NO PREP

Ground-Penetrating Radar

X-Ray Vision for Dirt

Includes: Student reading, case study, differentiated questions, teacher key

Name: Period: Date:

Ground-Penetrating Radar: X-Ray Vision for Dirt

How Radar Sees Underground

Ground-penetrating radar, universally known by its abbreviation GPR, is one of the most versatile tools in an archaeologist's detection toolkit. Unlike LiDAR, which looks down from aircraft, GPR works at ground level. An operator pushes or pulls a wheeled antenna unit across the surface, and the device sends pulses of electromagnetic energy into the ground. When those pulses encounter a boundary between different materials, such as soil and stone, soil and metal, or soil and a void like a tunnel or chamber, some of the energy bounces back to the surface. The GPR unit records these reflections, and specialized software

Name: **Period:** **Date:**

Ground-Penetrating Radar: X-Ray Vision for Dirt

How Radar Sees Underground

Ground-penetrating radar, universally known by its abbreviation GPR, is one of the most versatile tools in an archaeologist's detection toolkit. Unlike LiDAR, which looks down from aircraft, GPR works at ground level. An operator pushes or pulls a wheeled antenna unit across the surface, and the device sends pulses of electromagnetic energy into the ground. When those pulses encounter a boundary between different materials, such as soil and stone, soil and metal, or soil and a void like a tunnel or chamber, some of the energy bounces back to the surface. The GPR unit records these reflections, and specialized software converts them into images that show what lies beneath the surface. The principle is similar to medical ultrasound, except that GPR uses radio waves instead of sound waves. Just as an ultrasound creates an image of structures inside the human body, GPR creates an image of structures inside the earth. The depth of penetration depends on the frequency of the radar signal and the properties of the soil. Lower frequencies penetrate deeper but produce less detail, while higher frequencies provide sharper images but reach only shallow depths. In ideal conditions, such as dry sandy soil, GPR can detect features several meters below the surface. In wet clay, which absorbs radar energy, the effective depth might be less than a meter. GPR produces what are called radargrams, two-dimensional slices showing the subsurface along the path the antenna traveled. By conducting a series of parallel passes across a site, archaeologists can build up a three-dimensional picture of buried features. Modern GPR systems can be attached to vehicles or even small robots, allowing rapid survey of large areas. The data can then be processed into horizontal time-slices that show features at different depths, essentially creating floor plans of buried structures layer by layer.

Mapping the Invisible

GPR has been used to investigate some of the most famous archaeological sites in the world. At Stonehenge in England, GPR surveys have revealed a network of buried pits, ditches, and what appear to be the foundations of timber structures surrounding the stone circle. These hidden features suggest that the monument we see today was part of a much larger ceremonial landscape that extended far beyond the visible stones. In Rome, GPR has been used to map buried sections of ancient buildings without disturbing the modern city above. The technology has located aqueducts, roads, and entire building complexes beneath the streets and piazzas of the modern capital. At Pompeii, GPR has identified rooms and structures that have not yet been excavated, helping archaeologists plan future digs and prioritize which areas to investigate first. One of GPR's most powerful applications is in cemetery and burial archaeology. The technology can detect individual graves, burial vaults, and even the outlines of coffins without disturbing the dead. This is invaluable for managing historic cemeteries where headstones have been lost or moved, and it has been used to locate burials at sites ranging from Colonial American churchyards to medieval European plague pits. GPR can distinguish between disturbed and undisturbed soil, which helps identify where graves have been dug and refilled, even centuries after the burials took place.

Searching for Unmarked Graves

Perhaps the most emotionally charged application of GPR in recent years has been the search for unmarked graves at former residential schools in Canada and similar institutions around the world. In 2021, the Tk'emlups te Secwepemc First Nation announced that GPR had detected soil anomalies consistent with approximately 215 unmarked burials at the site of the former Kamloops Indian Residential School in British Columbia. The announcement sent shockwaves across Canada and the world, reigniting urgent conversations about the legacy of residential schools and the treatment of Indigenous children. GPR cannot technically confirm the presence of human remains without excavation. What it detects are anomalies in the subsurface, patterns of disturbed soil, voids, and density changes that are consistent with burials. The distinction matters because some anomalies can be caused by tree roots, old infrastructure, or natural soil variations. However, when GPR anomalies are found at a site with documented historical evidence of deaths and burials, and when

the anomalies match the size, spacing, and pattern expected of graves, the evidence is considered compelling. The use of GPR at residential school sites has raised important questions about how the technology is deployed and who controls the results. Indigenous communities have generally insisted on leading or co-leading the investigations, controlling the pace of the work, and deciding what information is made public. In many cases, communities have chosen not to excavate, preferring to honor the dead by leaving them undisturbed while using GPR data to document what happened. This represents a powerful example of how archaeological technology can serve justice and healing rather than purely academic research. Similar searches have been conducted at historical institutions in the United States, Ireland, Australia, and other countries with histories of forced institutional care. In each case, GPR has provided a non-invasive way to investigate sensitive sites without the physical and emotional trauma of excavation, giving communities the information they need to make their own decisions about how to proceed.

What GPR Can and Cannot Do

For all its capabilities, GPR has significant limitations that archaeologists must understand. The technology's effectiveness is heavily dependent on soil conditions. Dry, sandy, or gravelly soils are ideal because they allow radar signals to penetrate deeply and produce clear reflections. Wet clay soils, by contrast, absorb radar energy rapidly, limiting penetration depth and producing noisy, hard-to-read data. In some environments, GPR simply does not work well enough to be useful. GPR also requires a relatively flat, accessible surface to operate. Dense vegetation, steep slopes, and rocky terrain can all make it difficult or impossible to push the antenna unit across the ground. While some newer systems are mounted on drones or can be carried by hand for difficult terrain, these adaptations come with tradeoffs in data quality and coverage area. Interpretation of GPR data requires significant expertise. The raw radargrams are not intuitive images that anyone can read. They require processing and analysis by specialists who understand how different materials and features produce different reflection patterns. A buried stone wall, a water pipe, a tree root, and a burial can all produce similar-looking anomalies in the raw data. Without experience and context, it is easy to misidentify features or miss them entirely. Despite these limitations, GPR remains one of the most important non-invasive investigation tools in modern archaeology. It fills a critical niche: the ability

to see into the ground at the scale of individual rooms, walls, and graves without breaking the surface. When combined with other methods like LiDAR for large-scale landscape mapping and traditional excavation for detailed investigation, GPR provides the medium-resolution view that connects the big picture to the small details.

Key Information: Ground-Penetrating Radar

Detail	Information
How GPR works	Sends electromagnetic pulses into the ground and records reflections from buried features
Similar to	Medical ultrasound, but uses radio waves instead of sound waves
Ideal soil conditions	Dry, sandy, or gravelly soils allow deepest penetration and clearest images
Poor soil conditions	Wet clay absorbs radar energy, limiting depth and producing noisy data
Radargram	A two-dimensional image showing subsurface features along the path the antenna traveled
Kamloops discovery (2021)	GPR detected anomalies consistent with approximately 215 unmarked burials at a former residential school
Key advantage	Non-invasive: investigates subsurface features without disturbing or destroying them
Key limitation	Detects anomalies, not definitive identifications; requires expert interpretation and sometimes excavation to confirm

Case Study: The Search at St. Andrew's

Kaya Blackwood stood at the edge of the overgrown field and tried to steady her breathing. Behind her, a GPR technician named James was calibrating the equipment. Ahead of her, hidden somewhere beneath knee-high grass and wildflowers, were the possible graves of children who had attended St. Andrew's Indian Residential School between 1920 and 1969. Kaya was the community liaison for the Anishinaabe Nation's investigation committee, and she had spent two years advocating for this search. Her great-aunt had attended St. Andrew's and never came home. "We are not doing this for science," Kaya told James quietly as he prepared to begin the first transect. "We are doing this so our families can know." Over the next five days, James pushed the GPR unit along carefully marked lanes across the field. The data revealed fourteen anomalies consistent with grave shafts: rectangular areas of disturbed soil, roughly the right size and depth, spaced at regular intervals. Kaya presented the findings to the community council. "The GPR cannot tell us who is there," she explained. "It tells us something is there. The question now is whether we excavate or whether we honor them where they are." The council voted unanimously to designate the area as sacred ground and install a memorial, without excavation.

1. Based on the reading, explain why the GPR findings at St. Andrew's are considered compelling evidence of burials even though GPR cannot confirm the presence of human remains. What factors strengthen the interpretation?

2. The community chose not to excavate despite the GPR findings. How does this decision reflect the reading's discussion of how archaeological technology can serve justice and healing rather than purely academic research?

Multiple Choice

1. How does ground-penetrating radar create images of subsurface features?

    a) By detecting heat signatures from buried objects

    b) By using X-rays to photograph underground structures

    c) By measuring the magnetic properties of buried metals and analyzing their electromagnetic signatures

    d) By sending electromagnetic pulses into the ground and recording reflections from material boundaries

2. In what type of soil does GPR work most effectively?

    a) Dry, sandy, or gravelly soils

    b) Dense volcanic rock

    c) Wet clay that absorbs radar signals and reduces the penetration depth

    d) Frozen permafrost

3. Why is GPR described as non-invasive?

    a) It costs less than traditional excavation methods

    b) It requires only one operator

    c) It investigates subsurface features without disturbing or destroying them

    d) It uses harmless radio waves that do not affect living organisms or wildlife

Matching

Write the letter of the correct definition on the line next to each term.

Term	Definition
1. ___ GPR	A) An unexpected pattern or disturbance in subsurface data that may indicate a buried feature
2. ___ Anomaly	B) A two-dimensional image produced by GPR showing subsurface features along a survey path
3. ___ Non-invasive	C) Ground-penetrating radar, a device that sends radio wave pulses into the ground to detect buried features
4. ___ Electromagnetic	D) An investigation method that examines a site without physically disturbing or destroying it
5. ___ Radargram	E) Relating to the combined electric and magnetic waves used by radar and similar technologies

Fill-in-the-Blank

1. GPR is similar in principle to medical _____, but it uses radio waves instead of sound waves.

2. In 2021, GPR detected anomalies consistent with approximately 215 unmarked burials at the former _____ Indian Residential School in British Columbia.

3. A two-dimensional image showing subsurface features along the path the GPR antenna traveled is called a _____.

Short Answer

Answer each question in 2-4 complete sentences.

1. Explain why soil conditions affect GPR performance. Compare how GPR works in dry sandy soil versus wet clay, and explain why the difference matters for archaeological investigations.

2. The reading describes how GPR has been used at former residential school sites. Why is a non-invasive technology particularly important for these types of investigations?

3. Why does GPR data require expert interpretation? What could go wrong if someone without training tried to read a GPR radargram?