Ore Body Battleship

Introduction:

This activity simulates the process of prospecting for phosphate ore by collecting core samples. Geologists collect core samples to determine where phosphate deposits are in an area. They make a map of the underground deposits so the dragline operators know where to mine. Draglines are expensive to operate and ore is expensive to process; therefore, the geologist must be efficient and accurate when gathering core samples. A core sample is taken approximately every 2.5 acres.

Prospecting (taking and analyzing core samples) and dragline operations are not the only major costs in mining. What the dragline digs up must be processed to separate the phosphate rock from sand and clay. In addition, the permitting and reclamation costs need to be considered. The mining companies must apply to the state for a permit to mine the land. Reclamation is the process of restoring disturbed land that was mined back to its natural state or other permit-designated beneficial use. Since 1975, the Florida Department of Environmental Protection (DEP) has been regulating a law passed by Florida's legislature requiring mined lands to be reclaimed. Reclamation is very complex and the reclamation plan is made before mining even begins. While geologists take core samples of the environment to prospect for ore, a reclamation plan is also being made to repair the disturbance to the land that will be done when the ore is mined.

Failure to comply with the law or excessive damage to the land can lead to fines or charges from the DEP.

Standards:

SC.D.1.2.1	MA.6.A.5.1	MA.912.A.10.1
SC.D.1.3.1	MA.6.A.5.2	MA.912.A.10.2
SC.D.1.4.7	MA.6.A.5.3	SC.912.E.6.4
SC.D.2.3.2	LA.6.1.6.5	SC.912.E.6.6
MA.5.S.7.2	LA.6.4.2.2	

Objectives:

- Students will know what an ore mineral is
- Students will know why reclamation is an important aspect of mining
- Students will know what state regulations are in place to permit mining and ensure reclamation
- Students will be able to find percentages of a number and use models to compare fractions, percentages, and decimals. They will also be able to analyze data by comparing and ordering numbers.

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Vocabulary:

geology	matrix
Geologist	overburden
prospect	slurry
efficient	reclamation
core sample	

Materials:

2 different colors of Play-Doh for each group (preferably gray and green)
2 inch drinking straw (1 per pair)
2½ inch nail (1 per pair)

Procedure:

1. Select a partner for "Ore Body Battleship."
2. Create a key on Plot Diagram #1. Choose locations on the grid where ore deposits can be found and mark and draw the deposits. These deposits can be scattered randomly, grouped together horizontally, diagonally, or vertically. The deposits can be any shape (circles, squares, blobs, etc.)
3. Using your key (Plot Diagram #1) lay out one color (gray) of Play-Doh to represent the shapes on the corresponding grid of Plot Diagram #2 to represent the ore deposit. Make sure the Play-Doh is at least ¼" thick.
4. Cover the grid of Plot Diagram #2 with the second color (green) of Play-Doh, making sure to completely cover your "mineral deposit," but be careful not to cover the letters and numbers.
5. Switch deposits with another team. Each team will take turns taking core samples by using the straw and nail.
6. Using the straw, take a core sample from the center of each grid on Plot Diagram #2 that corresponds with the circles on Plot Diagram #3. Use the nail to push the Play-Doh out of the straw. Every time you take a core sample, record your findings on the *Mineral Deposit Record Sheet* or Plot Diagram #3. If you find matrix or phosphate in your sample, mark an "X" in the circle that represents where you took that core sample from. If you do not find matrix, mark an "O" in the circle that represents the location you took that core sample from. The game is over when both teams have taken 16 samples from the designated spots on Plot Diagram #3. This represents the ratio that a geologist uses when taking a sample approximately every 2.5 acres. **Remember, no peeking, cheating, making a mess, or using tools inappropriately. The DEP is watching and they will charge you fines. Also, try to use skill and accuracy while mining.**
7. Fill out Data Table #1 and complete Worksheet #1.
8. From these samples, your data table, and your worksheet, decide if it would be economical to mine the deposit and if so, where the best place to mine for the "phosphate" would be.
9. Compare your findings with the other team's key to see how accurate you were.
10. As a class, fill out Data Table #2 and decide which team was the best team of geologists, creating the best plan for phosphate extraction.

Analysis/Conclusions:

1. Why is prospecting done before phosphate is mined?
2. What criteria make an area economical to mine?
3. Why do you lose money if you mine in an area that does not have phosphate?
4. Why is it important to find phosphate?
5. Why is reclamation important?
6. Why is the land reclaimed after the phosphate has been removed from the land?
7. Which group made the most profit? The most loss?
8. Which group was the most efficient and successful? Why?
9. Is money the only factor that determines success? Why or why not?
10. What is the impact of mining on industry and the environment? What are some solutions to the problems that might arise before, during, and after the mining process?

Teacher's Note:

This activity is not age-specific. For older students, the entire activity can be done to integrate science and math. Students will be able to discuss the scientific process, economics, and environmental impact. This activity can be extended with some critical thinking questions where the students come up with alternative solutions to the impacts of mining on industry and the environment.

For younger students (K-6), this activity can be shortened where students stop at Data Table #1. They can compare and contrast the number of samples taken to the number of deposits found and analyze their success. There are scientific, economic, and environmental implications even if this activity is shortened.

Extensions:

1. Students can analyze the perimeter of their plots. If there is a concentration along the perimeter what could this mean for the adjacent lands?
2. In this activity we are analyzing the sample in two dimensions. Have the students analyze the sample as three-dimensional. Is there enough ore in the sample to economically mine this site?
3. Students can also try to find relevance in time by evaluating how long it took to complete this activity.

Data:
Data Table #1

Number of Core Samples Taken	Number of Core Samples Containing Ore	Threshold $\frac{\text{Number of samples containing ore} \times 100}{\text{Number of core samples taken}}$
16		%

A threshold of 25% or higher would make this area viable for mining. Proceed to Worksheet #1 to figure out *why* a threshold of 25% is viable.

Data Table #2

Group	Number of Core Samples Taken	Number of Core Samples Containing Ore (Data Table #1)	Calculated Threshold (%) (Data Table #1)	Calculated Economic Value (worksheet)
	16			
	16			
	16			
	16			
	16			
	16			
	16			
	16			

Worksheet #1

1. How many core samples did you take?

Quantity		Cost			
_____	x	$2,000	=	$_____	(1)

2. Cost for mining permits. (fixed rate) $100,000 (2)

3. What are the mining and processing costs for your parcel of land?

Acres		Cost			
_____	x	$20,000	=	$_____	(3)

4. **TOTAL COST FOR MINING - (add lines 1, 2 and 3)** $_____ (4)

5. How many acres did you find that contained phosphate? (NOTE - each box is 2.5 acres)

Boxes containing ore			Acres		Value			
_____	X 2.5 =	_____		x	$150,000	=	$_____	(5)

6. Did you comply with DEP laws and regulations?

	Quantity		Cost			
Fines	_____	x	$25,000	=	$_____	(6a)
	Quantity		**Value**			
Rewards	_____	x	$5,000	=	$_____	(6b)

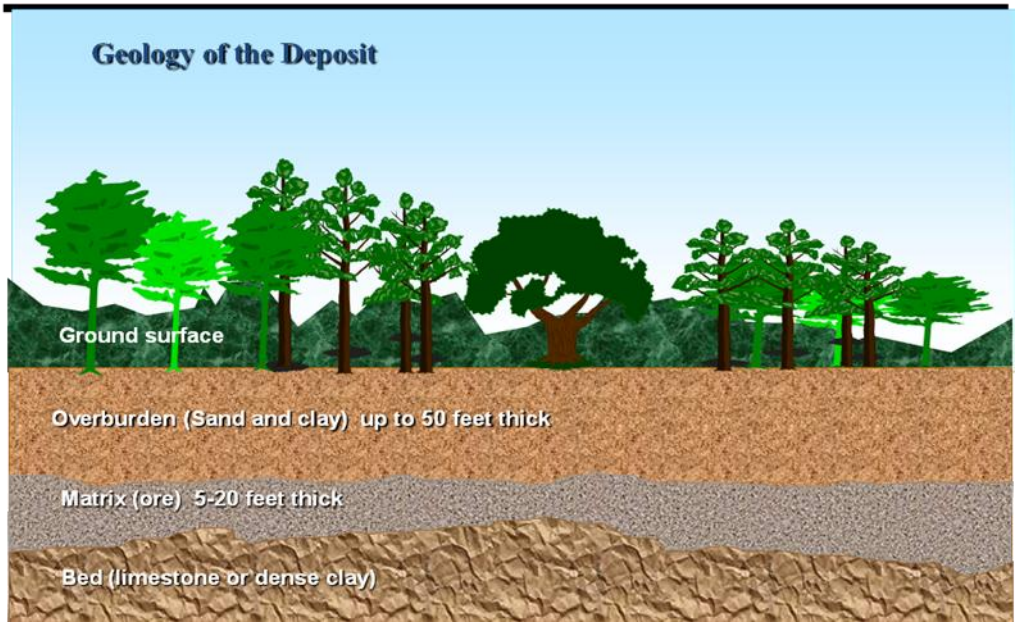
7. How many acres were you required to reclaim? (NOTE - you must reclaim all of the land that has been disturbed)

Acres		Cost			
_____	x	$15,000	=	$_____	(7)

8. Is it economical to mine the phosphate deposit?

Cost of mining (line 4)	$_____ a	
DEP fines (line 6a)	$_____ b	
Reclamation costs (line 7)	$_____ c	
Total expenses - add (a), (b) and (c)		$_____ d
Rewards earned (line 6b)	$_____ e	
Value of mined phosphate (line 5)	$_____ f	
Total income - add (e) and (f)		$_____ g
TOTAL PROFIT/LOSS - subtract (d) from (g)		$_____

If "g" is larger than "d", you made a profit
If "d" is larger than "g", you have a loss



Key: (Note: Plot diagrams are an aerial view of the picture above)

PLOT DIAGRAM #1 (Key)	A	B	C	D
1				
2				
3				
4				

Scale: Each Box equals 2.5 acres = 40 acre parcel

PLOT DIAGRAM #2 (Game)	A	B	C	D
1				
2				
3				
4				

Scale: Each Box equals 2.5 acres = 40 acre parcel

PLOT DIAGRAM #3	A	B	C	D
1				
2				
3				
4				

DEP FINE

$25,000

(Due to unclean mining, permit issues, etc)

DEP REWARD

$5,000

(Due to clean mining, environmental merit, etc)

DEP FINE

$25,000

(Due to unclean mining, permit issues, etc)

DEP REWARD

$5,000

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