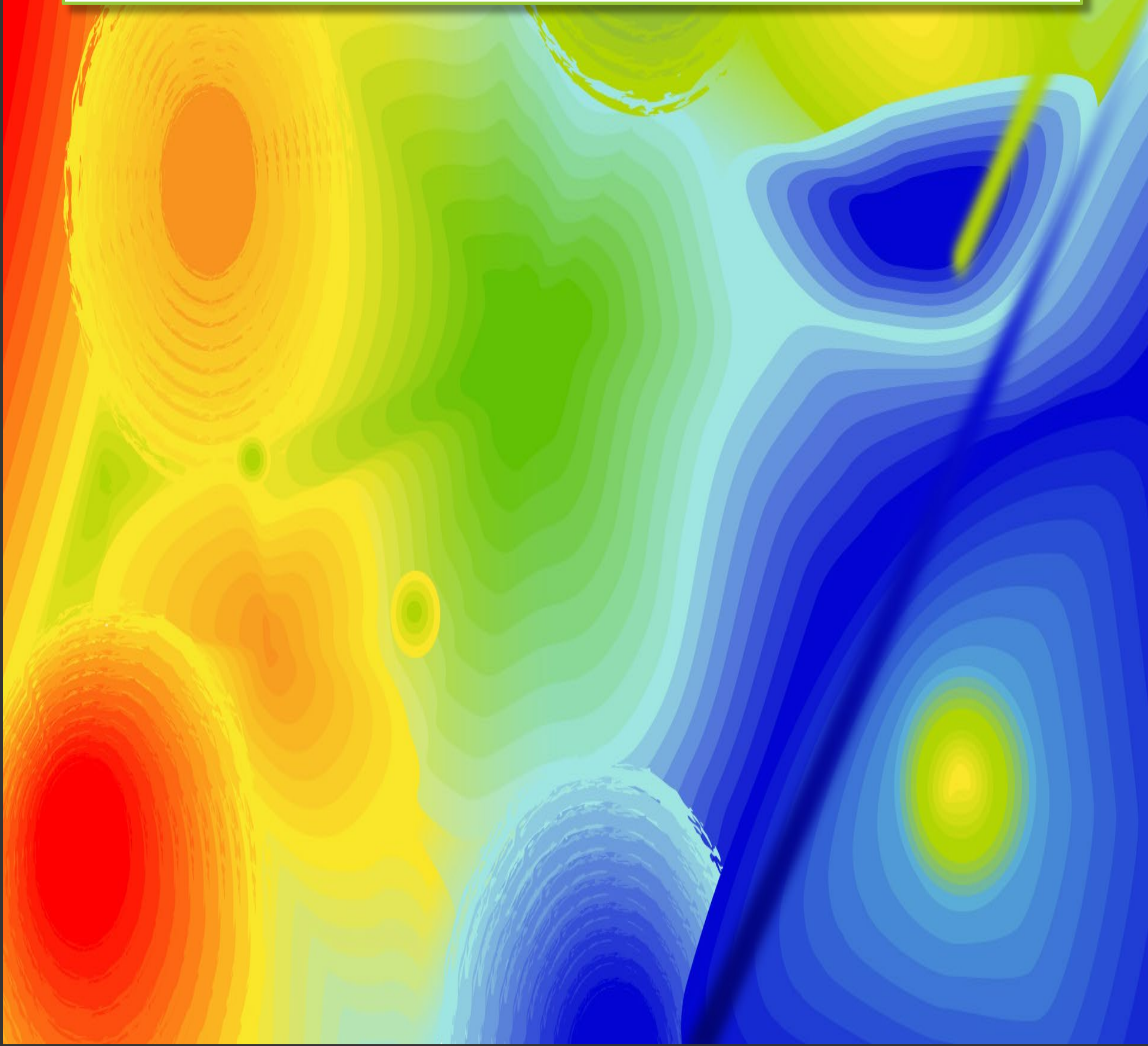
Exploration Box



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AUSTRALIAN EARTH SCIENCE EDUCATION

Exploration Box – Teacher Resource

Powering Careers in Energy Link:

Unit 2: Demonstrate an understanding of the importance of science in LNG operations.

Background Information:

The science, technology and data interpretation that goes into the exploration for oil and gas reservoirs is extremely complex and continuously improving. It is very easy to spend a lot of time on small components of the larger picture without stepping back to consider a typical exploration program. This activity allows you to investigate exploration in a broader sense, highlighting keys steps in an easy-to-understand way. Students will also enjoy the competitive nature of this activity.

To understand what you would be looking for when exploring for oil and gas, you first need to understand how oil and gas reservoirs are formed. It is therefore recommended that students have covered these materials before attempting this activity.

Suggested activities:

- Porosity and permeability
- Oil and gas migration to traps
- Sedimentary basins

Aim

To identify an area that may contain oil and gas, using the data provided.

Materials

Per class

- A large food storage container (or similar). It needs to be A4, or slightly larger (or you will need to print the working grid to suit the size of this container)
- Opaque paper to wrap the base, sides and open top of the container (so students cannot see inside)
- 2 copies of the working grid (provided in this package)
- Sticky tape
- Small container (6cm or less in diameter) x 3
- Chocolate sauce
- Pack of wooden skewers

Per student

- Exploration Box worksheet (including working grid)
- Pens and pencils (coloured would be best)
- Access to the Exploration for Oil and Gas presentation (ideally worked through as a projection at the front of the classroom. This will be critical to share/explain to students so they can understand the maps they are looking at. See presentation notes available at the end of this package, for more information,

Safety Notes

Ensure you are sitting in a suitable position to avoid eye strain when viewing the presentation.

Method

Prior to the lesson

1. Set up the exploration box by:
    a. Wrapping the bottom and sides of the container (if it is transparent) using the opaque paper and sticky tape. Cut off a sheet to wrap the top but put it aside until later.
    b. Stick a copy of the working grid into the base of the container.
    c. Fill the small containers (1/2 to 2/3) with chocolate sauce and place them into the container, centred on grid squares D2, I7 and H9 (the containers will likely overlap other squares, this is okay). You may wish to tape these down, so they don't move during transport and handling of the box. These are the locations of the oil, do not share these with the students!
    d. Tape the last piece of paper over the top of the box (ensuring there are no places to see in and that it is tight) and then stick the working grid on top of this (ensuring that it lines up with the one in the base of the container).

During the lesson

1. Hand out the worksheets to students outlining the task for the day.
2. Project the Exploration for Oil and Gas presentation at the front of the classroom and run the students through the content (see the notes for more information), ensuring that students annotate their maps with provided data (gravity, magnetic and seeps).
3. At the appropriate point of the presentation ask students to choose a square (e.g., A3) for further exploration, giving them time to complete their notes to justify their choice.
4. Continue through the presentation, outlining data they don't have access to today, including seismic and 3D visualisations.
5. Ask students to elect to drill a square by pitching to you (an investor). You may choose to only approve those that refer clearly back to the information provided in making this decision. Once approved, students should make their way to the exploration box (see above for set up) and 'drill' through the square (anywhere within its parameters is fine) using a wooden skewer (we recommend you hold the paper across the top of the box tight, to ensure a clean break through the papers). Once pulled back out they will be able to determine their success (or failure) by the presence (or absence) of oil (chocolate sauce). You may like to award prizes to students with successful drilling campaigns.
6. Continue drilling with the class, allowing time to discuss next steps and conclusions.

Results

Annotated working grid should highlight key areas of interest (see presentation notes for hints) using a clear system (with a key).

My chosen grid for further exploration (drilling) is: *answers will vary*

For the following reasons (justification):

Answers will vary but should include references to gravity and magnetic surveys and possibly seep locations. They should highlight things like faults and/or salt dome locations as traps.

Discussion

1. Which areas were successful in the exploration program? How does this relate to the provided data?

This will depend on how large the containers were that you put into the exploration box, but should centre around D2, I7 and H9.

D2 has low density rocks in the subsurface (gravity survey), the magnetic survey suggests it might be part of a sedimentary basin (low magnetism) and it is near a seep location.

I7 is very near a fault and on the edge of a salt dome – both traps (as seen in the gravity and magnetic surveys). It is also in an area of low-density rocks (gravity survey) and possibly within a larger sedimentary basin (magnetic survey). It is further from a seep location (but don't forget that oil can migrate below cap rock to seep out at distant locations).

H9 is very near a fault and on the edge of a salt dome (as seen in the gravity and magnetic surveys). It is also in an area of low-density rocks (gravity survey) and possibly within a larger sedimentary basin (magnetic survey). It is quite near to a seep location.

2. In reality, what else would (or could) be done prior to undertaking an exploration drilling program?

More detailed gravity and magnetic surveys in the area of interest. Seismic surveys and geochemical surveys. (students may also come up with other suggestions, like recruitment, bringing in more experts…).

Evaluation

1. Is this activity a good representation of a drilling program? Why or why not?

Answers will vary. In reality no. Broad data for a large area would be used to narrow down to smaller areas of interest. Following that, extensive surveying (gravity, magnetic, geochemical, seismic and more) would be completed for the smaller area and comprehensive analysis of the data generated would be completed before planning for exploration drilling was to even begin. There is also the issue of having the lease to explore and drill an area.

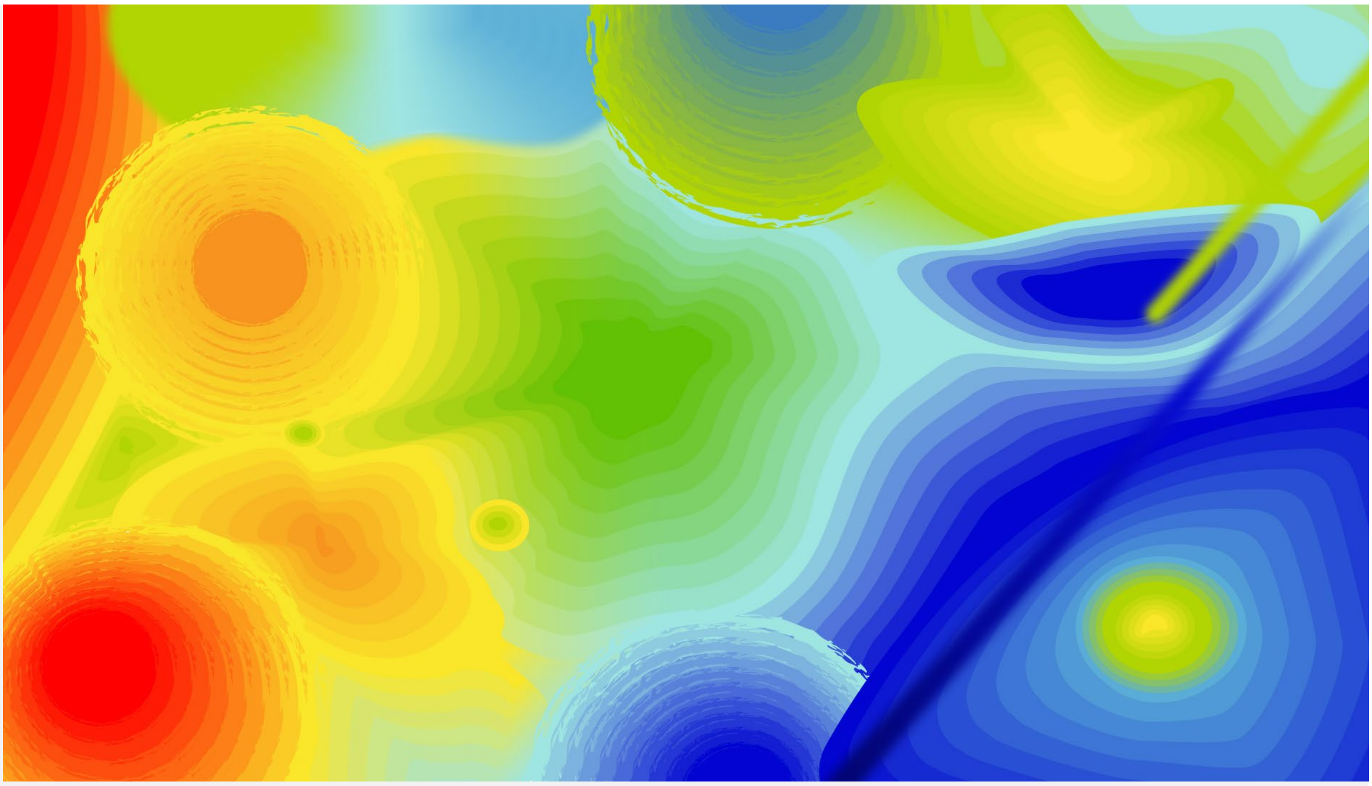
However, it is a nice, abbreviated look at the major processes that occur.

Extension:

- Research how gravity, magnetic and/or seismic surveys are conducted (what science and technology do they use?) and what do they tell us. Prepare an infographic or short presentation to share your results.

References:

Tompkins, D. & Watkins, J. Exploring Earth and Environmental Science Year 12. Earth Science Western Australia.



Exploration Box

Aim

To identify an area that may contain oil and gas, using the data provided.

Materials

Per student

- Exploration Box worksheet (including working grid)
- Pens and pencils (coloured would be best)
- Access to the Exploration for Oil and Gas presentation (projected at the front of the classroom)

Safety Notes

Ensure you are sitting in a suitable position to avoid eye strain when viewing the presentation.

Method

1. View the Exploration for Oil and Gas presentation.
2. When you are asked to, mark your working grid (see last page of worksheet) with information from the gravity, magnetic and seep surveys. You can use your own technique for this, and you don't have to make an exact copy of what is on the screen. For example, you might colour all of the areas that are suitable on the gravity map in one colour and those suitable on the magnetic map another (or label them with different symbols). Don't forget to include a key on the side of your map to make your system clear.
3. When your teacher asks you to, choose a square (e.g., A3) for further exploration. Completing your justification in the results section below (the more detailed, the better).

4. View the rest of the presentation, learning about data you don't have access to today, including seismic and 3D visualisations.
5. You can now seek permission to drill your chosen square by pitching it to an investor (your teacher). The investor will only approve pitches that are clear and refer back to the data. If your pitch is successful, you will be invited to 'drill' the exploration box. Using a wooden skewer pierce a hole through the top of the box (at any point in your chosen square) and push the skewer all the way to the base. Remove the skewer and examine for evidence of 'oil'.
6. Complete the results, discussion and evaluation sections of this worksheet.

Results

Annotate the working grid as your teacher progresses through the presentation (see next page).

My chosen grid for further exploration (drilling) is: ____

For the following reasons (justification):

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Discussion

1. Which areas were successful in the exploration program? How does this relate to the provided data?

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2. In reality, what else would (or could) be done prior to undertaking an exploration drilling program?

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Evaluation

1. Is this activity a good representation of a drilling program? Why or why not?

____

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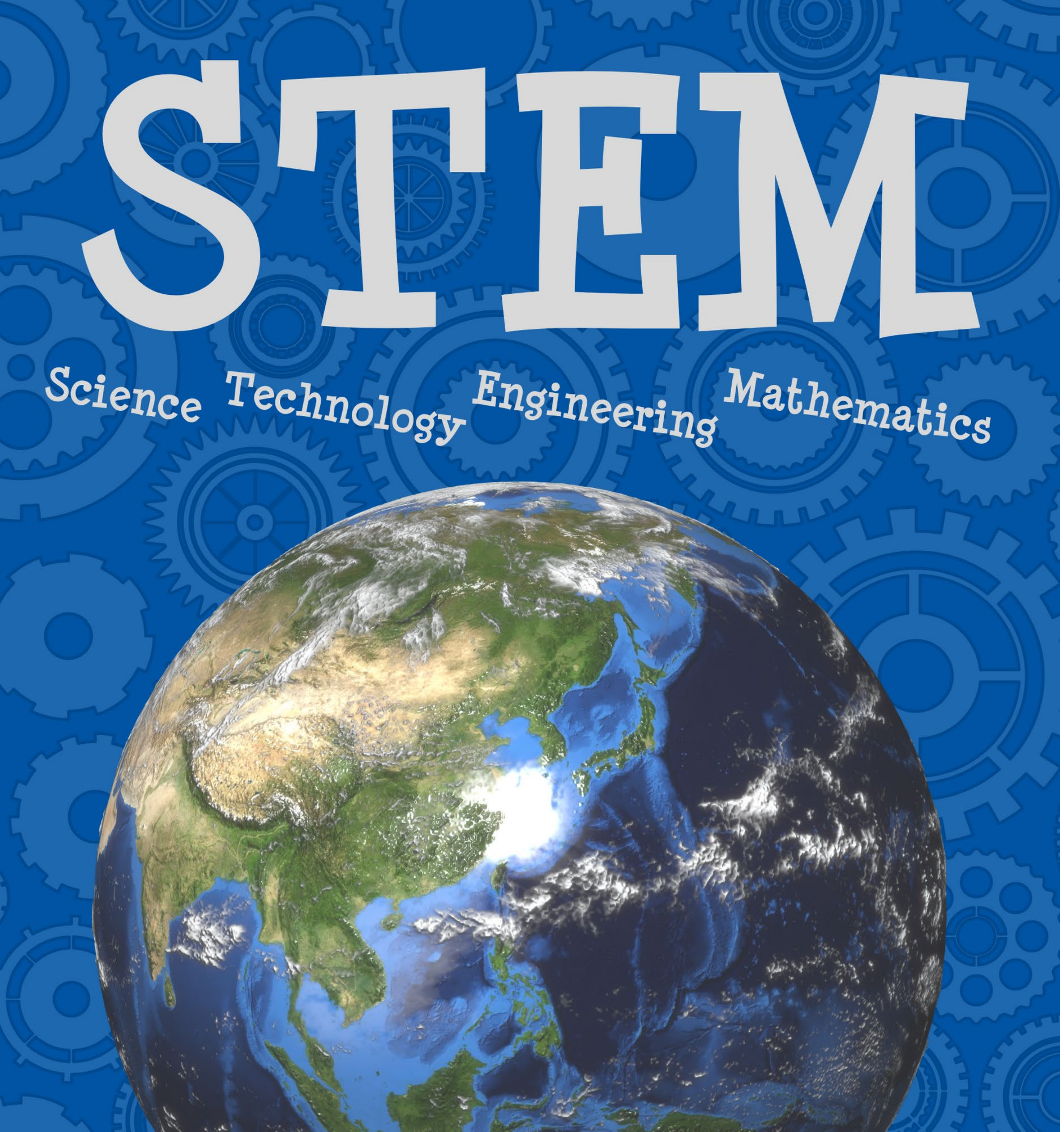

Exploration for Oil and Gas

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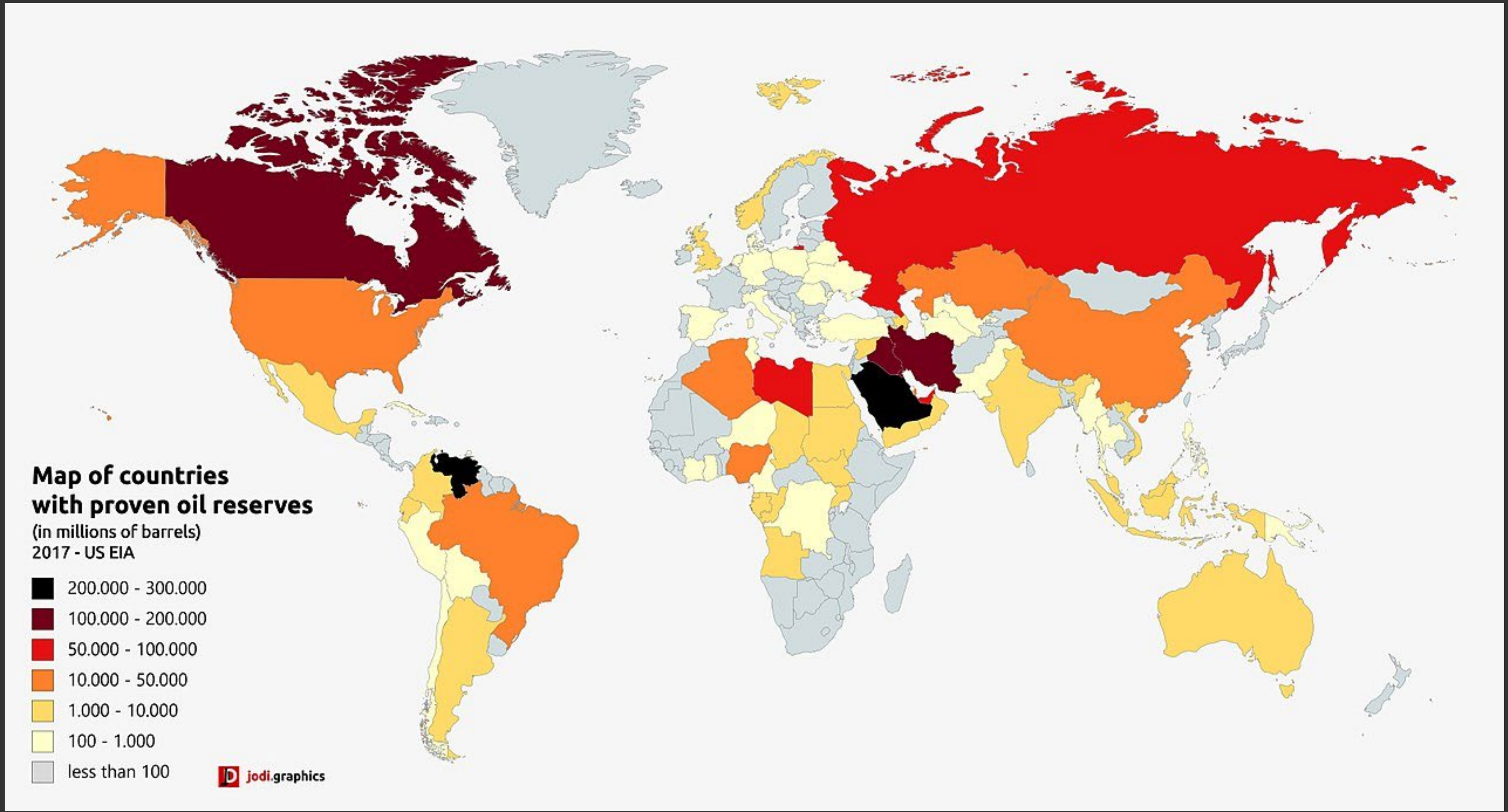
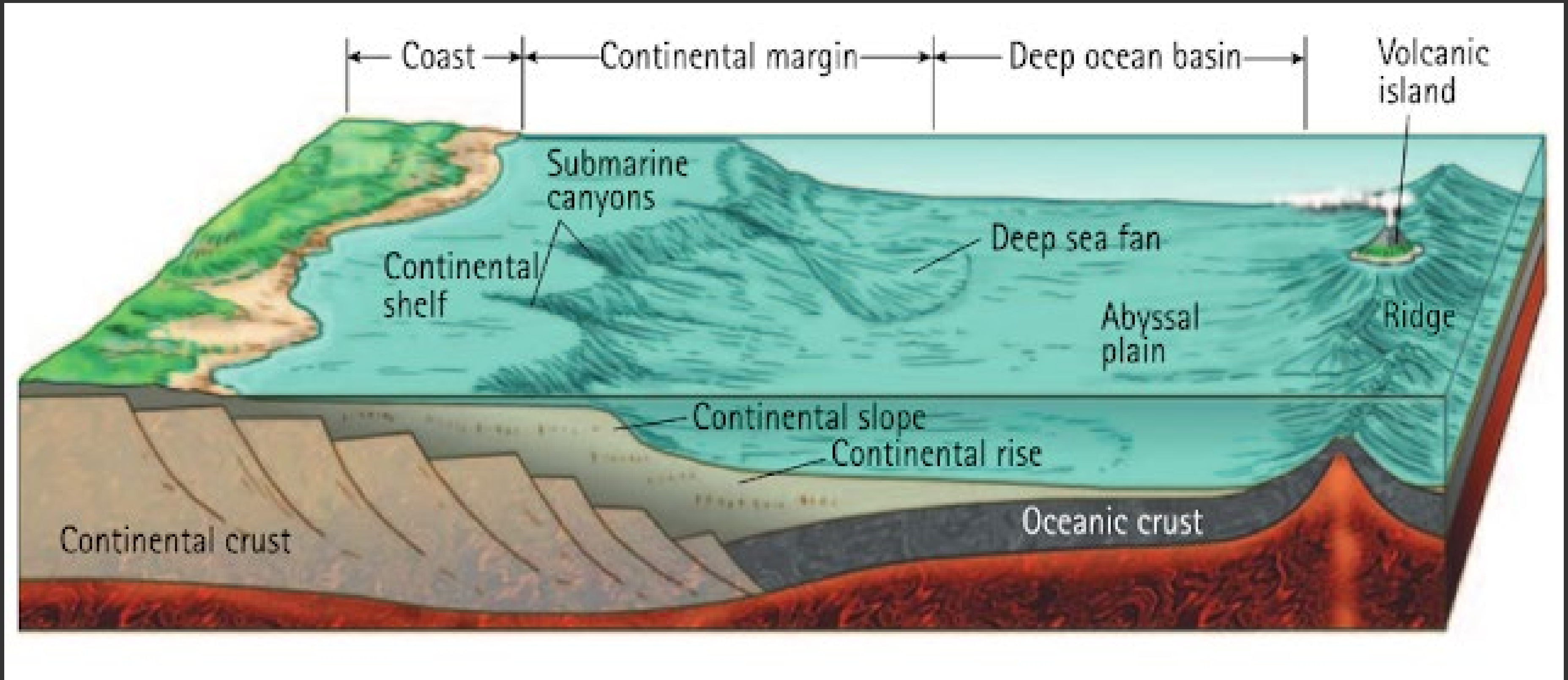
Look where it was found before



Past setting is important



Your exploration area

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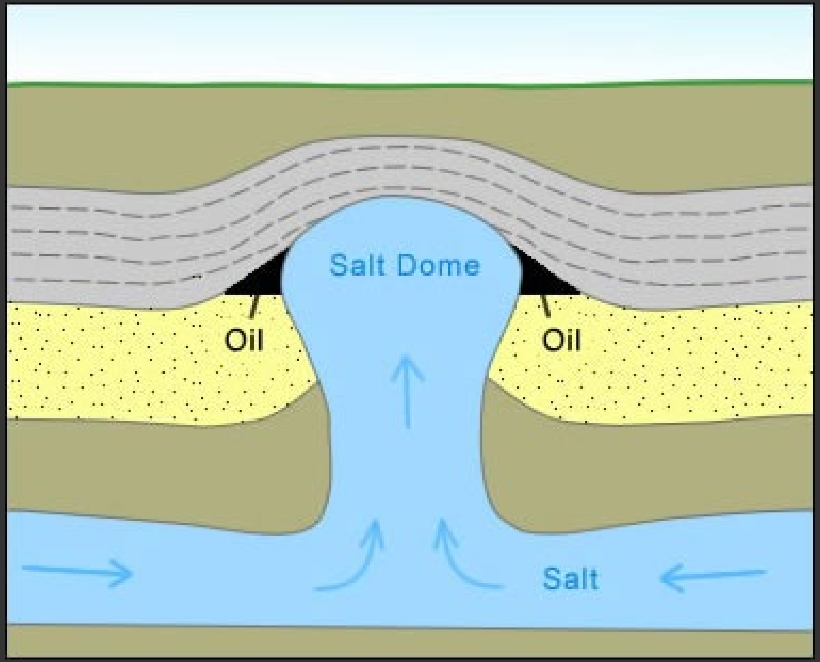
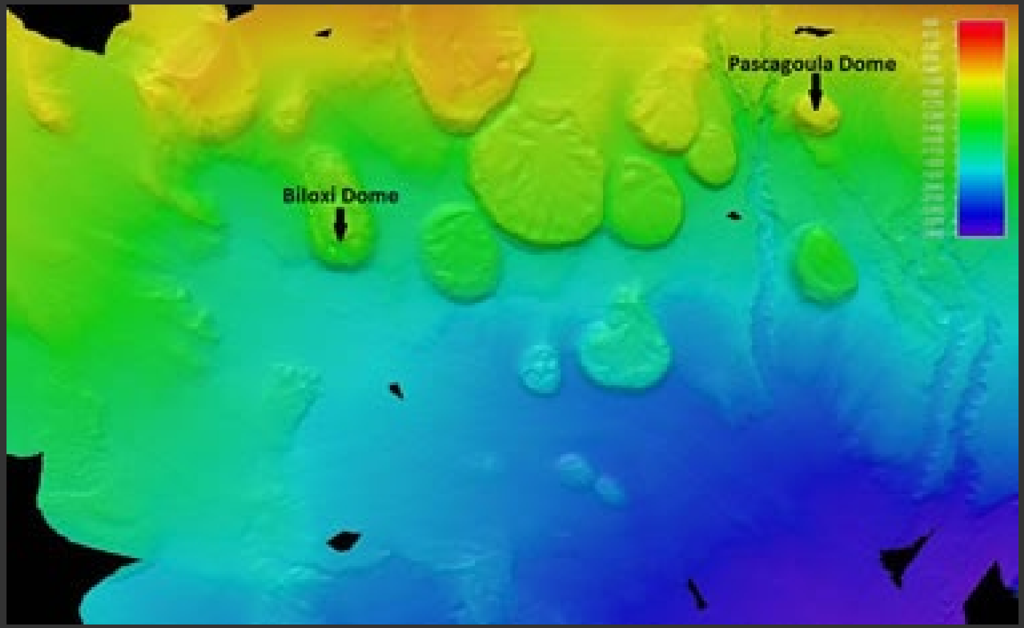
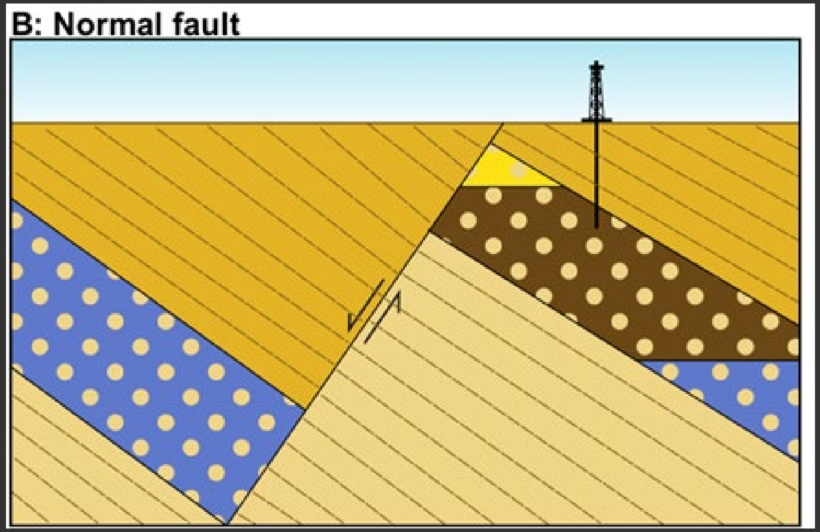
WORKING GRID

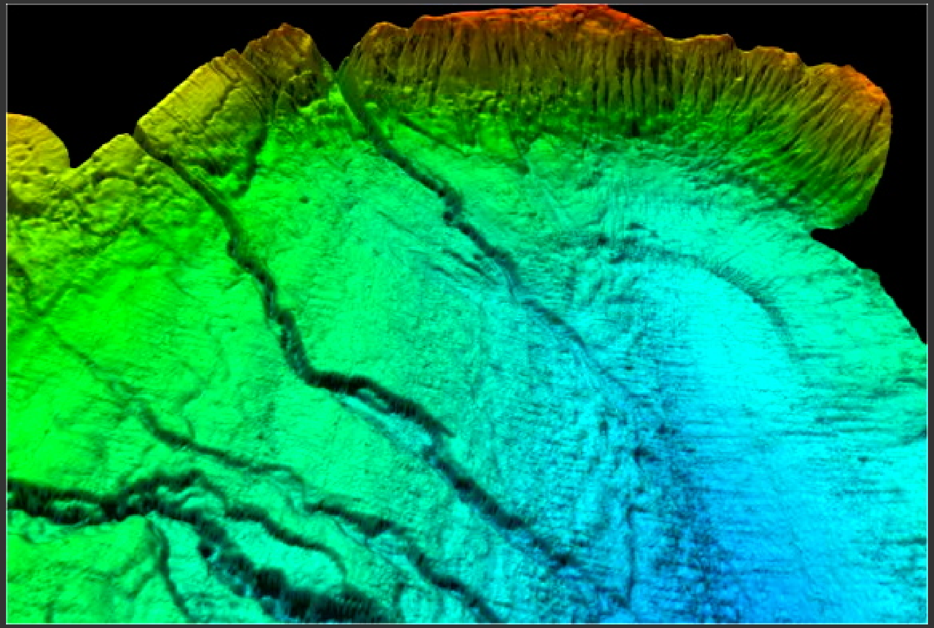
Geological Maps - looking for surface expressions



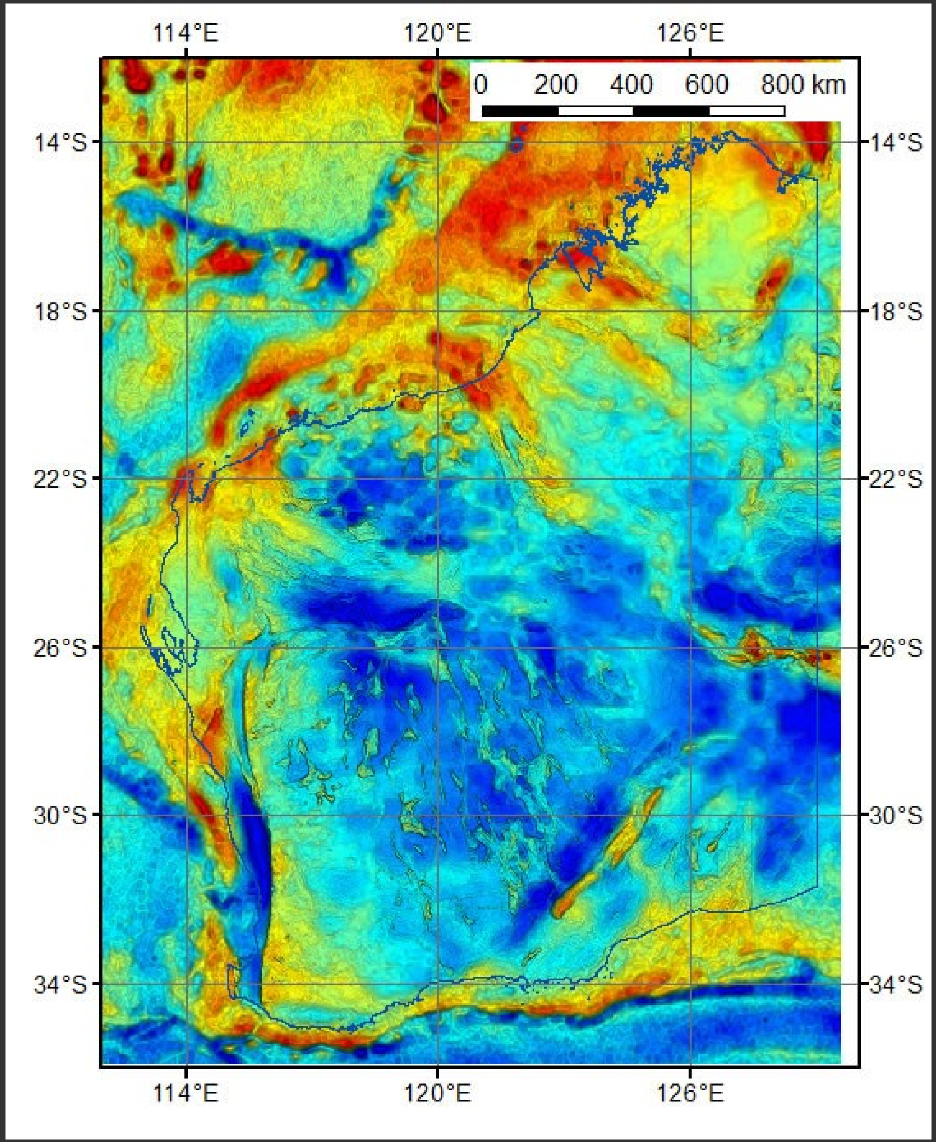


Geological Maps – looking for surface expressions

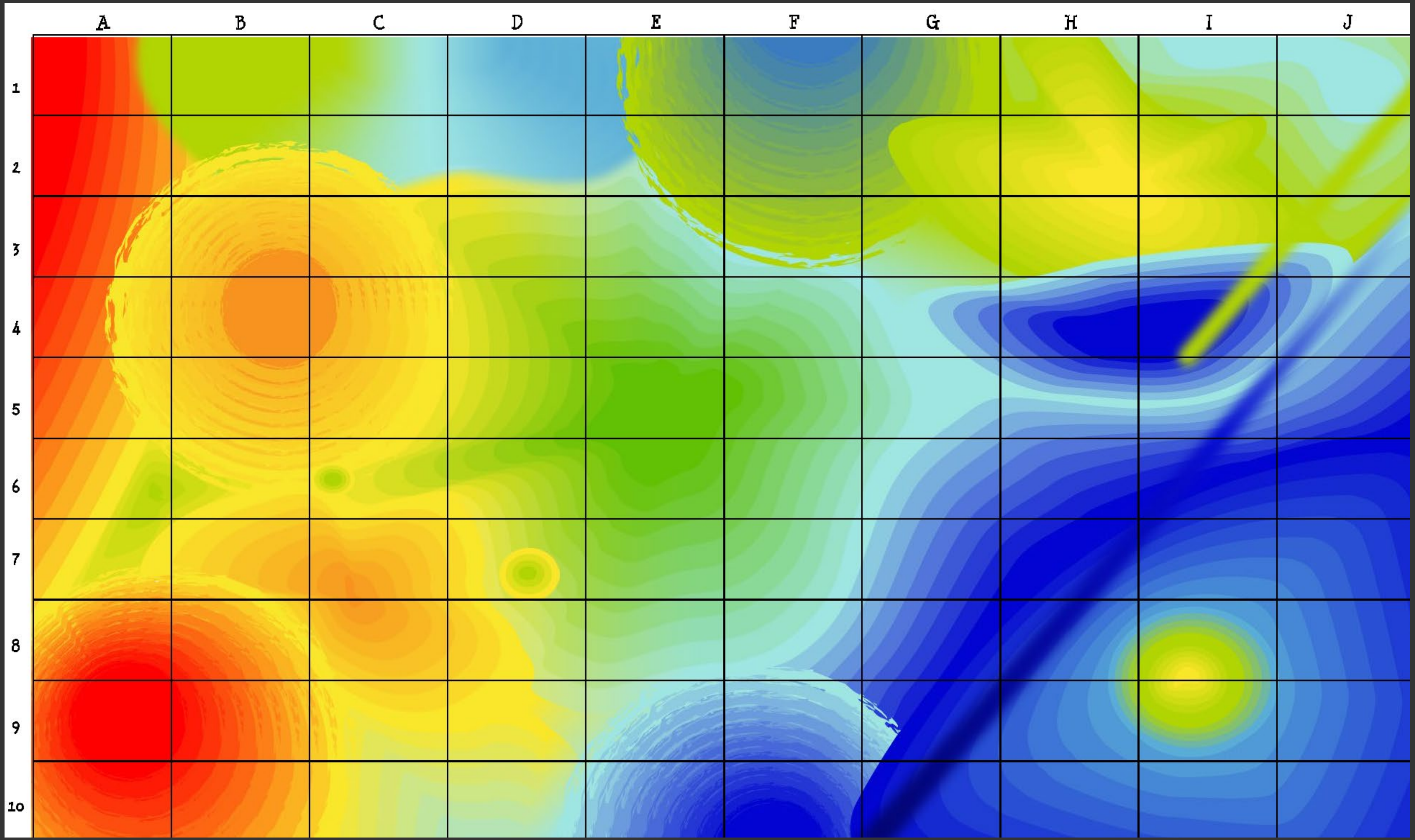




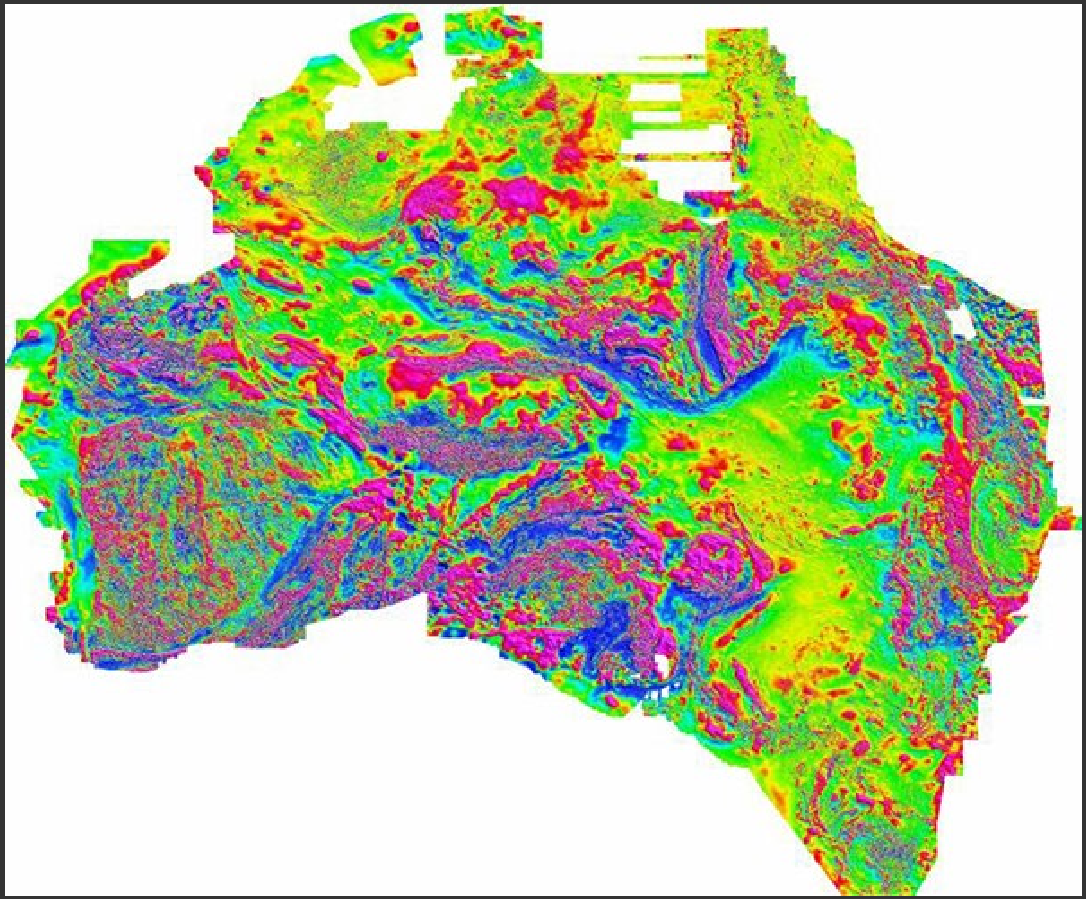
Geophysical studies – gravity survey



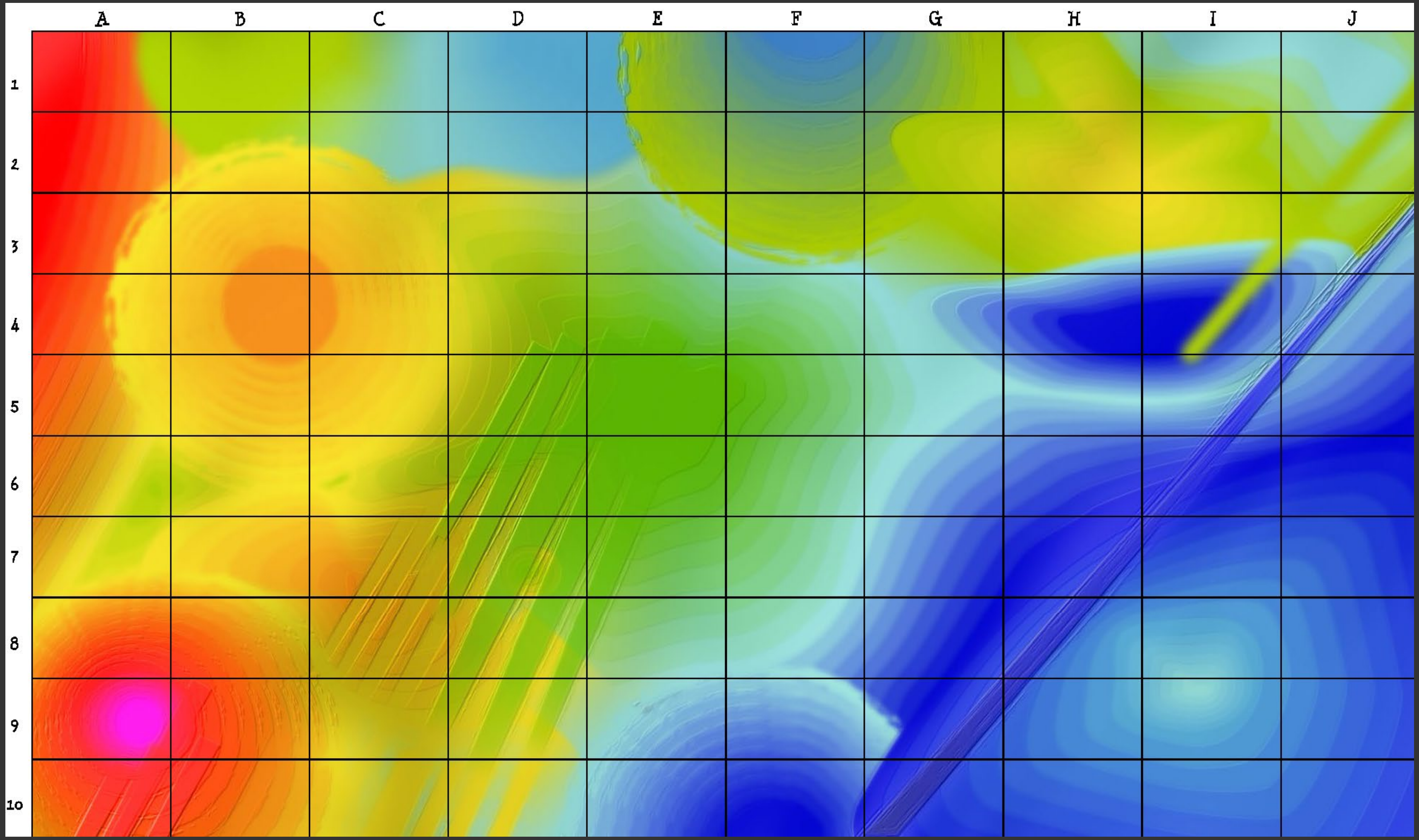
Your gravity survey map



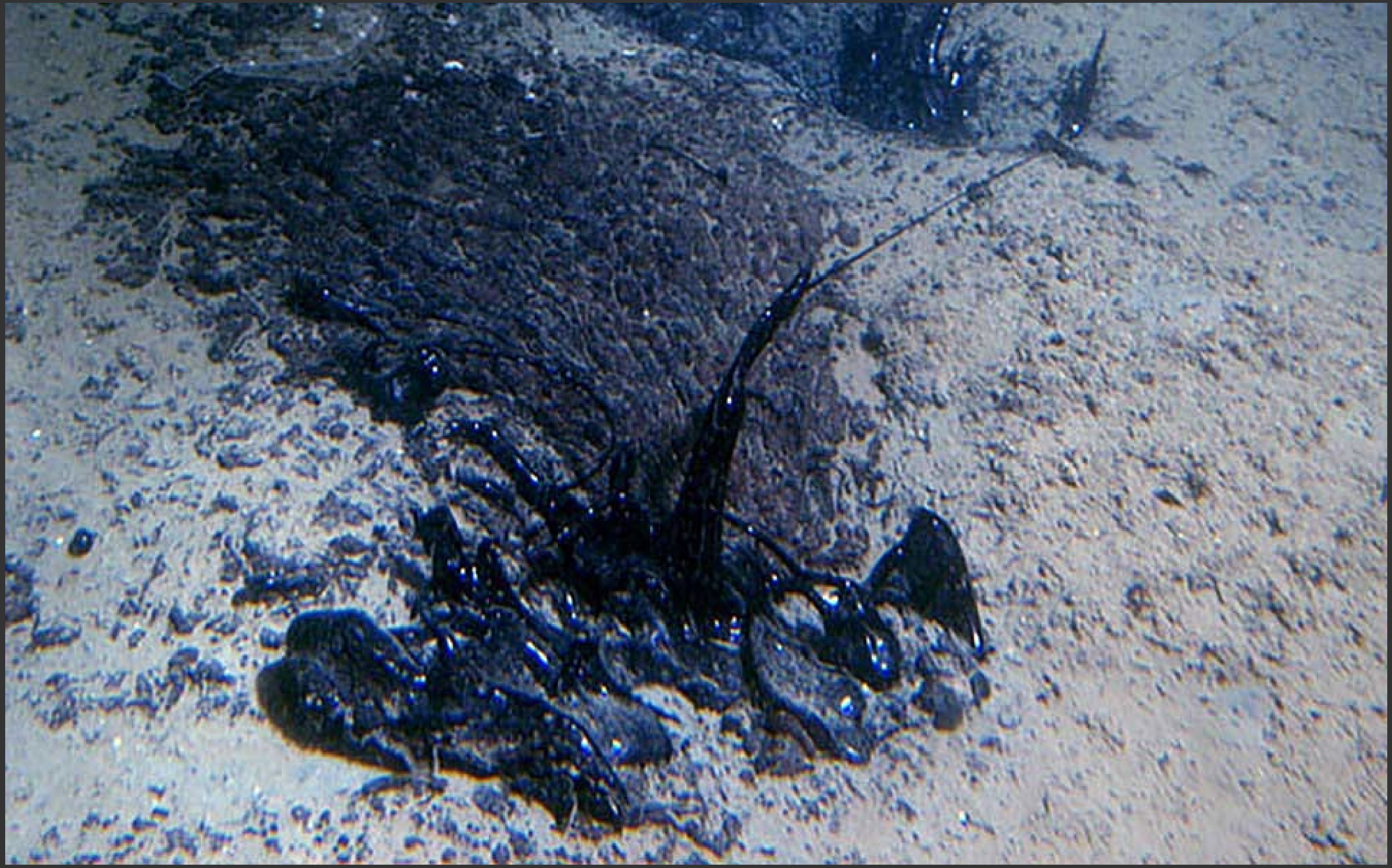
Geophysical studies – magnetic survey



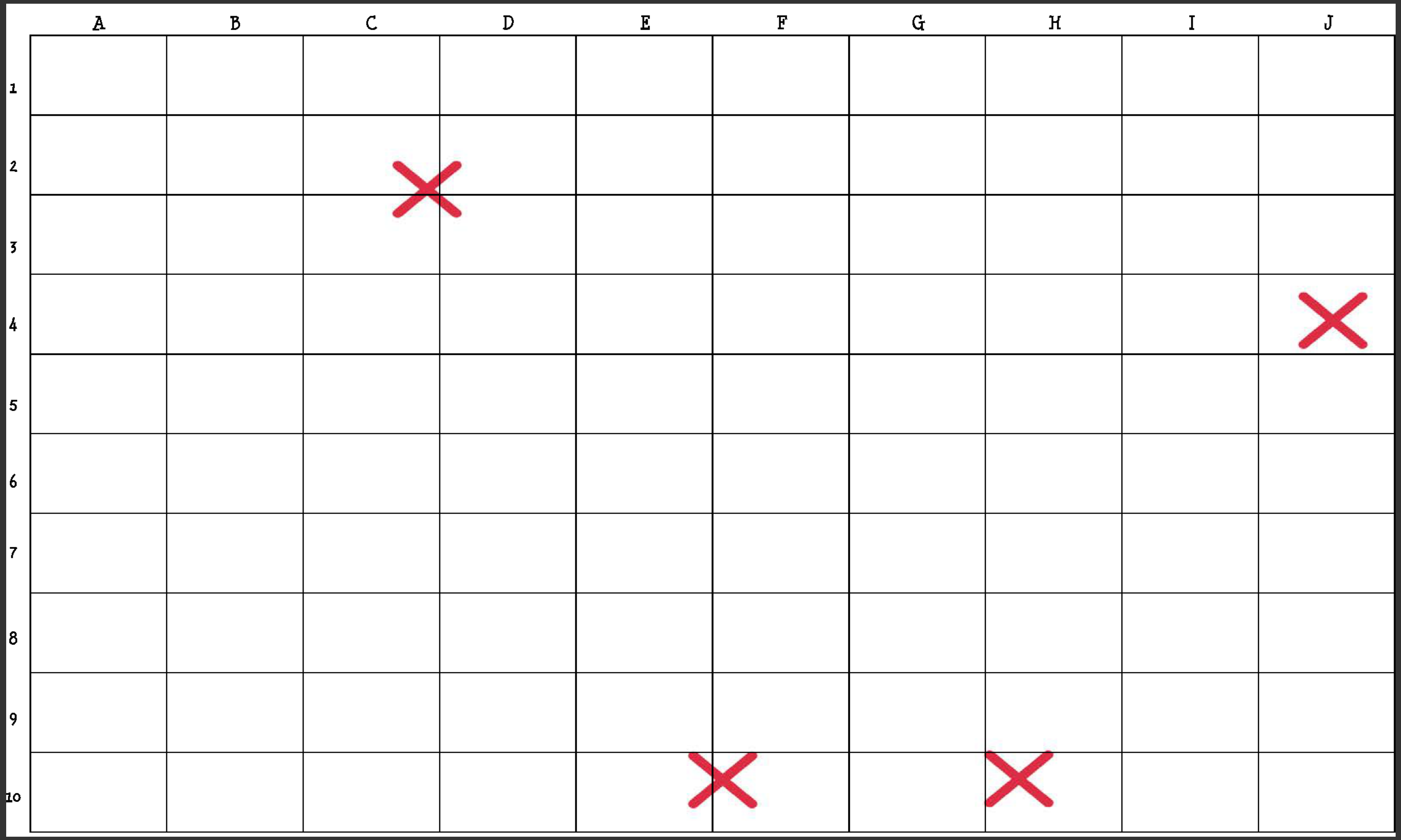
Your magnetic survey map



Examining the seafloor - looking for oil seeps



Your recorded seep locations



Choose an area

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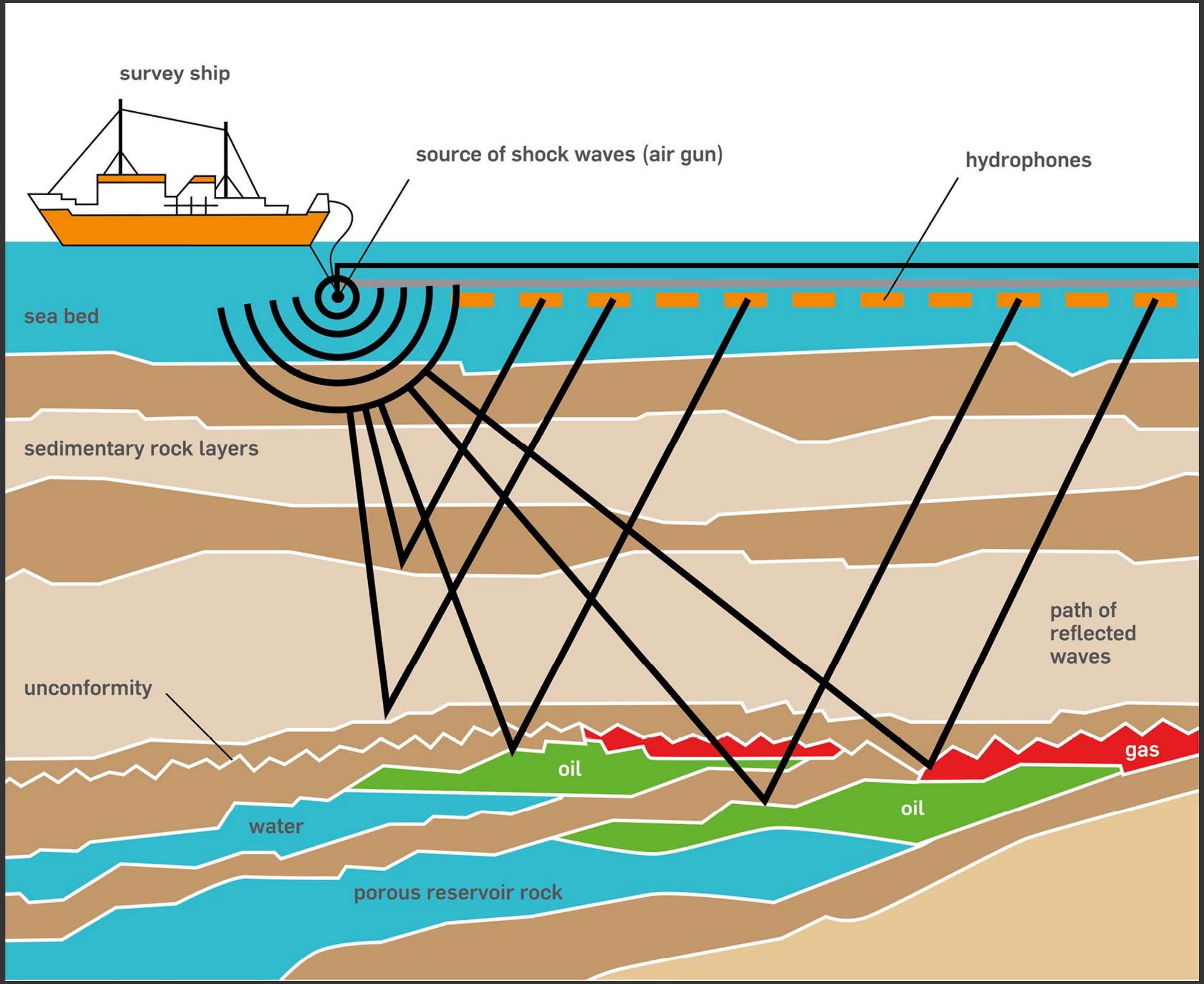
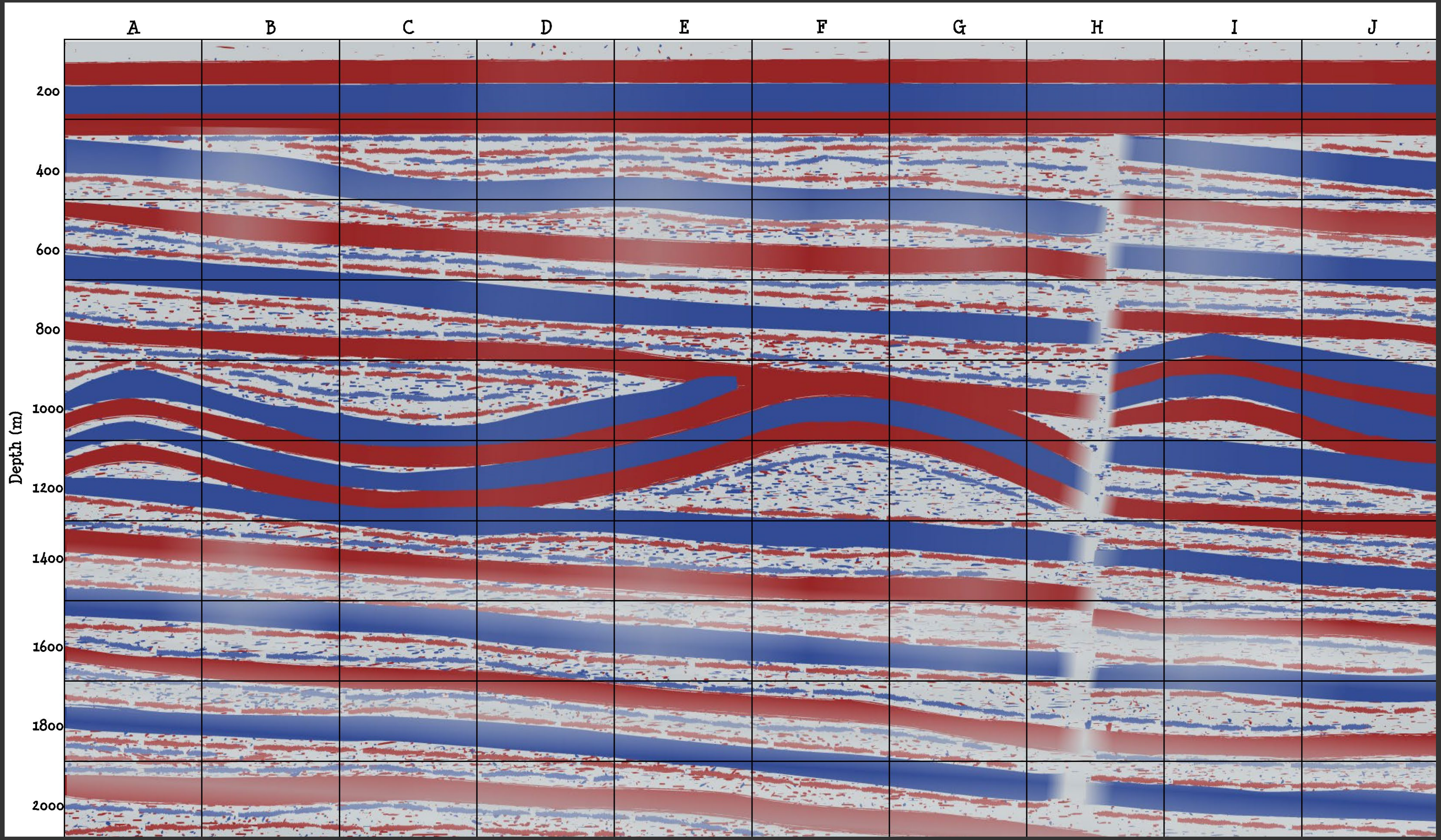
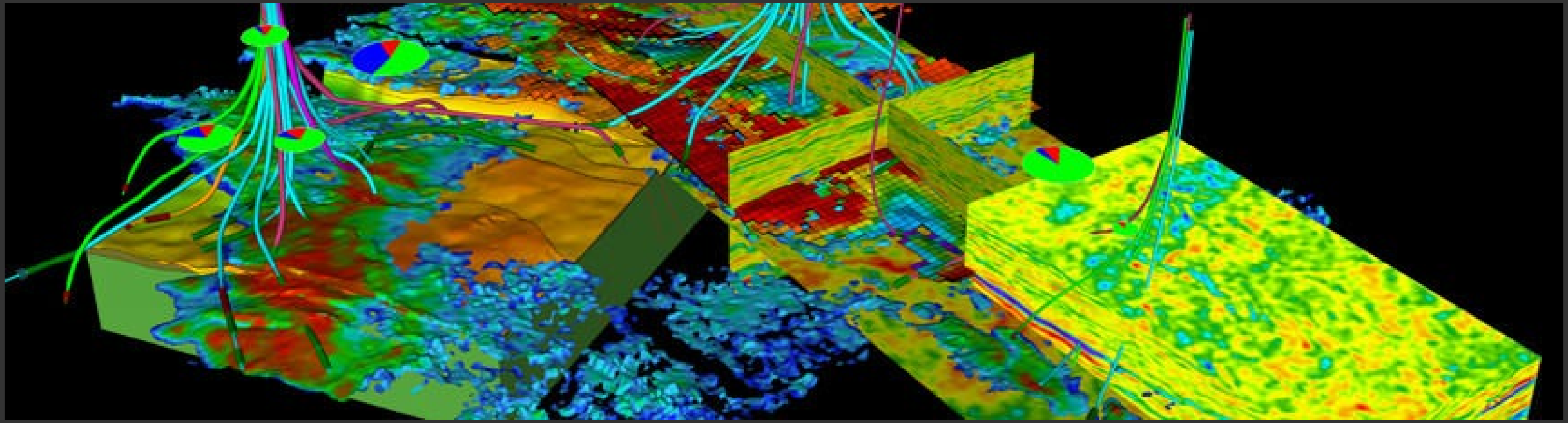
Seismic surveys



Large seismic line



Create 3D (or 4D) visualisations



Drill an exploratory well

Examine core samples

References and Image Sources

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- Salt Domes, Geology.com, accessed on 18/05/2020
- Fault surface expression, geosciusyd.edu.au, accessed on 18/05/2020
- Oil seep, Donna Schroeder, U.S. Geological Survey, accessed at noaa.gov, on 18/05/2020
- Hypersprectral imaging, Jim Ellis, Ellis GeoSpatial, Environmental Science & Engineering, accessed on 18/05/2020
- Gravity Survey, Department of Mines Industry Regulation and Safety of WA, accessed on 18/05/2020
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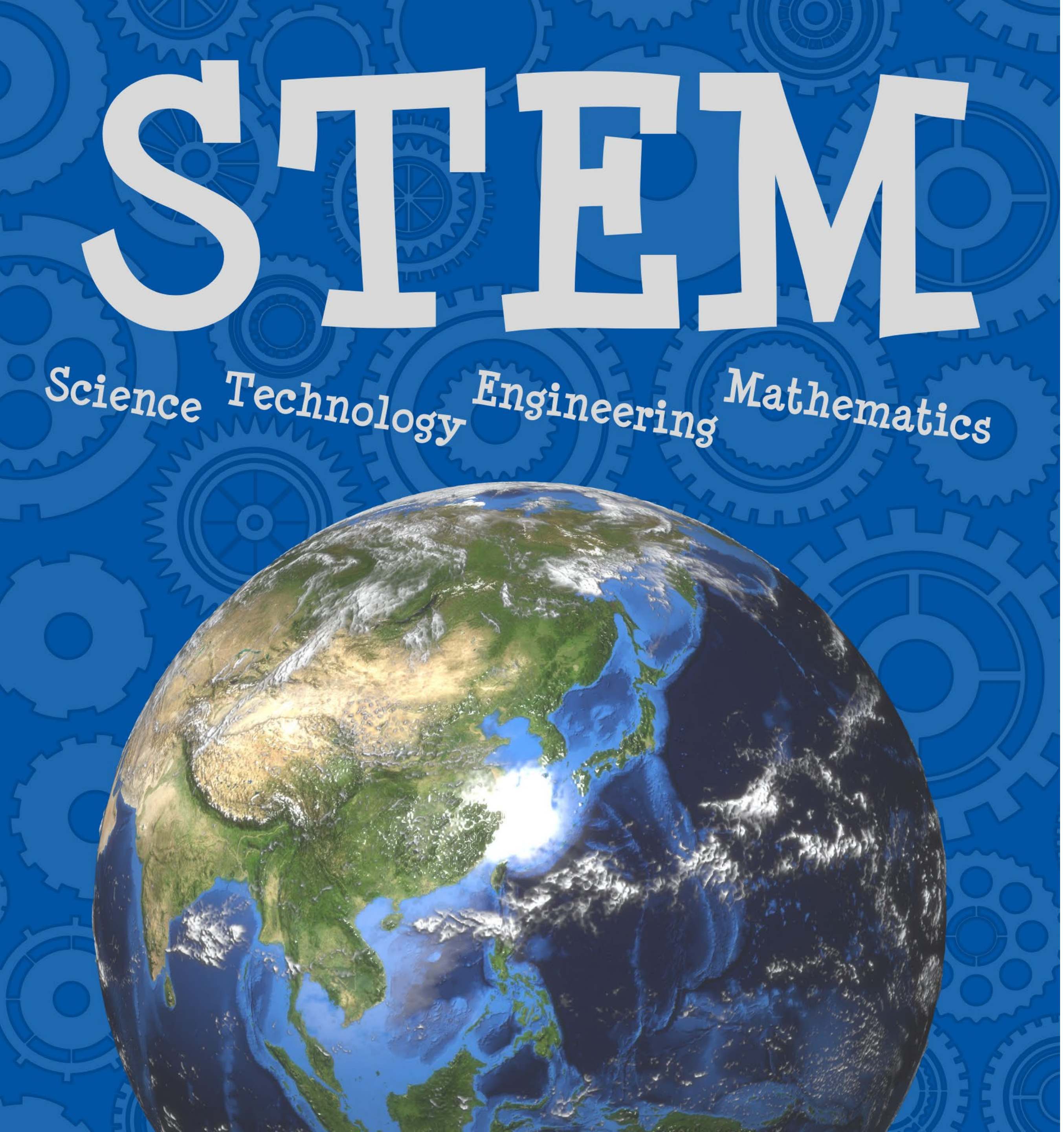
- Core Sample, geosociety.org, accessed on 18/05/2020
- COVIZ 4D, accessed at dgi.com, accessed on 18/05/2020
- Oil and Gas Reservoirs – Tompkins, D and Watkins, J, Exploring Earth and Environmental Science, Year 12, ESWA
- All other photos and diagrams from ESWA's catalogue or licensed for use through Canva



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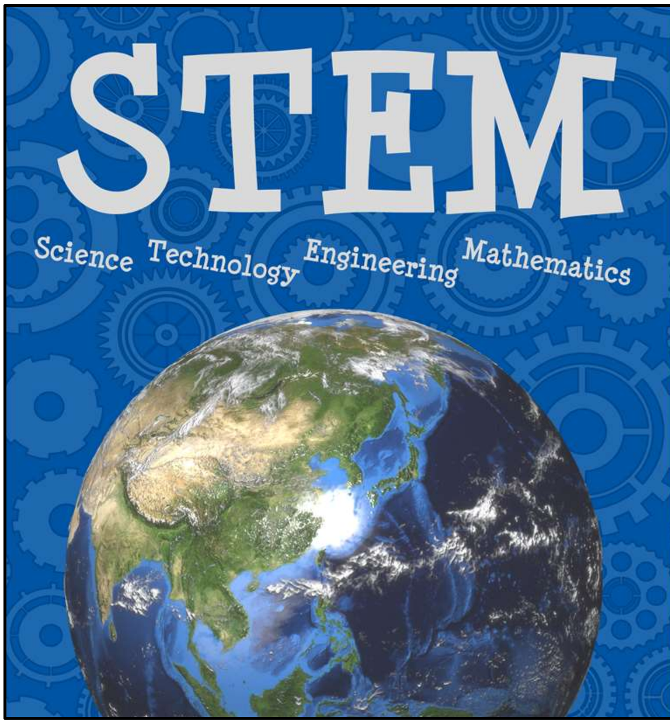

Exploration for Oil and Gas

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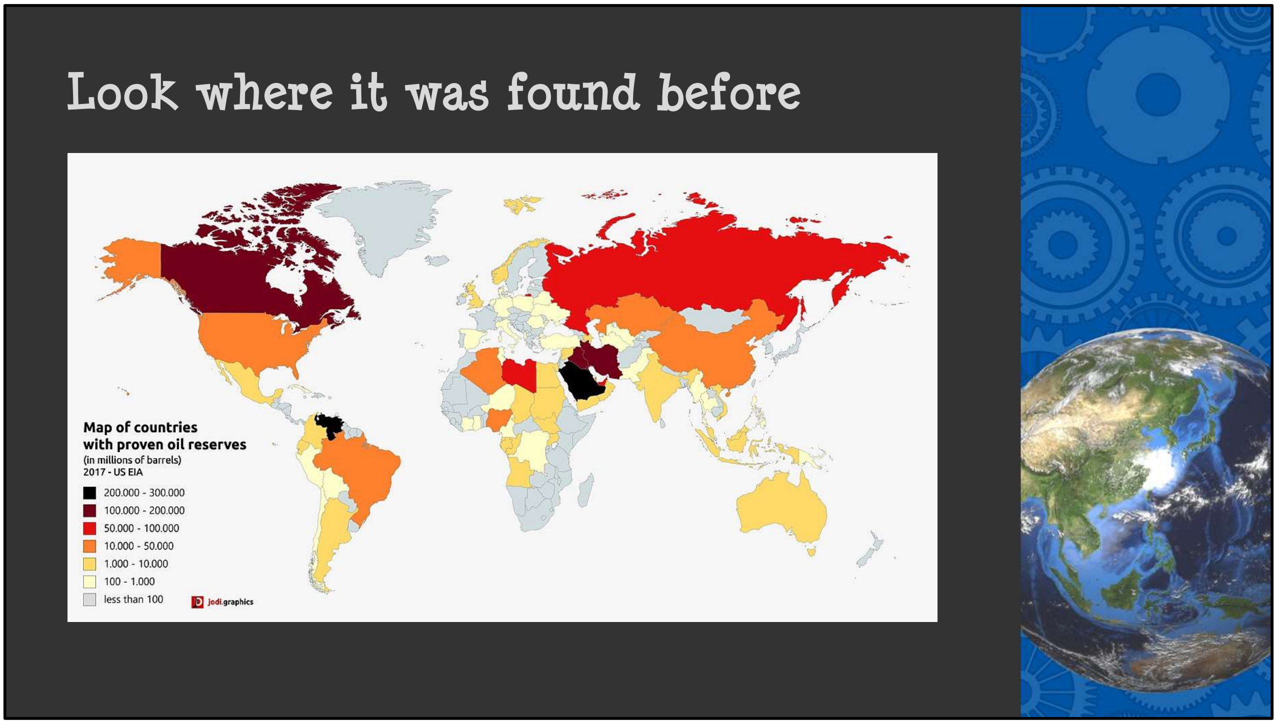
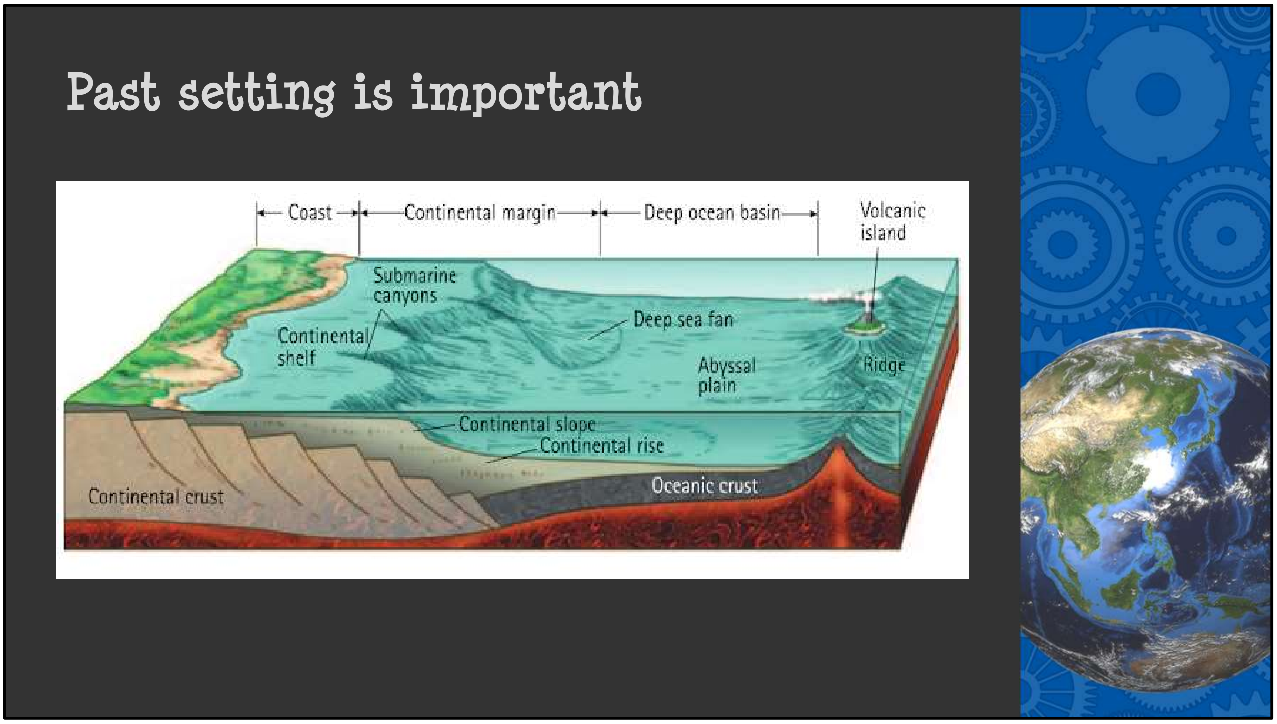
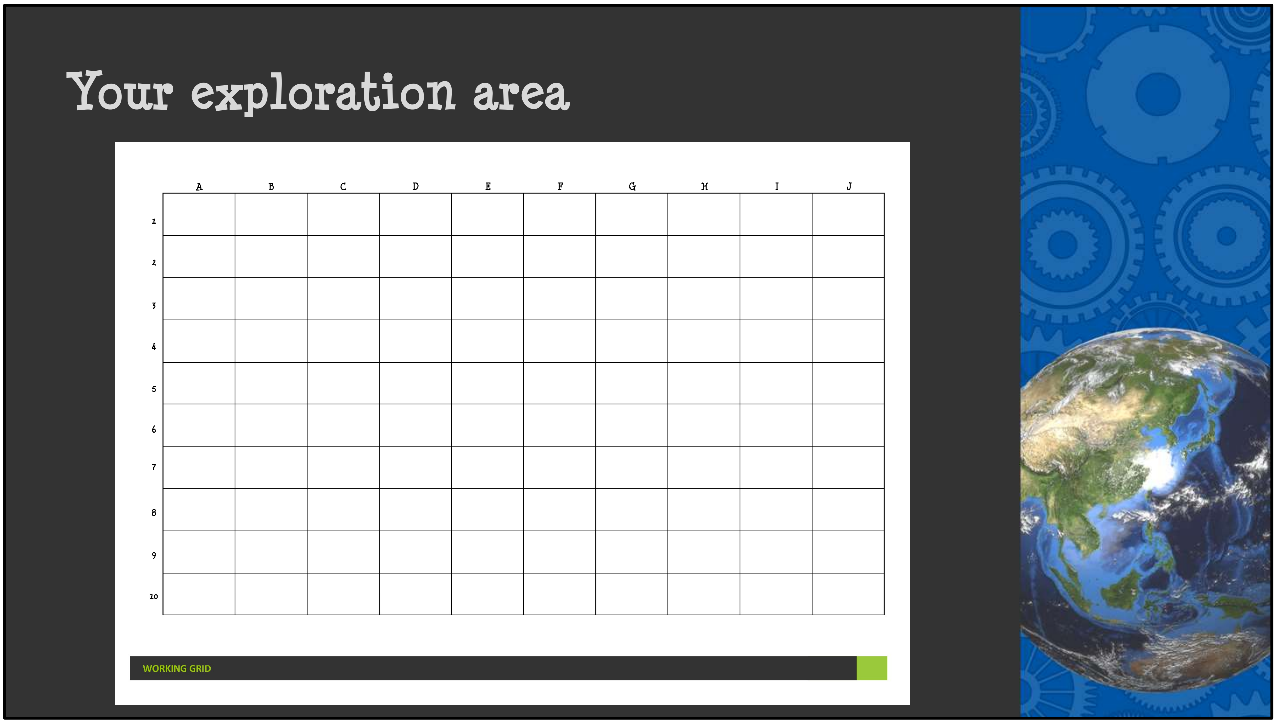


1. You have the highest chance of discovering oil and gas where it has been discovered before – in a known basin/reservoir. A lot of exploration occurs in these areas.

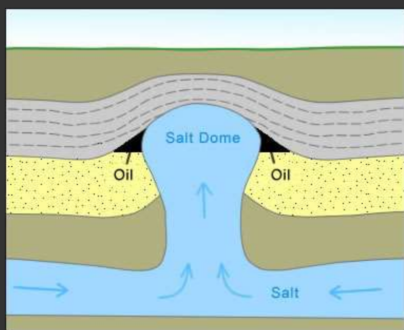


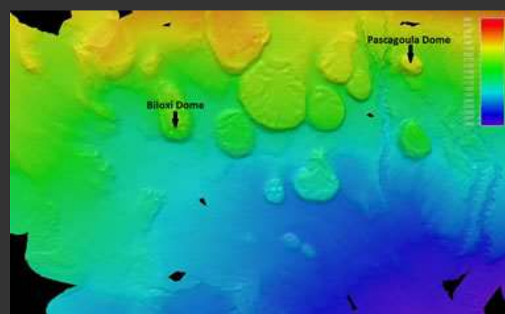
2. If the area has been explored in the past you will have a good idea of the past setting. You are typically looking for oil and gas somewhere that has been a shallow ocean basin from 2bya to 20mya.



Ensure students have a copy of the working grid (it should be the third, and final, page of their worksheet). Student will be annotating this grid with the information they are provided. They can use colours or symbols or any method they choose as long as they create a clear key.

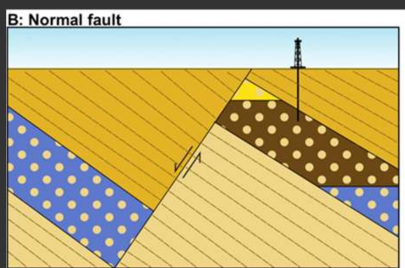
Geological Maps – looking for surface expressions

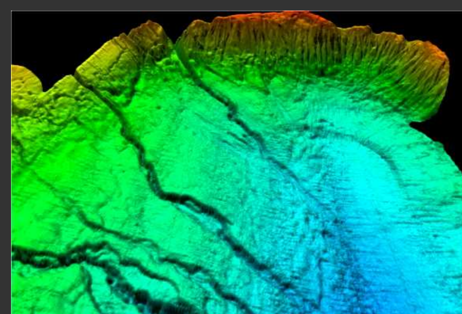




3. The geology of the area is examined. Certain geological features are key to oil and gas basins. Salt domes are effective traps for oil and gas and can sometimes be seen through geophysical exploration.

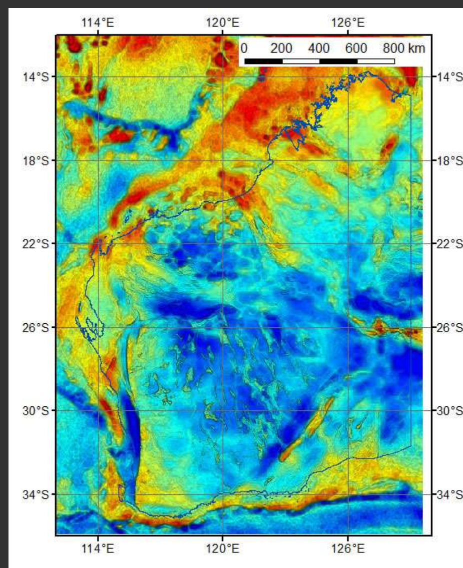
Geological Maps – looking for surface expressions



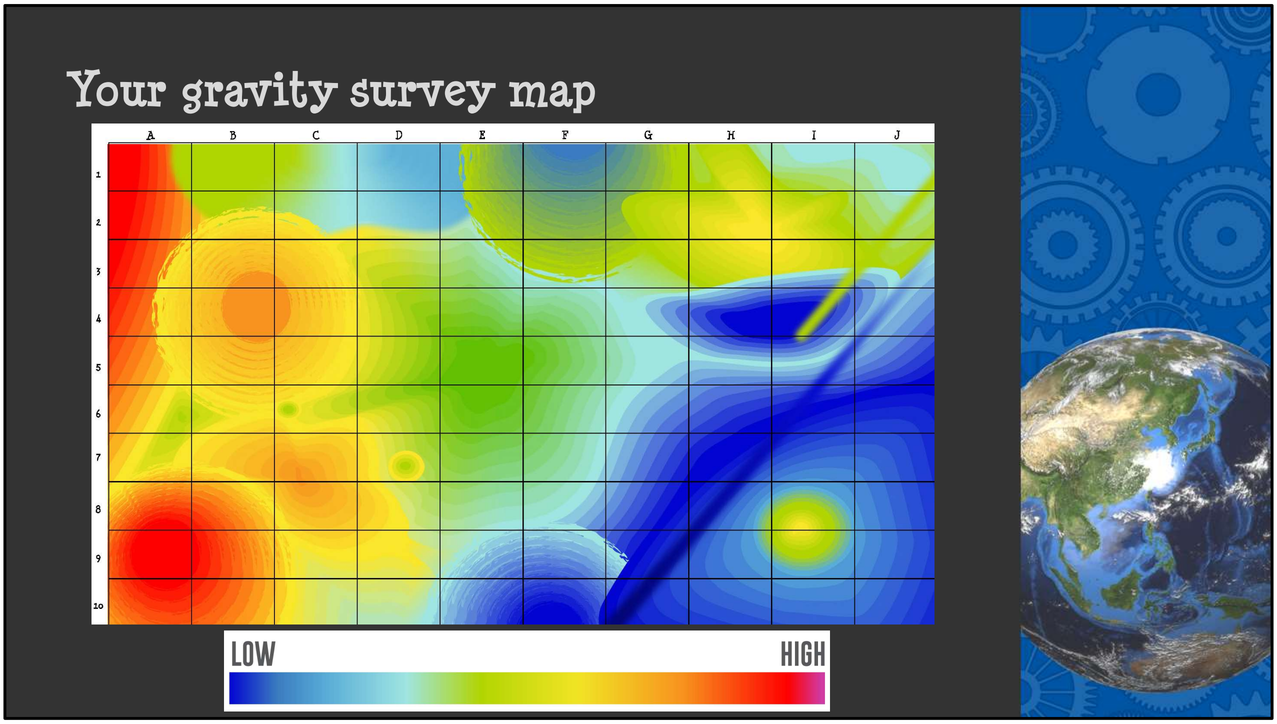


Faults are also potential traps for oil and gas and can be seen during geophysical exploration

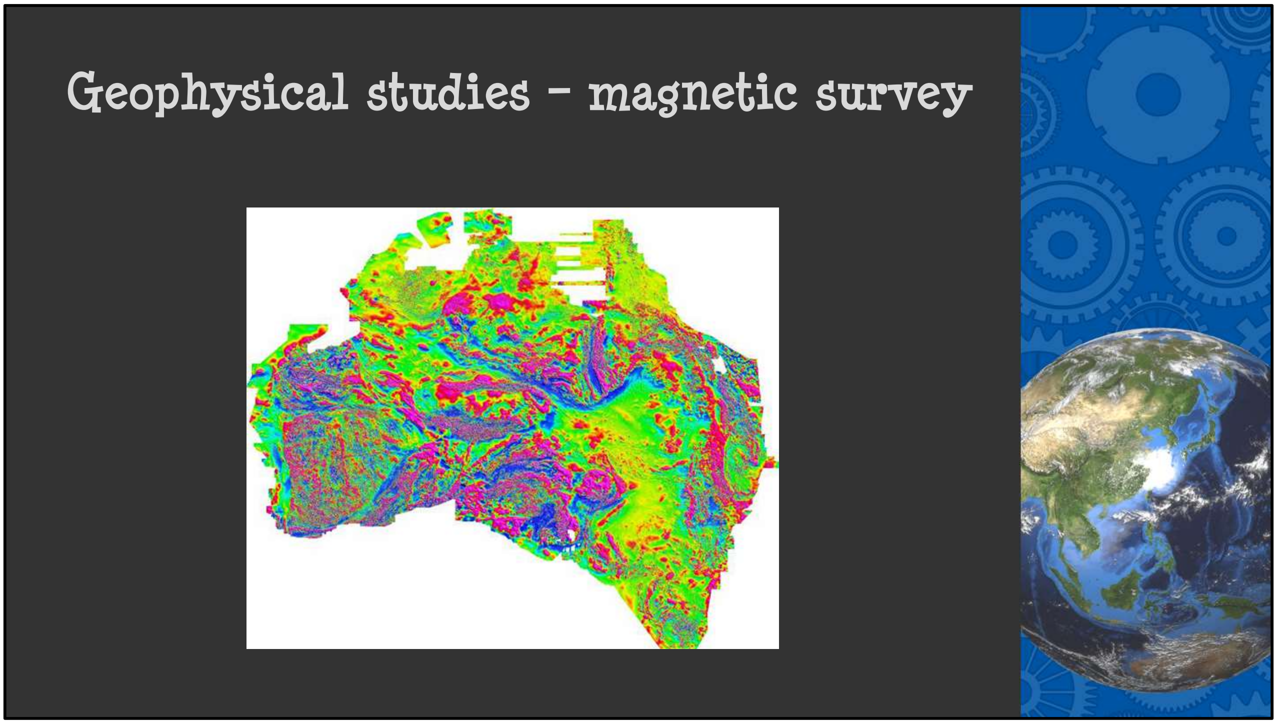
Geophysical studies – gravity survey



Many of these structures are identified through gravity surveys. Gravity surveys measure differences in the gravitational pull due to rocks and structures in the subsurface. This typically follows the density of these rocks in the subsurface. Areas where the gravitational pull is significantly lower than normal are coloured blue (indicating low density) and areas where the gravitational pull is significantly higher than normal are coloured red (indicating high density). The rest of the scale is gradational = blue to green to yellow to orange to red.

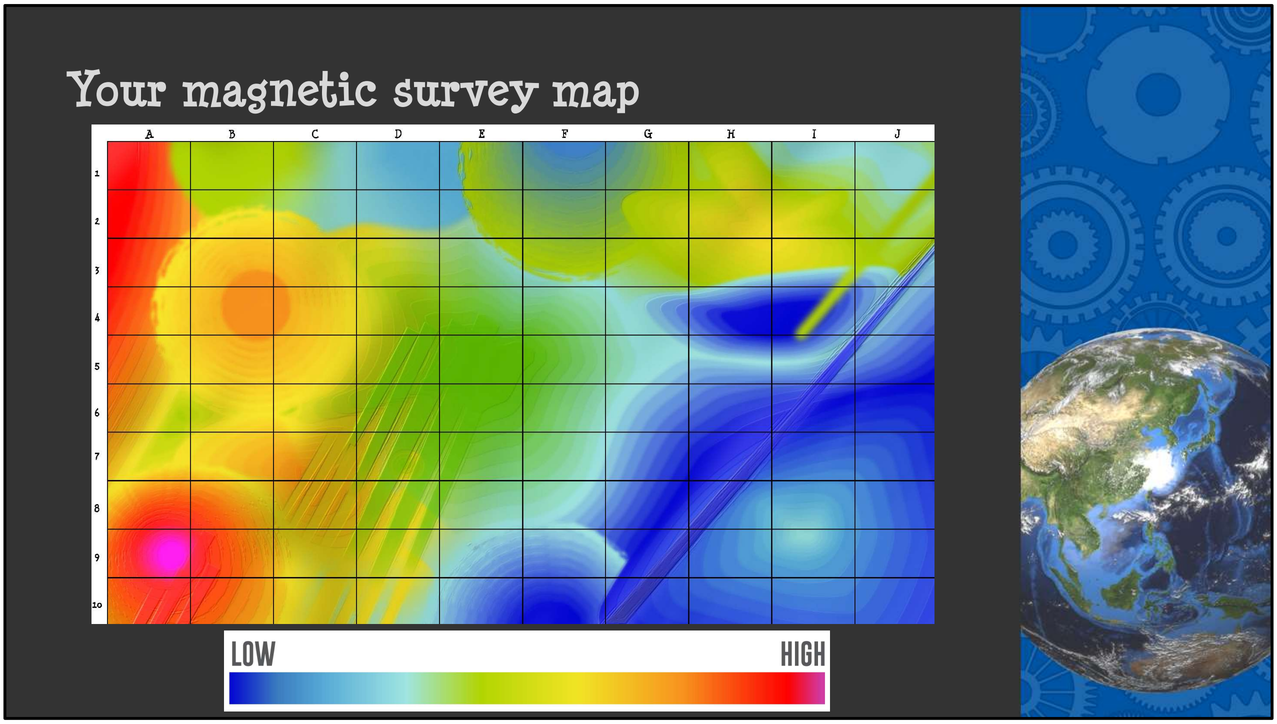


This is the gravity survey map for your area.
Would you expect oil and gas to have a high (red) or low (blue) gravitational pull = low (low density)
What about the rocks they are hosted in? = low (low density)
What about potential trap structures, like salt domes and faults? Typically on the lower end too
Annotate your map with areas of interest (FYI – note the salt dome in the bottom right corner and the fault cutting across that corner, also the low density area nearer the top of the map)



Another geophysical survey than can be undertaken is a magnetic survey. This measures differences in the magnetic pull of an area (against normal) which is again due to rocks and structures in the subsurface.

Typically, thick sedimentary beds show as magnetic lows (there are some exceptions around the world where basins are filled with magnetic minerals in sediments washed in from the continent). Igneous and metamorphic rocks are more likely to contain magnetic minerals and will therefore often show up as highs.



This is the magnetic survey map of your area
Would you expect oil and gas to have a high (red) or low (blue) magnetic pull = low
What about the rocks they are hosted in? = low
What about potential trap structures, like salt domes and faults? Typically on the lower end too
Annotate your map with areas of interest (FYI – note the salt dome in the bottom right corner is still visible and the fault cutting across that corner, also the low magnetic pull nearer the top of the map)

Examining the seafloor – looking for oil seeps

4. Oil Seeps - because cap (or seal) rocks and traps are not always 100% effective there may also be seepage of oil onto the surface. The seafloor can be surveyed for these seeps.

It is important to note that the seep may not be directly above the reservoir. The oil may have migrated along underneath the cap rock and come up through fractures and faults adjacent to the reservoir.

These are the locations of seeps for the area you are working in

Choose an area

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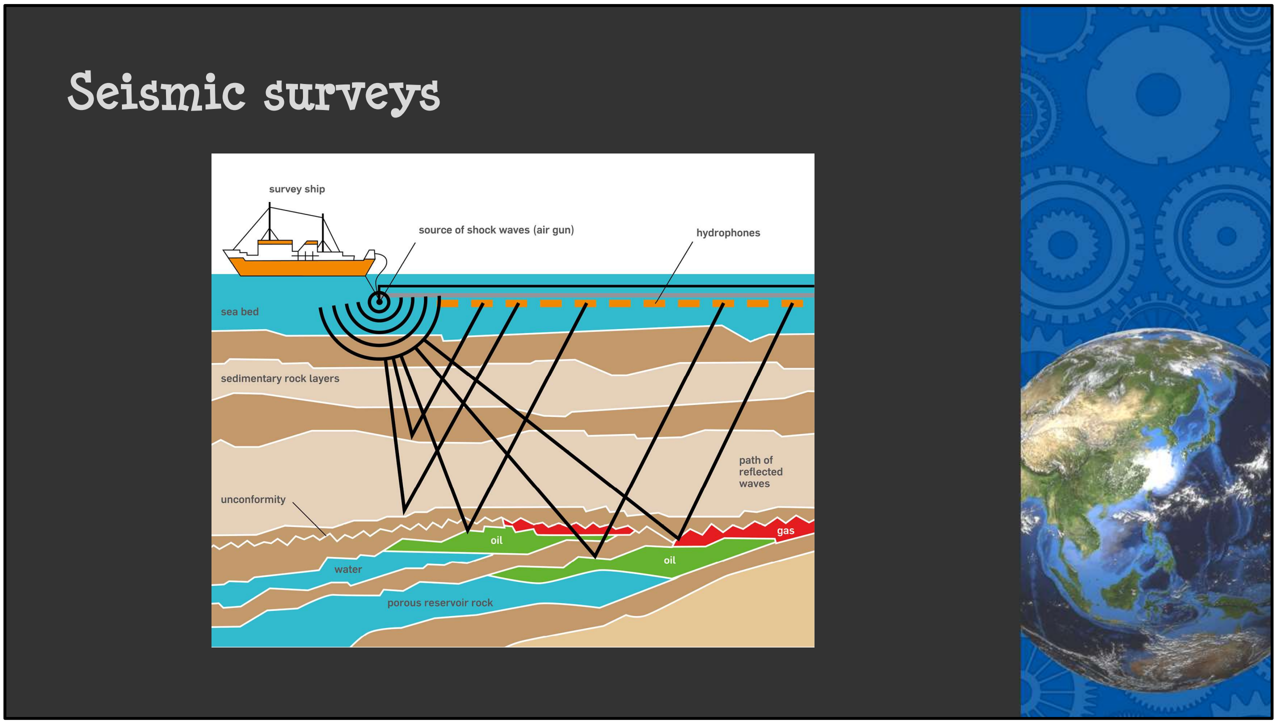
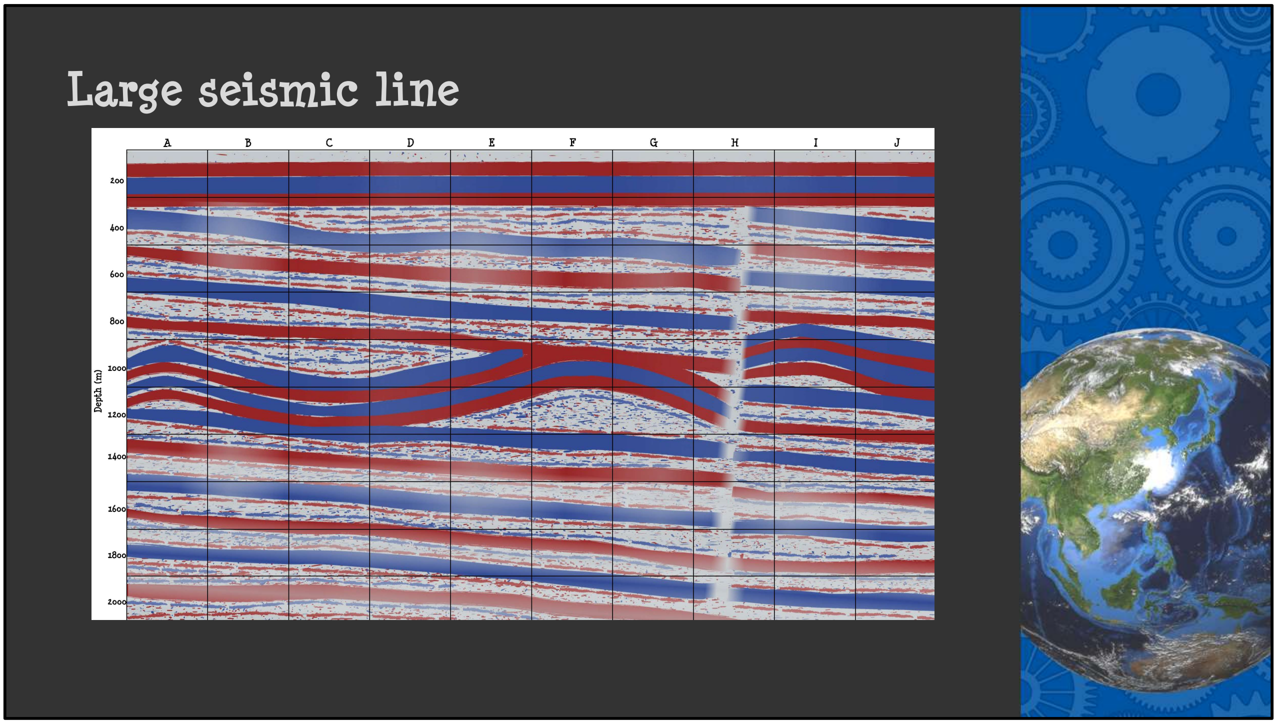
Using all of the information provided choose a square to explore further (for example A3 or D9). Make notes and be prepared to justify your answer.



5. Seismic surveys are a key exploration tool. The area is usually explored in transects. Survey ships trail equipment that generate shock waves. These shock waves are reflected (and refracted – there are a few different types of survey) by rocks and rock structures below. These reflections are collected by hydrophones trailing the boat and recorded. The time taken for these waves to return can be used to calculate the depth of reflection. This can be used to produce a picture, that can be interpreted to identify key rock layers and structures in the subsurface.



It is important to mention that this is just one transect through the area. This was taken from survey line 8 on your maps. We are no longer looking at a birds eye view of a map but downwards from the surface.

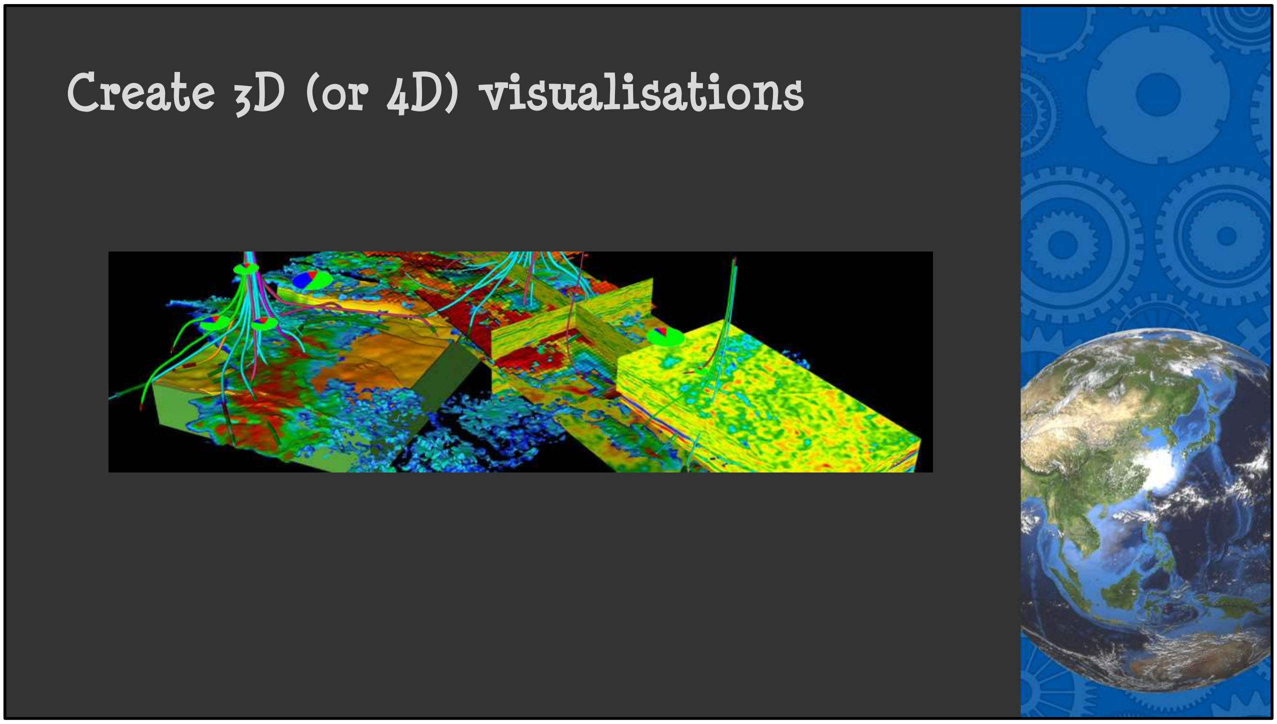
This would be a good time to show the students the exploration box they will be drilling into soon so they can see the top (birds eye view) they have been working with. Now show them the side and explain that this is what we are looking at with the seismic survey. It helps us to determine potential depths of key features.

The darker lines are where there has been strong reflection of waves.

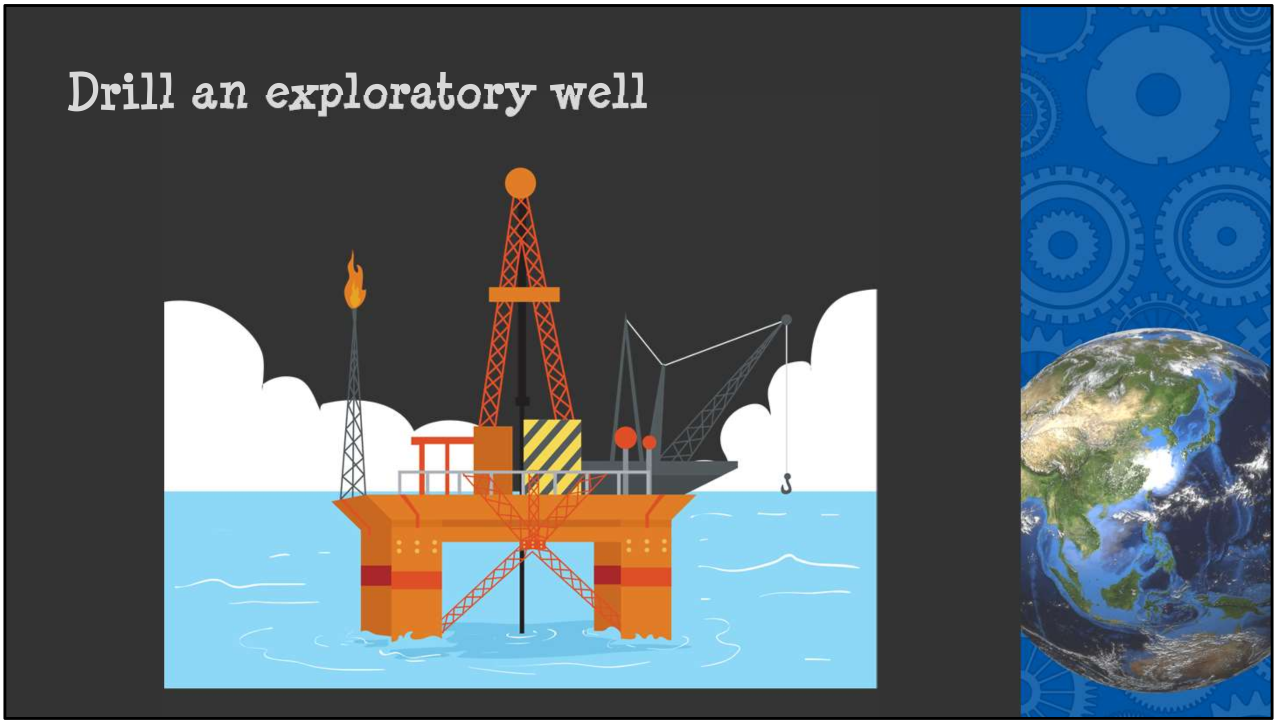
What sorts of features would reflect waves strongly? More dense rocks and structures – perhaps cap rock.

Can you see any features? The anticlines around F-G and I. Also the fault that cuts through at H.

What depth will we need to drill past, taken from this survey? 1,100-1,200m (depending on where we are) to get below what looks to be cap rock.



6. Extensive amounts of information are taken to put together 3D visualisations of the reservoir.
Sometimes 4D visualisations are constructed, looking to replicate the formation of the reservoir over time in the hopes of predicting oil and gas migration pathways.
All of this uses an enormous amount of STEM skill.



7. Finally, if all of the information looks promising, proper permissions are obtained and if the financing is available, exploratory well/s are drilled.
Students should claim the square they would like to drill, for example E8, by presenting an investor pitch. Why do they think this is the most promising area? They must use evidence from the surveys that were conducted (it is important to remind them that they won't be using seismic or 3D data for their square. These were only provided as examples – data was not available for their location).
I like to have the students nominate to pitch to the whole class and if convincing enough give them permission to drill (insert the skewer at that location to see what they bring up) – see teacher notes for further instruction on the exploration box.

Examine core samples

8. Some of the students would have come up with oil, other traces, many none. This is the case in the real world. Well explored basins tend to have a higher success rate (until they have been really extensively explored and then it drops again, as the oil and gas has been found). Less explored basins have a much lower ‘strike’ rate.
In any case, exploration wells are great places to continue scientific investigation of the reservoir – testing the rocks, geochemistry, fluids and more.

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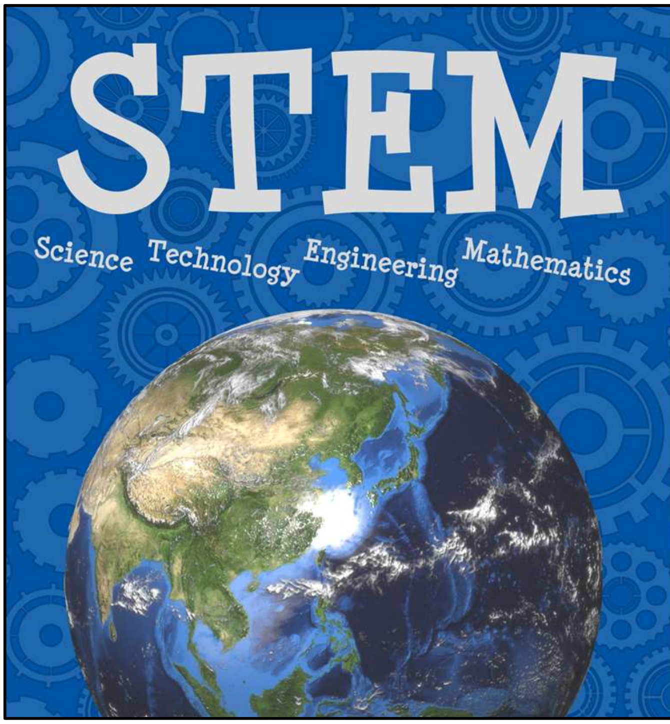

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