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GEOTHERMAL GRADIENT STUDIES IN OREGON

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Heat flows from the interior of the earth at an average rate of 1.5 microcalories per square centimeter per second. This is equivalent to about 150 Btu's per square mile per second; over the whole earth over a year's time this heat energy is equivalent to that contained in 170 billion barrels of oil. In most of the world this heat is too diffuse to be used, but in some regions, such as the circum-Pacific volcanic belt, heat flow is several times normal. Under some geologic conditions this heat energy is transferred to circulating underground waters, forming a geothermal reservoir. In that way the earth's heat is trapped and stored and can be tapped by drilling, making the heat available for use as either hot water or steam, depending upon the characteristics of the particular reservoir.

Surface manifestations, such as hot springs and geysers, indicate the presence of geothermal reservoirs, but in some regions where these hot waters do not come to the surface they can be detected by the measurement of geothermal gradients or heat flow.

The geothermal gradient is the rate of temperature increase with depth. Normally this is about 1 degree Celcius per 100 feet or more, frequently written as 30°C/Km. In geothermal areas the gradient is often several times the "normal;" for example, at The Geysers geothermal field in California steam at temperatures of about 240°C is reached at 3000 to 4000 feet. This is a geothermal gradient of 200 to 250°C/Km or six times the world "normal."

Geothermal gradients are relatively simple to measure as they are merely a plot temperature and depth, but certain factors must be taken into consideration in order that the geothermal gradient figure be meaningful. For example, the annual change in near-surface temperatures due to variations in solar heating makes it necessary to take the temperature measurements at a depth not influenced by solar heat, generally at least 150 feet. Temperature gradients measured in open holes or in areas of permeable rocks can be affected by upward or downward movement of ground water. If these factors are taken into consideration, geothermal gradients can be a useful tool for outlining prospective geothermal areas.

For thermal gradient measurements to be most useful, however, the thermal conductivity of the rocks should also be determined, as they vary widely in their ability to conduct heat. A rock that is a good insulator, such as loosely compacted tuff, will, for the same amount of heat flow, show a high geothermal gradient; a rock with poor insulating ability, like

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Heat-flow measurements ar
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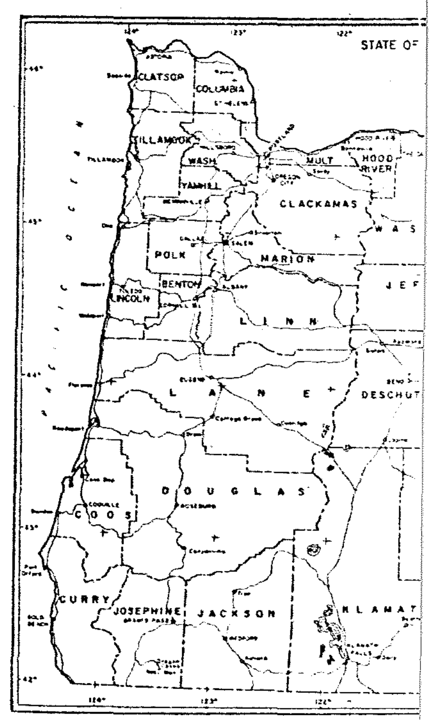
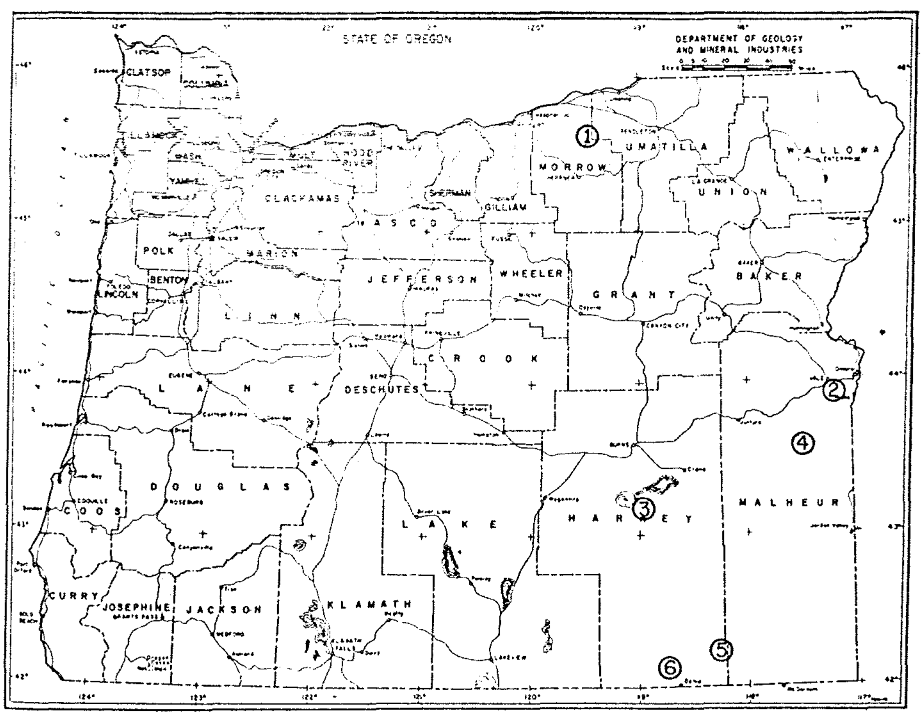


1. Butter Creek
2. Chalk Butte - Cow Holl
3. Harney

a granite, will show a low geothermal gradient. By combining thermal gradient measurements and thermal conductivity data, a heat-flow determination can be made that will give a more accurate picture of subsurface conditions than would temperature gradient alone.

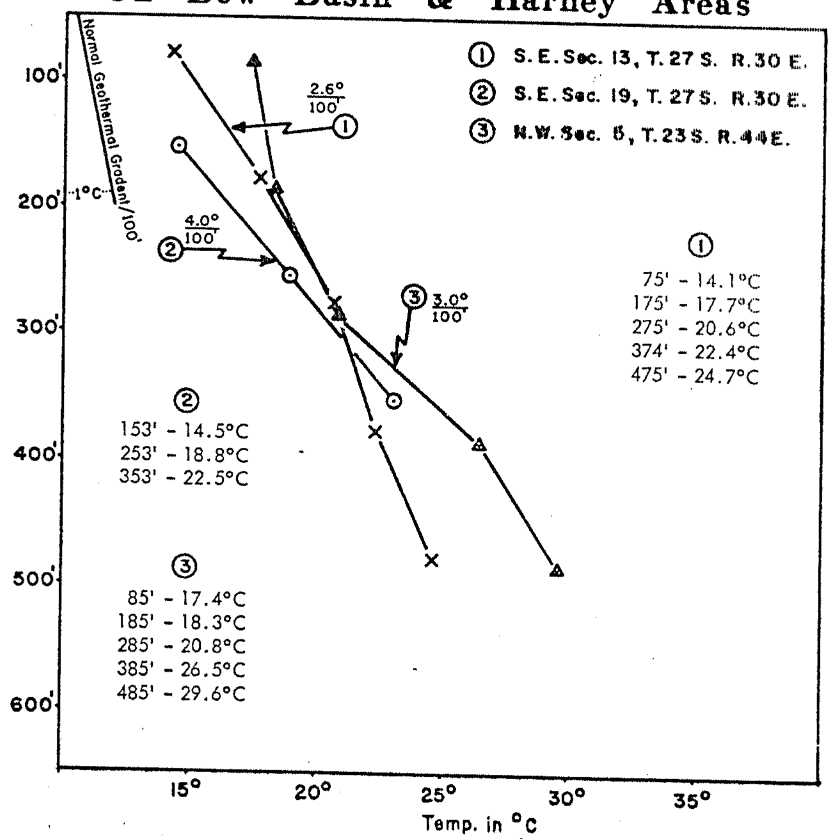
Heat-flow measurements are very sparse and as yet there are none in Oregon because of the complexity of the conductivity measurements and because of a former lack of economic incentive to make them. The Department of Geology and Mineral Industries has been taking geothermal gradient measurements over the last few years whenever drill holes, made for other purposes, have become available (see map for locations). Although geothermal gradients do not present as accurate a picture as do heat-flow measurements, with some knowledge of the underlying rocks a reasonable estimate of conductivity, and therefore heat flow, can be made.

The accompanying graphs show geothermal gradients taken at scattered points in eastern Oregon. They are presented as a progress report. Others will be published from time to time as more data become available.

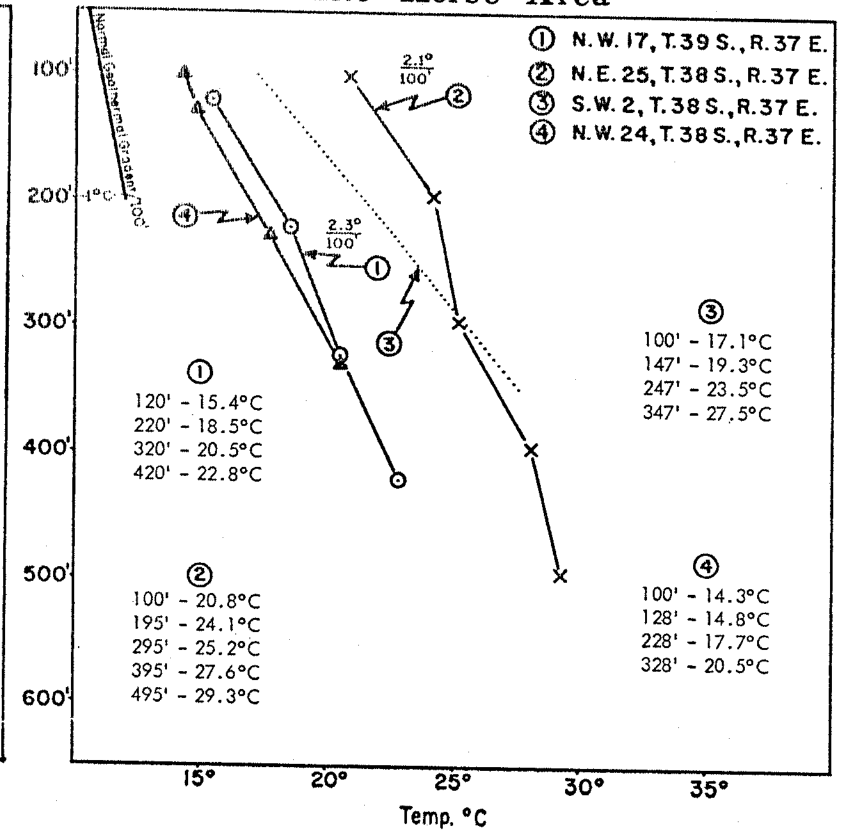


1. Butter Creek
2. Chalk Butte - Cow Hollow
3. Harney
4. Ox Bow Basin
5. White Horse
6. Pueblo Mountains

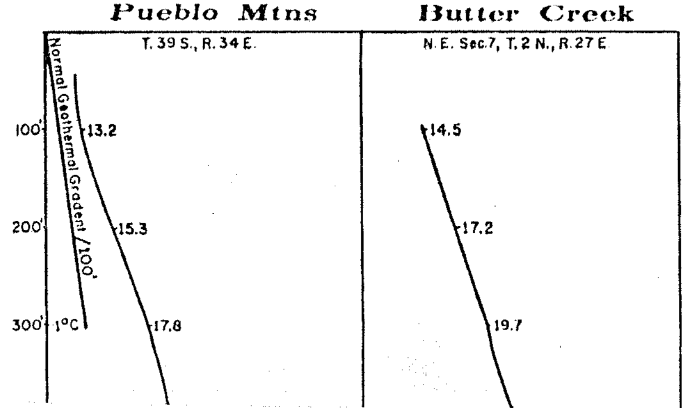
Ox Bow Basin & Harney Areas



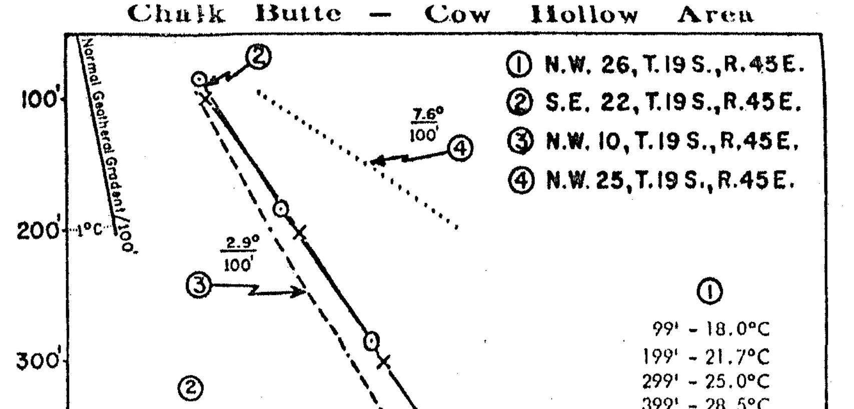
White Horse Area



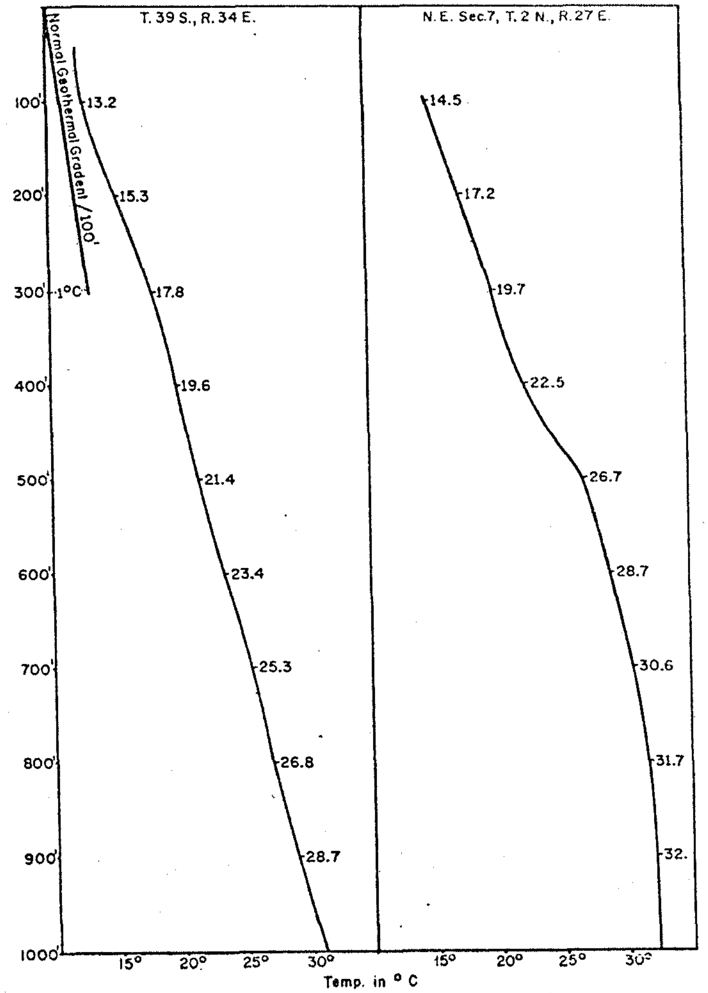
Pueblo Mtns / Butter Creek



Chalk Butte — Cow Hollow Area



Pueblo Mtns — Butter Creek



Chalk Butte — Cow Hollow Area