CARBON COMICS 2

CENTER FOR APPLIED ISOTOPE STUDIES

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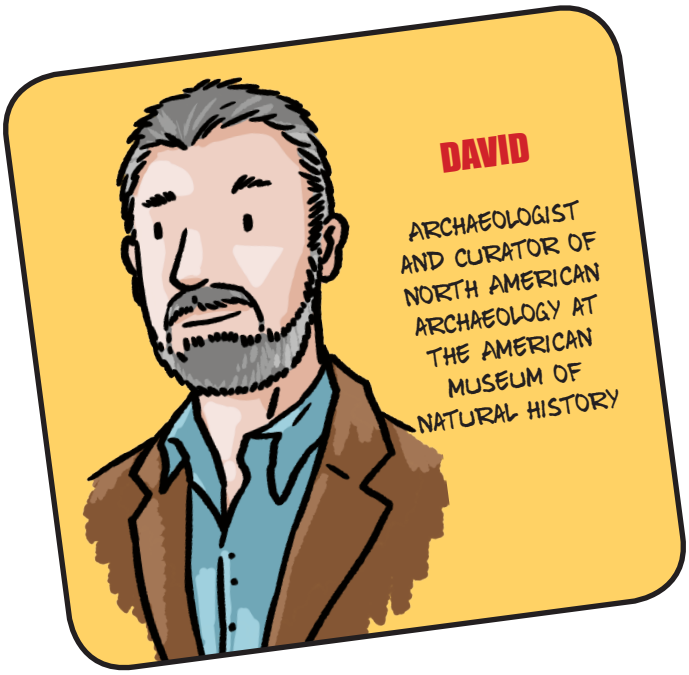
UNLOCKING the PAST!

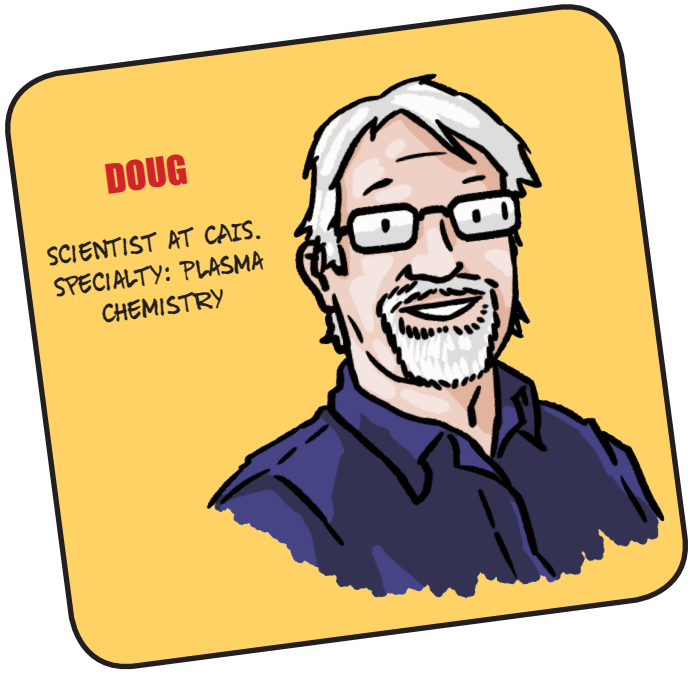
THE SCIENCE OF ARCHAEOMETALLURGY

HOW THE TEAM AT CAIS KNOWS WHERE THIS MISSION BELL WAS MADE!

WELCOME TO THE CENTER FOR APPLIED ISOTOPE STUDIES (CAIS), AND THE AMAZING WORLD OF ARCHAEOMETALLURGY - WHERE ARCHAEOLOGISTS AND PHYSICISTS USE SCIENCE TO UNLOCK THE PAST! WE'RE GOING TO BE SHOWING YOU HOW THE CHEMICALS INSIDE ANCIENT OBJECTS CAN TELL US WHERE AN OBJECT WAS MADE - EVEN SOMETHING THAT'S BEEN BURIED IN THE EARTH FOR HUNDREDS OF YEARS.

DOING THIS KIND OF SCIENCE TAKES A WHOLE TEAM OF PEOPLE. HERE ARE THE ARCHAEOLOGISTS AND RESEARCH SCIENTISTS AT CAIS WHO MAKE ARCHAEOMETALLURGY POSSIBLE - THEY'RE GOING TO TELL YOU WHAT ARCHAEOMETALLURGY IS USED FOR, HOW IT WORKS AND HOW THEY DO IT.






ANNA AND DAVE ARE EXCAVATING A SPANISH MISSION ON ST. CATHERINES ISLAND.
DAVE, I'M FINDING A LOT OF FRAGMENTS OF METAL IN THE GRAVES WE'RE EXCAVATING.
IT'S BRONZE: THAT'S REALLY INTERESTING!
I THINK THEY'RE PIECES OF MISSION BELLS.
YES, I THINK YOU'RE RIGHT.
THE ARCHAEOLOGISTS ON ST. CATHERINES ARE LOOKING FOR EVIDENCE THAT HELPS US UNDERSTAND THE LIVES OF THE FIRST EUROPEAN SETTLERS IN THE NEW WORLD.
MISSION BELLS WERE USUALLY MADE BACK IN SPAIN AND BROUGHT WITH THE SETTLERS WHEN THEY TRAVELLED TO THE NEW WORLD.
PERHAPS WHEN THE MISSION WAS DESTROYED, PEOPLE WANTED TO KEEP THE FRAGMENTS OF THE BELLS TO REMIND THEM OF THEIR DISTANT HOMELAND.
HMM. I WONDER WHERE THE BELL WAS ACTUALLY MADE?

AT CAIS IN GEORGIA:

HI ANNA! YES, WE CAN DEFINITELY HELP YOU FIND AN ANSWER. YOU'VE BROUGHT US SOME OF THE BELL FRAGMENTS SO WE CAN GET STARTED!

HMM. I CAN SEE UNDER THE MICROSCOPE THAT THE METAL HAS NOT BEEN CAST VERY WELL.

CAN YOU SEE THOSE BUBBLES? THEY MEAN THAT THE BRONZE USED TO MAKE THE BELL COOLED TOO QUICKLY IN THE MOULD.

HOW WERE THE MISSION BELLS MADE?

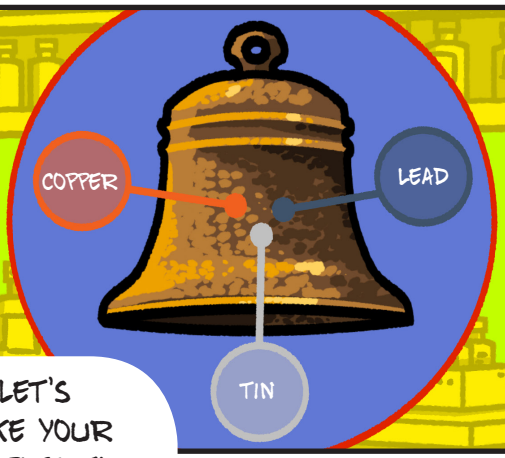
1. FIRST, THE SHAPE OF THE BELL IS MADE OUT OF WAX SURROUNDED BY A MOULD MADE OF CLAY.
2. RED-HOT LIQUID BRONZE IS POURED INTO THE SPACE BETWEEN THE TWO PARTS OF THE MOULD. THE WAX MELTS AND RUNS OUT.
3. THE BRONZE GOES INTO THE SPACE LEFT BEHIND BY THE MELTED WAX, TAKING THE SAME SHAPE.

THE BUBBLES MEAN THE BELLS PROBABLY WEREN'T MADE IN SPAIN. SPANISH BELL-CASTERS WERE VERY GOOD AT MAKING BELLS, AND THEY WOULDN'T HAVE LET THE METAL COOL TOO QUICKLY.

CAN WE FIND OUT WHERE THE METAL CAME FROM? THAT MIGHT TELL US WHERE THE BELLS WERE MADE.

WELL, THE METAL CONTAINS COPPER, TIN AND LEAD... *

... SO, YES: I THINK THE LEAD ISOTOPES COULD TELL US.



LET'S TAKE YOUR SAMPLES TO DOUG.

* SCIENTISTS OFTEN USE THESE ABBREVIATIONS:
COPPER: CU TIN: SN LEAD: PB

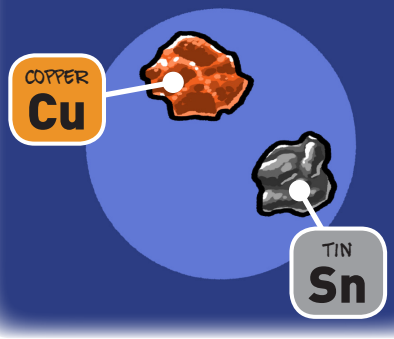
4 THE BRONZE COOLS AND GOES SOLID.

5 THE CLAY PARTS OF THE MOULD ARE TAKEN AWAY, AND WHAT IS LEFT IS THE BRONZE BELL.

6 FINALLY, THE BELL IS TRIMMED, POLISHED AND TUNED SO THAT IT MAKES THE CORRECT SOUND.

WHY IS THERE LEAD IN THE BRONZE BELLS?

BRONZE IS AN "ALLOY", WHICH MEANS IT IS A METAL MADE FROM TWO OTHER METALS.



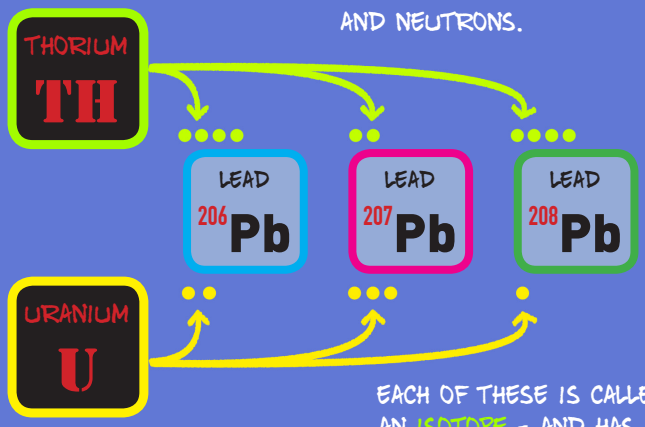
HOWEVER, BOTH COPPER AND TIN ARE VERY SOFT – SO BRONZE CAN OFTEN CRACK.

LEAD WAS ADDED TO THE BRONZE TO MAKE IT STRONGER. IT COOLS MORE SLOWLY THAN COPPER AND TIN.

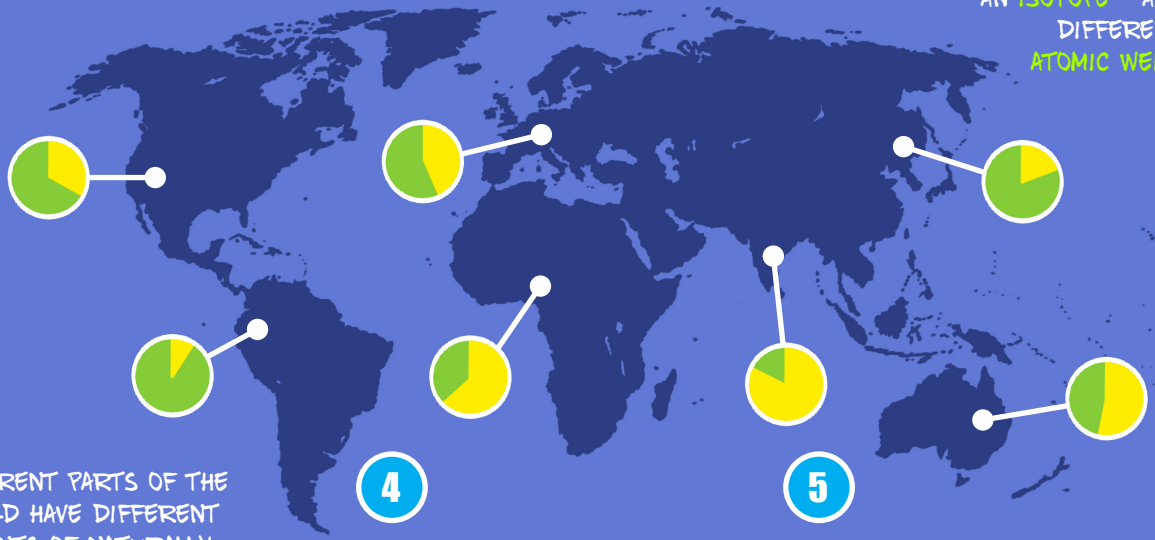
1 LEAD IS DUG OUT OF THE GROUND IN LEAD MINES. IN THE ROCKS AND SOIL SURROUNDING LEAD ARE OTHER ELEMENTS.

2 TWO OF THESE ELEMENTS – THORIUM AND URANIUM – ARE RADIOACTIVE. NEUTRONS AND PROTONS TRAVEL FROM THESE ELEMENTS AND ATTACH THEMSELVES TO THE LEAD ATOMS.

THIS CREATES LEAD ATOMS WITH DIFFERENT NUMBERS OF PROTONS AND NEUTRONS.



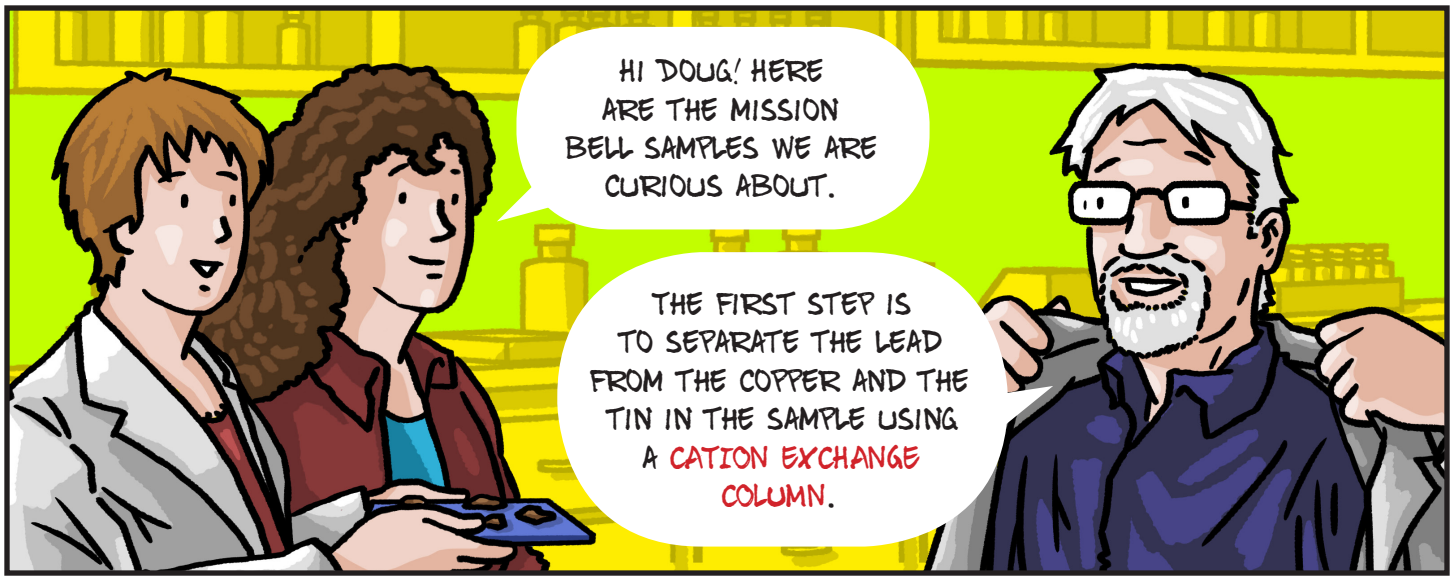
EACH OF THESE IS CALLED AN ISOTOPE – AND HAS A DIFFERENT ATOMIC WEIGHT.

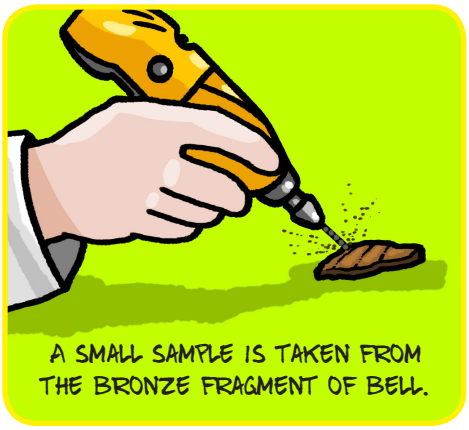


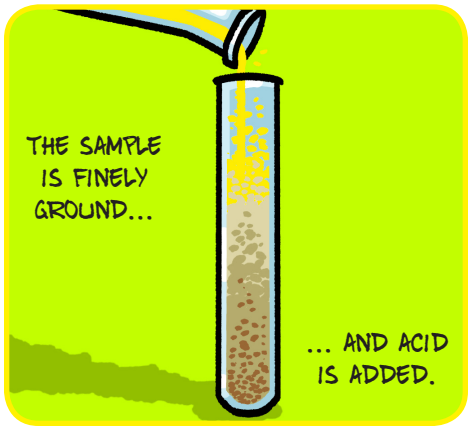
3 DIFFERENT PARTS OF THE WORLD HAVE DIFFERENT AMOUNTS OF NATURALLY-OCCURRING THORIUM AND URANIUM IN THE SOIL AND ROCKS...

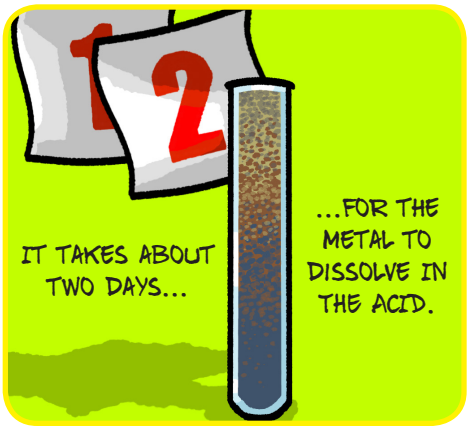
4 ... AND THEY CREATE DIFFERENT AMOUNTS OF EACH KIND OF LEAD ISOTOPE.

5 SO HOW MUCH OF EACH ISOTOPE YOU HAVE IN A SAMPLE OF LEAD WILL TELL YOU WERE THAT LEAD CAME FROM.







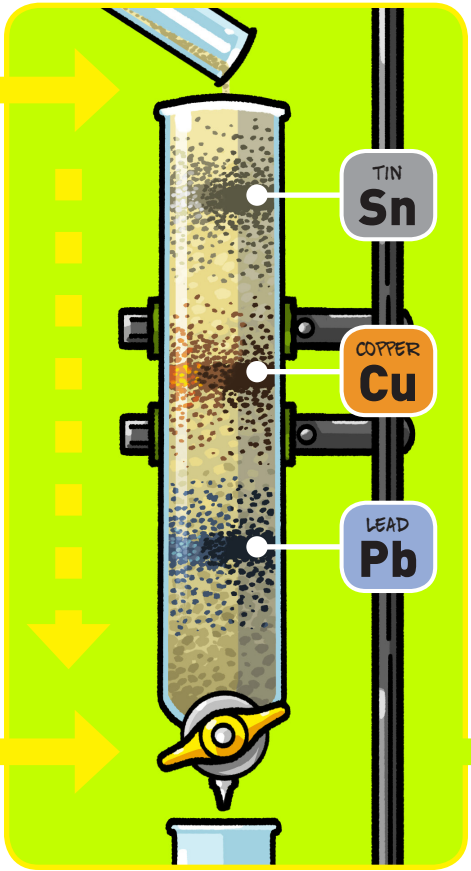


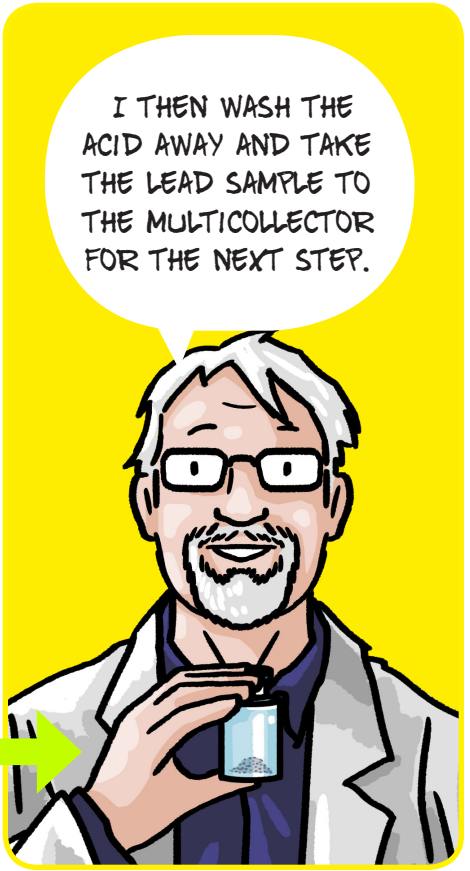
THE SAMPLE IS POURED INTO THE COLUMN...

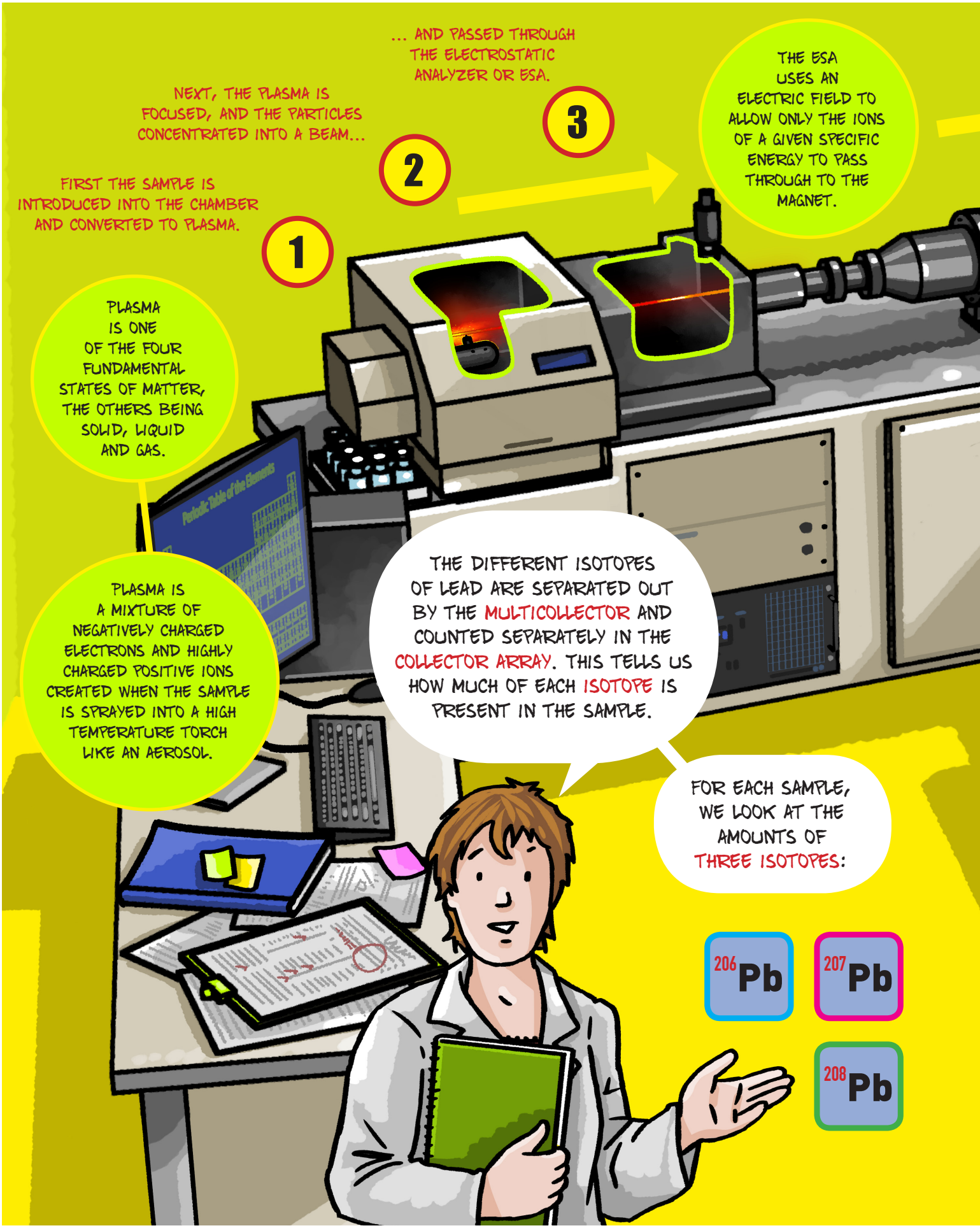
EVERYTHING FLOWS THROUGH THE COLUMN AND DRIPS OUT THE BOTTOM.

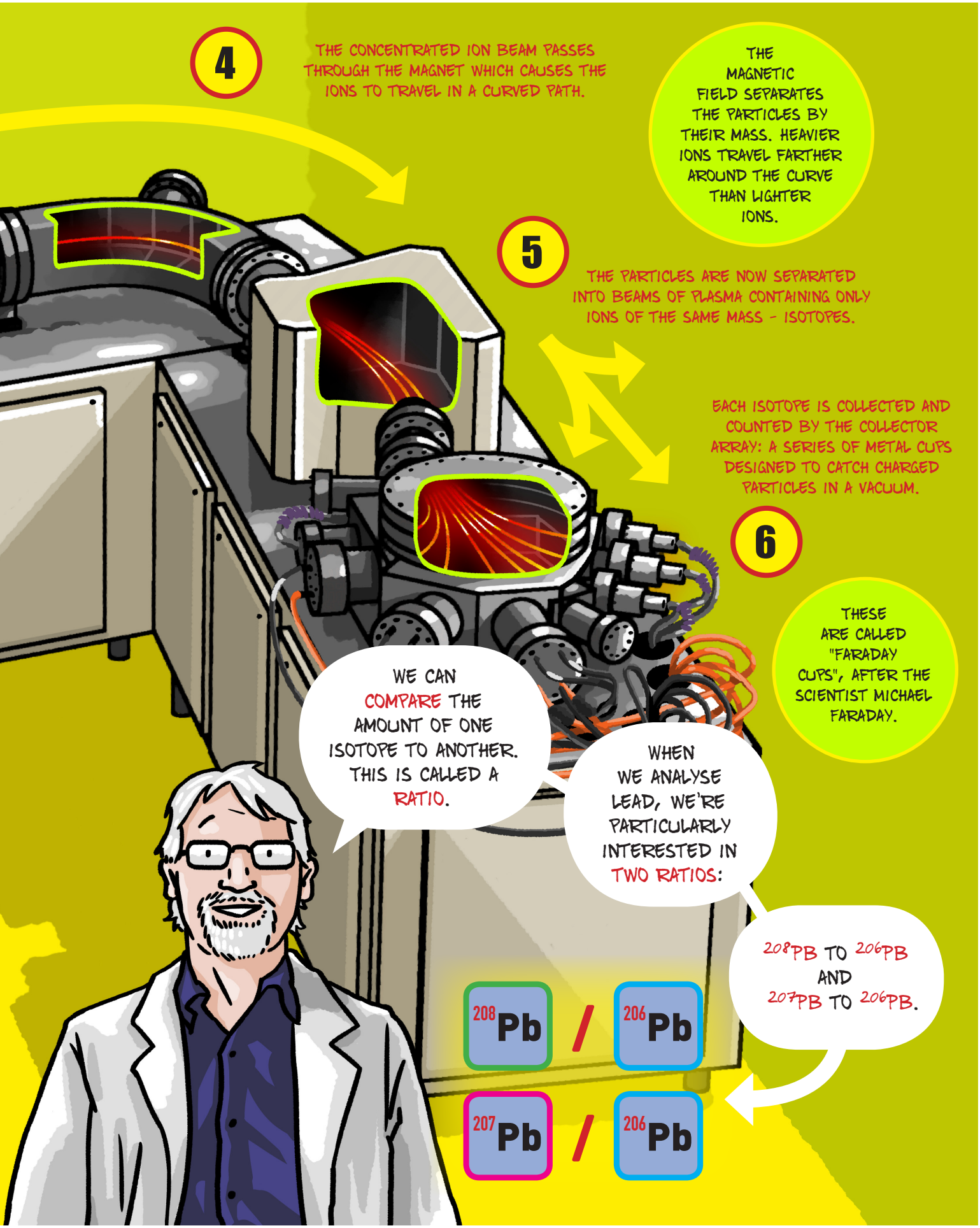
BECAUSE DIFFERENT ELEMENTS ARE HEAVIER, THEY MOVE DOWN THROUGH THE COLUMN AT DIFFERENT SPEEDS.

IT TAKES A WHOLE AFTERNOON FOR THE SAMPLE TO PASS THROUGH THE COLUMN, AND WE WAIT UNTIL THE TIME IS RIGHT TO EXTRACT JUST THE LEAD FROM THE SAMPLE.





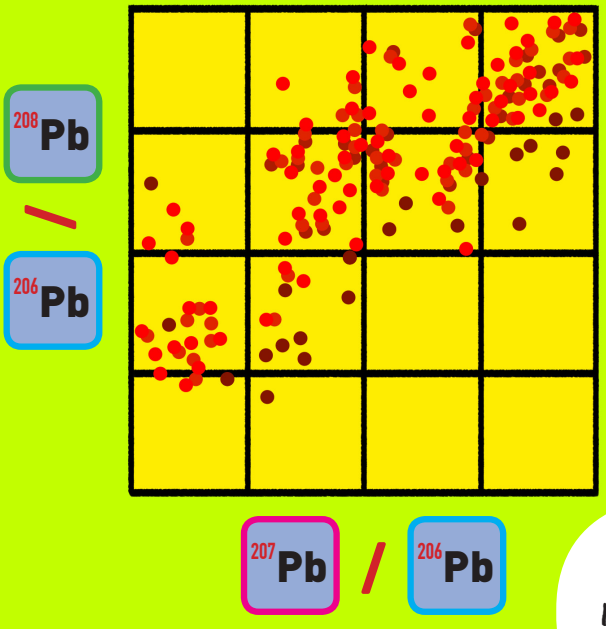

FIRST THE SAMPLE IS INTRODUCED INTO THE CHAMBER AND CONVERTED TO PLASMA.
1
NEXT, THE PLASMA IS FOCUSED, AND THE PARTICLES CONCENTRATED INTO A BEAM...
2
... AND PASSED THROUGH THE ELECTROSTATIC ANALYZER OR ESA.
3
THE ESA USES AN ELECTRIC FIELD TO ALLOW ONLY THE IONS OF A GIVEN SPECIFIC ENERGY TO PASS THROUGH TO THE MAGNET.
PLASMA IS ONE OF THE FOUR FUNDAMENTAL STATES OF MATTER, THE OTHERS BEING SOLID, LIQUID AND GAS.
PLASMA IS A MIXTURE OF NEGATIVELY CHARGED ELECTRONS AND HIGHLY CHARGED POSITIVE IONS CREATED WHEN THE SAMPLE IS SPRAYED INTO A HIGH TEMPERATURE TORCH LIKE AN AEROSOL.
THE DIFFERENT ISOTOPES OF LEAD ARE SEPARATED OUT BY THE MULTICOLLECTOR AND COUNTED SEPARATELY IN THE COLLECTOR ARRAY. THIS TELLS US HOW MUCH OF EACH ISOTOPE IS PRESENT IN THE SAMPLE.
FOR EACH SAMPLE, WE LOOK AT THE AMOUNTS OF THREE ISOTOPES:
206Pb
207Pb
208Pb


4
THE CONCENTRATED ION BEAM PASSES THROUGH THE MAGNET WHICH CAUSES THE IONS TO TRAVEL IN A CURVED PATH.
THE MAGNETIC FIELD SEPARATES THE PARTICLES BY THEIR MASS. HEAVIER IONS TRAVEL FARTHER AROUND THE CURVE THAN LIGHTER IONS.
5
THE PARTICLES ARE NOW SEPARATED INTO BEAMS OF PLASMA CONTAINING ONLY IONS OF THE SAME MASS - ISOTOPES.
EACH ISOTOPE IS COLLECTED AND COUNTED BY THE COLLECTOR ARRAY: A SERIES OF METAL CUPS DESIGNED TO CATCH CHARGED PARTICLES IN A VACUUM.
6
THESE ARE CALLED "FARADAY CUPS", AFTER THE SCIENTIST MICHAEL FARADAY.
WE CAN COMPARE THE AMOUNT OF ONE ISOTOPE TO ANOTHER. THIS IS CALLED A RATIO.
WHEN WE ANALYSE LEAD, WE'RE PARTICULARLY INTERESTED IN TWO RATIOS:
208PB TO 206PB AND 207PB TO 206PB.
208Pb / 206Pb
207Pb / 206Pb

THIS DATA SHOWS US HOW MUCH OF EACH LEAD ISOTOPE WERE IN THE SAMPLE FROM THE BELLS.

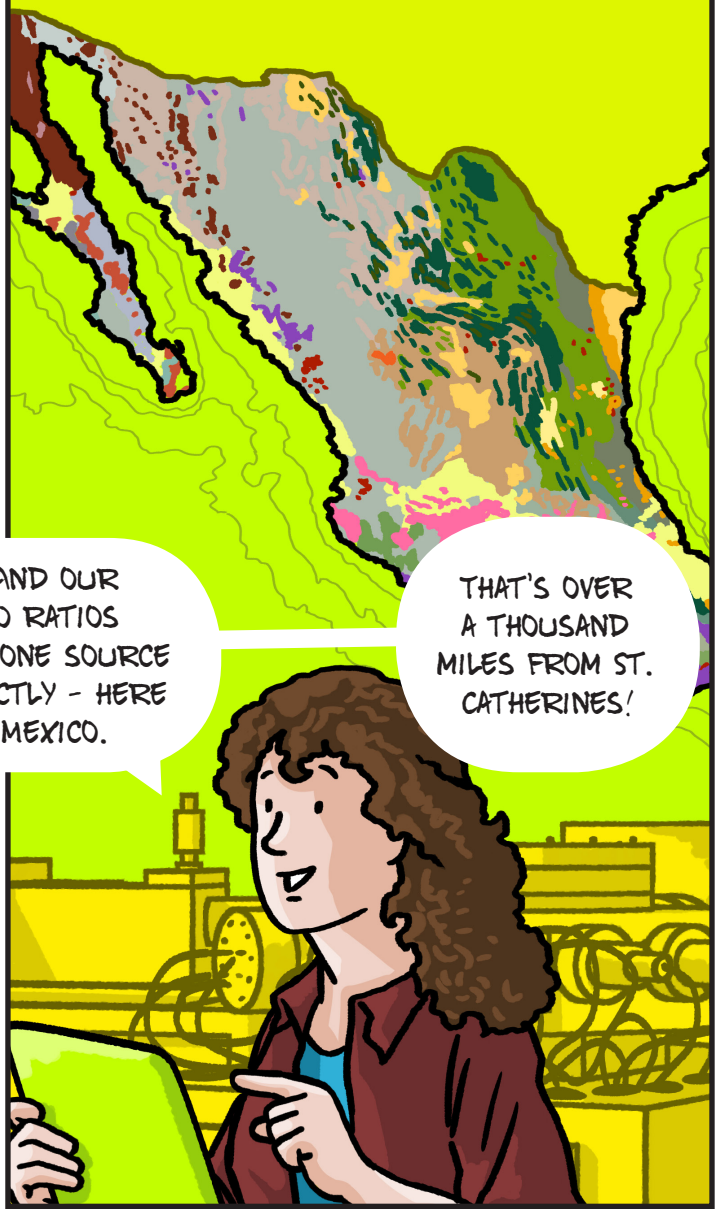
NOW WE CAN MATCH THE RATIOS FOUND IN YOUR SAMPLE WITH RATIOS FROM KNOWN SOURCES OF LEAD.

THIS CHART SHOWS DIFFERENT SETS OF THESE TWO RATIOS...



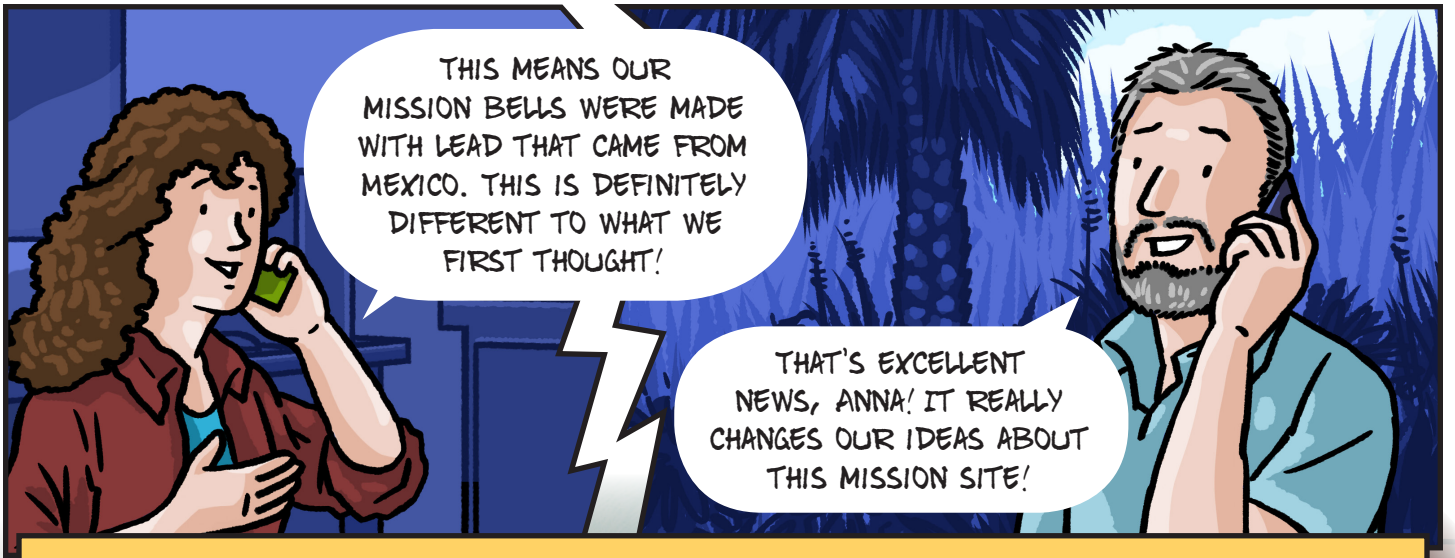
EACH DOT ON THE CHART IS A KNOWN SOURCE OF LEAD...

... WHICH HELP PINPOINT THE LOCATION ON A GEOLOGICAL MAP.

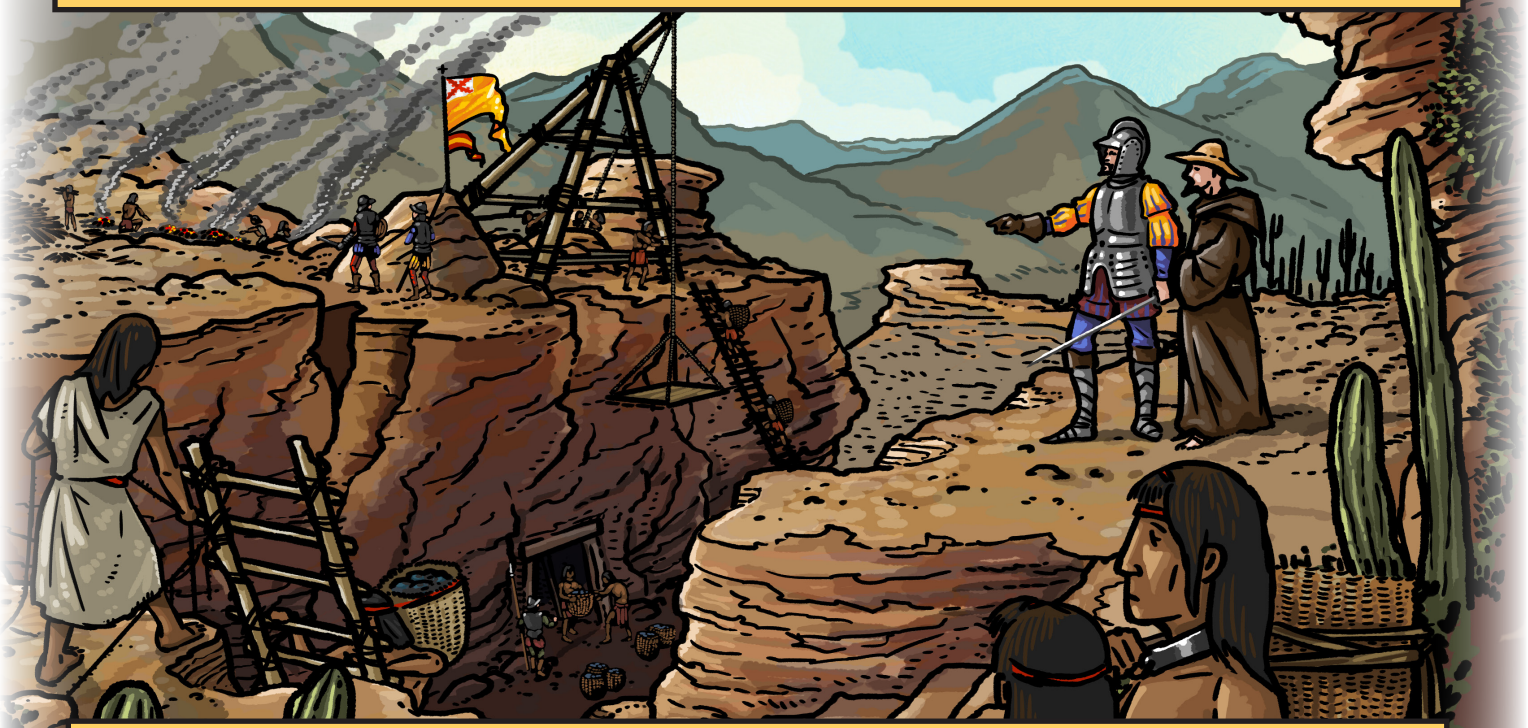


...AND OUR TWO RATIOS MATCH ONE SOURCE PERFECTLY - HERE IN MEXICO.

THAT'S OVER A THOUSAND MILES FROM ST. CATHERINES!



KNOWING WHERE METAL FOR MAKING OBJECTS LIKE THESE MISSION BELLS COMES FROM IS REALLY IMPORTANT. IT TELLS US HOW DISTANT HISTORICAL PLACES IN NORTH AMERICA ARE RELATED.



WORK DONE AT THE CENTER FOR APPLIED ISOTOPE STUDIES IS HELPING US CONNECT SITES LIKE ST. CATHERINES TO SITES IN OTHER PLACES AND OTHER COUNTRIES. THE SCIENCE AT CAIS HELPS US UNDERSTAND HOW THE FIRST EUROPEAN SETTLERS IN THE NEW WORLD LIVED.

Stable Isotope Ecology Laboratory
CENTER FOR APPLIED ISOTOPE STUDIES
at the University of Georgia

Carbon Comics No. 2 - *Unlocking The Past: Archaeometallurgy*

Written by Alice M. W. Hunt and John G. Swogger
Illustrated by John G. Swogger
Translated by Maria Jose Rivera Araya
Additional Translation by Bjorn Evans

SEPARATE THE ISOTOPES!

GAME FOR TWO PLAYERS: TAKE TURNS DRAWING STRAIGHT LINES FROM ONE + TO ANOTHER, TRY AND MAKE A BOX AROUND A GROUP OF LEAD ISOTOPE ATOMS OF THE SAME COLOUR. WHOEVER SEPARATES OUT THE MOST ATOMS, WINS! ONE PLAYER CHALLENGE: DRAW A SINGLE, CONTINUOUS LINE FROM ONE + TO ANOTHER, WITHOUT CROSSING OVER YOUR LINE, AND SEE HOW MANY ISOTOPE ATOMS YOU CAN SEPARATE BY COLOUR!