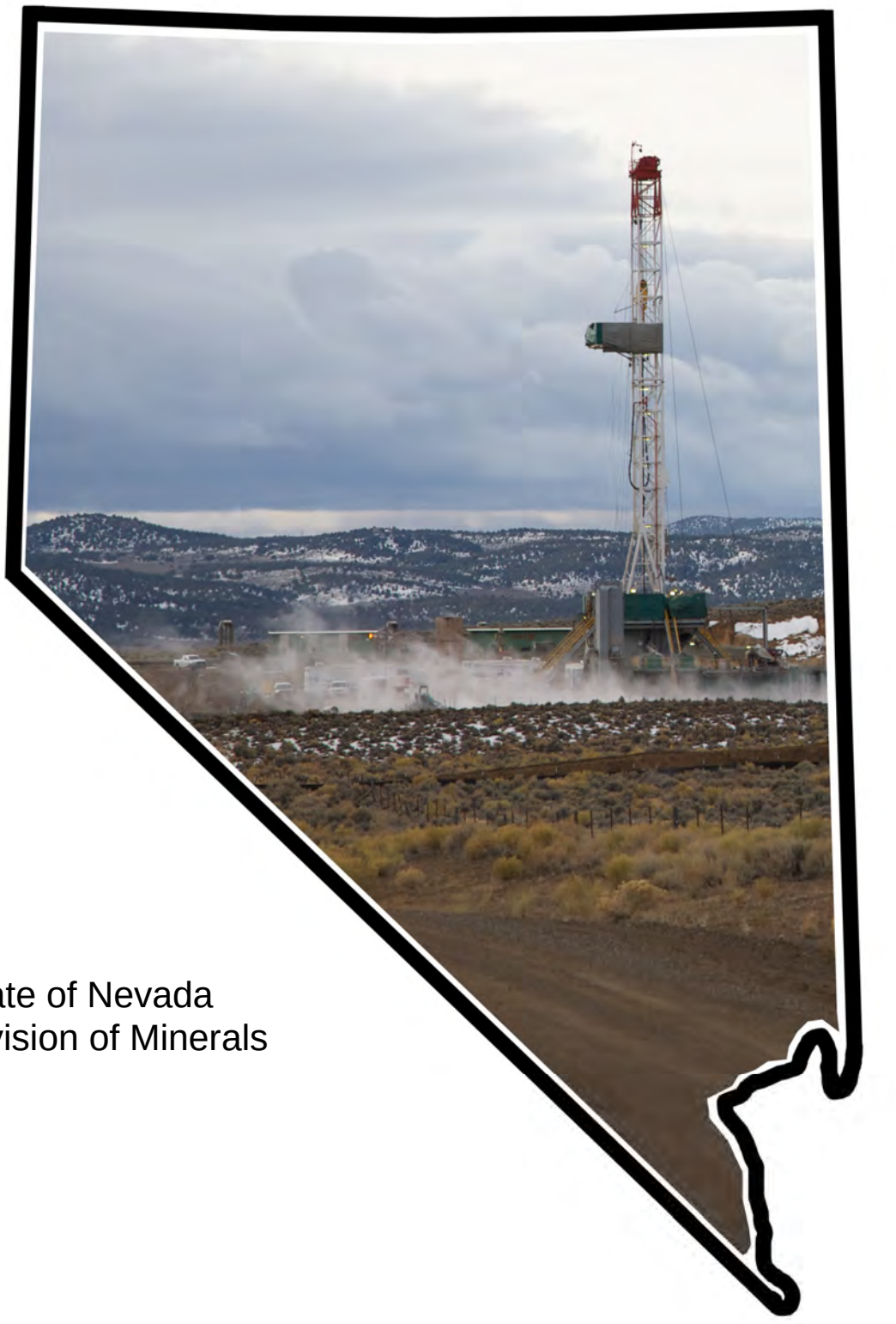
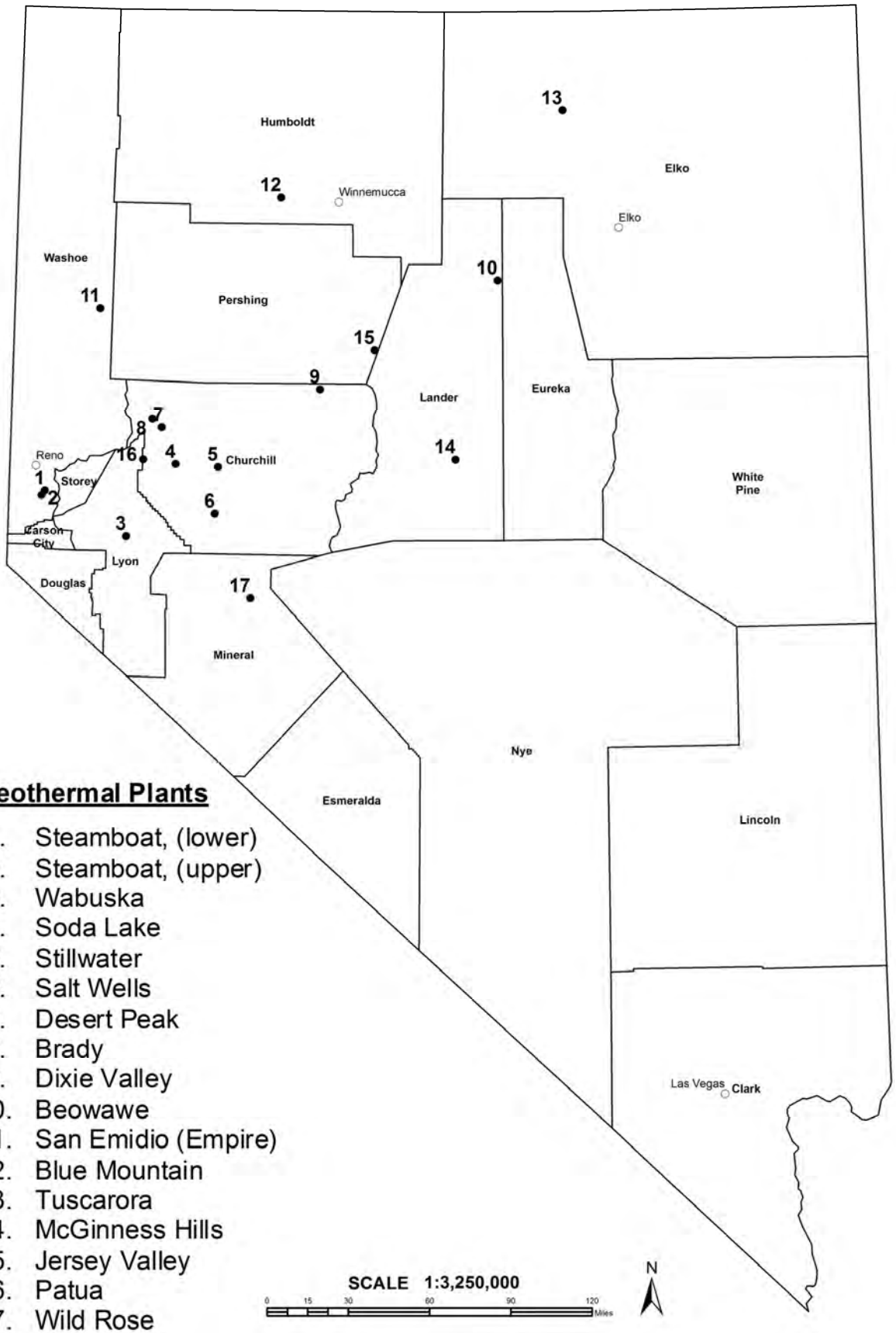
Geothermal Resources in Nevada Activity Book 2015



State of Nevada
Division of Minerals

Geothermal Plants 2015



Geothermal Plants

1. Steamboat, (lower)
2. Steamboat, (upper)
3. Wabuska
4. Soda Lake
5. Stillwater
6. Salt Wells
7. Desert Peak
8. Brady
9. Dixie Valley
10. Beowawe
11. San Emidio (Empire)
12. Blue Mountain
13. Tuscarora
14. McGinness Hills
15. Jersey Valley
16. Patua
17. Wild Rose

Geothermal Resources in Nevada Activity Book 2015

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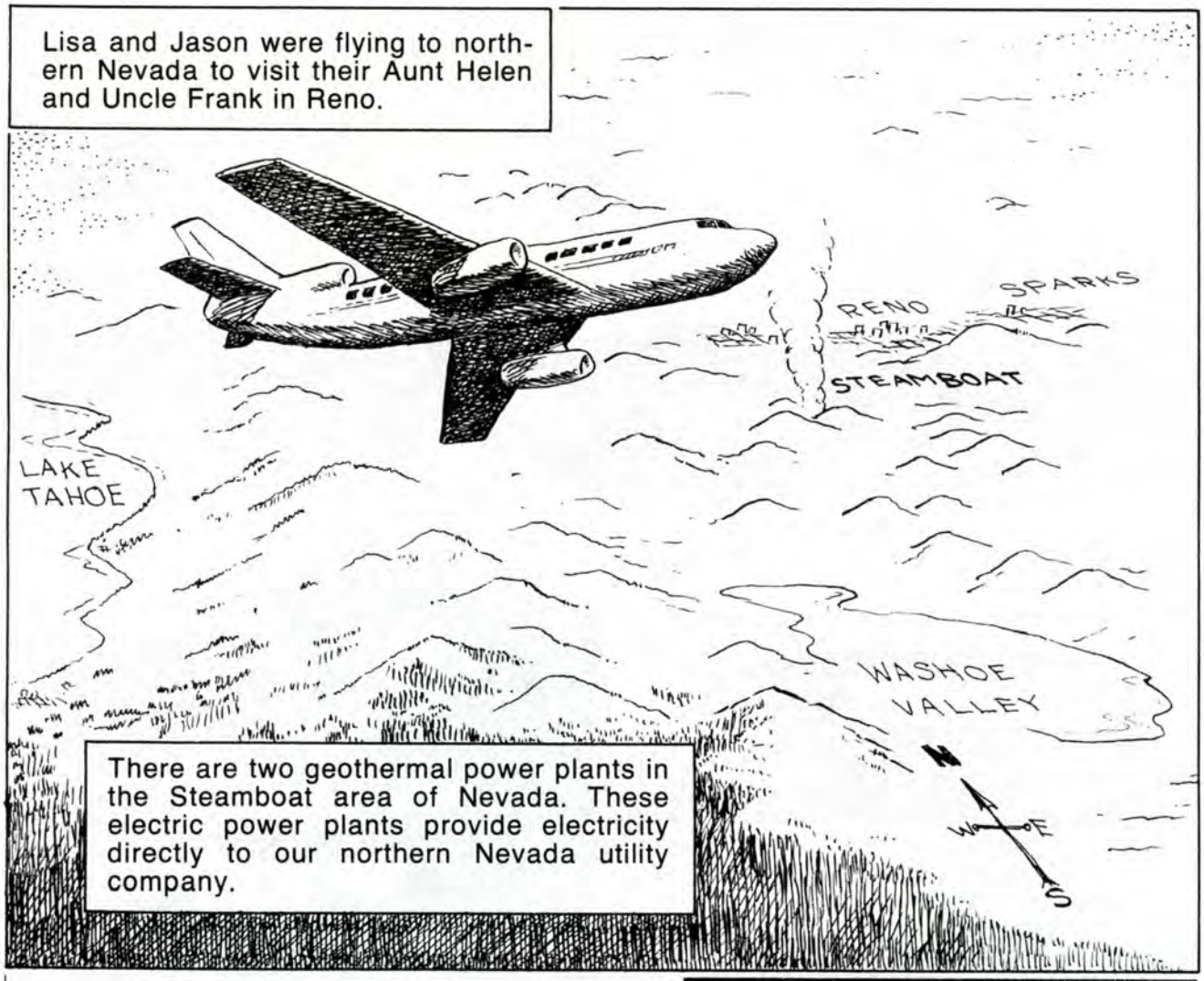
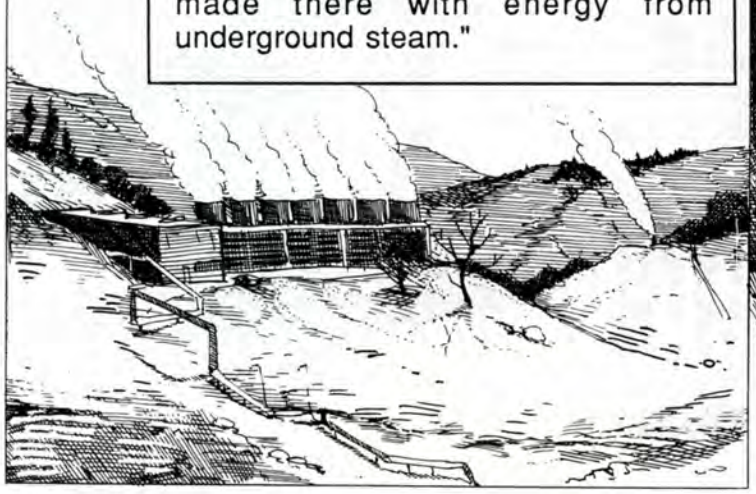
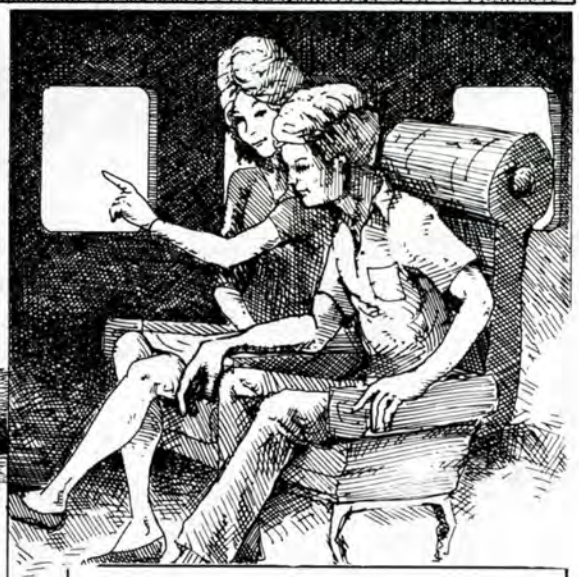
Lisa and Jason were flying to northern Nevada to visit their Aunt Helen and Uncle Frank in Reno.



There are two geothermal power plants in the Steamboat area of Nevada. These electric power plants provide electricity directly to our northern Nevada utility company.

The plane passed near Steamboat. Lisa and Jason saw white puffs rising from rugged, green hillsides. "On your right is the Steamboat geothermal field," said the pilot. "Electricity is made there with energy from underground steam."





"Where does the steam come from? I hope we can visit Steamboat and find out."


Lisa and Jason prepared to land.
Uncle Frank and Aunt Helen met them at the airplane.
Uncle Frank, we saw a lot of steam puffs coming from Steamboat.
And we flew over the power plant. Have you ever been to the Steamboat geothermal field?
Yes, I've been there many times. Your Aunt Helen is a geologist interested in geothermal energy.
Could you tell us about geothermal energy?
Sure.
What does "geothermal" mean, Aunt Helen?
"Geo" means "earth", and "thermal" means "heat".

"Geothermal" means the "heat from the earth."

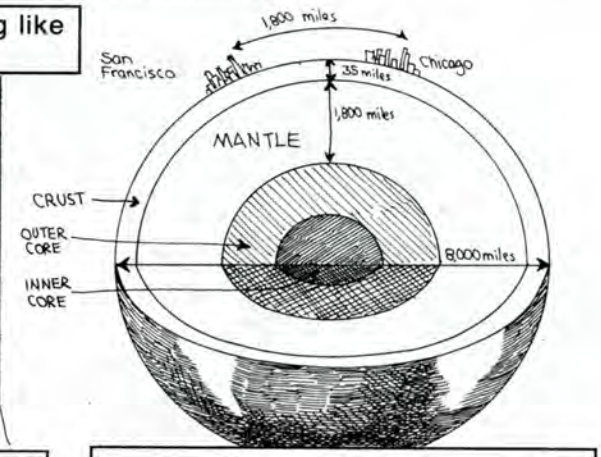
You mean, the earth is hot inside?

Oh, yes. Even though it may be cold outdoors, the deeper in the earth you go, the hotter it gets, all the way to the center, about 4,000 miles below us. Enough heat is in the earth to supply our energy needs for millions of years. But, most of the heat is too deep for us to use.

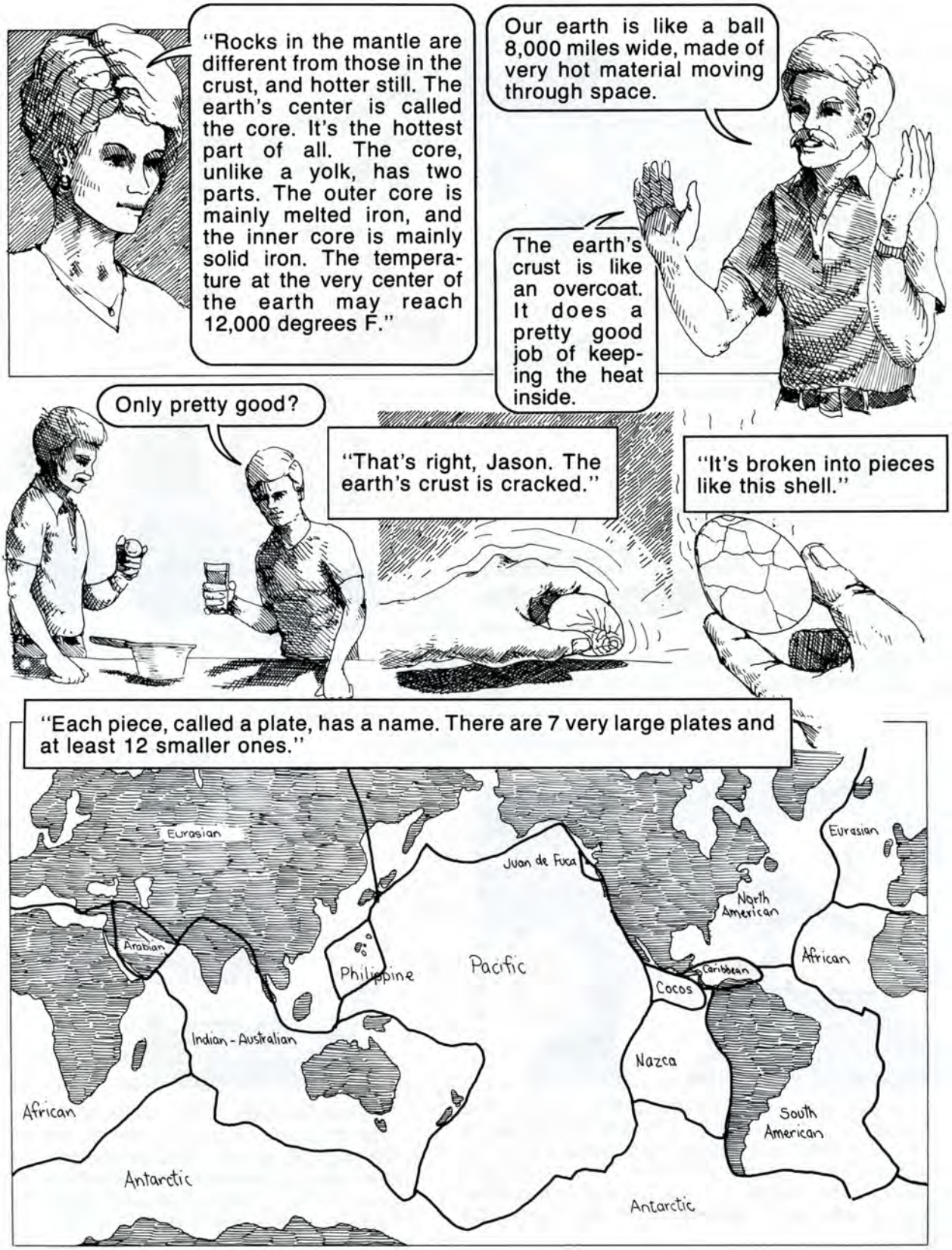
"In oil fields, water and oil pumped from wells over 2 miles deep are almost as hot as boiling water," said Aunt Helen, as she lifted a pan of eggs from the stove.

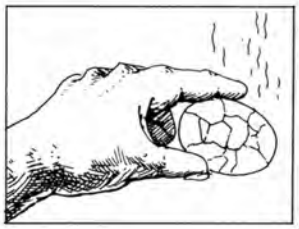
"In fact, the inside of the earth is something like the inside of this hardboiled egg."

"Lisa, pretend the egg shell is the land we live on, the crust of the earth. The shell, or crust, is about 3 miles thick under the oceans and up to 35 miles thick under the land. The crust gets very hot. The deeper you go, the hotter it gets — about 2 degrees Fahrenheit (F) for every 100 feet."

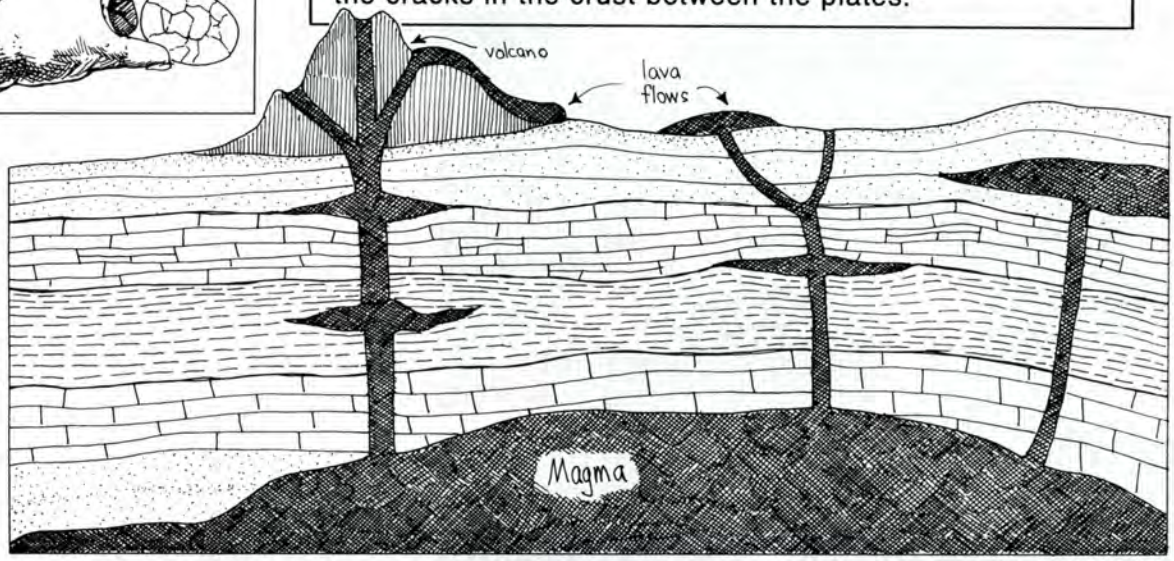


"Below the crust is the white of the egg, the part of the earth we call the mantle. It is about 1,800 miles thick, the distance between San Francisco and Chicago. The mantle ends about halfway to the center of the earth."


"Rocks in the mantle are different from those in the crust, and hotter still. The earth's center is called the core. It's the hottest part of all. The core, unlike a yolk, has two parts. The outer core is mainly melted iron, and the inner core is mainly solid iron. The temperature at the very center of the earth may reach 12,000 degrees F."
Our earth is like a ball 8,000 miles wide, made of very hot material moving through space.
The earth's crust is like an overcoat. It does a pretty good job of keeping the heat inside.
Only pretty good?
"That's right, Jason. The earth's crust is cracked."
"It's broken into pieces like this shell."
"Each piece, called a plate, has a name. There are 7 very large plates and at least 12 smaller ones."
Eurasian
Juan de Fuca
North American
Eurasian
Arabian
Philippine
Pacific
Caribbean
African
Cocos
Indian - Australian
Nazca
African
South American
Antarctic
Antarctic



"Like the steam rising through the cracks in the shell, streams of hot, melted rock, called magma, rise through the cracks in the crust between the plates."



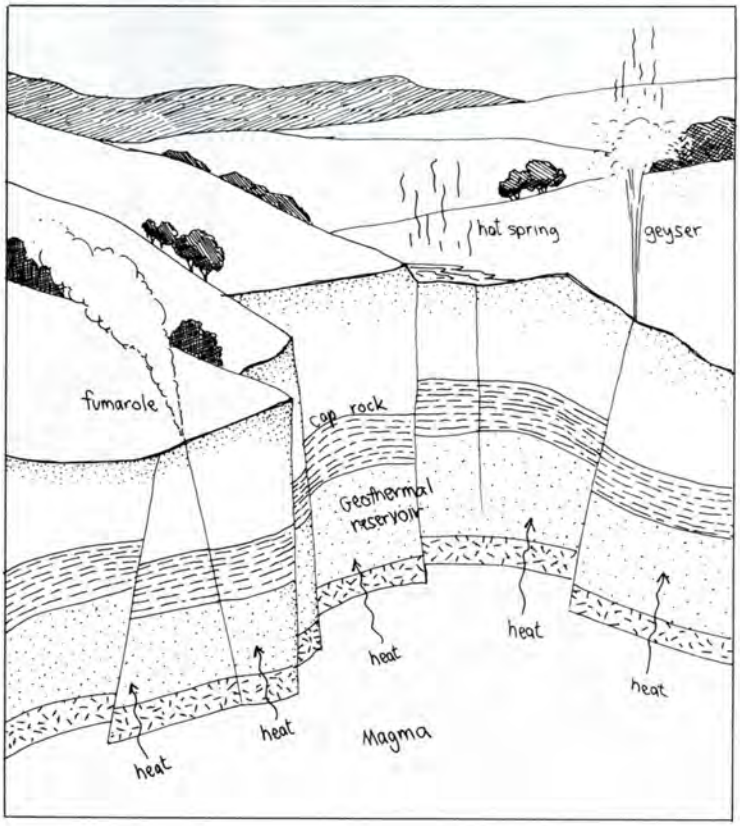
"Some of the magma reaches the surface, where it's called lava. The lava cools and hardens quickly, forming features such as volcanos and lava flows. The magma still underground cools and hardens much more slowly. For a long time, maybe thousands of years, it heats nearby rocks and water."

"The magma and the hot rocks and hot water make up our geothermal resources.

"The hot water is called geothermal water. If it flows out on the surface, it's a hot spring. If it spurts out like a fountain, it's a geyser. If it puffs out as steam, it's a fumarole.

"Sometimes, the geothermal water is trapped underground in the hot rocks. This is called a geothermal reservoir.

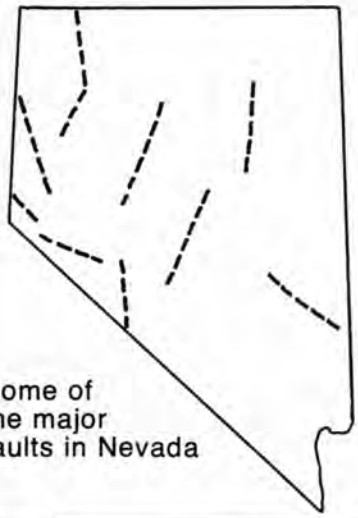
"In Nevada we have hundreds of hot springs and fumaroles, and many geothermal reservoirs."



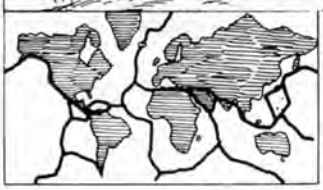
The cracks are important, aren't they? Geothermal resources and cracks in the earth go together!

"That's right," said Aunt Helen. "The cracks are called faults, and there are many in Nevada."

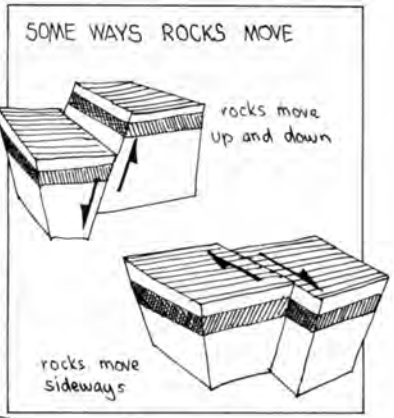
"What causes the cracks?" asked Lisa.

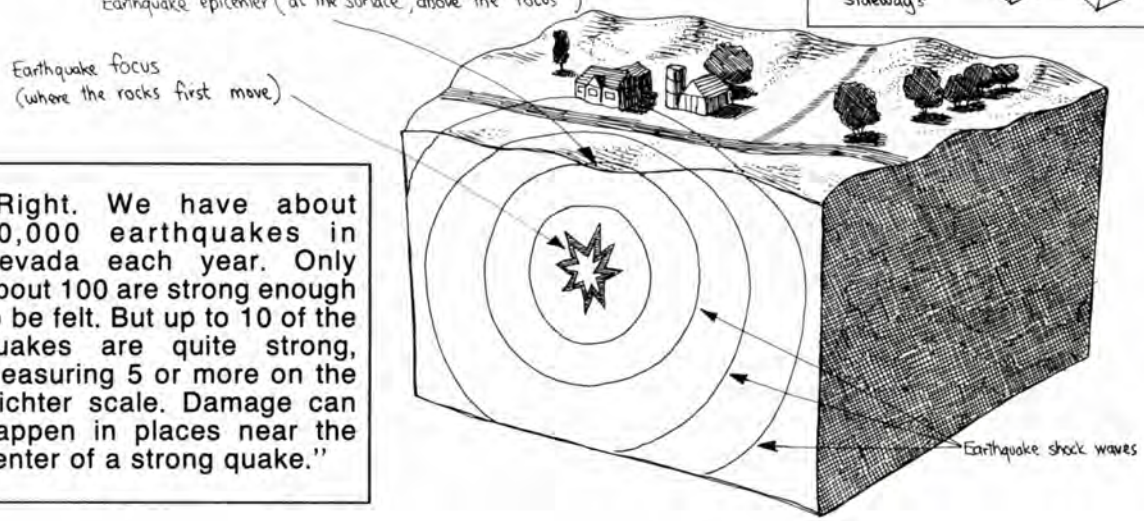


Some of the major faults in Nevada

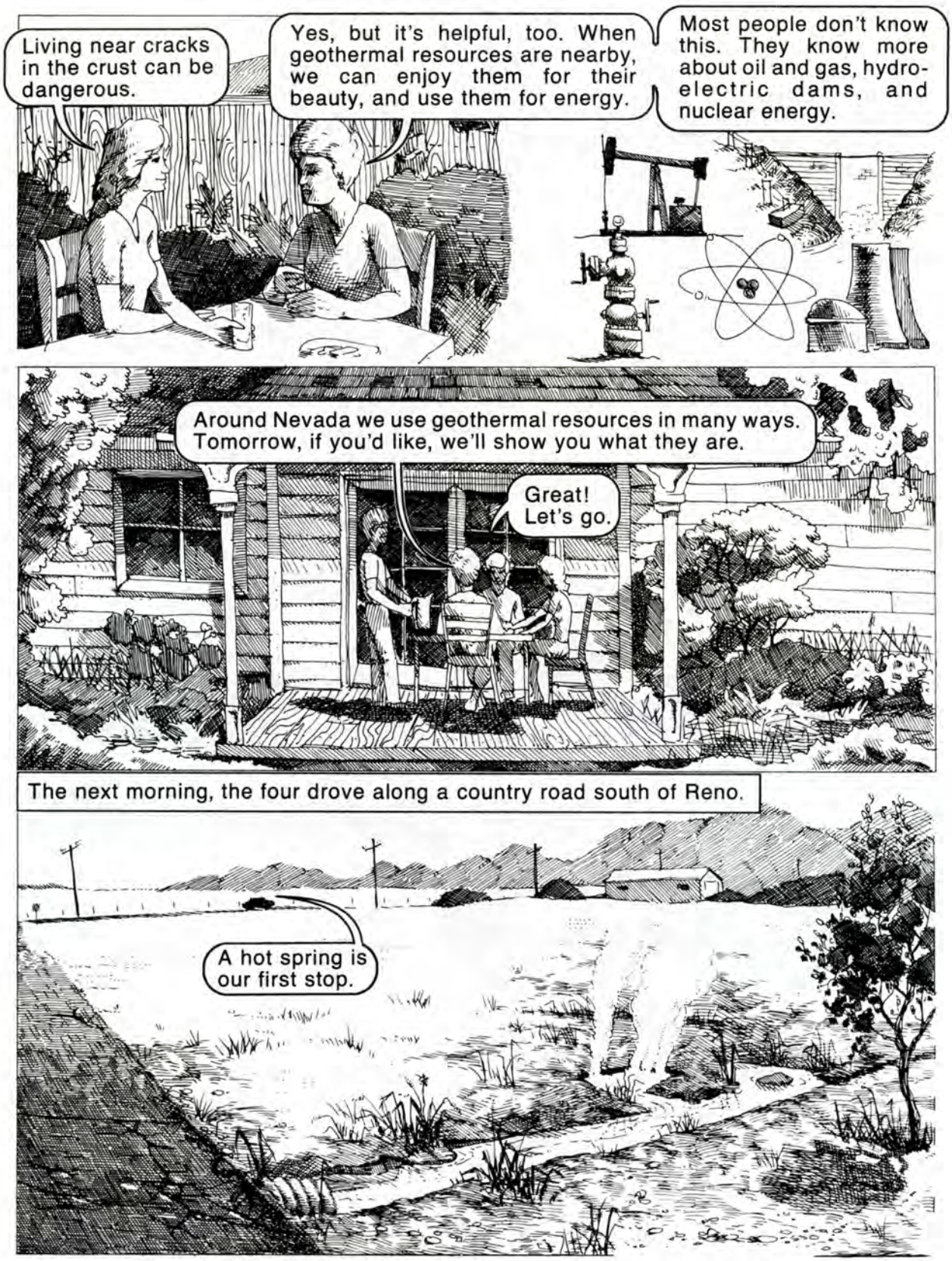


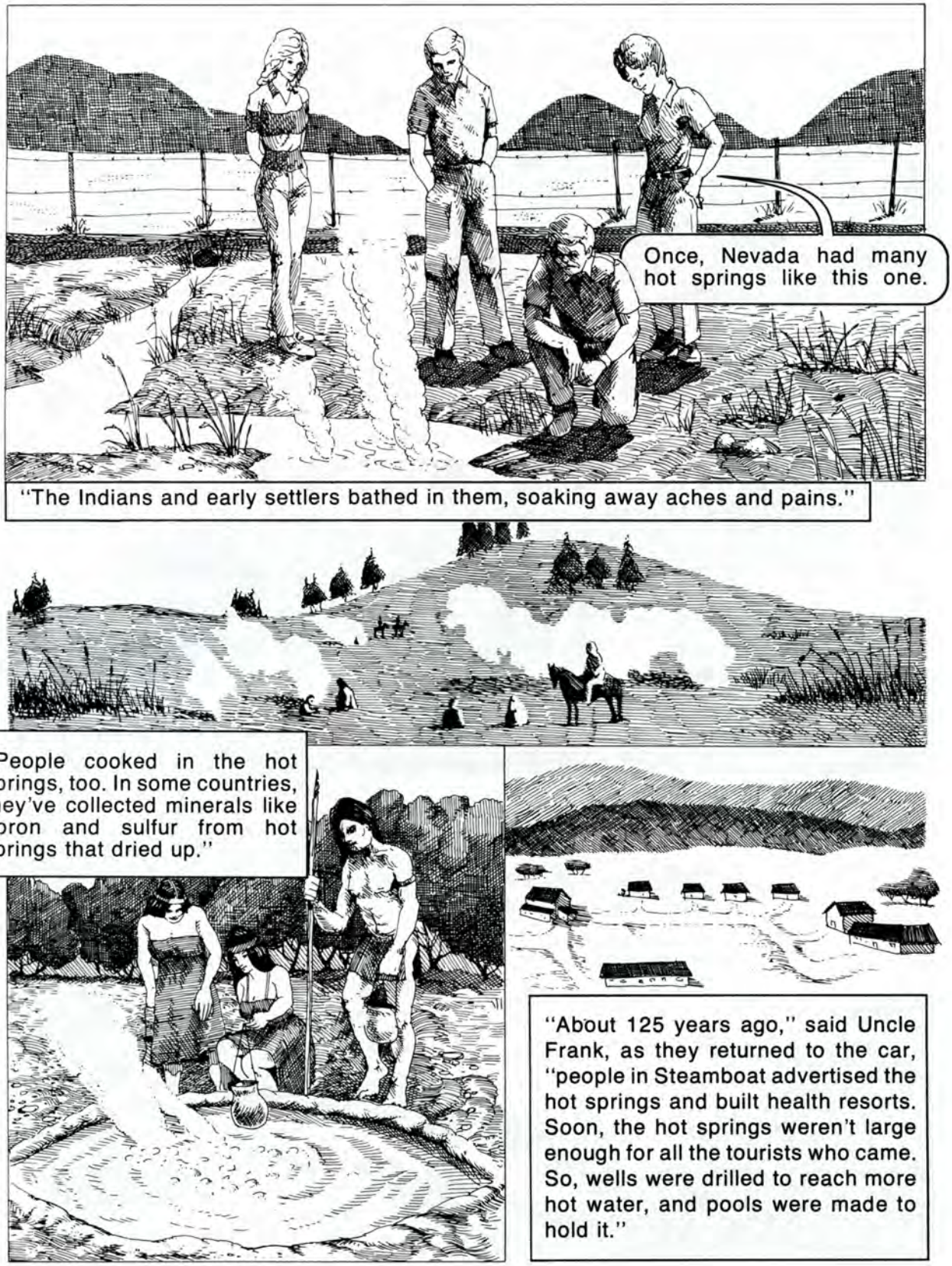
"The plates in the earth's crust are always moving," said Uncle Frank. "This strains the rocks. Finally, they break with a jolt and slip past each other. The jolts are what we call . . . ."

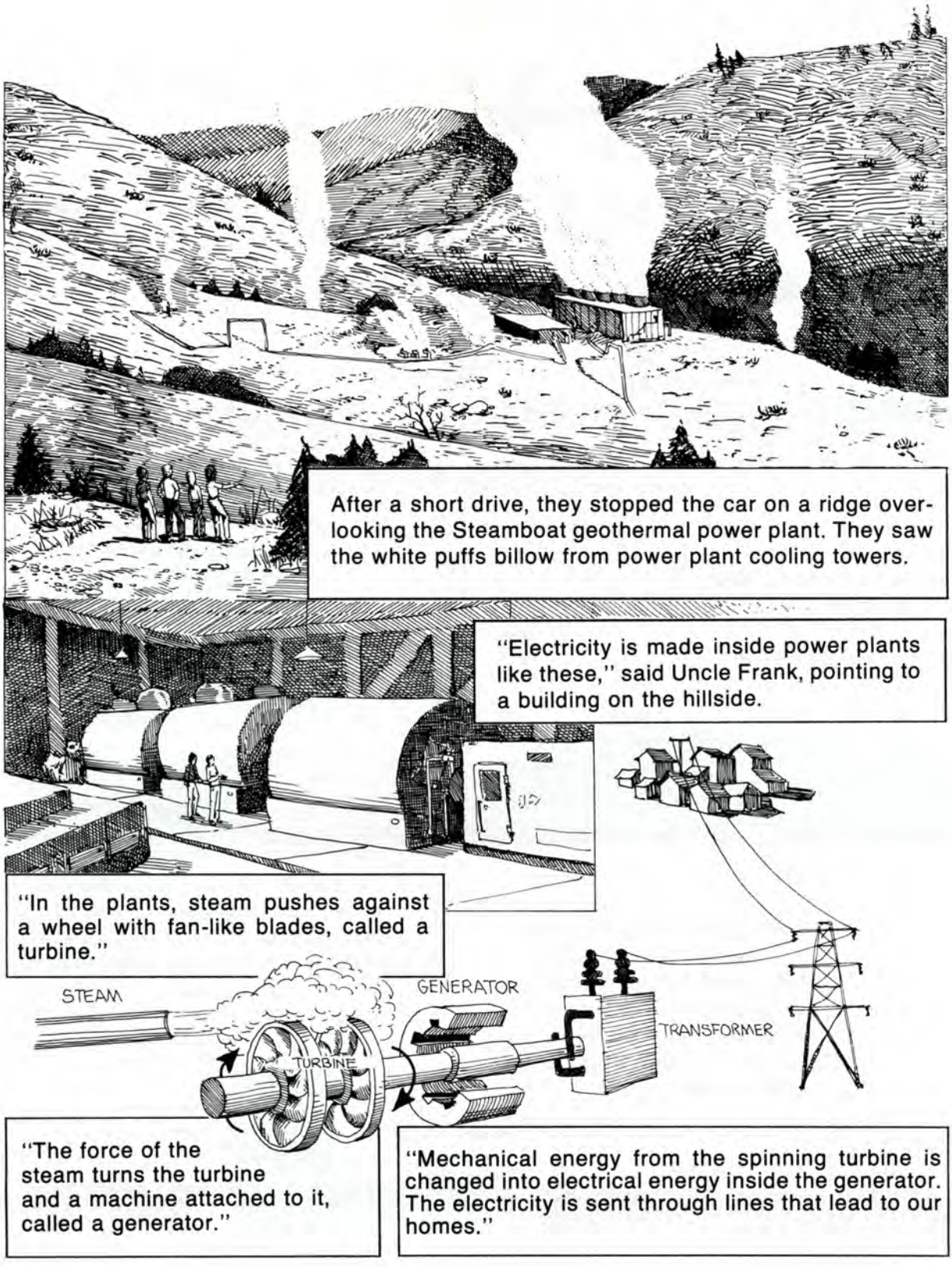


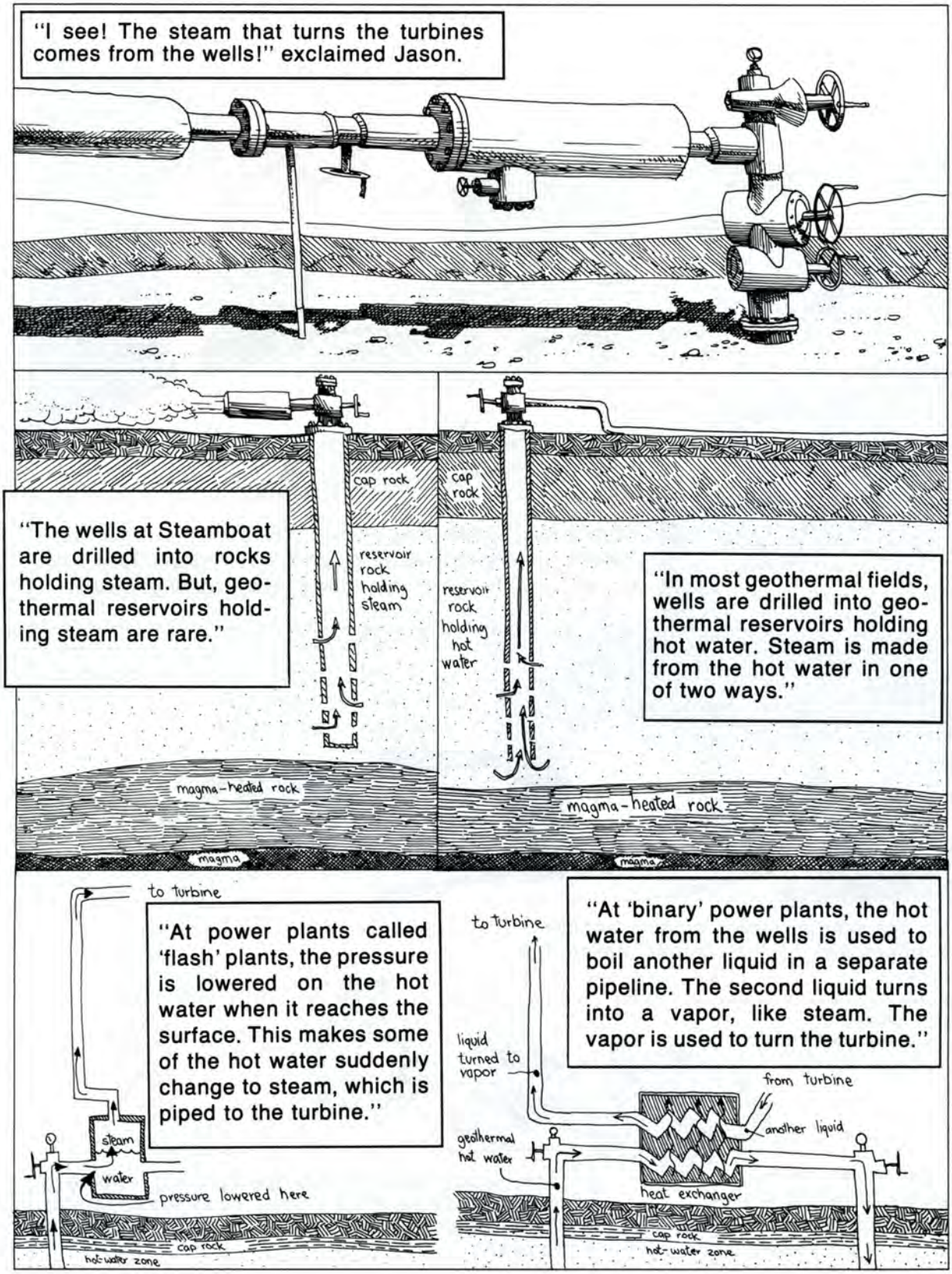


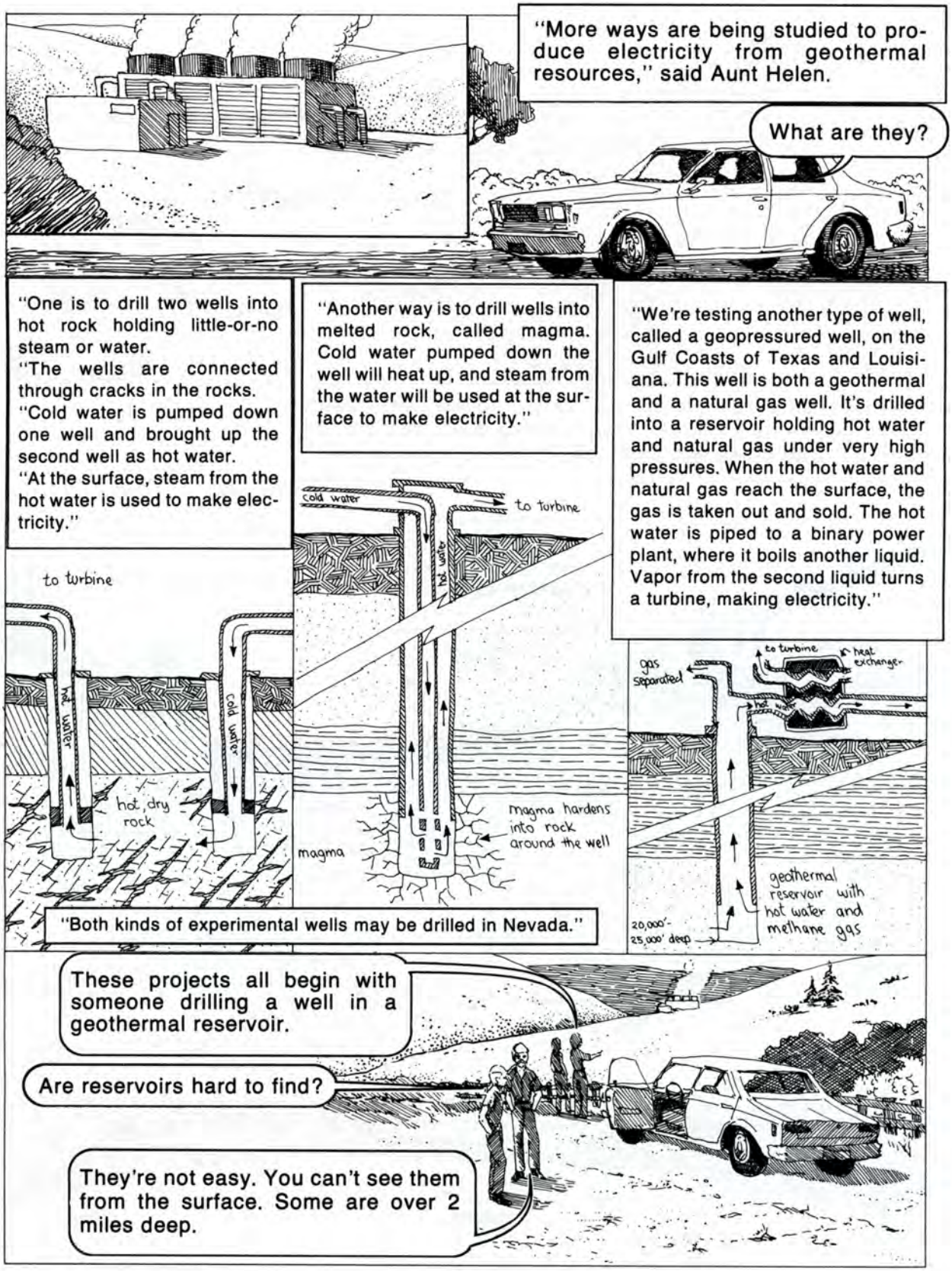
"Right. We have about 10,000 earthquakes in Nevada each year. Only about 100 are strong enough to be felt. But up to 10 of the quakes are quite strong, measuring 5 or more on the Richter scale. Damage can happen in places near the center of a strong quake."

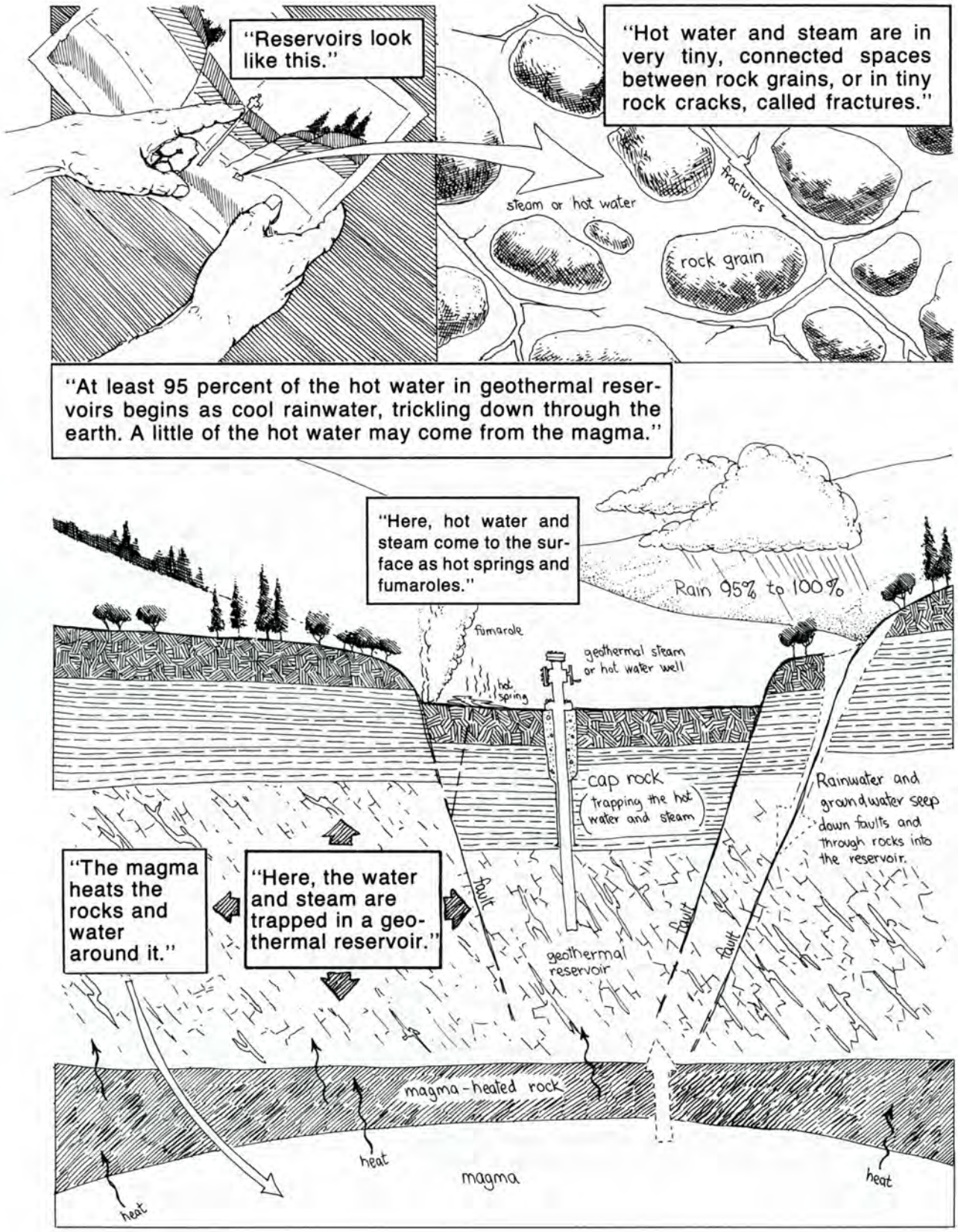

Living near cracks in the crust can be dangerous.
Yes, but it's helpful, too. When geothermal resources are nearby, we can enjoy them for their beauty, and use them for energy.
Most people don't know this. They know more about oil and gas, hydro-electric dams, and nuclear energy.
Around Nevada we use geothermal resources in many ways. Tomorrow, if you'd like, we'll show you what they are.
Great! Let's go.
The next morning, the four drove along a country road south of Reno.
A hot spring is our first stop.


Once, Nevada had many hot springs like this one.
"The Indians and early settlers bathed in them, soaking away aches and pains."
"People cooked in the hot springs, too. In some countries, they've collected minerals like boron and sulfur from hot springs that dried up."
"About 125 years ago," said Uncle Frank, as they returned to the car, "people in Steamboat advertised the hot springs and built health resorts. Soon, the hot springs weren't large enough for all the tourists who came. So, wells were drilled to reach more hot water, and pools were made to hold it."


After a short drive, they stopped the car on a ridge overlooking the Steamboat geothermal power plant. They saw the white puffs billow from power plant cooling towers.
"Electricity is made inside power plants like these," said Uncle Frank, pointing to a building on the hillside.
"In the plants, steam pushes against a wheel with fan-like blades, called a turbine."
STEAM
GENERATOR
TURBINE
TRANSFORMER
"The force of the steam turns the turbine and a machine attached to it, called a generator."
"Mechanical energy from the spinning turbine is changed into electrical energy inside the generator. The electricity is sent through lines that lead to our homes."

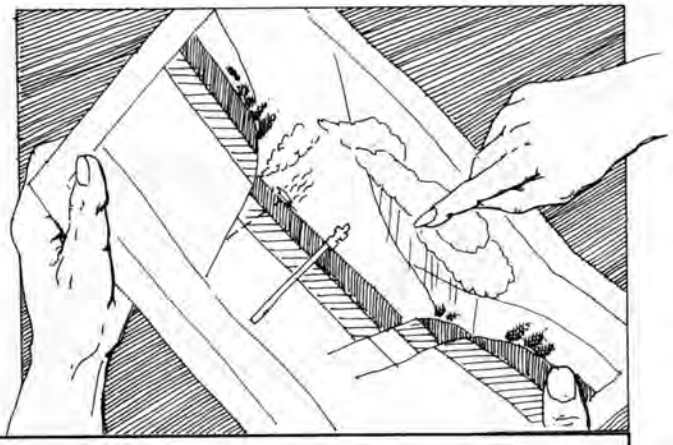

"I see! The steam that turns the turbines comes from the wells!" exclaimed Jason.
"The wells at Steamboat are drilled into rocks holding steam. But, geothermal reservoirs holding steam are rare."
cap rock
reservoir rock holding steam
magma-heated rock
magma
cap rock
reservoir rock holding hot water
"In most geothermal fields, wells are drilled into geothermal reservoirs holding hot water. Steam is made from the hot water in one of two ways."
magma-heated rock
magma
to turbine
"At power plants called 'flash' plants, the pressure is lowered on the hot water when it reaches the surface. This makes some of the hot water suddenly change to steam, which is piped to the turbine."
steam
water
pressure lowered here
cap rock
hot-water zone
to turbine
"At 'binary' power plants, the hot water from the wells is used to boil another liquid in a separate pipeline. The second liquid turns into a vapor, like steam. The vapor is used to turn the turbine."
liquid turned to vapor
from turbine
another liquid
geothermal hot water
heat exchanger
cap rock
hot-water zone


"More ways are being studied to produce electricity from geothermal resources," said Aunt Helen.
What are they?
"One is to drill two wells into hot rock holding little-or-no steam or water.
"The wells are connected through cracks in the rocks.
"Cold water is pumped down one well and brought up the second well as hot water.
"At the surface, steam from the hot water is used to make electricity."
"Another way is to drill wells into melted rock, called magma. Cold water pumped down the well will heat up, and steam from the water will be used at the surface to make electricity."
"We're testing another type of well, called a geopressured well, on the Gulf Coasts of Texas and Louisiana. This well is both a geothermal and a natural gas well. It's drilled into a reservoir holding hot water and natural gas under very high pressures. When the hot water and natural gas reach the surface, the gas is taken out and sold. The hot water is piped to a binary power plant, where it boils another liquid. Vapor from the second liquid turns a turbine, making electricity."
to turbine
hot water
cold water
hot, dry rock
cold water
to turbine
hot water
magma
magma hardens into rock around the well
to turbine
heat exchanger
gas separated
hot water
geothermal reservoir with hot water and methane gas
20,000'-25,000' deep
"Both kinds of experimental wells may be drilled in Nevada."
These projects all begin with someone drilling a well in a geothermal reservoir.
Are reservoirs hard to find?
They're not easy. You can't see them from the surface. Some are over 2 miles deep.


"Reservoirs look like this."
"Hot water and steam are in very tiny, connected spaces between rock grains, or in tiny rock cracks, called fractures."
steam or hot water
fractures
rock grain
"At least 95 percent of the hot water in geothermal reservoirs begins as cool rainwater, trickling down through the earth. A little of the hot water may come from the magma."
"Here, hot water and steam come to the surface as hot springs and fumaroles."
Rain 95% to 100%
fumarole
hot spring
geothermal steam or hot water well
cap rock
trapping the hot water and steam
Rainwater and groundwater seep down faults and through rocks into the reservoir.
"The magma heats the rocks and water around it."
"Here, the water and steam are trapped in a geothermal reservoir."
fault
fault
fault
geothermal reservoir
magma-heated rock
heat
heat
heat
magma

"I see!" Lisa said. "The rainfall continues to refill the fractures and the spaces between the rock grains.

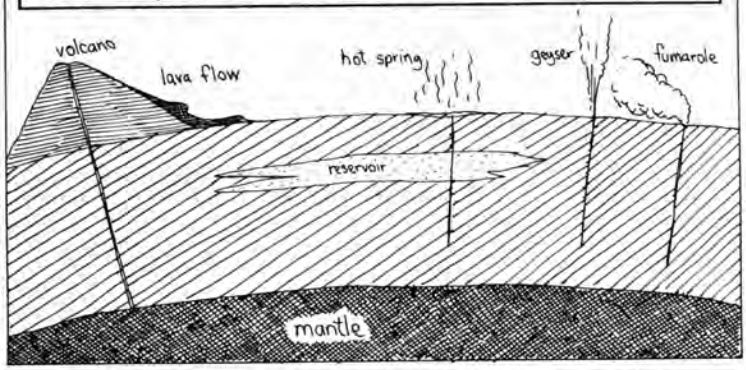
"Yes," said Uncle Frank, "and the hot rocks continue to heat the rainwater."

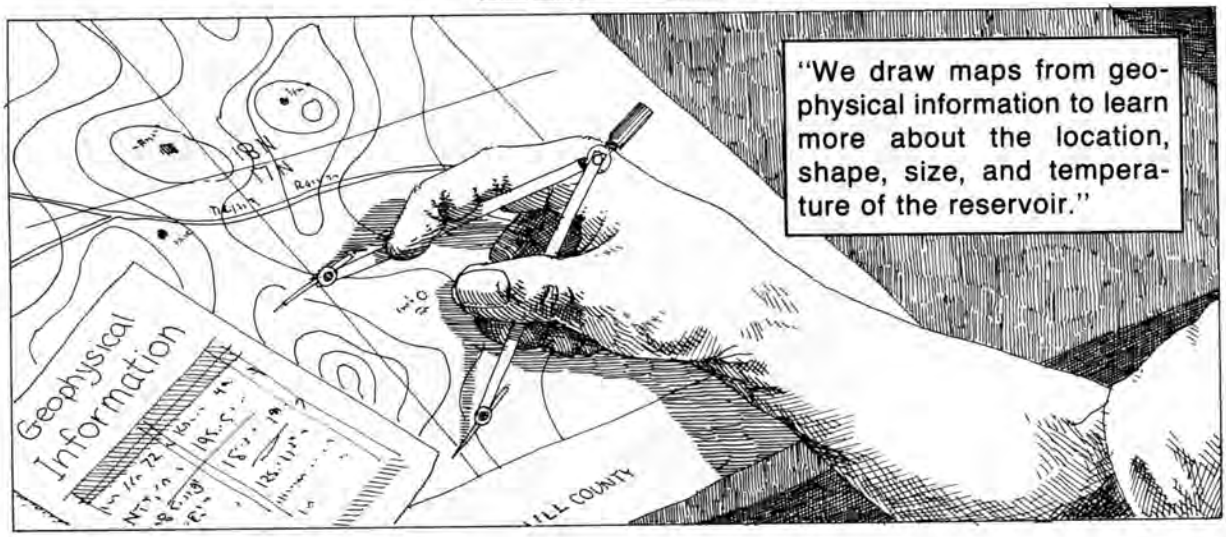


"This is why we call geothermal resources renewable. Many can be used over and over, maybe for hundreds of years. This is especially true when used geothermal water is returned to the reservoir through injection wells. Oil, natural gas, and other mineral resources are not renewable. They are used once and gone forever."

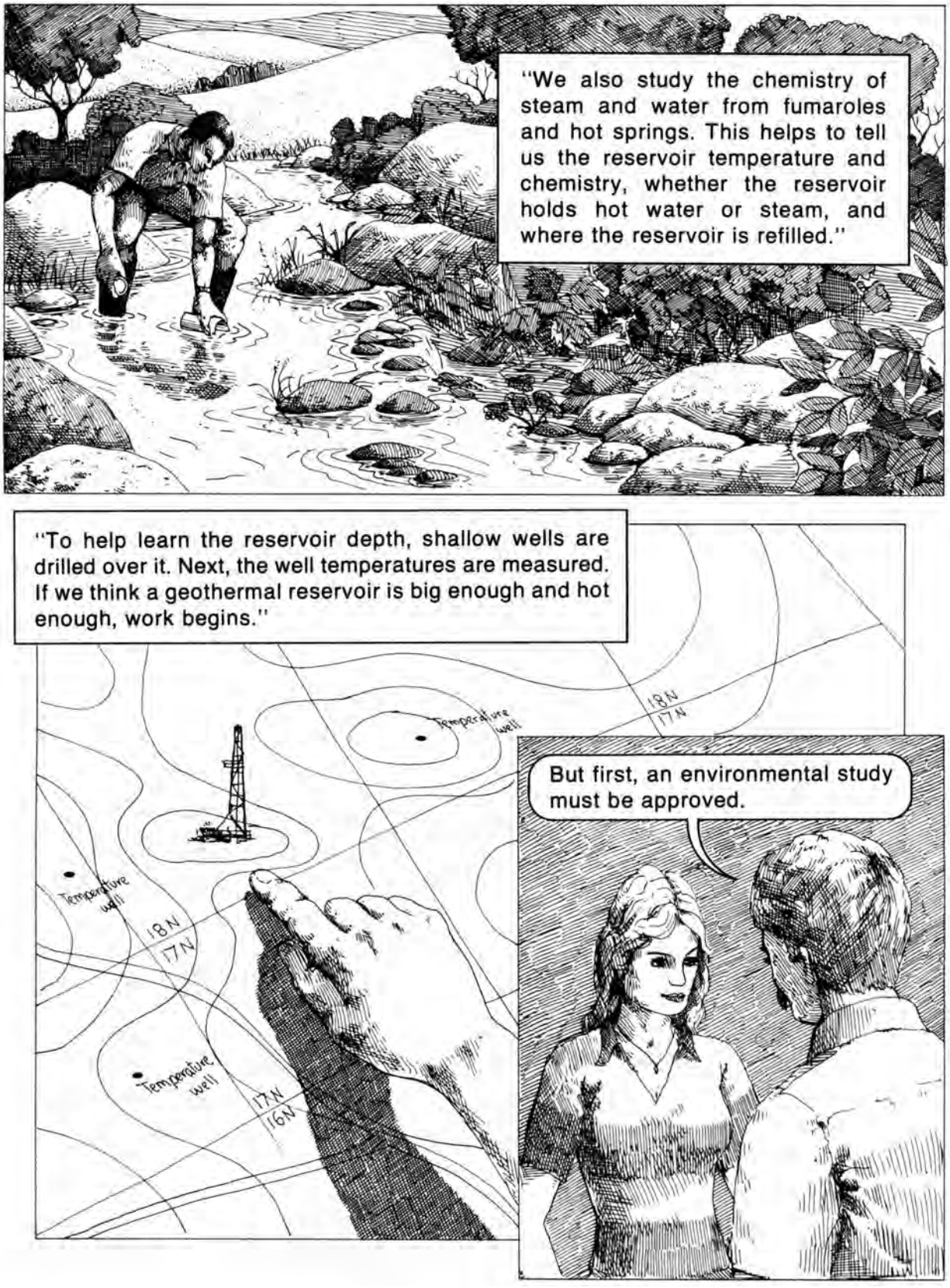
Are geothermal reservoirs near hot springs?

"Sometimes. Hot springs, fumaroles—all are signs, but not proof, that a reservoir is near," said Aunt Helen. "Special scientific information and tools help us discover the reservoirs."

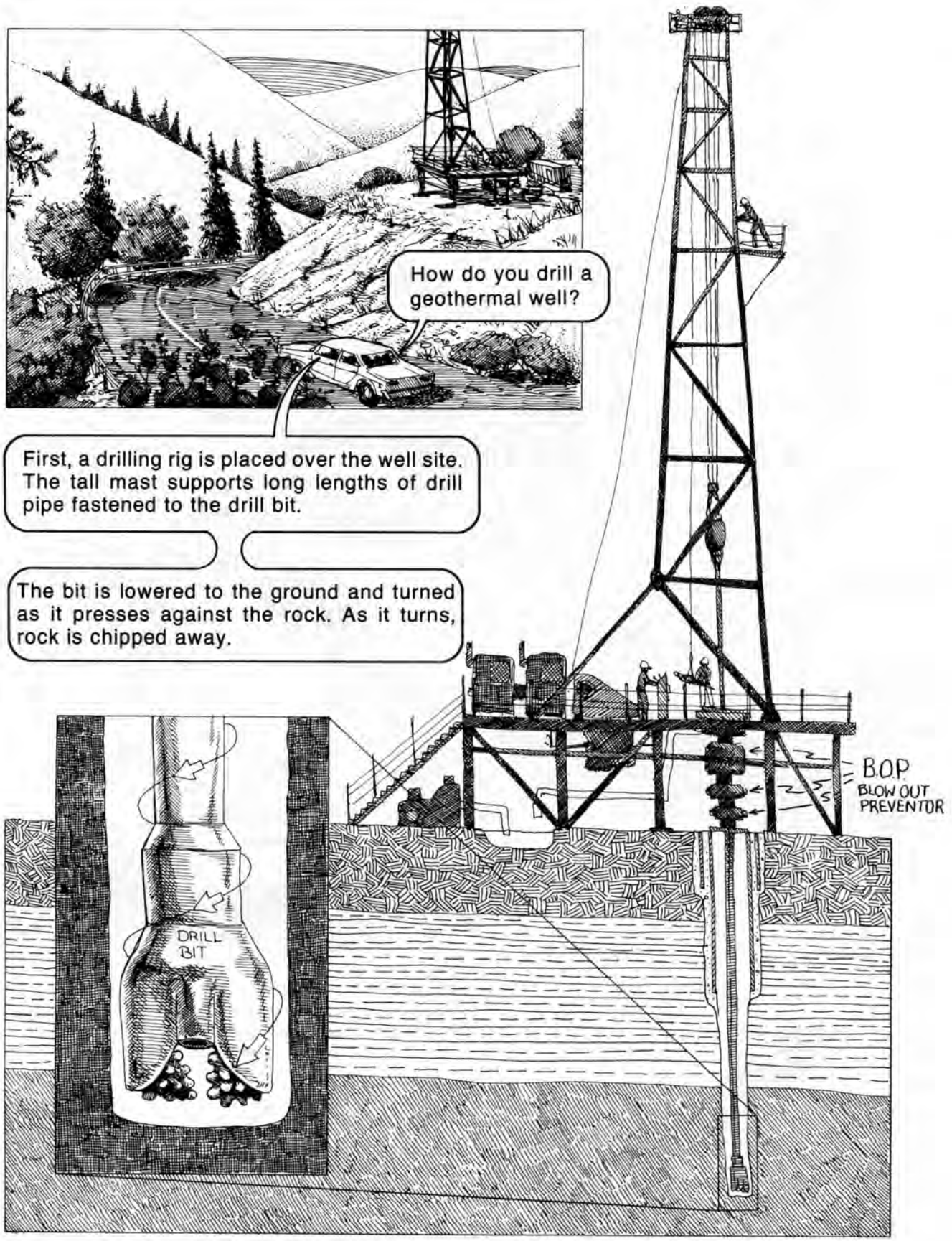


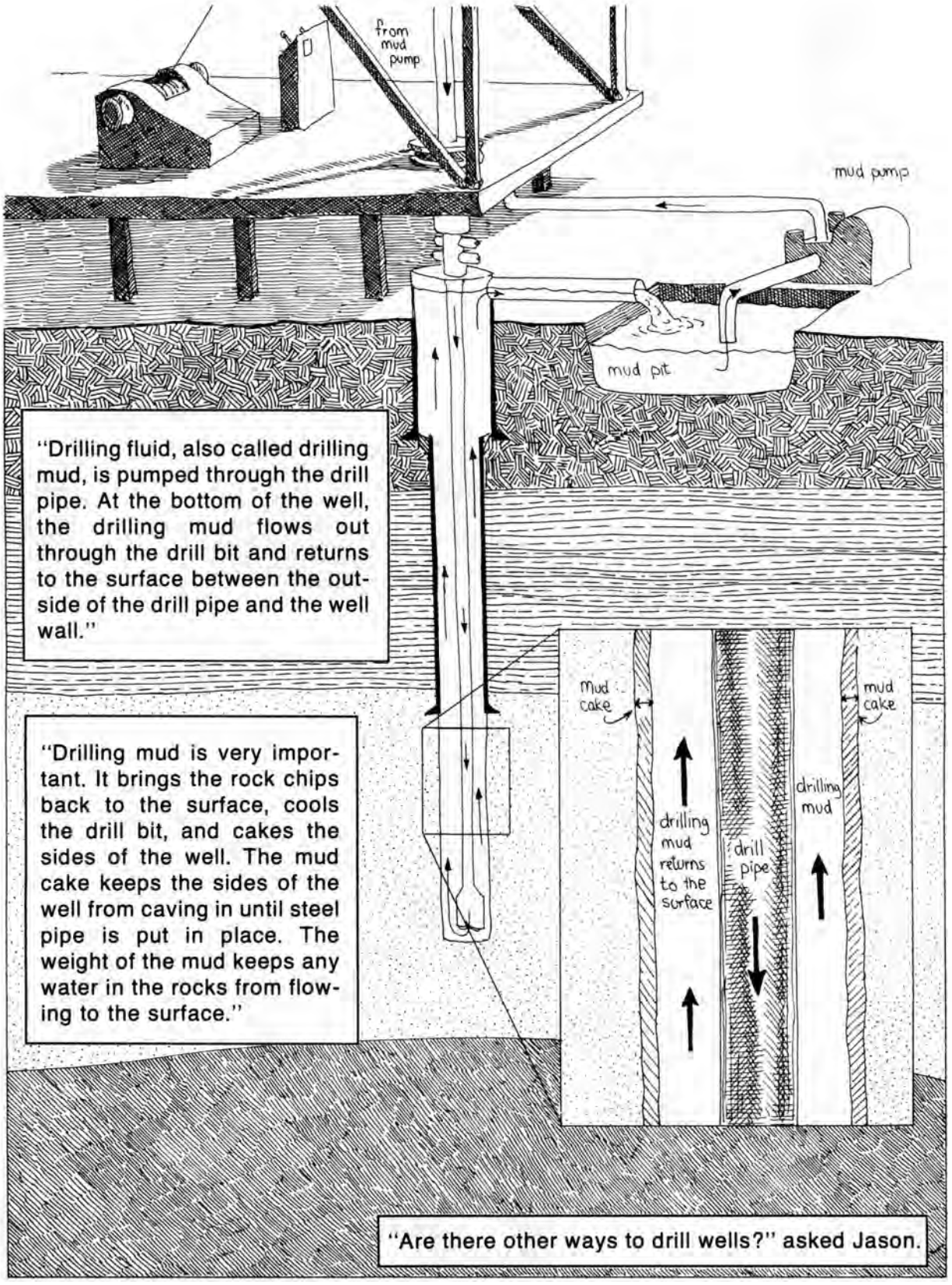


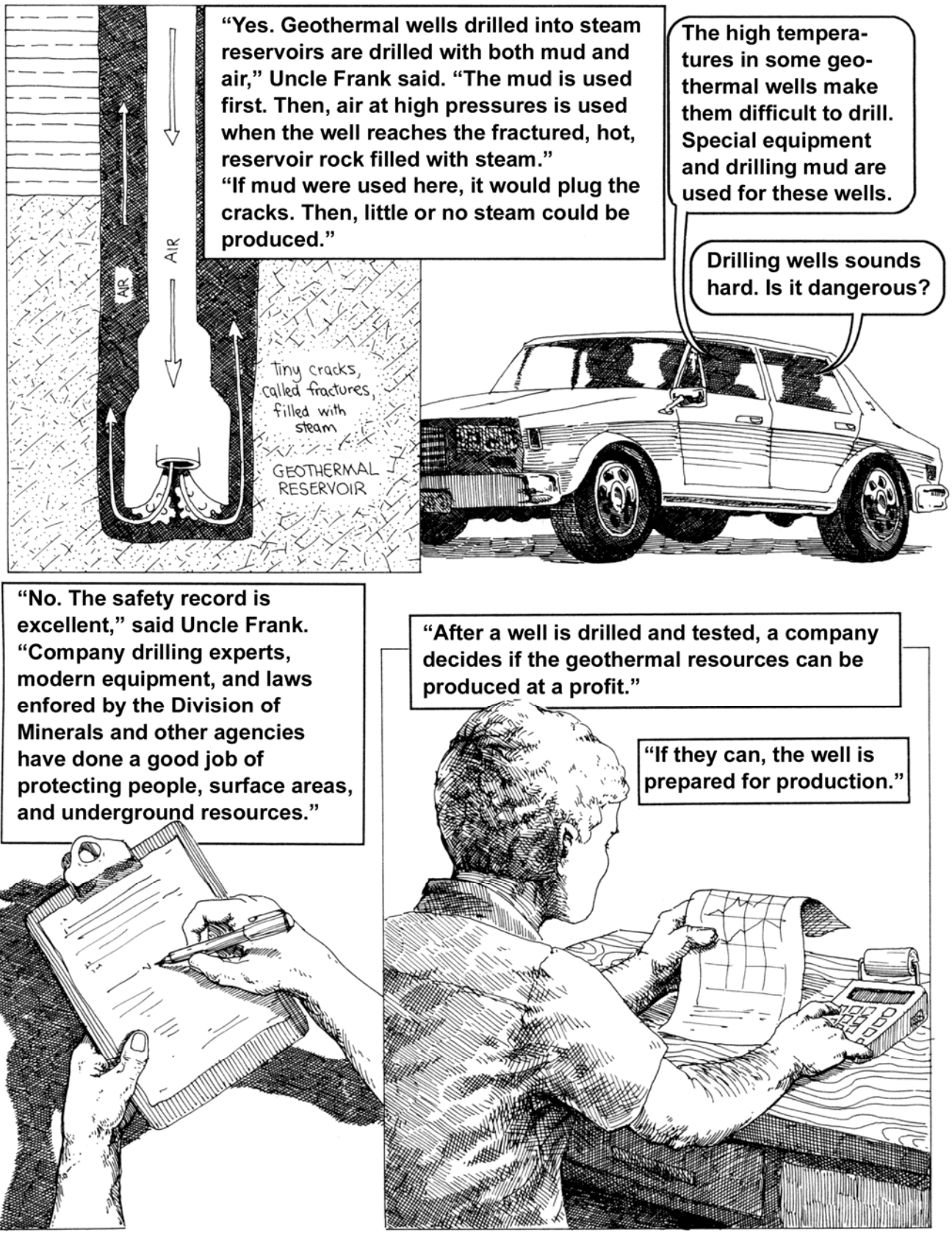
"We draw maps from geophysical information to learn more about the location, shape, size, and temperature of the reservoir."

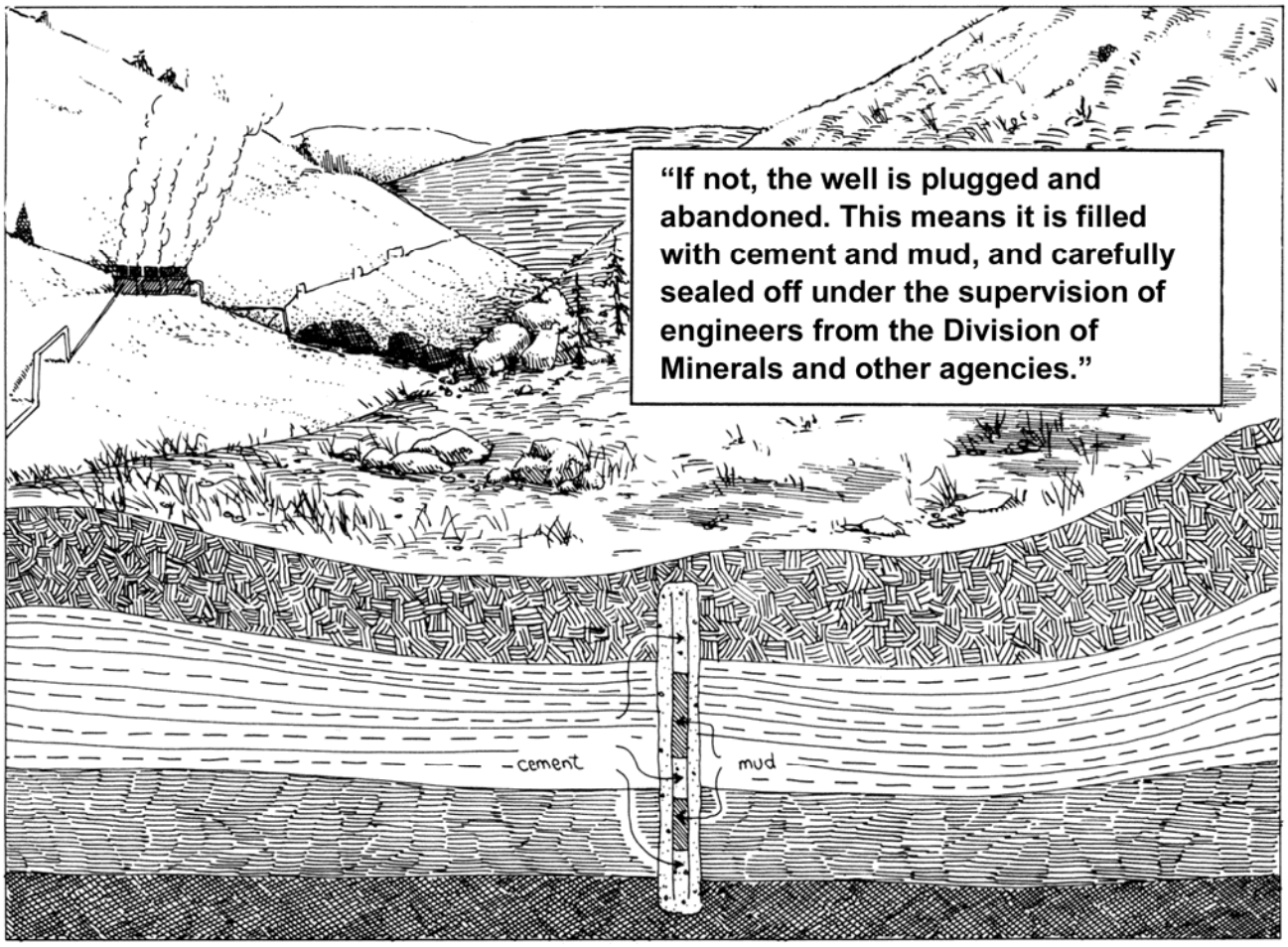

"We also study the chemistry of steam and water from fumaroles and hot springs. This helps to tell us the reservoir temperature and chemistry, whether the reservoir holds hot water or steam, and where the reservoir is refilled."
"To help learn the reservoir depth, shallow wells are drilled over it. Next, the well temperatures are measured. If we think a geothermal reservoir is big enough and hot enough, work begins."
Temperature well
18N
17N
Temperature well
18N
17N
Temperature well
17N
16N
But first, an environmental study must be approved.

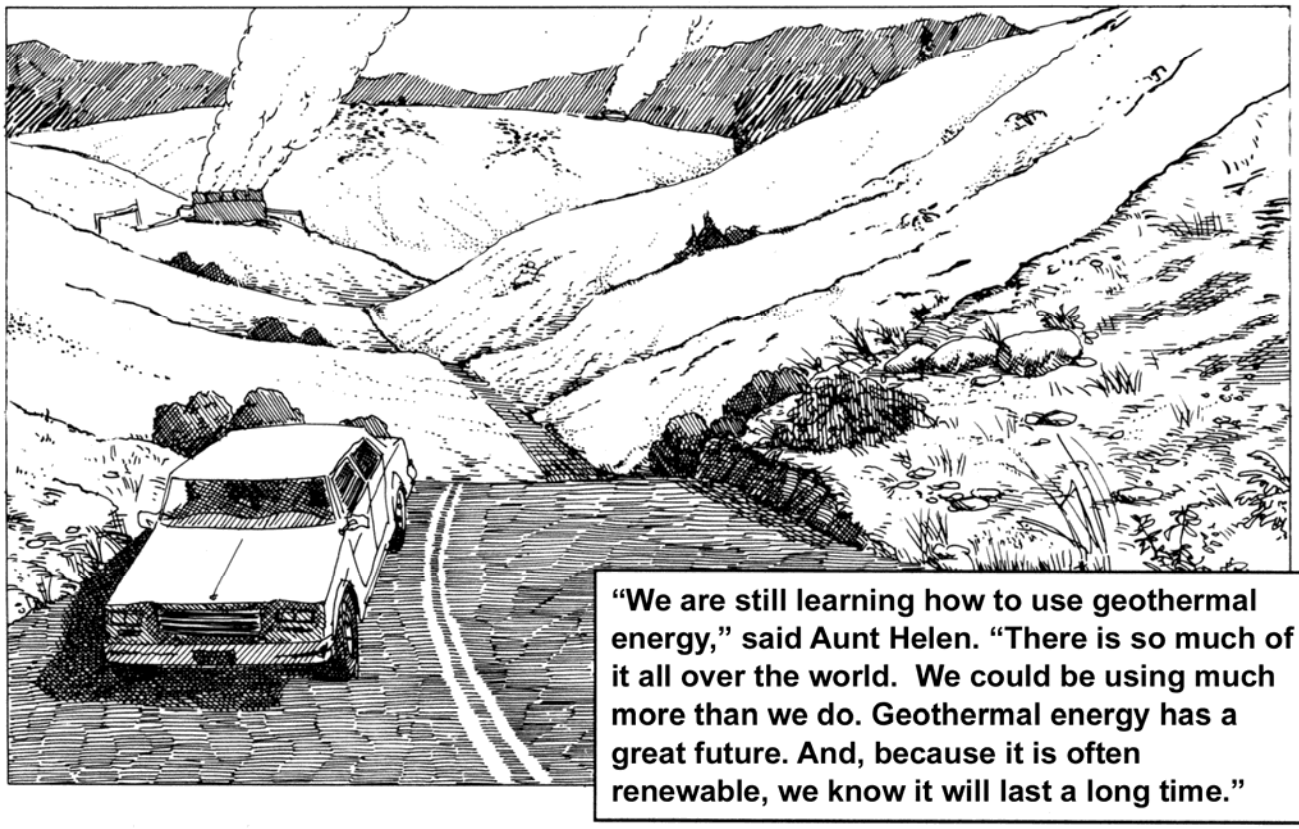

"What's that?" asked Jason.
"A description of the site as it is now—the natural and man-made areas, and a description of how the site will be changed by the project."
"A lot of paper work has to be made out and sent to several goverment agencies to obtain permits to drill a well."
"If a project is approved . . .
Permit to Drill
. . . a company can receive a drilling permit."

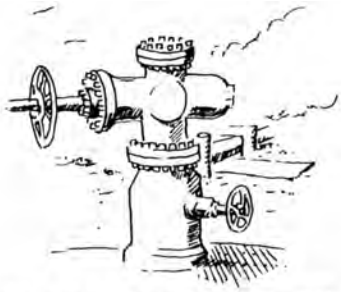

How do you drill a geothermal well?
First, a drilling rig is placed over the well site. The tall mast supports long lengths of drill pipe fastened to the drill bit.
The bit is lowered to the ground and turned as it presses against the rock. As it turns, rock is chipped away.
DRILL BIT
B.O.P
BLOW OUT PREVENTOR


from mud pump
mud pump
mud pit
"Drilling fluid, also called drilling mud, is pumped through the drill pipe. At the bottom of the well, the drilling mud flows out through the drill bit and returns to the surface between the outside of the drill pipe and the well wall."
"Drilling mud is very important. It brings the rock chips back to the surface, cools the drill bit, and cakes the sides of the well. The mud cake keeps the sides of the well from caving in until steel pipe is put in place. The weight of the mud keeps any water in the rocks from flowing to the surface."
mud cake
mud cake
drilling mud returns to the surface
drill pipe
drilling mud
"Are there other ways to drill wells?" asked Jason.


"Yes. Geothermal wells drilled into steam reservoirs are drilled with both mud and air," Uncle Frank said. "The mud is used first. Then, air at high pressures is used when the well reaches the fractured, hot, reservoir rock filled with steam."
"If mud were used here, it would plug the cracks. Then, little or no steam could be produced."
AIR
AIR
Tiny cracks, called fractures, filled with steam
GEOTHERMAL RESERVOIR
The high temperatures in some geothermal wells make them difficult to drill. Special equipment and drilling mud are used for these wells.
Drilling wells sounds hard. Is it dangerous?
"No. The safety record is excellent," said Uncle Frank. "Company drilling experts, modern equipment, and laws enfored by the Division of Minerals and other agencies have done a good job of protecting people, surface areas, and underground resources."
"After a well is drilled and tested, a company decides if the geothermal resources can be produced at a profit."
"If they can, the well is prepared for production."

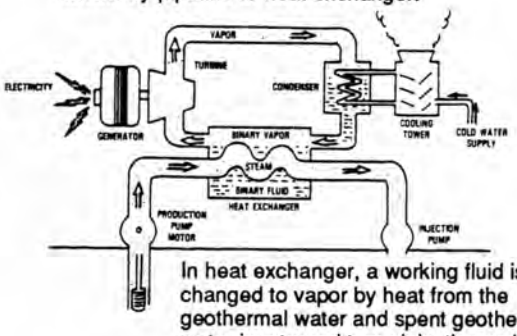

"If not, the well is plugged and abandoned. This means it is filled with cement and mud, and carefully sealed off under the supervision of engineers from the Division of Minerals and other agencies."
cement
mud


"We are still learning how to use geothermal energy," said Aunt Helen. "There is so much of it all over the world. We could be using much more than we do. Geothermal energy has a great future. And, because it is often renewable, we know it will last a long time."



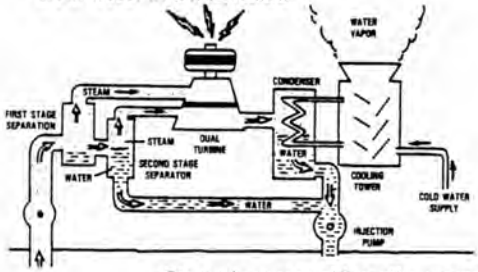
Steam and/or geothermal water is produced from well and gathered in pipeline and piped to geothermal power plant where electric power is produced.

A) In binary system, geothermal water travels by pipeline to heat exchanger.



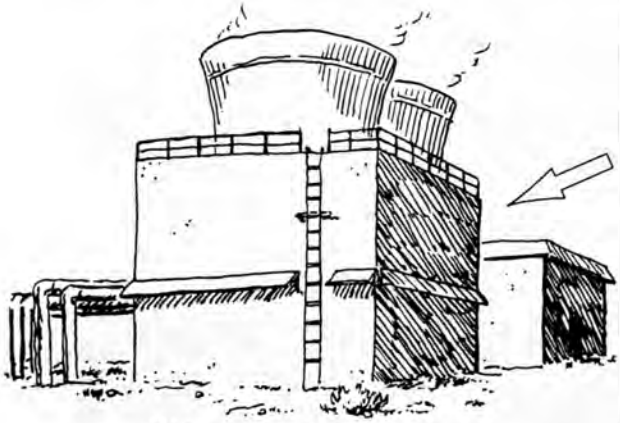
In heat exchanger, a working fluid is changed to vapor by heat from the geothermal water and spent geothermal water is returned to an injection well.

B) In flash system, steam is separated from water in a flash tank.

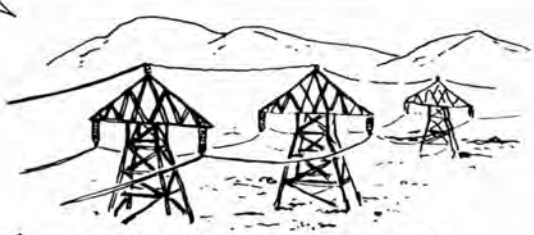


Steam is removed from the upper part of the tank by separation and unvaporized geothermal water is returned to an injection well.

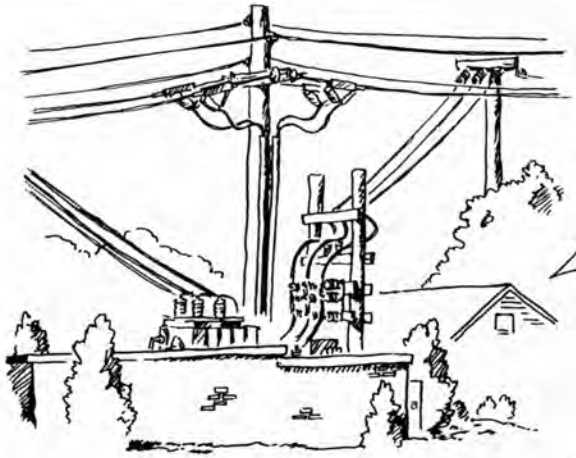
The vapor (A) or steam (B) then spins a turbine which drives a generator.



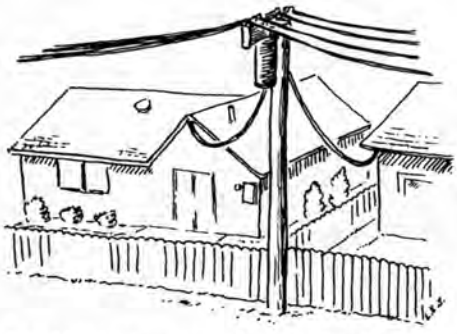
Water cooling towers.



In both systems, electricity generated is transmitted by transmission line.



The electricity is passed through a power substation for distribution.

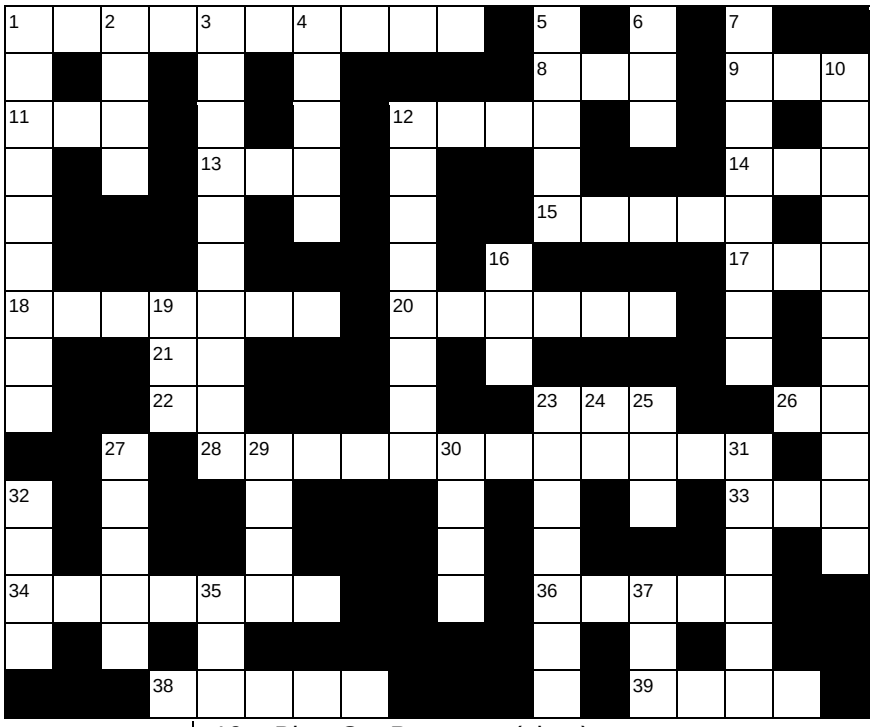


Electrical power is distributed to consumers.

Geothermal Links

- American Council for Renewable Energy (ACORE) - http://www.acore.org/
- Bureau of Land Management - Nevada Geothermal Program - http://www.nv.blm.gov/minerals/geothermal/index.htm
- Energy and Geoscience Institute (EGI) at the University of Utah - http://www.egi.utah.edu. Geothermal Technology & Research
- GeoExchange, Geothermal Heat Pump Consortium - http://www.geoexchange.org. Fascinating Facts about GeoExchange Systems and How Does It Work?
- Geothermal and UIC FAQs - http://ndep.nv.gov/bwpc/uic01.htm. This contains important information for geothermal companies drilling injection wells.
- Geothermal Biz.com - http://www.geothermal-biz.com/. Geothermal biz.com was created to help the geothermal entrepreneur-companies, small businesses, Native American tribes, homeowners, and individuals-develop geothermal direct use and small power generation projects.
- Geothermal Energy Association - http://www.geo-energy.org/
- Geothermal Resources Council - http://www.geothermal.org
- GHP Technology, Case Studies - International Ground Source Heat Pump Association - http://www.igshpa.okstate.edu
- Great Basin Center for Geothermal Energy at the University of Nevada, Reno – http://www.gbcge.org
- National Pollutant Discharge Elimination System (NPDES) - http://water.epa.gov/polwaste/npdes/
- National Renewable Energy Laboratory (NREL) - http://www.nrel.gov/geothermal. Geothermal Program; Access reports and publications on geothermal energy by Gerald Nix, Charles Kutscher, Barbara Farhar, Keith Gawlik, Brandon Owens, Walter Short.
- Nevada Bureau of Mines and Geology, Nevada Mineral Industry Reports (MI) (click on individual report for FREE DOWNLOAD) - http://pubs.nbmg.unr.edu/Mineral-Industry-s/1860.htm
- Nevada Bureau of Mines and Geology, Geothermal Energy - http://www.nbmg.unr.edu/geothermal/index.html
- Nevada Commission on Mineral Resources, Division of Minerals - http://minerals.nv.gov/programs/geothermal
- Nevada State Office of Energy, Renewable Energy - http://energy.nv.gov
- Public Utilities Commission of Nevada - http://puc.nv.gov
- Renewable Energy Policy Project & CREST (Center for Renewable Energy & Sustainable Technology) - http://www.repp.org/
- Sandia National Laboratories Geothermal Research Dept. - http://energy.sandia.gov/category/geothermal/
- Southern Methodist University Geothermal Laboratory - http://www.smu.edu/geothermal/
- Stanford Geothermal Program - http://pangea.stanford.edu/departments/ere/
- U.S. DOE Geothermal Technologies Program – http://energy.gov/eere/geothermal/geothermal-energy-us-department-energy
- U.S. Geological Survey, USGS Open-file Report 99-425 online version 1.0, "Geothermal Industry Temperature Profiles from the Great Basin" – http://pubs.usgs.gov/of/1999/of99-425/webmaps/home.html

Geothermal Crossword



ACROSS

1. Heat from the earth
8. A golf gadget
9. The first number
11. A wall __ __ __
12. A __ __ __ __ line
13. A hot water tub
14. Real small
15. An old volcano source
17. A small child
18. What turns a generator?
20. A small earthquake
21. I left it __ __ the desk
22. A movie rating
23. Something to drive or ride in
26. Direct current (abrv.)
28. One use of geothermal
33. What you do at lunch
34. What erupts?
36. A watering hole in the desert
38. The outside of bread or the earth
39. Major conflicts

DOWN

1. What makes electricity?
2. Three are needed in baseball
3. A warm water pond
4. Sonar and __ __ __ __ __ are used on ships
5. What hot water turns into
6. Get ready; get __ __ __; go!
7. Not cold water
10. What gives us light and power?
12. A crack in the earth
16. A hot drink
19. Blow Out Preventer (abrv.)
23. The formation that is drilled through to reach a geothermal source
24. It is __ __ your house
25. A spare __ __ __ or Adam's __ __ __
27. What moves in an earthquake?
29. What you feel when you hurt
30. What geothermal water produces
31. What "Old Faithful" is
32. What flows from a volcano
35. What you breathe
37. What you do with a needle and thread

T	A	O	B	M	A	E	T	S	R	E	W	O	L	U	V	L	O
A	E	M	E	Q	U	O	I	S	V	J	H	S	P	R	I	N	G
O	T	R	O	D	X	I	S	L	A	P	C	P	I	R	G	G	O
B	S	B	I	A	Y	T	I	L	Q	I	E	M	A	E	T	S	X
A	L	L	A	P	T	X	E	E	V	R	A	N	Y	T	E	T	I
W	I	U	W	O	M	E	S	W	S	T	W	O	R	A	S	B	D
A	N	E	D	E	S	E	R	T	P	E	A	K	D	W	M	E	M
B	G	M	C	A	M	S	E	L	N	M	B	U	F	L	T	O	L
U	F	O	G	P	O	A	M	A	U	P	U	T	S	L	E	W	Z
S	W	U	I	U	M	U	T	S	K	I	S	I	X	I	D	A	U
Y	A	N	O	B	X	Y	Z	U	S	R	K	S	A	T	I	W	N
A	D	T	O	I	L	O	E	K	A	L	A	D	O	S	X	E	Q
M	I	A	T	E	S	A	B	D	F	H	J	L	O	Z	L	I	D
S	T	I	R	F	O	D	I	X	I	E	V	A	L	L	E	Y	E
H	O	N	O	B	T	B	C	B	A	Q	I	A	R	S	T	S	M

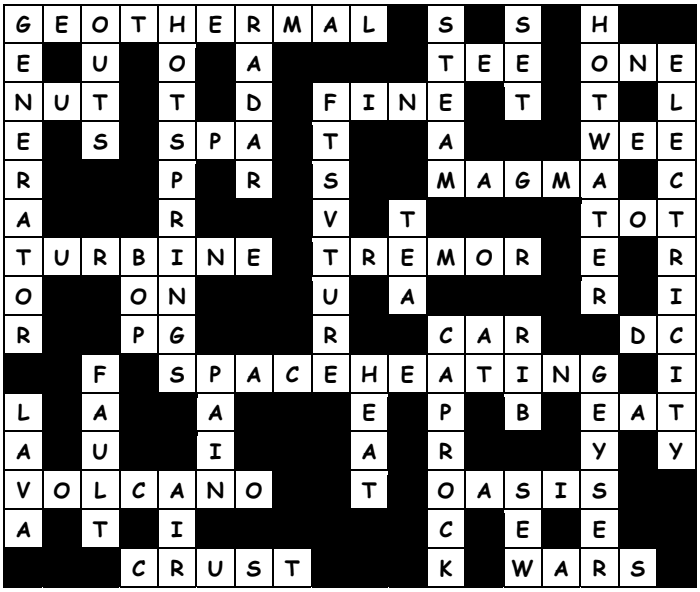
Seek and Find

1. BEOWAWE
2. DESERT PEAK
3. WABUSKA
4. DIXIE VALLEY
5. EMPIRE
6. SODA LAKE
7. STILLWATER
8. UPPER STEAMBOAT
9. LOWER STEAMBOAT
10. BRADY
11. SALT WELLS
12. BLUE MOUNTAIN

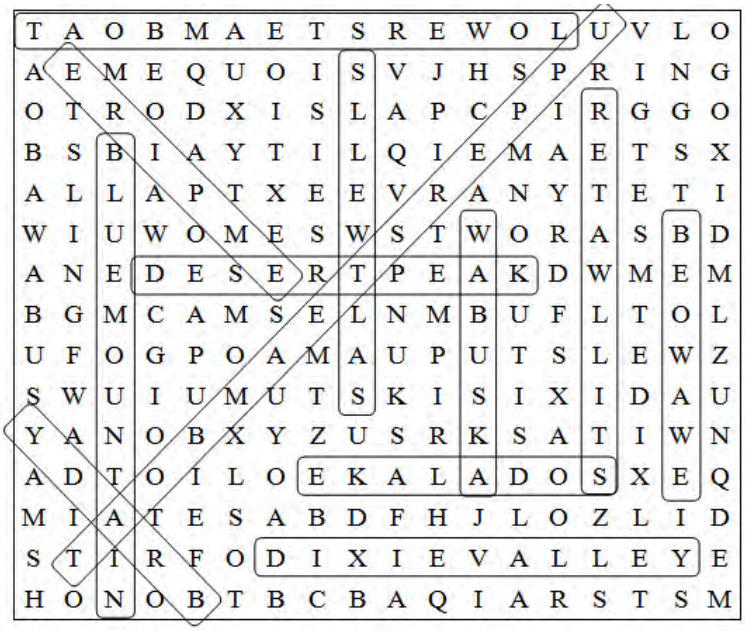
Geothermal Questions

1. What is the source of heat needed to have a geothermal resource?
2. Name two uses of geothermal energy or heat.
3. What are some signs that a geothermal resource is nearby?
4. What are the two types of systems used for geothermal production of electricity?
5. Are geothermal resources renewable? Why?
6. What type of rock is it necessary to drill through to get to a geothermal resource?
7. What did the Indians and pioneers use geothermal hot springs for?
8. How many power plants are producing in Nevada from geothermal resources?
9. What is the estimated temperature at the center of the earth?
10. How wide is the planet earth?
11. How many plates cover the earth's surface?
12. Name all or most of the geothermal fields in Nevada that produce electrical power.
13. What are the cracks in the earth called?
14. What piece of equipment turns a generator?

Geothermal Crossword Answers



Seek and Find Answers



Answers to Geothermal Questions

1. Magma
2. Electric power, space heating
3. The presence of hot springs or fumaroles
4. Binary and direct flash
5. Yes, because the condensed steam (water) is put back into the resource
6. Cap rock
7. To bathe in
8. Fourteen (14) (with Steamboat upper and lower counting as two.)
9. 12,000 degrees F
10. 8,000 miles wide
11. Nineteen (19)
12. Steamboat (upper and lower), Wabuska, Soda Lake, Stillwater, Salt Wells, Desert Peak, Brady, Dixie Valley, Beowawe, Empire, Blue Mountain, Tuscarora, McGinness Hills
13. Faults