[ ]	6.80
POTASSIUM NITRATE ---------	0.00 grams	( )	0.00
OTHER ------------------	0.00 grams	( )	0.00
FLOUR ------------------	4.16 grams	[ ]	2.08
TOTAL CHARGE +ORE	201.69 g		100.85
Flux charge only	172.53 gr		86.27

No 10

SYENITE

FOR MONOSILICATE SLAGS INVOLVING ORES WITH 15% OR LESS METALICS

	Percent
Silica QUARTZ ETC.	62.00
Ca,Mg,Ba,Sr as OXIDE or CO3	3.50
Feldspars any TYPE (AVG.)	29.80
Aluminas as CLAY,TALC, ETC.	0.00
METALS** OXIDE,SULFIDE,-ATE	4.70
TOTAL %	100.00

YOUR FLUX FORMULA IS:	29.16-1 AT	[ ]	14.58-1/2 AT
SODIUM CARBONATE (ANHYD)---	25.12 grams	[ ]	12.56
RED LEAD or LITHARGE-------	105.70 grams	[ ]	52.85
SILICA ------------------	0.35 grams	[ ]	0.18
BORAX GLASS----------------	7.60 grams	[ ]	3.80
CALCIUM OXIDE (LIME)-------	8.06 grams	[ ]	4.03
RED IRON OXIDE-------------	12.27 grams	[ ]	6.14
POTASSIUM NITRATE ---------	0.00 grams	( )	0.00
OTHER ------------------	0.00 grams	( )	0.00
FLOUR ------------------	4.02 grams	[ ]	2.01
TOTAL CHARGE +ORE	192.29 g		96.14
Flux charge only	163.13 gr		81.56

No 11

TRACHYTE

FOR MONOSILICATE SLAGS INVOLVING ORES WITH 15% OR LESS METALICS

	Percent
Silica QUARTZ ETC.	61.00
Ca,Mg,Ba,Sr as OXIDE or CO3	4.20
Feldspars any TYPE (AVG.)	29.50
Aluminas as CLAY,TALC, ETC.	0.00
METALS** OXIDE,SULFIDE,-ATE	5.30
TOTAL %	100.00

YOUR FLUX FORMULA IS:	29.16-1 AT	[ ]	14.58-1/2 AT
SODIUM CARBONATE (ANHYD)---	25.07 grams	[ ]	12.54
RED LEAD or LITHARGE-------	106.04 grams	[ ]	53.02
SILICA ------------------	0.42 grams	[ ]	0.21
BORAX GLASS----------------	7.58 grams	[ ]	3.79
CALCIUM OXIDE (LIME)-------	7.93 grams	[ ]	3.97
RED IRON OXIDE-------------	12.18 grams	[ ]	6.09
POTASSIUM NITRATE ---------	0.00 grams	( )	0.00
OTHER ------------------	0.00 grams	( )	0.00
FLOUR ------------------	3.99 grams	[ ]	2.00
TOTAL CHARGE +ORE	192.38 g		96.19
Flux charge only	163.22 gr		81.61

No 12

MONZONITE

FOR MONOSILICATE SLAGS INVOLVING ORES WITH 15% OR LESS METALICS

	Percent
Silica QUARTZ ETC.	60.00
Ca,Mg,Ba,Sr as OXIDE or CO3	7.20
Feldspars any TYPE (AVG.)	26.50
Aluminas as CLAY,TALC, ETC.	0.00
METALS** OXIDE,SULFIDE,-ATE	6.30
TOTAL %	100.00

YOUR FLUX FORMULA IS:	29.16-1 AT	[ ]	14.58-1/2 AT
SODIUM CARBONATE (ANHYD)---	25.97 grams	[ ]	12.99
RED LEAD or LITHARGE-------	108.22 grams	[ ]	54.11
SILICA ------------------	0.72 grams	[ ]	0.36
BORAX GLASS----------------	7.36 grams	[ ]	3.68
CALCIUM OXIDE (LIME)-------	7.80 grams	[ ]	3.90
RED IRON OXIDE-------------	12.41 grams	[ ]	6.20
POTASSIUM NITRATE ---------	0.00 grams	( )	0.00
OTHER ------------------	0.00 grams	( )	0.00
FLOUR ------------------	3.98 grams	[ ]	1.99
TOTAL CHARGE +ORE	195.63 g		97.81
Flux charge only	166.47 gr		83.23

No 13

ANDESITE (CALCIC) [ISLAND ARCS]

FOR MONOSILICATE SLAGS INVOLVING ORES WITH 15% OR LESS METALICS

	Percent
Silica QUARTZ ETC.	59.50
Ca,Mg,Ba,Sr as OXIDE or CO3	10.30
Feldspars any TYPE (AVG.)	23.20
Aluminas as CLAY,TALC, ETC.	0.00
METALS** OXIDE,SULFIDE,-ATE	7.00
TOTAL %	100.00

YOUR FLUX FORMULA IS:	29.16-1 AT	[ ]	14.58-1/2 AT
SODIUM CARBONATE (ANHYD)---	27.09 grams	[ ]	13.54
RED LEAD or LITHARGE-------	110.52 grams	[ ]	55.26
SILICA ------------------	1.03 grams	[ ]	0.52
BORAX GLASS----------------	7.12 grams	[ ]	3.56
CALCIUM OXIDE (LIME)-------	7.74 grams	[ ]	3.87
RED IRON OXIDE-------------	12.75 grams	[ ]	6.37
POTASSIUM NITRATE ---------	0.00 grams	( )	0.00
OTHER ------------------	0.00 grams	( )	0.00
FLOUR ------------------	3.99 grams	[ ]	2.00
TOTAL CHARGE +ORE	199.39 g		99.70
Flux charge only	170.23 gr		85.12

No 14

ANDESITE (ALKALI CALCIC) [CONTINENTAL INTERIOR]

FOR MONOSILICATE SLAGS INVOLVING ORES WITH 15% OR LESS METALICS

	Percent
Silica QUARTZ ETC.	59.10
Ca,Mg,Ba,Sr as OXIDE or CO3	7.30
Feldspars any TYPE (AVG.)	27.80
Aluminas as CLAY,TALC, ETC.	0.00
METALS** OXIDE,SULFIDE,-ATE	5.80
TOTAL %	100.00

YOUR FLUX FORMULA IS:	29.16-1 AT	[ ]	14.58-1/2 AT
SODIUM CARBONATE (ANHYD)---	25.75 grams	[ ]	12.87
RED LEAD or LITHARGE-------	107.12 grams	[ ]	53.56
SILICA ------------------	0.73 grams	[ ]	0.37
BORAX GLASS----------------	7.54 grams	[ ]	3.77
CALCIUM OXIDE (LIME)-------	7.68 grams	[ ]	3.84
RED IRON OXIDE-------------	12.25 grams	[ ]	6.13
POTASSIUM NITRATE ---------	0.00 grams	( )	0.00
OTHER ------------------	0.00 grams	( )	0.00
FLOUR ------------------	3.98 grams	[ ]	1.99
TOTAL CHARGE +ORE	194.21 g		97.11
Flux charge only	165.05 gr		82.53

No 15

ANDESITE

FOR MONOSILICATE SLAGS INVOLVING ORES WITH 15% OR LESS METALICS

	Percent
Silica QUARTZ ETC.	59.00
Ca,Mg,Ba,Sr as OXIDE or CO3	10.20
Feldspars any TYPE (AVG.)	23.50
Aluminas as CLAY,TALC, ETC.	0.00
METALS** OXIDE,SULFIDE,-ATE	7.30
TOTAL %	100.00

YOUR FLUX FORMULA IS:	29.16-1 AT	[ ]	14.58-1/2 AT
SODIUM CARBONATE (ANHYD)---	26.87 grams	[ ]	13.44
RED LEAD or LITHARGE-------	110.41 grams	[ ]	55.20
SILICA ------------------	1.02 grams	[ ]	0.51
BORAX GLASS----------------	7.14 grams	[ ]	3.57
CALCIUM OXIDE (LIME)-------	7.67 grams	[ ]	3.84
RED IRON OXIDE-------------	12.64 grams	[ ]	6.32
POTASSIUM NITRATE ---------	0.00 grams	( )	0.00
OTHER ------------------	0.00 grams	( )	0.00
FLOUR ------------------	3.98 grams	[ ]	1.99
TOTAL CHARGE +ORE	198.88 g		99.44
Flux charge only	169.72 gr		84.86

No 16

SYENITE [SODA CLASE]

FOR MONOSILICATE SLAGS INVOLVING ORES WITH 15% OR LESS METALICS

	Percent
Silica QUARTZ ETC.	58.00
Ca,Mg,Ba,Sr as OXIDE or CO3	7.00
Feldspars any TYPE (AVG.)	29.50
Aluminas as CLAY,TALC, ETC.	0.00
METALS** OXIDE,SULFIDE,-ATE	5.50
TOTAL %	100.00

YOUR FLUX FORMULA IS:	29.16-1 AT	[ ]	14.58-1/2 AT
SODIUM CARBONATE (ANHYD)---	25.28 grams	[ ]	12.64
RED LEAD or LITHARGE-------	105.83 grams	[ ]	52.91
SILICA ------------------	0.70 grams	[ ]	0.35
BORAX GLASS----------------	7.74 grams	[ ]	3.87
CALCIUM OXIDE (LIME)-------	7.54 grams	[ ]	3.77
RED IRON OXIDE-------------	12.00 grams	[ ]	6.00
POTASSIUM NITRATE ---------	0.00 grams	( )	0.00
OTHER ------------------	0.00 grams	( )	0.00
FLOUR ------------------	3.97 grams	[ ]	1.99
TOTAL CHARGE +ORE	192.22 g		96.11
Flux charge only	163.06 gr		81.53

No 17

NEPHELINE SYENITE

FOR MONOSILICATE SLAGS INVOLVING ORES WITH 15% OR LESS METALICS

	Percent
Silica QUARTZ ETC.	56.00
Ca,Mg,Ba,Sr as OXIDE or CO3	2.60
Feldspars any TYPE (AVG.)	36.80
Aluminas as CLAY,TALC, ETC.	0.00
METALS** OXIDE,SULFIDE,-ATE	4.60
TOTAL %	100.00

YOUR FLUX FORMULA IS:	29.16-1 AT	[ ]	14.58-1/2 AT
SODIUM CARBONATE (ANHYD)---	22.83 grams	[ ]	11.41
RED LEAD or LITHARGE-------	100.72 grams	[ ]	50.36
SILICA ------------------	0.26 grams	[ ]	0.13
BORAX GLASS----------------	8.39 grams	[ ]	4.19
CALCIUM OXIDE (LIME)-------	7.28 grams	[ ]	3.64
RED IRON OXIDE-------------	11.00 grams	[ ]	5.50
POTASSIUM NITRATE ---------	0.00 grams	( )	0.00
OTHER ------------------	0.00 grams	( )	0.00
FLOUR ------------------	3.90 grams	[ ]	1.95
TOTAL CHARGE +ORE	183.55 g		91.77
Flux charge only	154.39 gr		77.19

No 18

FELDSPATHOID SYENITE

FOR MONOSILICATE SLAGS INVOLVING ORES WITH 15% OR LESS METALICS

	Percent
Silica QUARTZ ETC.	55.50
Ca,Mg,Ba,Sr as OXIDE or CO3	3.50
Feldspars any TYPE (AVG.)	35.00
Aluminas as CLAY,TALC, ETC.	0.00
METALS** OXIDE,SULFIDE,-ATE	6.00
TOTAL %	100.00

YOUR FLUX FORMULA IS:	29.16-1 AT	[ ]	14.58-1/2 AT
SODIUM CARBONATE (ANHYD)---	22.99 grams	[ ]	11.50
RED LEAD or LITHARGE-------	102.38 grams	[ ]	51.19
SILICA ------------------	0.35 grams	[ ]	0.18
BORAX GLASS----------------	8.17 grams	[ ]	4.09
CALCIUM OXIDE (LIME)-------	7.22 grams	[ ]	3.61
RED IRON OXIDE-------------	11.04 grams	[ ]	5.52
POTASSIUM NITRATE ---------	0.00 grams	( )	0.00
OTHER ------------------	0.00 grams	( )	0.00
FLOUR ------------------	3.86 grams	[ ]	1.93
TOTAL CHARGE +ORE	185.16 g		92.58
Flux charge only	156.00 gr		78.00

No 19

DIORITE

FOR MONOSILICATE SLAGS INVOLVING ORES WITH 15% OR LESS METALICS

	Percent
Silica QUARTZ ETC.	53.50
Ca,Mg,Ba,Sr as OXIDE or CO3	14.50
Feldspars any TYPE (AVG.)	22.50
Aluminas as CLAY,TALC, ETC.	9.50
METALS** OXIDE,SULFIDE,-ATE	0.00
TOTAL %	100.00

YOUR FLUX FORMULA IS:	29.16-1 AT	[ ]	14.58-1/2 AT
SODIUM CARBONATE (ANHYD)---	30.54 grams	[ ]	15.27
RED LEAD or LITHARGE-------	103.70 grams	[ ]	51.85
SILICA ------------------	2.97 grams	[ ]	1.49
BORAX GLASS----------------	7.19 grams	[ ]	3.60
CALCIUM OXIDE (LIME)-------	6.96 grams	[ ]	3.48
RED IRON OXIDE-------------	13.05 grams	[ ]	6.53
POTASSIUM NITRATE ---------	0.00 grams	( )	0.00
OTHER ------------------	0.00 grams	( )	0.00
FLOUR ------------------	4.20 grams	[ ]	2.10
TOTAL CHARGE +ORE	197.75 g		98.88
Flux charge only	168.59 gr		84.30

No 20

PYROXENE GABBRO

FOR MONOSILICATE SLAGS INVOLVING ORES WITH 15% OR LESS METALICS

	Percent
Silica QUARTZ ETC.	52.00
Ca,Mg,Ba,Sr as OXIDE or CO3	19.20
Feldspars any TYPE (AVG.)	19.00
Aluminas as CLAY,TALC, ETC.	9.80
METALS** OXIDE,SULFIDE,-ATE	0.00
TOTAL %	100.00

YOUR FLUX FORMULA IS:	29.16-1 AT	[ ]	14.58-1/2 AT
SODIUM CARBONATE (ANHYD)---	32.13 grams	[ ]	16.07
RED LEAD or LITHARGE-------	105.60 grams	[ ]	52.80
SILICA ------------------	3.49 grams	[ ]	1.74
BORAX GLASS----------------	7.04 grams	[ ]	3.52
CALCIUM OXIDE (LIME)-------	6.76 grams	[ ]	3.38
RED IRON OXIDE-------------	13.45 grams	[ ]	6.73
POTASSIUM NITRATE ---------	0.00 grams	( )	0.00
OTHER ------------------	0.00 grams	( )	0.00
FLOUR ------------------	4.23 grams	[ ]	2.12
TOTAL CHARGE +ORE	201.86 g		100.93
Flux charge only	172.70 gr		86.35

No 21

BASALT [HI ALUMINA]

FOR MONOSILICATE SLAGS INVOLVING ORES WITH 15% OR LESS METALICS

	Percent
Silica QUARTZ ETC.	51.00
Ca,Mg,Ba,Sr as OXIDE or CO3	17.90
Feldspars any TYPE (AVG.)	21.10
Aluminas as CLAY,TALC, ETC.	10.00
METALS** OXIDE,SULFIDE,-ATE	0.00
TOTAL %	100.00

YOUR FLUX FORMULA IS:	29.16-1 AT	[ ]	14.58-1/2 AT
SODIUM CARBONATE (ANHYD)---	31.34 grams	[ ]	15.67
RED LEAD or LITHARGE-------	104.12 grams	[ ]	52.06
SILICA ------------------	3.39 grams	[ ]	1.70
BORAX GLASS----------------	7.21 grams	[ ]	3.60
CALCIUM OXIDE (LIME)-------	6.63 grams	[ ]	3.32
RED IRON OXIDE-------------	13.10 grams	[ ]	6.55
POTASSIUM NITRATE ---------	0.00 grams	( )	0.00
OTHER ------------------	0.00 grams	( )	0.00
FLOUR ------------------	4.20 grams	[ ]	2.10
TOTAL CHARGE +ORE	199.14 g		99.57
Flux charge only	169.98 gr		84.99

No 22

LAMPROPHYRE

FOR MONOSILICATE SLAGS INVOLVING ORES WITH 15% OR LESS METALICS

	Percent
Silica QUARTZ ETC.	50.60
Ca,Mg,Ba,Sr as OXIDE or CO3	16.00
Feldspars any TYPE (AVG.)	23.70
Aluminas as CLAY,TALC, ETC.	9.70
METALS** OXIDE,SULFIDE,-ATE	0.00
TOTAL %	100.00

YOUR FLUX FORMULA IS:	29.16-1 AT	[ ]	14.58-1/2 AT
SODIUM CARBONATE (ANHYD)---	30.31 grams	[ ]	15.15
RED LEAD or LITHARGE-------	102.58 grams	[ ]	51.29
SILICA ------------------	3.15 grams	[ ]	1.58
BORAX GLASS----------------	7.42 grams	[ ]	3.71
CALCIUM OXIDE (LIME)-------	6.58 grams	[ ]	3.29
RED IRON OXIDE-------------	12.73 grams	[ ]	6.36
POTASSIUM NITRATE ---------	0.00 grams	( )	0.00
OTHER ------------------	0.00 grams	( )	0.00
FLOUR ------------------	4.17 grams	[ ]	2.08
TOTAL CHARGE +ORE	196.09 g		98.05
Flux charge only	166.93 gr		83.47

No 23

BASALT [THOLEIITE]

FOR MONOSILICATE SLAGS INVOLVING ORES WITH 15% OR LESS METALICS

	Percent
Silica QUARTZ ETC.	50.50
Ca,Mg,Ba,Sr as OXIDE or CO3	19.80
Feldspars any TYPE (AVG.)	17.80
Aluminas as CLAY,TALC, ETC.	0.00
METALS** OXIDE,SULFIDE,-ATE	11.90
TOTAL %	100.00

YOUR FLUX FORMULA IS:	29.16-1 AT	[ ]	14.58-1/2 AT
SODIUM CARBONATE (ANHYD)---	28.00 grams	[ ]	14.00
RED LEAD or LITHARGE-------	115.03 grams	[ ]	57.51
SILICA -----------------	1.98 grams	[ ]	0.99
BORAX GLASS----------------	6.85 grams	[ ]	3.42
CALCIUM OXIDE (LIME)-------	6.57 grams	[ ]	3.28
RED IRON OXIDE-------------	12.37 grams	[ ]	6.18
POTASSIUM NITRATE ---------	0.00 grams	( )	0.00
OTHER -----------------	0.00 grams	( )	0.00
FLOUR -----------------	3.81 grams	[ ]	1.90
TOTAL CHARGE +ORE	203.76 g		101.88
Flux charge only	174.60 gr		87.30

No 24

NORITE

FOR MONOSILICATE SLAGS INVOLVING ORES WITH 15% OR LESS METALICS

	Percent
Silica QUARTZ ETC.	50.40
Ca,Mg,Ba,Sr as OXIDE or CO3	22.00
Feldspars any TYPE (AVG.)	19.40
Aluminas as CLAY,TALC, ETC.	8.20
METALS** OXIDE,SULFIDE,-ATE	0.00
TOTAL %	100.00

YOUR FLUX FORMULA IS:	29.16-1 AT	[ ]	14.58-1/2 AT
SODIUM CARBONATE (ANHYD)---	32.24 grams	[ ]	16.12
RED LEAD or LITHARGE-------	105.81 grams	[ ]	52.91
SILICA -----------------	3.51 grams	[ ]	1.76
BORAX GLASS----------------	7.32 grams	[ ]	3.66
CALCIUM OXIDE (LIME)-------	6.55 grams	[ ]	3.28
RED IRON OXIDE-------------	13.39 grams	[ ]	6.70
POTASSIUM NITRATE ---------	0.00 grams	( )	0.00
OTHER -----------------	0.00 grams	( )	0.00
FLOUR -----------------	4.23 grams	[ ]	2.12
TOTAL CHARGE +ORE	202.22 g		101.11
Flux charge only	173.06 gr		86.53

No 25

ANORTHOSITE

FOR MONOSILICATE SLAGS INVOLVING ORES WITH 15% OR LESS METALICS

	Percent
Silica QUARTZ ETC.	50.10
Ca,Mg,Ba,Sr as OXIDE or CO3	17.30
Feldspars any TYPE (AVG.)	22.80
Aluminas as CLAY,TALC, ETC.	9.80
METALS** OXIDE,SULFIDE,-ATE	0.00
TOTAL %	100.00

YOUR FLUX FORMULA IS:	29.16-1 AT	[ ]	14.58-1/2 AT
SODIUM CARBONATE (ANHYD)---	30.73 grams	[ ]	15.36
RED LEAD or LITHARGE-------	103.05 grams	[ ]	51.53
SILICA ------------------	3.30 grams	[ ]	1.65
BORAX GLASS----------------	7.38 grams	[ ]	3.69
CALCIUM OXIDE (LIME)-------	6.51 grams	[ ]	3.26
RED IRON OXIDE-------------	12.82 grams	[ ]	6.41
POTASSIUM NITRATE ---------	0.00 grams	( )	0.00
OTHER ------------------	0.00 grams	( )	0.00
FLOUR ------------------	4.18 grams	[ ]	2.09
TOTAL CHARGE +ORE	197.13 g		98.57
Flux charge only	167.97 gr		83.99

No 26

GABBRO [OLIVINE FREE]

FOR MONOSILICATE SLAGS INVOLVING ORES WITH 15% OR LESS METALICS

	Percent
Silica QUARTZ ETC.	50.00
Ca,Mg,Ba,Sr as OXIDE or CO3	14.50
Feldspars any TYPE (AVG.)	32.50
Aluminas as CLAY,TALC, ETC.	0.00
METALS** OXIDE,SULFIDE,-ATE	3.00
TOTAL %	100.00

YOUR FLUX FORMULA IS:	29.16-1 AT	[ ]	14.58-1/2 AT
SODIUM CARBONATE (ANHYD)---	25.97 grams	[ ]	12.99
RED LEAD or LITHARGE-------	102.11 grams	[ ]	51.06
SILICA ------------------	1.45 grams	[ ]	0.73
BORAX GLASS----------------	8.65 grams	[ ]	4.33
CALCIUM OXIDE (LIME)-------	6.50 grams	[ ]	3.25
RED IRON OXIDE-------------	11.53 grams	[ ]	5.77
POTASSIUM NITRATE ---------	0.00 grams	( )	0.00
OTHER ------------------	0.00 grams	( )	0.00
FLOUR ------------------	4.00 grams	[ ]	2.00
TOTAL CHARGE +ORE	189.37 g		94.69
Flux charge only	160.21 gr		80.11

No 27

ESSEXITE

FOR MONOSILICATE SLAGS INVOLVING ORES WITH 15% OR LESS METALICS

	Percent
Silica QUARTZ ETC.	48.60
Ca,Mg,Ba,Sr as OXIDE or CO3	11.80
Feldspars any TYPE (AVG.)	28.60
Aluminas as CLAY,TALC, ETC.	11.00
METALS** OXIDE,SULFIDE,-ATE	0.00
TOTAL %	100.00

YOUR FLUX FORMULA IS:	29.16-1 AT	[ ]	14.58-1/2 AT
SODIUM CARBONATE (ANHYD)---	28.36 grams	[ ]	14.18
RED LEAD or LITHARGE-------	98.84 grams	[ ]	49.42
SILICA -----------------	2.94 grams	[ ]	1.47
BORAX GLASS----------------	7.70 grams	[ ]	3.85
CALCIUM OXIDE (LIME)-------	6.32 grams	[ ]	3.16
RED IRON OXIDE-------------	11.88 grams	[ ]	5.94
POTASSIUM NITRATE ---------	0.00 grams	( )	0.00
OTHER -----------------	0.00 grams	( )	0.00
FLOUR -----------------	4.08 grams	[ ]	2.04
TOTAL CHARGE +ORE	189.27 g		94.64
Flux charge only	160.11 gr		80.06

No 28

BASALT [ALKALI-OLIVINE]

FOR MONOSILICATE SLAGS INVOLVING ORES WITH 15% OR LESS METALICS

	Percent
Silica QUARTZ ETC.	48.40
Ca,Mg,Ba,Sr as OXIDE or CO3	18.30
Feldspars any TYPE (AVG.)	20.00
Aluminas as CLAY,TALC, ETC.	13.30
METALS** OXIDE,SULFIDE,-ATE	0.00
TOTAL %	100.00

YOUR FLUX FORMULA IS:	29.16-1 AT	[ ]	14.58-1/2 AT
SODIUM CARBONATE (ANHYD)---	31.83 grams	[ ]	15.91
RED LEAD or LITHARGE-------	103.25 grams	[ ]	51.63
SILICA -----------------	3.96 grams	[ ]	1.98
BORAX GLASS----------------	6.97 grams	[ ]	3.48
CALCIUM OXIDE (LIME)-------	6.29 grams	[ ]	3.15
RED IRON OXIDE-------------	12.96 grams	[ ]	6.48
POTASSIUM NITRATE ---------	0.00 grams	( )	0.00
OTHER -----------------	0.00 grams	( )	0.00
FLOUR -----------------	4.18 grams	[ ]	2.09
TOTAL CHARGE +ORE	198.59 g		99.29
Flux charge only	169.43 gr		84.71

No 29

BASALT [PICRITE]

FOR MONOSILICATE SLAGS INVOLVING ORES WITH 15% OR LESS METALICS

	Percent
Silica QUARTZ ETC.	48.30
Ca,Mg,Ba,Sr as OXIDE or CO3	28.10
Feldspars any TYPE (AVG.)	11.00
Aluminas as CLAY,TALC, ETC.	12.60
METALS** OXIDE,SULFIDE,-ATE	0.00
TOTAL %	100.00

YOUR FLUX FORMULA IS:	29.16-1 AT	[ ]	14.58-1/2 AT
SODIUM CARBONATE (ANHYD)---	35.67 grams	[ ]	17.83
RED LEAD or LITHARGE-------	109.10 grams	[ ]	54.55
SILICA ------------------	4.83 grams	[ ]	2.41
BORAX GLASS----------------	6.50 grams	[ ]	3.25
CALCIUM OXIDE (LIME)-------	6.28 grams	[ ]	3.14
RED IRON OXIDE-------------	14.25 grams	[ ]	7.12
POTASSIUM NITRATE ---------	0.00 grams	( )	0.00
OTHER ------------------	0.00 grams	( )	0.00
FLOUR ------------------	4.30 grams	[ ]	2.15
TOTAL CHARGE +ORE	210.07 g		105.04
Flux charge only	180.91 gr		90.46

No 30

GABBRO [ALKALI]

FOR MONOSILICATE SLAGS INVOLVING ORES WITH 15% OR LESS METALICS

	Percent
Silica QUARTZ ETC.	46.80
Ca,Mg,Ba,Sr as OXIDE or CO3	21.70
Feldspars any TYPE (AVG.)	19.20
Aluminas as CLAY,TALC, ETC.	12.30
METALS** OXIDE,SULFIDE,-ATE	0.00
TOTAL %	100.00

YOUR FLUX FORMULA IS:	29.16-1 AT	[ ]	14.58-1/2 AT
SODIUM CARBONATE (ANHYD)---	32.40 grams	[ ]	16.20
RED LEAD or LITHARGE-------	103.98 grams	[ ]	51.99
SILICA ------------------	4.14 grams	[ ]	2.07
BORAX GLASS----------------	7.11 grams	[ ]	3.56
CALCIUM OXIDE (LIME)-------	6.08 grams	[ ]	3.04
RED IRON OXIDE-------------	13.04 grams	[ ]	6.52
POTASSIUM NITRATE ---------	0.00 grams	( )	0.00
OTHER ------------------	0.00 grams	( )	0.00
FLOUR ------------------	4.19 grams	[ ]	2.09
TOTAL CHARGE +ORE	200.09 g		100.05
Flux charge only	170.93 gr		85.47

No 31

GABBRO [HYPERTHENE OLIVINE]

FOR MONOSILICATE SLAGS INVOLVING ORES WITH 15% OR LESS METALICS

	Percent
Silica QUARTZ ETC.	46.50
Ca,Mg,Ba,Sr as OXIDE or CO3	22.10
Feldspars any TYPE (AVG.)	20.00
Aluminas as CLAY,TALC, ETC.	11.40
METALS** OXIDE,SULFIDE,-ATE	0.00
TOTAL %	100.00

YOUR FLUX FORMULA IS:	29.16-1 AT	[ ]	14.58-1/2 AT
SODIUM CARBONATE (ANHYD)---	32.15 grams	[ ]	16.08
RED LEAD or LITHARGE-------	103.80 grams	[ ]	51.90
SILICA ------------------	4.03 grams	[ ]	2.02
BORAX GLASS----------------	7.27 grams	[ ]	3.64
CALCIUM OXIDE (LIME)-------	6.05 grams	[ ]	3.02
RED IRON OXIDE-------------	12.96 grams	[ ]	6.48
POTASSIUM NITRATE ---------	0.00 grams	( )	0.00
OTHER ------------------	0.00 grams	( )	0.00
FLOUR ------------------	4.18 grams	[ ]	2.09
TOTAL CHARGE +ORE	199.60 g		99.80
Flux charge only	170.44 gr		85.22

No 32

PERIDOTITE

FOR MONOSILICATE SLAGS INVOLVING ORES WITH 15% OR LESS METALICS

	Percent
Silica QUARTZ ETC.	44.50
Ca,Mg,Ba,Sr as OXIDE or CO3	37.50
Feldspars any TYPE (AVG.)	5.50
Aluminas as CLAY,TALC, ETC.	12.50
METALS** OXIDE,SULFIDE,-ATE	0.00
TOTAL %	100.00

YOUR FLUX FORMULA IS:	29.16-1 AT	[ ]	14.58-1/2 AT
SODIUM CARBONATE (ANHYD)---	38.37 grams	[ ]	19.18
RED LEAD or LITHARGE-------	112.17 grams	[ ]	56.08
SILICA ------------------	5.75 grams	[ ]	2.88
BORAX GLASS----------------	6.41 grams	[ ]	3.21
CALCIUM OXIDE (LIME)-------	5.79 grams	[ ]	2.89
RED IRON OXIDE-------------	14.83 grams	[ ]	7.42
POTASSIUM NITRATE ---------	0.00 grams	( )	0.00
OTHER ------------------	0.00 grams	( )	0.00
FLOUR ------------------	4.35 grams	[ ]	2.18
TOTAL CHARGE +ORE	216.82 g		108.41
Flux charge only	187.66 gr		93.83

No 33

DUNITE

FOR MONOSILICATE SLAGS INVOLVING ORES WITH 15% OR LESS METALICS

	Percent
Silica QUARTZ ETC.	40.70
Ca,Mg,Ba,Sr as OXIDE or CO3	47.00
Feldspars any TYPE (AVG.)	4.10
Aluminas as CLAY,TALC, ETC.	8.20
METALS** OXIDE,SULFIDE,-ATE	0.00
TOTAL %	100.00

YOUR FLUX FORMULA IS:	29.16-1 AT	[ ]	14.58-1/2 AT
SODIUM CARBONATE (ANHYD)---	39.63 grams	[ ]	19.82
RED LEAD or LITHARGE-------	114.33 grams	[ ]	57.17
SILICA -----------------	6.01 grams	[ ]	3.01
BORAX GLASS----------------	6.98 grams	[ ]	3.49
CALCIUM OXIDE (LIME)-------	5.29 grams	[ ]	2.65
RED IRON OXIDE-------------	15.05 grams	[ ]	7.53
POTASSIUM NITRATE ---------	0.00 grams	( )	0.00
OTHER -----------------	0.00 grams	( )	0.00
FLOUR -----------------	4.38 grams	[ ]	2.19
TOTAL CHARGE +ORE	220.85 g		110.42
Flux charge only	191.69 gr		95.84

No. 34

TROCTOLITE

FOR MONOSILICATE SLAGS INVOLVING ORES WITH 15% OR LESS METALICS

	Percent
Silica QUARTZ ETC.	40.30
Ca,Mg,Ba,Sr as OXIDE or CO3	20.70
Feldspars any TYPE (AVG.)	34.00
Aluminas as CLAY,TALC, ETC.	0.00
METALS** OXIDE,SULFIDE,-ATE	5.00
TOTAL %	100.00

YOUR FLUX FORMULA IS:	29.16-1 AT	[ ]	14.58-1/2 AT
SODIUM CARBONATE (ANHYD)---	25.39 grams	[ ]	12.70
RED LEAD or LITHARGE-------	101.06 grams	[ ]	50.53
SILICA -----------------	2.07 grams	[ ]	1.04
BORAX GLASS----------------	9.12 grams	[ ]	4.56
CALCIUM OXIDE (LIME)-------	5.24 grams	[ ]	2.62
RED IRON OXIDE-------------	10.56 grams	[ ]	5.28
POTASSIUM NITRATE ---------	0.00 grams	( )	0.00
OTHER -----------------	0.00 grams	( )	0.00
FLOUR -----------------	3.84 grams	[ ]	1.92
TOTAL CHARGE +ORE	186.44 g		93.22
Flux charge only	157.28 gr		78.64

No. 35

QUARTZ ARENITE

FOR MONOSILICATE SLAGS INVOLVING ORES WITH 15% OR LESS METALICS

	Percent
Silica QUARTZ ETC.	95.80
Ca,Mg,Ba,Sr as OXIDE or CO3	2.70
Feldspars any TYPE (AVG.)	0.20
Aluminas as CLAY,TALC, ETC.	0.80
METALS** OXIDE,SULFIDE,-ATE	0.50
TOTAL %	100.00

YOUR FLUX FORMULA IS:	29.16-1 AT	[ ]	14.58-1/2 AT
SODIUM CARBONATE (ANHYD)---	36.05 grams	[ ]	18.03
RED LEAD or LITHARGE-------	125.35 grams	[ ]	62.68
SILICA ------------------	0.40 grams	[ ]	0.20
BORAX GLASS----------------	4.13 grams	[ ]	2.07
CALCIUM OXIDE (LIME)-------	12.45 grams	[ ]	6.23
RED IRON OXIDE-------------	18.65 grams	[ ]	9.33
POTASSIUM NITRATE ---------	0.00 grams	( )	0.00
OTHER ------------------	0.00 grams	( )	0.00
FLOUR ------------------	4.75 grams	[ ]	2.37
TOTAL CHARGE +ORE	230.95 g		115.48
Flux charge only	201.79 gr		100.90

No. 36

CHERTS/FLINTS

FOR MONOSILICATE SLAGS INVOLVING ORES WITH 15% OR LESS METALICS

	Percent
Silica QUARTZ ETC.	95.60
Ca,Mg,Ba,Sr as OXIDE or CO3	1.70
Feldspars any TYPE (AVG.)	0.90
Aluminas as CLAY,TALC, ETC.	1.20
METALS** OXIDE,SULFIDE,-ATE	0.60
TOTAL %	100.00

YOUR FLUX FORMULA IS:	29.16-1 AT	[ ]	14.58-1/2 AT
SODIUM CARBONATE (ANHYD)---	35.70 grams	[ ]	17.85
RED LEAD or LITHARGE-------	124.79 grams	[ ]	62.39
SILICA ------------------	0.36 grams	[ ]	0.18
BORAX GLASS----------------	4.14 grams	[ ]	2.07
CALCIUM OXIDE (LIME)-------	12.43 grams	[ ]	6.21
RED IRON OXIDE-------------	18.51 grams	[ ]	9.26
POTASSIUM NITRATE ---------	0.00 grams	( )	0.00
OTHER ------------------	0.00 grams	( )	0.00
FLOUR ------------------	4.73 grams	[ ]	2.37
TOTAL CHARGE +ORE	229.82 g		114.91
Flux charge only	200.66 gr		100.33

No. 37

ARKOSIC SANDSTONE

FOR MONOSILICATE SLAGS INVOLVING ORES WITH 15% OR LESS METALICS

	Percent
Silica QUARTZ ETC.	75.50
Ca,Mg,Ba,Sr as OXIDE or CO3	3.40
Feldspars any TYPE (AVG.)	8.20
Aluminas as CLAY,TALC, ETC.	10.40
METALS** OXIDE,SULFIDE,-ATE	2.50
TOTAL %	100.00

YOUR FLUX FORMULA IS:	29.16-1 AT	[ ]	14.58-1/2 AT
SODIUM CARBONATE (ANHYD)---	33.13 grams	[ ]	16.56
RED LEAD or LITHARGE-------	115.46 grams	[ ]	57.73
SILICA ------------------	2.00 grams	[ ]	1.00
BORAX GLASS----------------	4.67 grams	[ ]	2.34
CALCIUM OXIDE (LIME)-------	9.82 grams	[ ]	4.91
RED IRON OXIDE-------------	15.76 grams	[ ]	7.88
POTASSIUM NITRATE ---------	0.00 grams	( )	0.00
OTHER ------------------	0.00 grams	( )	0.00
FLOUR ------------------	4.38 grams	[ ]	2.19
TOTAL CHARGE +ORE	214.38 g		107.19
Flux charge only	185.22 gr		92.61

No. 38

AVG. SANDSTONE

FOR MONOSILICATE SLAGS INVOLVING ORES WITH 15% OR LESS METALICS

	Percent
Silica QUARTZ ETC.	75.20
Ca,Mg,Ba,Sr as OXIDE or CO3	6.60
Feldspars any TYPE (AVG.)	6.30
Aluminas as CLAY,TALC, ETC.	8.40
METALS** OXIDE,SULFIDE,-ATE	3.50
TOTAL %	100.00

YOUR FLUX FORMULA IS:	29.16-1 AT	[ ]	14.58-1/2 AT
SODIUM CARBONATE (ANHYD)---	33.64 grams	[ ]	16.82
RED LEAD or LITHARGE-------	117.81 grams	[ ]	58.91
SILICA ------------------	2.00 grams	[ ]	1.00
BORAX GLASS----------------	4.68 grams	[ ]	2.34
CALCIUM OXIDE (LIME)-------	9.78 grams	[ ]	4.89
RED IRON OXIDE-------------	15.97 grams	[ ]	7.98
POTASSIUM NITRATE ---------	0.00 grams	( )	0.00
OTHER ------------------	0.00 grams	( )	0.00
FLOUR ------------------	4.38 grams	[ ]	2.19
TOTAL CHARGE +ORE	217.41 g		108.70
Flux charge only	188.25 gr		94.12

No. 39

CLAY

FOR MONOSILICATE SLAGS INVOLVING ORES WITH 15% OR LESS METALICS

	Percent
Silica QUARTZ ETC.	71.40
Ca,Mg,Ba,Sr as OXIDE or CO3	1.30
Feldspars any TYPE (AVG.)	4.30
Aluminas as CLAY,TALC, ETC.	18.00
METALS** OXIDE,SULFIDE,-ATE	5.00
TOTAL %	100.00

YOUR FLUX FORMULA IS:	29.16-1 AT	[ ]	14.58-1/2 AT
SODIUM CARBONATE (ANHYD)---	33.49 grams	[ ]	16.75
RED LEAD or LITHARGE-------	115.56 grams	[ ]	57.78
SILICA ------------------	3.01 grams	[ ]	1.51
BORAX GLASS----------------	3.67 grams	[ ]	1.84
CALCIUM OXIDE (LIME)-------	9.28 grams	[ ]	4.64
RED IRON OXIDE-------------	15.37 grams	[ ]	7.68
POTASSIUM NITRATE ---------	0.00 grams	( )	0.00
OTHER ------------------	0.00 grams	( )	0.00
FLOUR ------------------	4.24 grams	[ ]	2.12
TOTAL CHARGE +ORE	213.79 g		106.90
Flux charge only	184.63 gr		92.32

No. 40

SILICEOUS OOZES [EARTHS]

FOR MONOSILICATE SLAGS INVOLVING ORES WITH 15% OR LESS METALICS

	Percent
Silica QUARTZ ETC.	67.10
Ca,Mg,Ba,Sr as OXIDE or CO3	3.20
Feldspars any TYPE (AVG.)	12.50
Aluminas as CLAY,TALC, ETC.	12.30
METALS** OXIDE,SULFIDE,-ATE	4.90
TOTAL %	100.00

YOUR FLUX FORMULA IS:	29.16-1 AT	[ ]	14.58-1/2 AT
SODIUM CARBONATE (ANHYD)---	30.93 grams	[ ]	15.46
RED LEAD or LITHARGE-------	112.23 grams	[ ]	56.11
SILICA ------------------	2.29 grams	[ ]	1.14
BORAX GLASS----------------	5.00 grams	[ ]	2.50
CALCIUM OXIDE (LIME)-------	8.72 grams	[ ]	4.36
RED IRON OXIDE-------------	14.30 grams	[ ]	7.15
POTASSIUM NITRATE ---------	0.00 grams	( )	0.00
OTHER ------------------	0.00 grams	( )	0.00
FLOUR ------------------	4.16 grams	[ ]	2.08
TOTAL CHARGE +ORE	206.80 g		103.40
Flux charge only	177.64 gr		88.82

No. 41

LITHIC ARENITE

FOR MONOSILICATE SLAGS INVOLVING ORES WITH 15% OR LESS METALICS

	Percent
Silica QUARTZ ETC.	66.10
Ca,Mg,Ba,Sr as OXIDE or CO3	13.60
Feldspars any TYPE (AVG.)	7.00
Aluminas as CLAY,TALC, ETC.	8.10
METALS** OXIDE,SULFIDE,-ATE	5.20
TOTAL %	100.00

YOUR FLUX FORMULA IS:	29.16-1 AT	[ ]	14.58-1/2 AT
SODIUM CARBONATE (ANHYD)---	33.49 grams	[ ]	16.75
RED LEAD or LITHARGE-------	117.30 grams	[ ]	58.65
SILICA -----------------	2.66 grams	[ ]	1.33
BORAX GLASS----------------	5.12 grams	[ ]	2.56
CALCIUM OXIDE (LIME)-------	8.59 grams	[ ]	4.30
RED IRON OXIDE-------------	15.19 grams	[ ]	7.60
POTASSIUM NITRATE ---------	0.00 grams	( )	0.00
OTHER -----------------	0.00 grams	( )	0.00
FLOUR -----------------	4.25 grams	[ ]	2.13
TOTAL CHARGE +ORE	215.77 g		107.88
Flux charge only	186.61 gr		93.30

No. 42

GRAYWACKE

FOR MONOSILICATE SLAGS INVOLVING ORES WITH 15% OR LESS METALICS

	Percent
Silica QUARTZ ETC.	63.70
Ca,Mg,Ba,Sr as OXIDE or CO3	6.50
Feldspars any TYPE (AVG.)	9.60
Aluminas as CLAY,TALC, ETC.	14.20
METALS** OXIDE,SULFIDE,-ATE	6.00
TOTAL %	100.00

YOUR FLUX FORMULA IS:	29.16-1 AT	[ ]	14.58-1/2 AT
SODIUM CARBONATE (ANHYD)---	31.84 grams	[ ]	15.92
RED LEAD or LITHARGE-------	113.41 grams	[ ]	56.70
SILICA -----------------	2.92 grams	[ ]	1.46
BORAX GLASS----------------	4.73 grams	[ ]	2.37
CALCIUM OXIDE (LIME)-------	8.28 grams	[ ]	4.14
RED IRON OXIDE-------------	14.29 grams	[ ]	7.15
POTASSIUM NITRATE ---------	0.00 grams	( )	0.00
OTHER -----------------	0.00 grams	( )	0.00
FLOUR -----------------	4.12 grams	[ ]	2.06
TOTAL CHARGE +ORE	208.76 g		104.38
Flux charge only	179.60 gr		89.80

No. 43

BLACHMUDS / SHALES [SLATES]

FOR MONOSILICATE SLAGS INVOLVING ORES WITH 15% OR LESS METALICS

	Percent
Silica QUARTZ ETC.	41.00
Ca,Mg,Ba,Sr as OXIDE or CO3	9.50
Feldspars any TYPE (AVG.)	18.80
Aluminas as CLAY,TALC, ETC.	25.70
METALS** OXIDE,SULFIDE,-ATE	5.00
TOTAL %	100.00

YOUR FLUX FORMULA IS:	29.16-1 AT	[ ]	14.58-1/2 AT
SODIUM CARBONATE (ANHYD)---	29.91 grams	[ ]	14.95
RED LEAD or LITHARGE-------	100.53 grams	[ ]	50.26
SILICA ------------------	5.06 grams	[ ]	2.53
BORAX GLASS----------------	5.60 grams	[ ]	2.80
CALCIUM OXIDE (LIME)-------	5.33 grams	[ ]	2.67
RED IRON OXIDE-------------	11.43 grams	[ ]	5.72
POTASSIUM NITRATE ---------	0.00 grams	( )	0.00
OTHER ------------------	0.00 grams	( )	0.00
FLOUR ------------------	3.84 grams	[ ]	1.92
TOTAL CHARGE +ORE	190.86 g		95.43
Flux charge only	161.70 gr		80.85

No. 44

DOLOMITIZED LIMESTONE

FOR MONOSILICATE SLAGS INVOLVING ORES WITH 15% OR LESS METALICS

	Percent
Silica QUARTZ ETC.	3.90
Ca,Mg,Ba,Sr as OXIDE or CO3	92.20
Feldspars any TYPE (AVG.)	0.50
Aluminas as CLAY,TALC, ETC.	1.40
METALS** OXIDE,SULFIDE,-ATE	2.00
TOTAL %	100.00

YOUR FLUX FORMULA IS:	29.16-1 AT	[ ]	14.58-1/2 AT
SODIUM CARBONATE (ANHYD)---	44.38 grams	[ ]	22.19
RED LEAD or LITHARGE-------	116.38 grams	[ ]	58.19
SILICA ------------------	9.44 grams	[ ]	4.72
BORAX GLASS----------------	9.46 grams	[ ]	4.73
CALCIUM OXIDE (LIME)-------	0.51 grams	[ ]	0.25
RED IRON OXIDE-------------	13.78 grams	[ ]	6.89
POTASSIUM NITRATE ---------	0.00 grams	( )	0.00
OTHER ------------------	0.00 grams	( )	0.00
FLOUR ------------------	4.22 grams	[ ]	2.11
TOTAL CHARGE +ORE	227.32 g		113.66
Flux charge only	198.16 gr		99.08

No. 45

LIMESTONE

FOR MONOSILICATE SLAGS INVOLVING ORES WITH 15% OR LESS METALICS

	Percent
Silica QUARTZ ETC.	1.00
Ca,Mg,Ba,Sr as OXIDE or CO3	96.00
Feldspars any TYPE (AVG.)	2.50
Aluminas as CLAY,TALC, ETC.	0.50
METALS** OXIDE,SULFIDE,-ATE	0.00
TOTAL %	100.00

YOUR FLUX FORMULA IS:	29.16-1 AT	[ ]	14.58-1/2 AT
SODIUM CARBONATE (ANHYD)---	44.82 grams	[ ]	22.41
RED LEAD or LITHARGE-------	114.36 grams	[ ]	57.18
SILICA -----------------	9.68 grams	[ ]	4.84
BORAX GLASS----------------	10.04 grams	[ ]	5.02
CALCIUM OXIDE (LIME)-------	0.13 grams	[ ]	0.07
RED IRON OXIDE-------------	13.68 grams	[ ]	6.84
POTASSIUM NITRATE ---------	0.00 grams	( )	0.00
OTHER -----------------	0.00 grams	( )	0.00
FLOUR -----------------	4.27 grams	[ ]	2.13
TOTAL CHARGE +ORE	226.12 g		113.06
Flux charge only	196.96 gr		98.48

We have stated that the RO group was actually divided into two groups which are considered separately. While calcium, magnesium, barium, and strontium compounds are represented on the worksheet (category B), lithium, sodium, potassium, and rubidium are noticeably absent, for they are, in reality, R_2O rather than RO. As such, they melt at very low temperatures. Therefore, their minerals are generally self-fluxing and may be ignored in our calculations.

To the best of your ability, (1) estimate the percentage of each of the five categories, (2) multiply the percent (as a whole number) times the factor given below each ingredient, (3) enter the answer in the space provided, and (4) total each column. Using these totals, fill in the blanks provided in *Your Flux Formula Is:*.

REMEMBER TO ADD the 38 grams of red lead oxide as noted below (+) on the worksheet. It is the lead which will provide the button, and if it is not present, there will be a serious error in the slag.

WORKSHEET FOR MONOSILICATE SLAGS INVOLVING ORES WITH 15% OR LESS METALLICS

PERCENTAGE CALCULATIONS

1) Silica	QUARTZ	______	(A*)
2) Ca,Mg,Ba,Sr as	OXIDE or CO_3	______	(B*)
3) Feldspars	any TYPE (AVG.)	______	(C*)
4) Aluminas as	CLAY,TALC,ETC.	______	(D*)
5) METALS --	OXIDE,SULFIDE,-ATE	______	(E*)
TOTAL PERCENTAGE		______	

MULTIPLY EACH ROW BY *%:	SODA	RED LEAD	SILICA	BORAX
A ______	0.36 = ______	0.88 = ______	xxxx = ______	0.04 = ______
B ______	0.46 = ______	0.78 = ______	0.10 = ______	0.10 = ______
C ______	0.04 = ______	0.16 = ______	xxxx = 0.0	0.16 = ______
D ______	0.39 = ______	0.39 = ______	0.16 = ______	xxxx = 0.0
E ______	xxxx = 0.0	1.20 = ______	xxxx = 0.0	xxxx = 0.0
		(+) = 38.0		
TOTALS	______g	______g	______g	______g

MULTIPLY EACH ROW BY *%:	LIME	IRON III	FLOUR
A ______	0.13 = ______	0.19 = ______	0.048 = ______
B ______	xxxx = 0.0	0.14 = ______	0.043 = ______
C ______	xxxx = 0.0	xxxx = 0.0	0.030 = ______
D ______	xxxx = 0.0	0.09 = ______	0.035 = ______
E ______	xxxx = 0.0	xxxx = 0.0	xxxx = 0.0
TOTALS	______	______	______

PROJECT # __________ NAME ______________________________ DATE __________

YOUR FLUX FORMULA IS:

ORE	29.16-1	
SODIUM CARBONATE	______	grams
RED LEAD or LITHARGE	______	grams
SILICA	______	grams
BORAX GLASS	______	grams
CALCIUM OXIDE (lime)	______	grams
RED IRON OXIDE	______	grams
POTASSIUM NITRATE	______	grams
OTHER	______	grams
FLOUR	______	grams
TOTAL CHARGE + ORE	______	grams

- -

INQUART (if any) = ______________ mg GOLD
______________ mg SILVER

TOTAL INQUART ______________ mg

- -

BUTTON WEIGHT ______________ grams

TOTAL WEIGHT OF BEAD ______________ mg

Minus GOLD (______________) mg = Oz Tr/TON ______________

Equals SILVER ______________ mg = Oz Tr/TON ______________

- -

COMMENTS: ____

____

____

____

____

PROJECT # ____________ NAME ______________________________ DATE __________

YOUR FLUX FORMULA IS:

ORE	29.16-1	
SODIUM CARBONATE	______	grams
RED LEAD or LITHARGE	______	grams
SILICA	______	grams
BORAX GLASS	______	grams
CALCIUM OXIDE (lime)	______	grams
RED IRON OXIDE	______	grams
POTASSIUM NITRATE	______	grams
OTHER	______	grams
FLOUR	______	grams
TOTAL CHARGE + ORE	______	grams

- -

INQUART (if any) = ______________ mg GOLD
______________ mg SILVER

TOTAL INQUART ______________ mg

- -

BUTTON WEIGHT ______________ grams

TOTAL WEIGHT OF BEAD ______________ mg

Minus GOLD (______________) mg = Oz Tr/TON ______________

Equals SILVER ______________ mg = Oz Tr/TON ______________

- -

COMMENTS: ____

____

____

____

____

PROJECT #__________ NAME__________________________ DATE__________

YOUR FLUX FORMULA IS:

ORE	29.16-1
SODIUM CARBONATE	_____ grams
RED LEAD or LITHARGE	_____ grams
SILICA	_____ grams
BORAX GLASS	_____ grams
CALCIUM OXIDE (lime)	_____ grams
RED IRON OXIDE	_____ grams
POTASSIUM NITRATE	_____ grams
OTHER	_____ grams
FLOUR	_____ grams
TOTAL CHARGE + ORE	_____ grams

- -

INQUART (if any) = __________ mg GOLD
__________ mg SILVER

TOTAL INQUART __________ mg

- -

BUTTON WEIGHT __________ grams

TOTAL WEIGHT OF BEAD __________ mg

Minus GOLD (__________) mg = Oz Tr/TON __________

Equals SILVER __________ mg = Oz Tr/TON __________

- -

COMMENTS:____