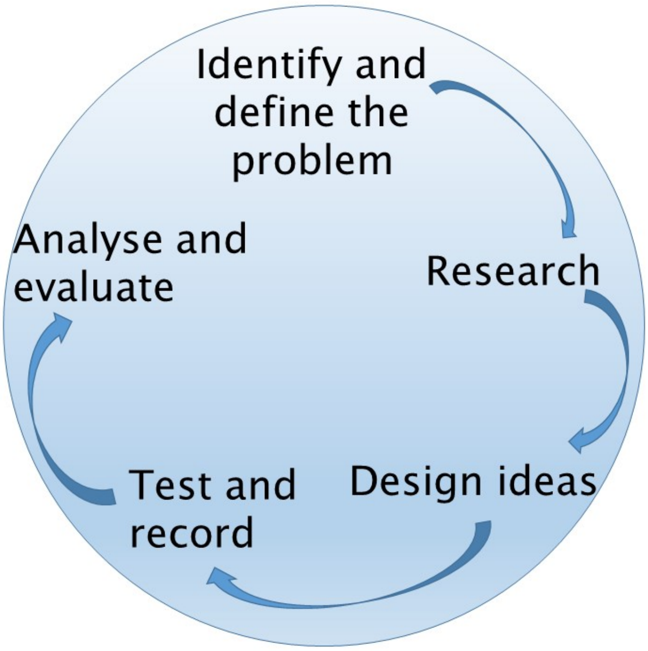
Searching for Iron Ore – Student Booklet

The Challenge

There has been a lot of activity around your local area, with geologists coming and going. There has been whispers of iron through the community and some people are even talking about the mining company wanting to buy lots of the land in the area for a possible mine. You are keen to find out if this could be true and want to know if your land could be worth a lot more than you thought, so you decide to do some geological exploration yourself.



Background Information

Western Australia is famous world-wide for its resources and mining industry. However, due to its isolation and low population, it can be quite a difficult place to get around – with limited road access and difficulty in maintaining supplies. Australia as a whole is very old and stable geologically speaking, with some of the oldest minerals in the world being found in rocks in WA. This means that most of the surface is deeply weathered and chemically altered, making it difficult for geologists to find rock outcrops and identify them easily.

In the past, geological mapping was carried out by very enthusiastic geologists, who loved to be in the field. They would note any rock outcrops they found and describe them in detail, eventually creating a map by inferring what was in between the outcrops (like a complicated dot-to-dot). Amazingly this has been carried out in Western Australia, despite the challenges highlighted. These maps were then used to analyse if it may be worth re-visiting the areas to look for resources.

Figure 1. An enthusiastic geologist, standing next to a rock outcrop on a mapping excursion.

More recently, the system of geological mapping has changed so that geophysical exploration occurs first. There are two main geophysical surveys which are used to locate iron ore due to the properties of iron which help it to stand out from surrounding rocks, the first of which is a gravity survey. In simple terms, rock types that contain minerals with larger mass will have a stronger gravitational pull. Just as the mass of the Sun pulls strongly on the planets in the solar system. Iron minerals are relatively dense and so rocks that are rich in iron ore will have a larger gravitational pull, than surrounding rocks. Using this principle, geophysicists can use data to determine the areas of denser rock and help locate potential iron ore sites.

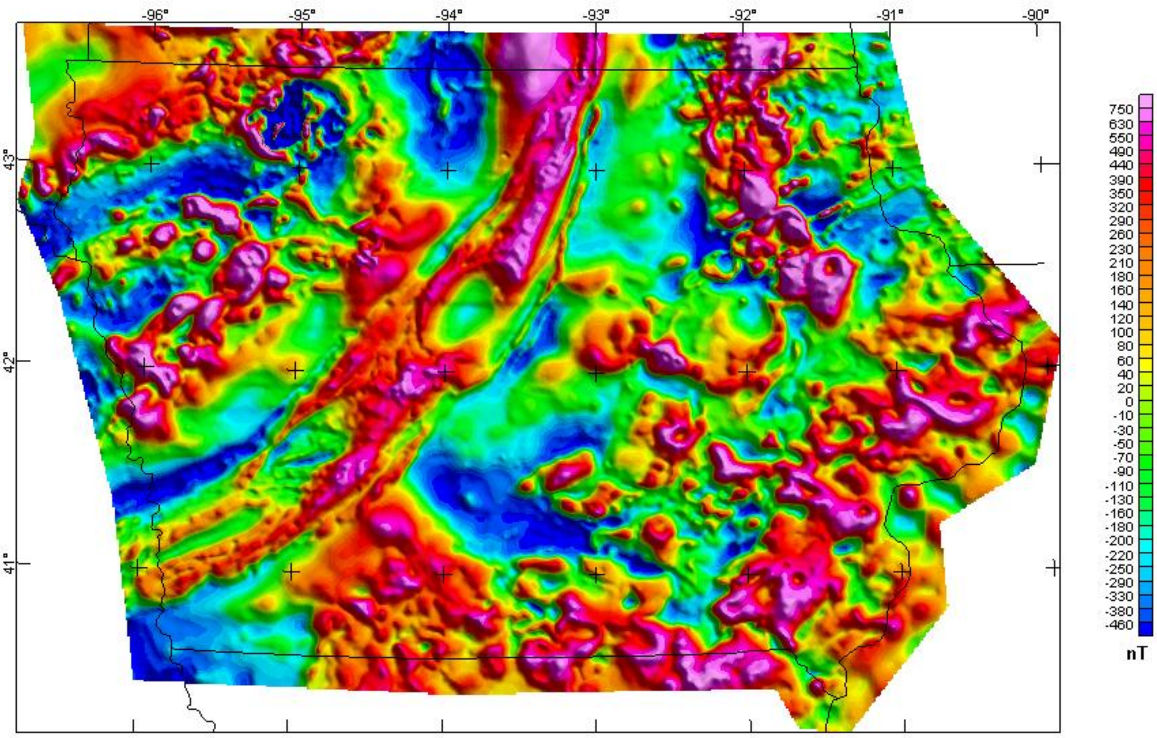


Figure 2. Gravity map of Iowa, showing areas of high gravity in red and low gravity in blue. (Kucks, Robert P. and Hill, Patricia L. U.S. Geological Survey, 2009)

The second geophysical technique which is also very helpful for locating iron ore, is magnetic surveying. For a large scale investigation, an aeroplane carrying a magnetometer will fly over an area collecting data. A high reading on the magnetometer indicates magnetic materials are attracting it. There are a lot of metals which have magnetic properties, iron being one of them. Therefore, an area with a high magnetic anomaly may indicate iron ore.

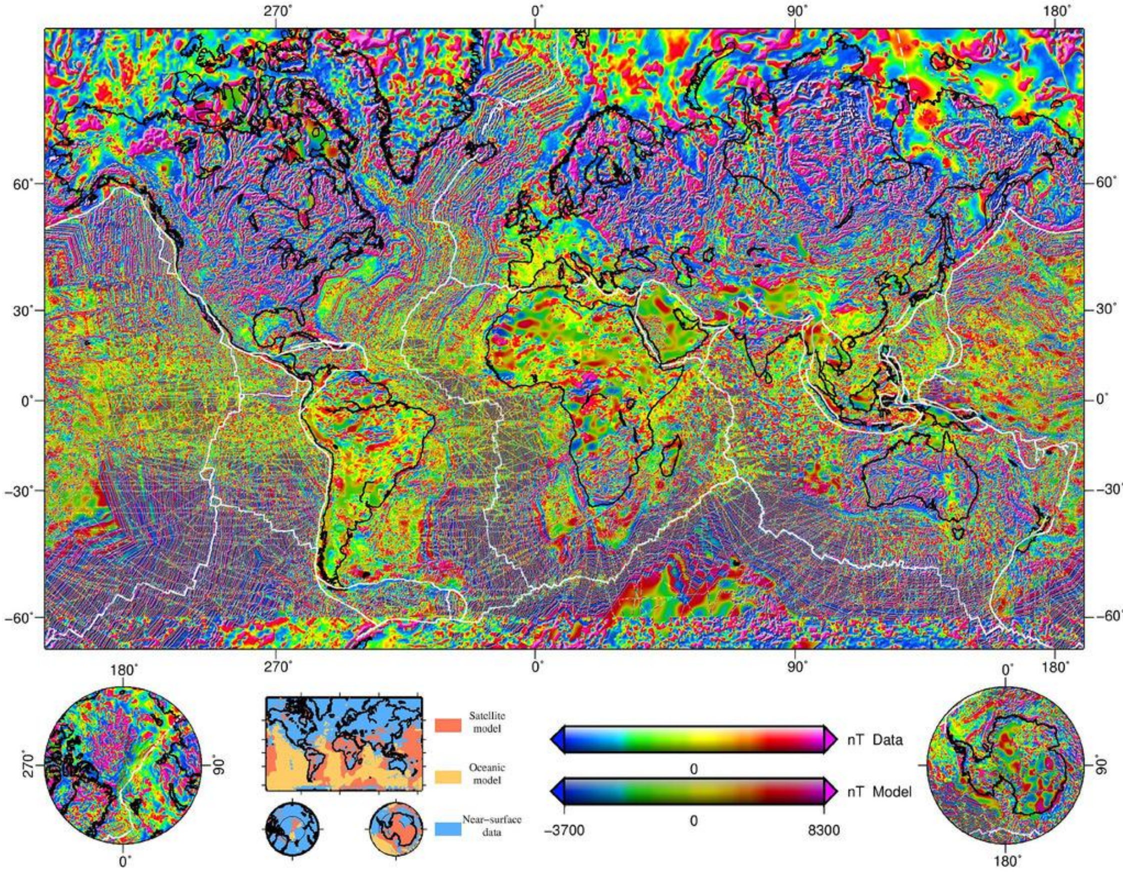


Image: Korhonen, J.V., Fairhead, J.D., Hamoudi, M., Hemant, K., Lesur, V., Mandea, M., Maus, S., Purucker, M., Ravat, D., Sazonova, T.,and Thebault, E., 2007, Magnetic Anomaly Map of the World (and associated DVD), Scale: 1:50,000,000, 1st edition, Commission for the Geological Map of the World, Paris, France.

Figure 3. Magnetic anomaly map of the world

These surveys can be carried out from the air, and so can cover a much larger area in a fraction of the time than people walking along the ground could, making them particularly useful in areas difficult to reach, such as outback WA and northern Queensland. These surveys can highlight any areas that look “interesting” for certain prospectors. Companies will then send in their exploration geologists to the areas of interest to complete the more traditional style geological mapping and sampling to determine if the area looks promising.

Background Research

1. What properties of iron make it useful?

Property	Definition	Why it is useful
Malleable		
Ductile		
Good conductor		
Oxidising		
High boiling and melting point		
High tensile strength		

2. What properties of iron might help to identify it?

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____

3. What is iron ore?

____

____

4. How did Banded Iron Formations (BIFs) form? Illustrate your answer with labelled diagrams.

5. Which rocks are frequently mined for iron ore in WA?

____

____

6. What might a rock that contains iron ore look like? (add some drawings or pictures from the internet).

7. How do the types of geophysical techniques that can be used to find iron ore work?

Technique	How it works	References / links
Gravitational survey		
Magnetic survey		

8. What is the trading price of iron and how much has it fluctuated over the past five years? (Insert graphs and references).

		References
Price today (date……………)		
Maximum price over the past 5 years		
Lowest price over the past 5 years		

9. Has iron ore been found near your area previously?

____

____

10. What are the locations of iron ore mines in WA? *Insert map highlighting the locations of the 5 biggest iron ore mines in WA, add references.*

Properties of Iron Ore

Objective

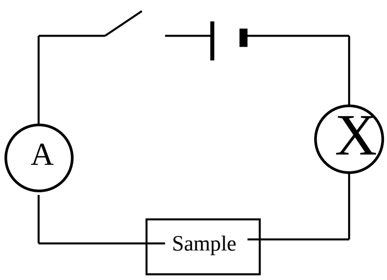
To describe the similarities and differences between different metals and highlight the key features that distinguish one from another. This information can be used to assist in the search for iron ore.

Equipment

- Different samples of metals (including iron) and/or samples of rocks, including iron ore
- 1 x 200 ml beaker per metal
- Sand paper
- Simple circuit: battery, 7 x wires, switch, bulb, 2 x crocodile clips, ammeter
- Magnet
- 1 M hydrochloric acid
- Ruler
- Safety glasses

Method

1) Make observations of each sample, such as colour, if it is shiny/ dull, reflective/not reflective, and any other interesting observation and record them in the results table.
2) If the sample is not shiny, gently rub it with sand paper and note if it becomes shiny – what does that tell us was happening on the surface of the metal?
3) Set up a simple series circuit as shown below, placing each sample between the crocodile clips in succession and record the current value on the ammeter in your table (this might be very small so you may have to put your ammeter onto the mA setting). Did the light glow?



4) Lay the sample on the table and then slowly bring the magnet towards each one, noting from which distance it becomes attracted to the magnet (if at all)

Figure 4. Testing the magnetic strength of different samples - measuring how far away the magnet is attracted to the sample.

5) Fill the beakers with 100 ml water and one at a time place each metal in the water, recording any observations in the results table such as float/ sink, fizz/ no fizz, colour change/no colour change. If there is a reaction, ensure you change the water between each test.
6) Pour out the water and add 100 ml of HCl solution and repeat step 5.

Results and Analysis

Present your findings in the table clearly.

Metal/ mineral	Colour	Reflective/ non-reflective	Shiny/ dull	Heavy/ light	Reaction in water	Reaction in acid	Current (mA)	Other observations

1) Were there any properties of iron which made it stand out from the other metals? If so what were they?

____

____

2) Was the piece of iron quite rusty, or shiny?

____

3) How reactive was the iron?

____

____

4) Do your results indicate that iron would be shiny in the field or rusty? What colour might it be?

____

____

5) What equipment would you take with you on a field trip to help you find identify iron ore?

____

____

____

Analysing Geophysical Maps

Objective

To be able to use GIS (Geographical Information Systems) data and secondary data to draw conclusions.

Equipment

Computer with internet connection

Method, Results and Analysis

1) Research magnetic and gravity surveys so that you understand how they are carried out, and what they show. Ensure you focus on how they can be used to detect iron ore. You may wish to watch these videos:
- magnetic surveys: https://www.youtube.com/watch?v=AZyNIGFHsE4
- gravity surveys: https://www.youtube.com/watch?v=9P6GEpxFtSY
2) Go to https://geoview.dmp.wa.gov.au/GeoViews/?Viewer=GeoVIEW to view the Geological Survey of Western Australia's interactive map (it might take a little while to load).
3) Locate your area on the map.
4) In the map layers column tick the box next to **geophysics imagery** and click on the **+** button so that the different survey types becomes visible.
5) Select the **gravity** layer by clicking on the box next to it. Answer the questions on the following page. Remove this layer by clicking in the box again. The red indicates a strong gravitational pull (dense rocks/materials) and the blue indicates a weak gravitational pull (low density rocks/materials). Green-yellow represent the mean.
6) Select the magnetic anomaly layer by clicking on the box next to it. Answer the questions on the following page. Remove this layer by clicking in the box again. The red indicates a strong magnetic pull (rocks/materials with magnetic minerals within them) and the blue indicates a weak magnetic pull (rocks/materials without magnetic minerals within them). Green-yellow represents rocks with a small amount of magnetic pull.

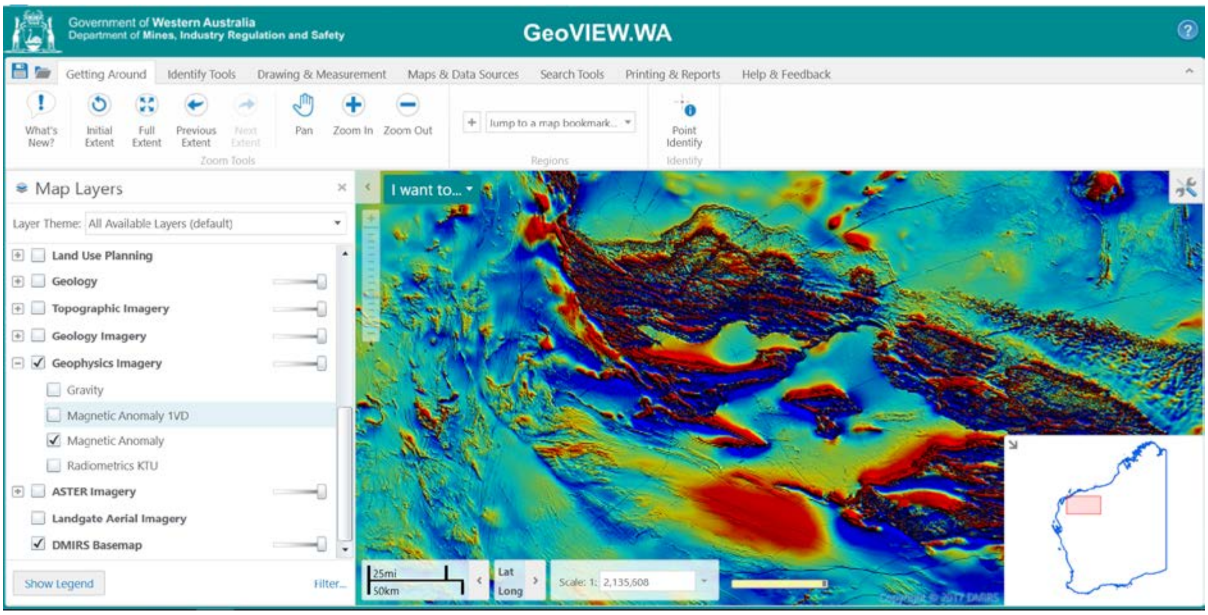


Figure 5. Geoview screen – with the magnetic anomaly layer selected for an area.

What colour did your area show up when you selected the gravity layer?

____

Do the rocks/materials in your area have a low (blue) or high (red) density?

____

Would you expect rocks containing iron to have a low (blue) or high (red) density?

____

What colour did your area show up when you selected the magnetic anomaly layer?

____

Do the rocks/materials in your area have a low (blue) or high (red) magnetic pull?

____

Would you expect rocks containing iron to have a strong magnetic pull?

____

Do you think there might be iron ore in your area?

____

7) Turn the geophysics imagery off (by clicking the button next to it) and select the **minerals** layer**,** select the **+** button, then the **Mines and Mineral Deposits (MINEDEX)** layer.

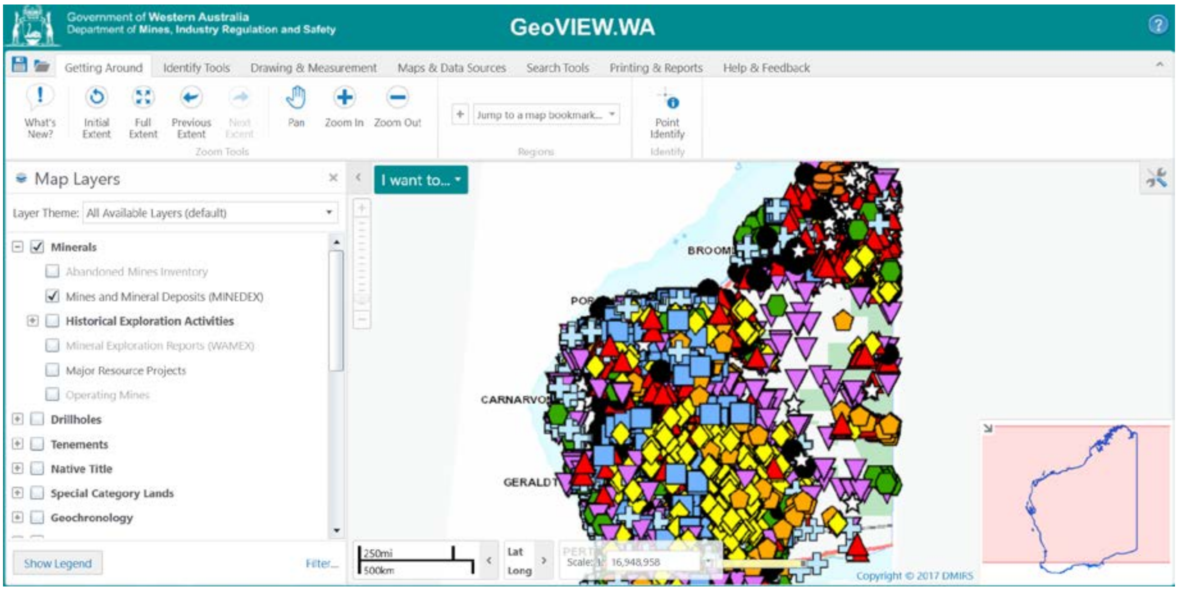


Figure 6. The Minerals and Mineral Deposits (MINDEX) layer.

8) **Right click** on any symbols that come up on your map (these are mines or known mineral deposits). Select **'what's here'** to find out more. You can double click on the results to find out even more detail.

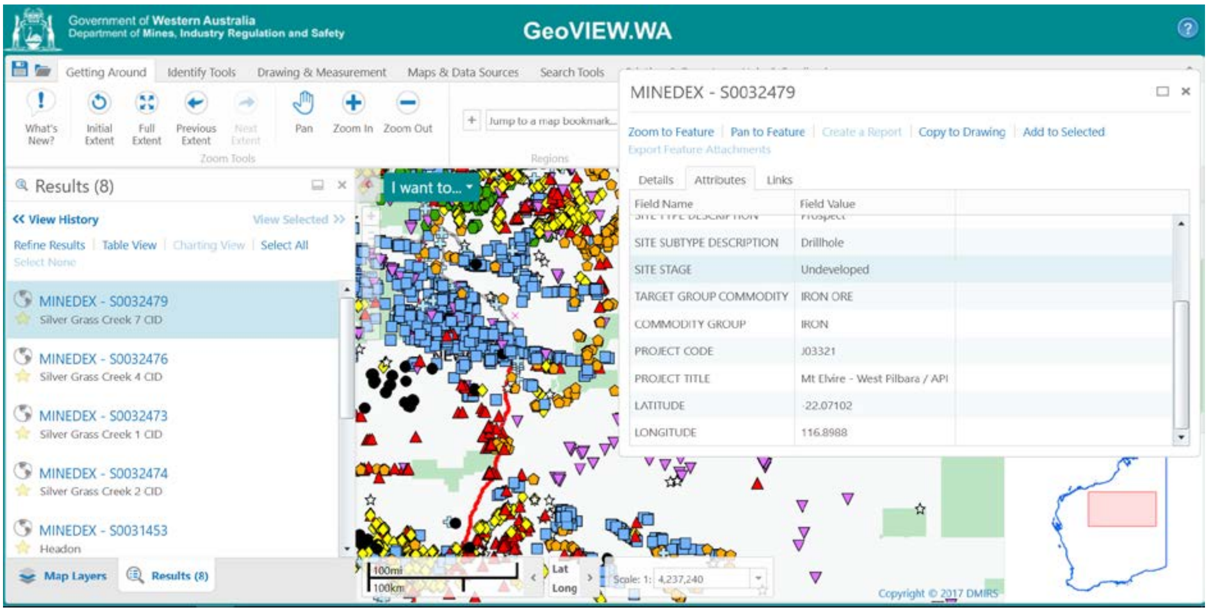


Figure 7. The target commodity for the select site is iron - this means they are looking for / mining for iron here.

Or alternatively you can click **show legend** at the base of the page, to see what each symbol represents.

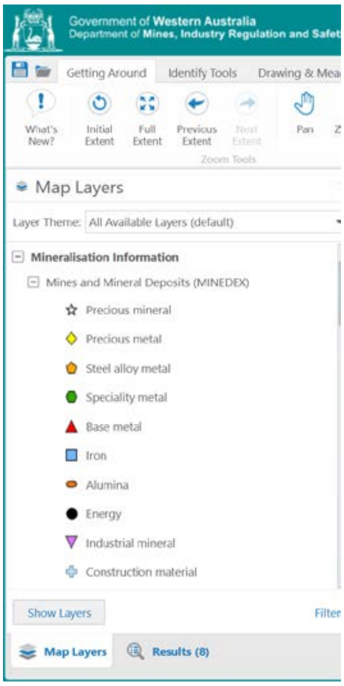


Figure 8. Key to MINEDEX symbols - the blue square shows where iron ore has been found and/or mined.

Were there any mines or drill holes in your area?

What were they mining/exploring for? (target commodity).

From your research do you think there could be iron ore near you, why? Use your previous answer to justify your conclusion.

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Modelling a Magnetic Survey

Objective

To conduct and evaluate an experiment to find hidden magnetic materials.

Equipment

- Opaque shallow plastic tray (around 40 cm x 25 cm x 10 cm)
- Magnetic materials/minerals (around 5 - 10 cm^3)
- Silica rich sand and rocks (not iron rich!)
- Magnet on hook (can be bought at most stationary merchants)
- Elastic band
- 2 x retort stands with clamp and boss heads
- 2 x rulers
- Whiteboard marker

Method

Set up

1) Place the minerals/magnetic materials in the opaque tray (to represent magnetic ore).
2) Mark the sides of the box North, South, East, and West.
3) Make a "buried treasure" map of your model using graph paper, ensuring it is to scale. Taking a photo is also a good idea.
4) Carefully cover with layers of sand and rocks to hide the ore.
5) Exchange your model and a blank grid (to scale) with another group.

Searching for the ore

1) Set up the retort stands so that they are at either side of the tray.
2) Clamp a ruler between the stands so that it is horizontal, and with the elastic band suspended over it.
3) Hook the magnet onto the elastic band and adjust the height of the ruler, if needed, so that the magnet is suspended a few cm from the surface – you may need to add tape to help prevent it from falling off the elastic band (but do not stick to the band as this will change the elasticity and ability of the band to stretch).
4) Starting in one of the northernmost corners, use your second ruler to measure and record the height of the magnet (above the surface) on your grid.
5) Move the elastic band five centimetres (see grid) along the ruler and wait for it to become level before you measure its height from the surface again, repeat until that line is complete.
6) Now move the tray so that you can survey the next grid line moving progressively "South," and survey in the same method as you did before.
7) Continue surveying in this systematic manner until you have surveyed the whole tray

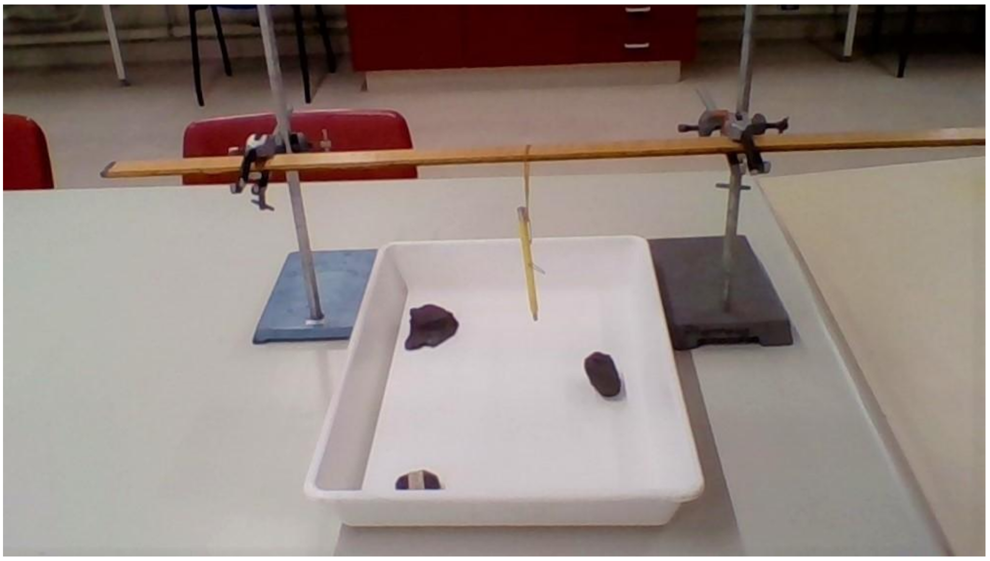

Figure 9. Set up with magnets/ magnetic minerals in tray (this should be covered in sand). Magnet on hook is suspended above by an elastic band and should be attracted to the hidden magnetic items as it passes over them.

Results and Analysis

1) Calculate the mean height of the magnet above the sand

2) On your grid locate the areas where the magnet was below the mean (closer to the surface) and highlight them in red, representing high magnetic pull.
3) On your grid locate areas where the magnet was above the mean (further away from the surface) and highlight the box in blue, representing low magnetic pull.
4) Where the magnet was equal to your mean, colour those boxes in green/ yellow representing average pull.
5) Using your data to infer where the hidden "ore" is located and check with the original group.

Conclusion and Evaluation

Could you find the "ore"? If not what were the difficulties?

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If you could improve the investigation what would you recommend?

____

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Mining is becoming more automated (using more machines/robots to do the work) to minimise risks to human safety and decrease costs. How could you use ICT or coding to make this experiment more technical and require less human input?

Grid outline to mark where "ore" is located (example).

North

South

Each box = 5 x 5 cm

Completed grid survey grid (example).

North

2.5	2.3	2.3	2.5	2.7
2.7	2.5	2.5	2.7	3.0
3.0	3.0	3.0	3.1	3.2
2.7	2.7	3.0	3.1	3.2
2.5	2.5	2.7	3.0	3.2
2.3	2.5	2.7	3.0	3.2
2.3	2.5	2.7	3.0	3.2

South

Each box = 5 x 5 cm