

Essentials of Geography



The Vista House observatory, built in 1918 as a rest stop for travelers and a memorial to the Oregon pioneers, sits on a dramatic promontory overlooking the Columbia River Gorge. Rivers serve as corridors of movement and transportation, physical and political boundaries, sites for recreation, and sources of hydropower. The ongoing interaction of humans with their environment is one of the essential themes in geographic science, discussed in Chapter 1. [Erik Harrison/Shutterstock.]

KEY LEARNING CONCEPTS

After reading the chapter, you should be able to:

- **Define** geography in general and physical geography in particular.
- **Discuss** human activities and human population growth as they relate to geographic science and **summarize** the scientific process.
- **Describe** systems analysis, open and closed systems, and feedback information and **relate** these concepts to Earth systems.
- **Explain** Earth's reference grid: latitude and longitude and latitudinal geographic zones and time.
- **Define** cartography and mapping basics: map scale and map projections.
- **Describe** modern geoscience techniques—the Global Positioning System (GPS), remote sensing, and geographic information systems (GIS)—and **explain** how these tools are used in geographic analysis.



GEOSYSTEMS now

Shale Gas: An Energy Resource for the Future?

In an area stretching 965 km (600 mi) from Ohio to western New York, methane lies deeply buried in a sedimentary rock deposit, the Marcellus Shale. Methane is the primary constituent of natural gas, and scientists suggest that this ancient rock layer, underlying 60% of Pennsylvania, may be one of the most significant reservoirs of natural gas in the world. Pennsylvania alone is dotted with nearly 6000 shale gas wells extracting pressurized methane (Figure GN 1.1).

Sources of Methane Methane is a chemical compound with the formula CH_4 and is a by-product of several natural processes: digestive activity of animals (cattle, sheep, bison) and termites; burning associated with wildfires; melting of arctic permafrost; and bacterial activity in bogs, swamps, and wetlands. Nearly 60% of the methane in our atmosphere comes from human sources, including natural gas production, beef and dairy production, rice cultivation, coal and oil extraction and burning, landfills, and wastewater treatment. In the United States, the natural gas industry makes up the largest percentage of methane emissions.

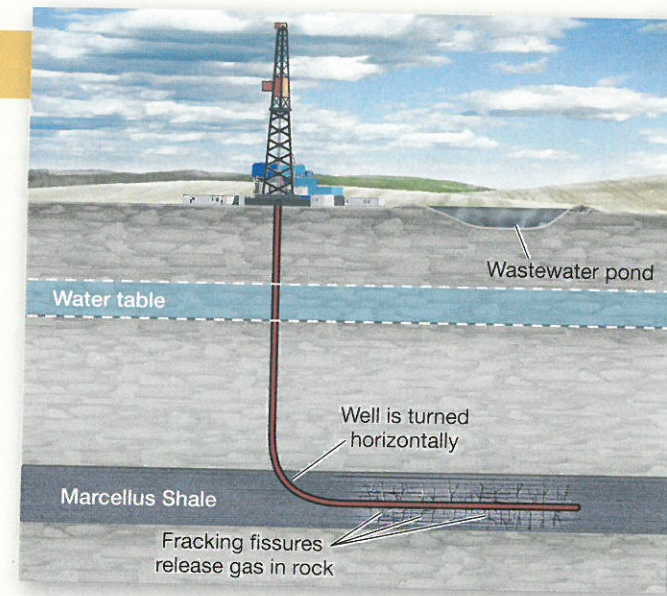
Drilling for Methane To release methane trapped within shale layers, the rock must be broken up so that gas diffuses into the cracks and flows upward. Over the past 20 years, advances in horizontal drilling techniques, combined with the process of hydraulic fracturing, or “fracking,” opened access to large amounts of natural gas previously deemed too expensive or difficult

to tap. A typical shale gas well descends vertically 2.4 km (1.5 mi), turns, and then extends horizontally into the rock strata. Horizontal drilling exposes a greater area of the rock, allowing more of it to be broken up and more gas to be released (Figure GN 1.2).

A pressurized fluid is pumped into the well to break up the rock. This fluid is 90% water, 9% sand or glass beads that prop open the fissures, and 1% chemical additives that act as lubricants. The specific chemicals used are as yet undisclosed by the industry. This use of an injected fluid to fracture the shale is the process of fracking. Gas then flows up the well to be collected at the surface.

Fracking uses massive quantities of water: approximately 15 million L (4 million gal) for each well system, flowing at a rate of 16,000 L (4200 gal) per minute—far more than could be provided by a public water system. In some regions, such intensive water use for energy extraction may deplete natural water sources, affecting stream or lake ecosystems, or redirect water from other uses.

The U.S. Energy Information Administration (EIA) projects a boom in shale gas extraction and production from fracking over the next 20 years, with U.S. production rising from 34% of all natural gas production in 2011 to 50% in 2040.



▲Figure GN 1.2 Horizontal drilling for hydraulic fracturing (fracking) and shale gas extraction.

accumulation in barns and homes, and possible explosions.

Methane adds to air pollution as a constituent in smog and is a potent greenhouse gas, absorbing heat from the Sun near Earth's surface and contributing to global climate change. In addition, scientific evidence links the injection of fluid into wastewater wells to earthquake activity and ground instability in Oklahoma, Texas, Ohio, West Virginia, and parts of the Midwest.

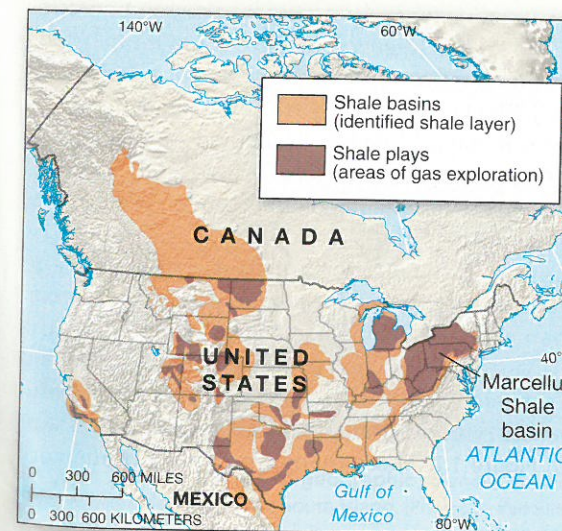
This rapidly expanding energy resource has varied impacts on air, water, land, and living Earth systems. However, many of the environmental effects of shale gas extraction remain unknown; further scientific study is critical.

Shale Gas and Elemental Geosystems

Resource location and distribution and human–environment interactions are important issues associated with shale gas extraction; these issues are also at the heart of geographic science. In this chapter, you work with several “Essentials of Geography”: spatial concepts, the scientific process, human–Earth connections, Earth systems thinking, and mapping. Throughout *Elemental Geosystems*, we expand the story of shale gas and its potential effects on global climate, surface water and groundwater resources, earthquake hazards, and ecosystem functions.

QUESTION AND EXPLORE To work with an interactive diagram called “Breaking Fuel from the Rock,” go to <http://ngm.nationalgeographic.com/2012/12/methane/lavelle-text>. For another perspective, go to <http://www.energyfromshale.org/shale-extraction-process>. Should the United States and other countries expand shale gas as an energy resource for the future?

▼Figure GN 1.1 Shale deposits and areas of exploration for natural gas extraction, United States and Canada. [U.S. Energy Information Administration.]



Environmental Effects As with other resource-extraction techniques, fracking leaves hazardous by-products. It produces large amounts of toxic wastewater, often held in wells or containment ponds. Any leak or failure of pond retaining walls spills pollutants into surface water supplies and groundwater.

Methane gas may leak around well casings, which tend to crack during the fracking process. Leaks can cause buildup of methane in groundwater, leading to contaminated drinking water wells, flammable tap water, methane