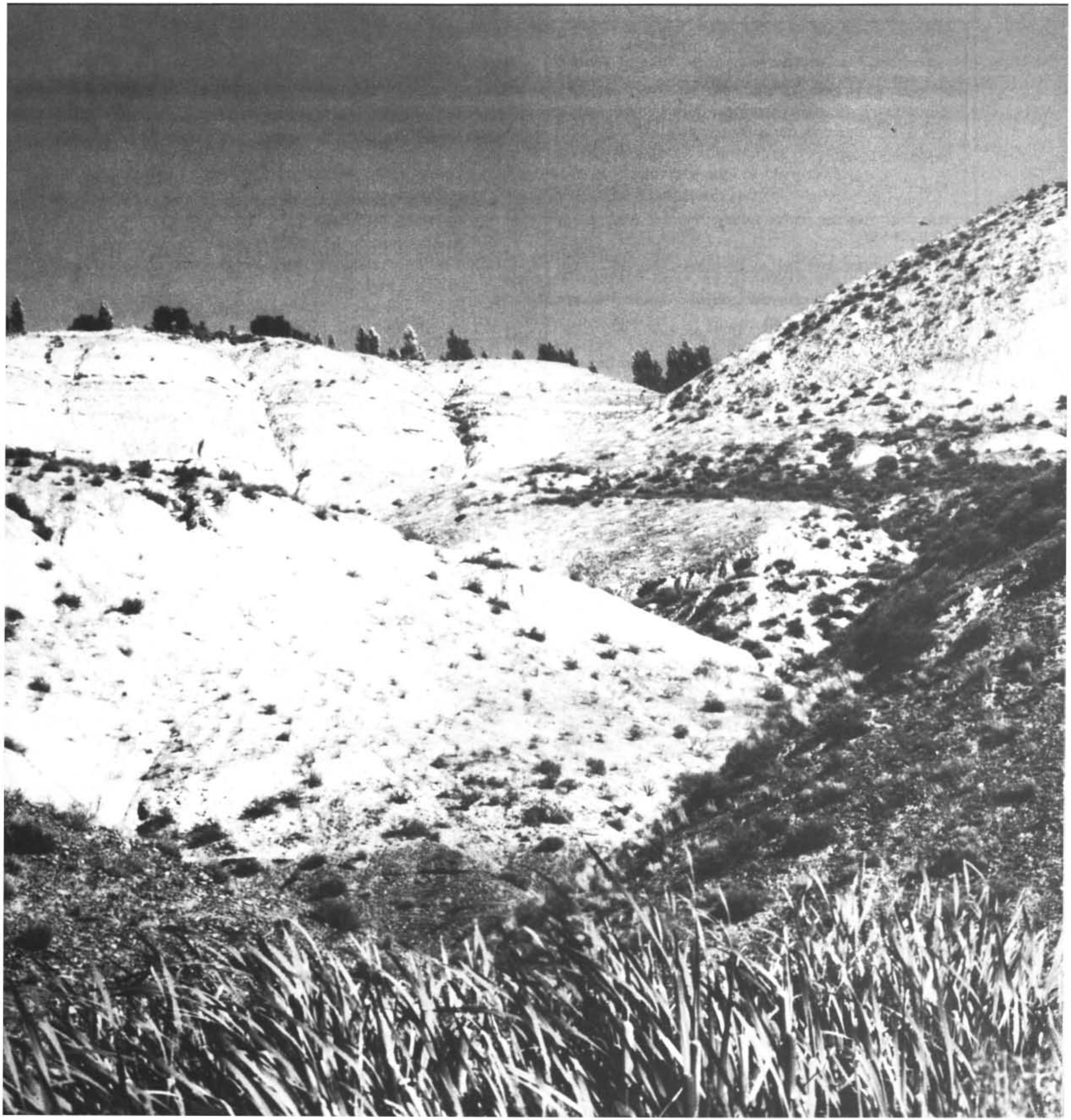
OREGON GEOLOGY

formerly THE ORE BIN

published by the Oregon Department of Geology and Mineral Industries

Volume 41, Number 8 August 1979



OREGON GEOLOGY

(ISSN 0164-3304)

Volume 41, Number 8 August 1979

Published monthly by the State of Oregon Department of Geology and Mineral Industries (Volumes 1 through 40 were entitled *The Ore Bin*).

Main Office: 1069 State Office Building, Portland 97201, phone (503) 229-5580.

Baker Field Office: 2033 First Street, Baker 97814, phone (503) 523-3133.
Howard C. Brooks, Resident Geologist

Grants Pass Field Office: 312 S.E. "H" Street, Grants Pass 97526, phone (503) 476-2496.
Len Ramp, Resident Geologist

Mined Land Reclamation Division: 1129 S.E. Santiam Road, Albany 97321, phone (503) 967-2039.
Standley L. Ausmus, Administrator

Subscription rates: 1 year, $4.00; 3 years, $10.00. Single issues, $.40 at counter, $.50 mailed.
Available back issues of *The Ore Bin:* $.25 at counter, $.50 mailed.

Address subscription orders, renewals, and changes of address to *Oregon Geology,* 1069 State Office Building, Portland, OR 97201.

Send news, notices, meeting announcements, articles for publication, and editorial correspondence to the editor, Portland office. The Department encourages author-initiated peer review for technical articles prior to submission. Any review should be noted in the acknowledgments.

Second class postage paid at Portland, Oregon.
Postmaster: Send address changes to *Oregon Geology,* 1069 State Office Building, Portland, OR 97201.

COVER PHOTO

White Bluffs, type section of the Ringold Formation, exposed along Columbia River in southeastern Washington. These deposits were studied for paleomagnetism. See article beginning on page 119. (Photo courtesy Duane R. Packer, Woodward-Clyde Consultants.)

Friends of Mineralogy to hold fifth annual symposium in September

The Friends of Mineralogy, Northwest Chapter, will hold their fifth annual symposium, "Sulfides and Sulfosalts," September 28 through 30, 1979, at the Bellevue Holiday Inn on Interstate 405 just across the floating bridge from Seattle, Washington. Symposium hours will be 7 p.m. to 11 p.m. Friday, 8 a.m. to 11 p.m. Saturday, and 8 a.m. to 12 a.m. Sunday.

Speakers will be Joseph Mandarino, Curator, Royal Ontario Museum; Les Zeihen, Consulting Mineralogist for the Anaconda Company, Butte, Montana; Robert Cook, Associate Professor of Geology, Auburn University, Auburn, Alabama; Joe Nagel and Colin Goodwin, University of British Columbia, Vancouver, B.C., Canada; and Bob Jackson, Collector, Renton, Washington. Lectures will be centered about the theme, "Sulfides and Sulfosalts."

Approximately 10 to 20 noncompetitive, educational exhibits related to finely crystallized sulfides and sulfosalts are anticipated.

Three well-known dealers, Nature's Treasures, The Mineral Mailbox, and Lidstroms, will be represented at the symposium.

The Saturday evening symposium will be informal and devoted to trading, examining dealers' minerals, attending microscope and mineral workshops, and socializing.

Additional information about the symposium can be obtained from Mike Groben, Rt. 1, Box 16, Coos Bay, Oregon 97420; phone: (503) 269-9032. □

CONTENTS

Paleomagnetism and age dating of the Ringold Formation and loess deposits in the State of Washington

by Duane R. Packer, Senior Project Geologist, Woodward-Clyde Consultants, Three Embarcadero Center, Suite 700, San Francisco, California 94111

Holocene, Pleistocene, and Pliocene geologic units in Oregon and Washington commonly display similar lithologies over large areas. Yet, inquiry into the nature of the units is becoming increasingly precise as we probe their meaning in terms of recent faulting and tectonism.

Paleomagnetism is one of several technologies now being used to increase our understanding of these units. Woodward-Clyde Consultants, under contract to the Washington Public Power Supply System, used paleomagnetic techniques to help establish the age of the Ringold Formation in southeastern Washington and Craigs Hill loess deposits at Ellensburg, Washington. This article describes types of techniques that may be applicable in addressing the poorly understood late Cenozoic geology, both in Washington and in Oregon.

All artwork and photographs are courtesy of Woodward-Clyde Consultants.

PALEOMAGNETISM

Introduction

Paleomagnetism is a useful tool for determining the dates of formation of sedimentary and igneous rocks. The application of paleomagnetism is based on the fact that rocks record the direction and intensity of the earth's magnetic field during their formation and retain this magnetic information for thousands to billions of years. The age-dating aspect of paleomagnetism takes advantage of the fact that the earth's magnetic field is dynamic and has undergone a number of distinctive changes in the geologic past.

The record of these changes can be used to date geologic materials. The most easily recognized of all these changes is a reversal of the earth's magnetic field, which has occurred many times in the geologic history of the earth. The last major reversal occurred 700,000 years ago (Figure 1).

Theory

The earth's magnetic field undergoes various changes in both intensity and direction over periods of time ranging from nanoseconds to millions of years. Reversals of the polarity of the earth's field, on which magnetostratigraphy is based, appear to have occurred randomly in the geologic past and are recorded in rocks worldwide. Complete reversals having durations on the order of 10^5 years are called magnetic polarity epochs. Complete reversals having durations on the order of 10^3 to 10^4 years are known as events. Significant changes in magnetic pole position, but not complete reversals, having durations on the order of 10^3 years are called magnetic excursions.

All of these magnetic phenomena have potential for use in dating, but polarity epochs and some events are the best dated and documented in geologic sections throughout the world. Other changes in declination and inclination (the magnetic azimuth and dip, respectively), called secular variations, take place on a continental scale and have durations of 10^2 to 10^3 years. These changes have application to dating in specific geographic areas such as Europe, where the known magnetic record over the past several thousand years includes secular variations. In other areas, the secular variation pattern could potentially be developed and applied to correlation problems.

Basically, paleomagnetism can be used to detect latitudinal movements relative to the earth's field, rotations about vertical and horizontal axes, and relative stratigraphic position in the magnetostratigraphic record. The application of paleomagnetic studies that has the greatest potential in engineering geology is based largely on magnetostratigraphy, which can be used as a relative age-dating and stratigraphic correlation tool in detecting and dating possible fault displacements in time-stratigraphic horizons.

Individual paleomagnetic polarity zones in themselves do not have unique characteristics that allow identification of, for example, an older normal zone from a younger normal zone. Therefore, some bracketing age data (paleontologic or radiometric), as well as a moderately continuous geologic section, are usually required as a basis for identifying the general age of the paleomagnetic zones.

Paleomagnetism is based on the characteristic ability of magnetic minerals to record and retain, in some cases on the order of billions of years, the magnetic field in which they were formed. This property is called natural remanent magnetization (NRM). One way in which NRM is acquired is by thermal rem-

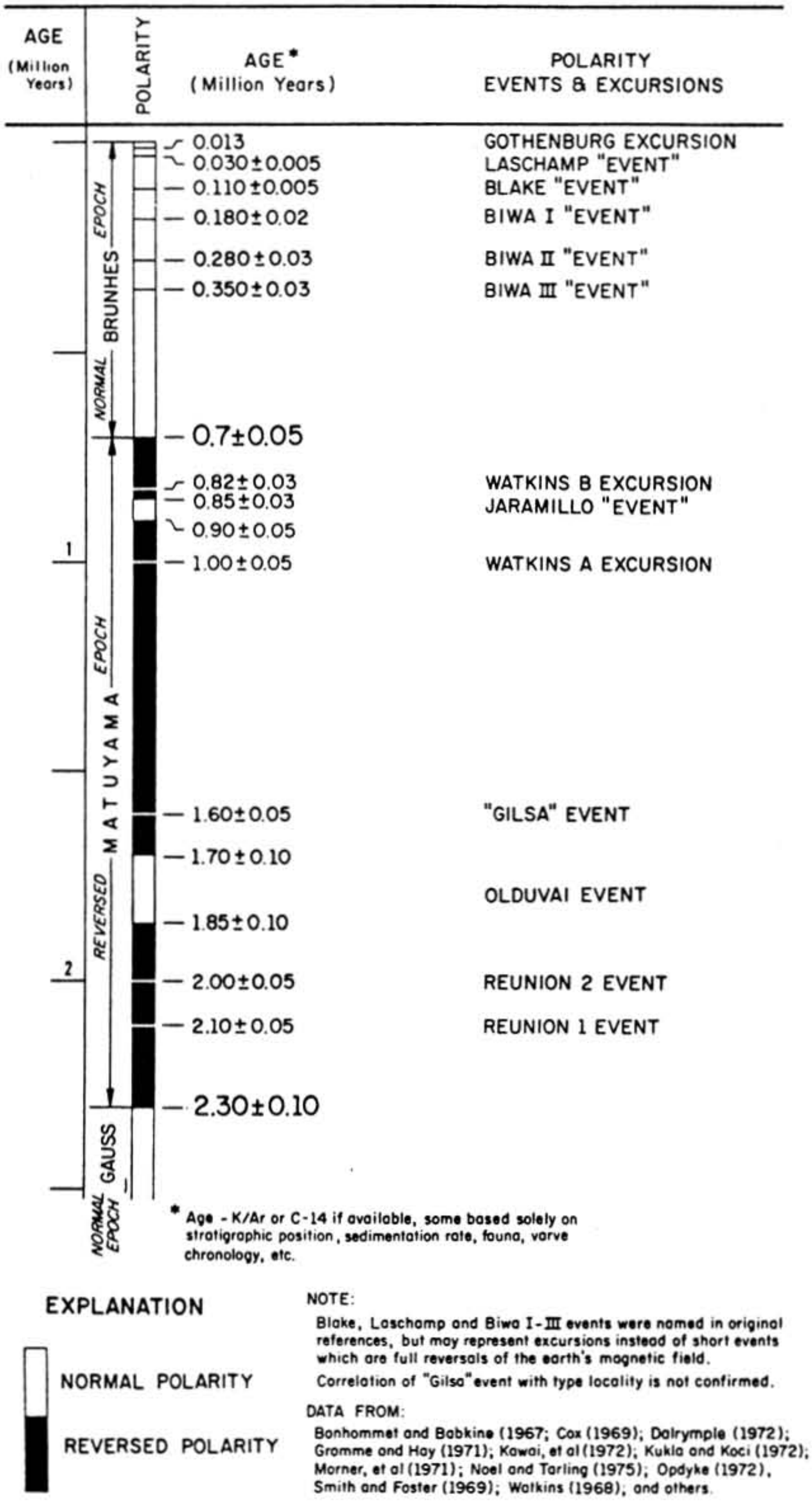


Figure 1. Magnetostratigraphy for the last 2.5 million years.

anent magnetization (TRM). A magnetic mineral acquires its magnetization as it cools through its Curie point, the temperature at which the atomic and molecular thermal energy become sufficiently low that the spin directions and magnetic moments become locked along the ambient field direction. Natural remanent magnetization in rocks is also dependent on many other factors, including crystal structure and crystal size.

Rocks can also acquire NRM by detrital remanent magnetization (DRM) and by chemical remanent magnetization (CRM). DRM is acquired by sedimentary magnetic particles aligning as small compass needles along the direction of the earth's magnetic field. CRM involves the oxidation or reduction of iron minerals, forming secondary minerals such as hematite, magnetite, or titano-magnetite. During their formation, these minerals record the direction of the earth's magnetic field. It is by this CRM process, for example, that red beds acquire their magnetization. Although it is a secondary magnetization, it is usually assumed to have occurred very close to the time of the formation of the rock and is therefore a record of the field at that time.

Many other secondary factors, including viscous remanent magnetization (VRM) and anhysteritic remanent magnetization (ARM), may have disturbed the original NRM in a rock. A large part of a paleomagnetic analysis therefore is directed at discovering and removing or correcting for disturbances to the original NRM direction. Two techniques are commonly used for this process: alternating field demagnetization and thermal demagnetization. It is not always possible to correct for magnetic disturbances, and some samples may yield no useful information about their original NRM direction. However, the effect of such samples can be discounted because they are usually relatively few and can be detected and isolated during the analysis.

RINGOLD FORMATION AND CRAIGS HILL LOESS

This report presents the results of the preliminary study of the paleomagnetic polarity of the Ringold Formation in the Hanford, Washington, area and two loess deposits in the Ellensburg and Yakima, Washington, areas. The objectives of the preliminary study of the Ringold Formation were to evaluate its magnetic stability and to determine whether or not it contains a polarity sequence suitable for age dating and correlation. Samples from approximately 120 m (400 ft) of silts and sands were collected from a section extending from a basal contact with a conglomerate up to a caliche cap and overlying loess. The section, the type section of the Ringold Formation, is exposed in the White Bluffs along the Columbia River in the west half of sec. 25, T. 11 N., R. 28 E. The approximate locations of the upper and lower parts of this section are shown in Figure 2. The cliff-forming unit from which the samples were taken is shown in Figure 3. The section was laterally offset to obtain maximum exposures.

A preliminary study of the paleomagnetic polarity was made of loess deposits overlying the Naneum conglomerate at Craigs Hill in the southern portion of sec. 36, T. 18 N., R. 18 E., at Ellensburg. The objectives of this study were to see if these deposits of loess are magnetically stable and were formed in a reversed magnetic field. Approximately 16 m (50 ft) of section, with samples from 11 stratigraphic levels, were collected at this location. The location of this section is shown in Figure 4.

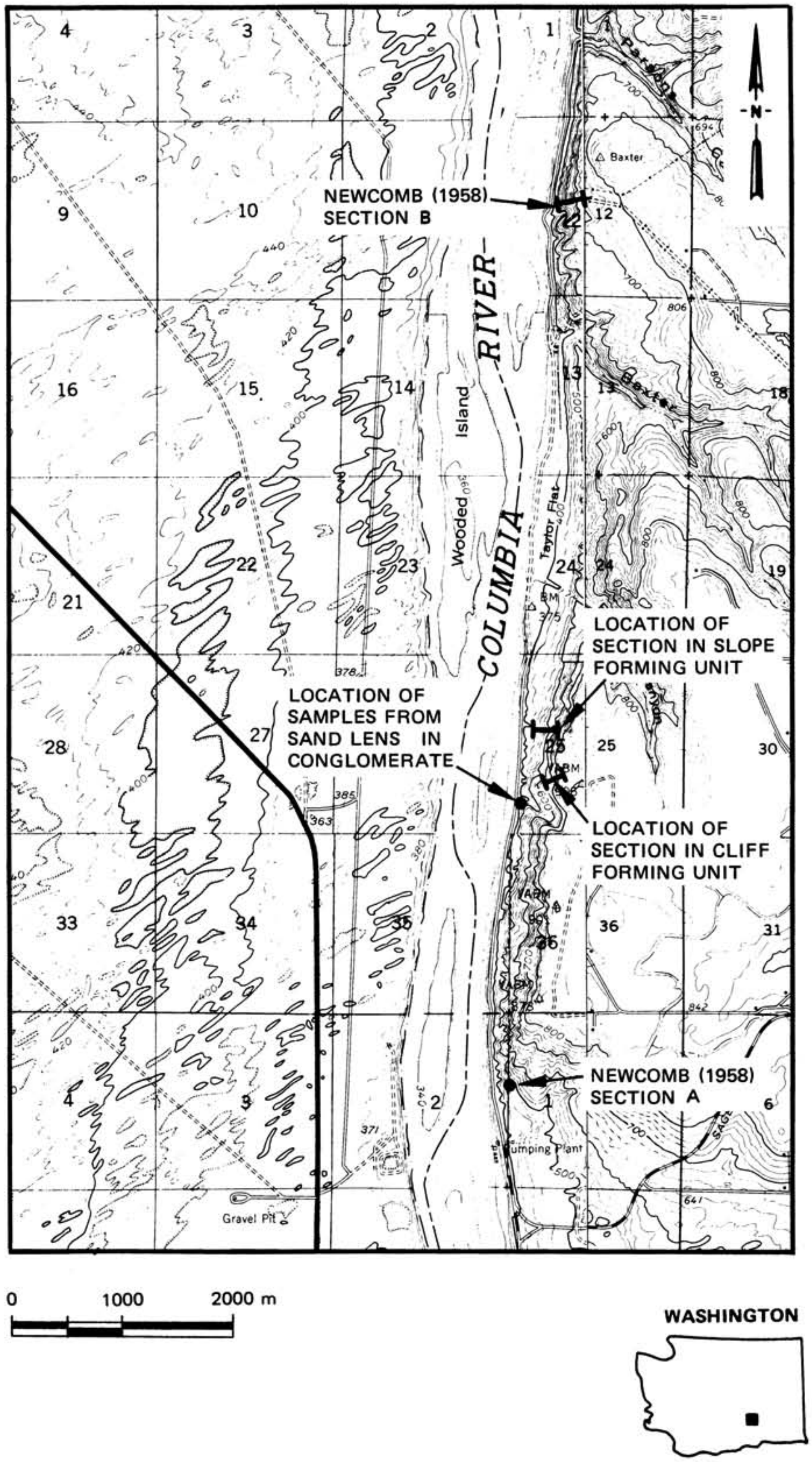


Figure 2. Location map of Ringold Formation section.

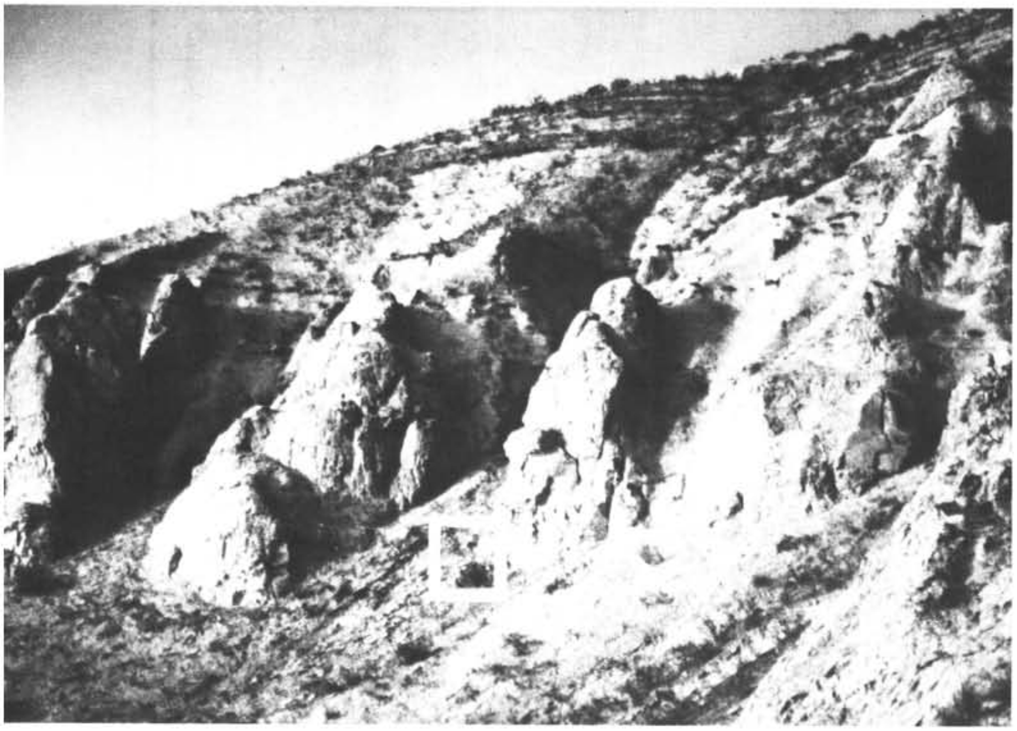


Figure 3a. Ringold Formation section. View to east showing bluffs of cliff-forming unit. Box is area of closeup shown in (b).

Figure 3b. Closeup of base of cliff-forming unit shown in (a). Arrow points to location from which oriented blocks for samples 5 and 6 were collected.

SAMPLE COLLECTION AND ANALYSIS

Paleomagnetic samples for this study were collected by two techniques. The most common technique for friable material was to hand carve a pedestal of the rock to fit into a 5 cm^3 plastic cube. The cube was oriented before removing the sample from the outcrop. The samples were sealed inside the plastic cubes with nonmagnetic fiberglass resin. The remaining samples were collected in oriented blocks from the cemented or consolidated lenses. These blocks were carefully reoriented in the laboratory, and sample cubes were cut from them. The approximate orientation errors for these samples are less than 5 degrees and randomly distributed, which for the purposes of this study do not affect the interpretation of the results.

Two samples were usually collected at each stratigraphic level to compare magnetic signatures as a check on the consistency of magnetization and the magnetic stability of the rock units. An attempt was made to sample at 5- to 7-m (16- to 23-ft) stratigraphic intervals, although for the most part, samples were selectively collected from the more resistant and most unweathered units.

The samples were measured with a superconducting rock magnetometer and were demagnetized in steps in a 400-Hz alternating field (AF) at four or more demagnetization levels. The number of demagnetization levels varied, depending on the magnetic coercivity ranges of the samples. The AF demagnetization unit is magnetically shielded and rotates the samples about three axes during demagnetization. The results of the AF demagnetization provide a means to evaluate the magnetic stability of the section by comparing the relative direction and intensity changes during demagnetization. All data were recorded and computed during measurement by an on-line computer.

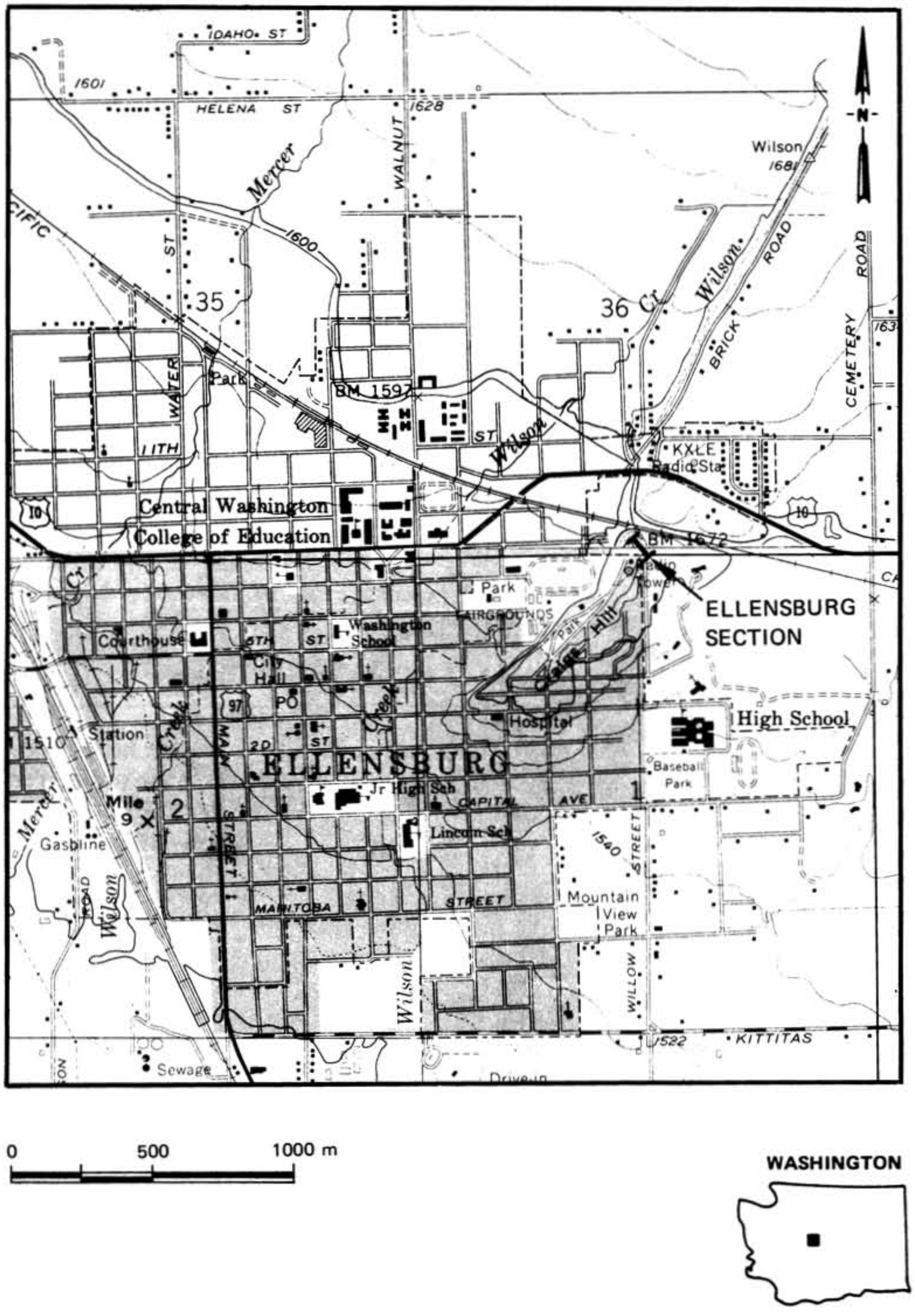
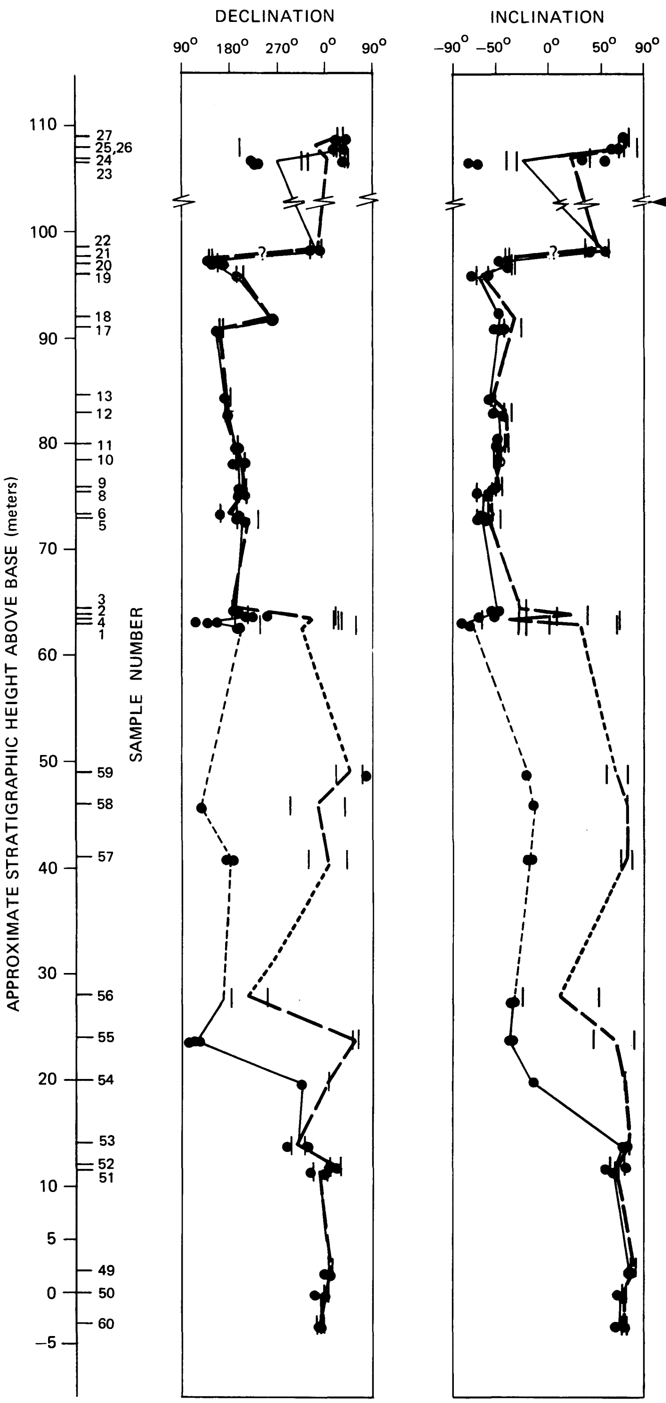


Figure 4. Location map of Craigs Hill loess section, Ellensburg, Washington.



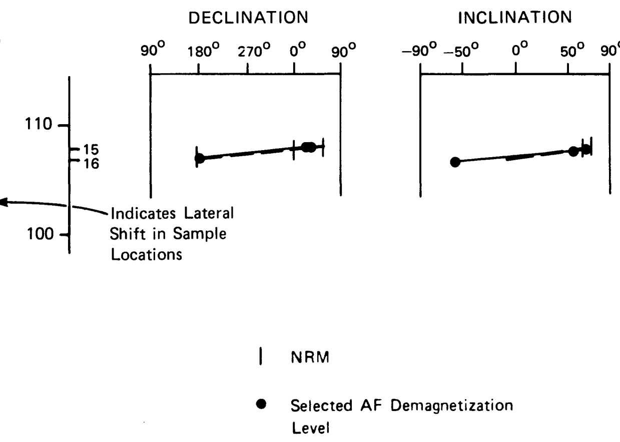


Figure 5. Declination and inclination versus stratigraphic height at Ringold Formation section.

RESULTS

Ringold Formation

Magnetic stability of the Ringold Formation is generally good, based on the relative declination and intensity changes during demagnetization. Of the approximately 37 stratigraphic levels, samples from a portion of the section (40 to 50 m [130 to 160 ft] above the base) had large secondary magnetization overprints. The resultant directions from this portion, although probably representing true polarity, may not represent the original magnetization direction. The variation of declination and inclination with stratigraphic height above the base for both the natural remanent magnetization (NRM) and the selected demagnetization levels are shown in Figure 5. These same results plotted on a stereonet are shown in Figure 6. The improved grouping for both normal and reverse direction after demagnetization further demonstrates magnetic stability.

The degree of magnetic stability of this section is also shown by the intensity of magnetization (Figure 7). The magnetization of samples from 70 m (230 ft) and above was more stable than most of the lower section. This part of the section has a consistently higher intensity of magnetization (Figure 7). The most unstable samples are from the part of the section between 40 and 50 m (130 to 160 ft), and they have relatively low magnetic intensities. The weakest NRM intensities were from 2 to 3×10^{-7} emu/cm^3 for the ash unit at approximately 65 m (210 ft) above the base of the section.

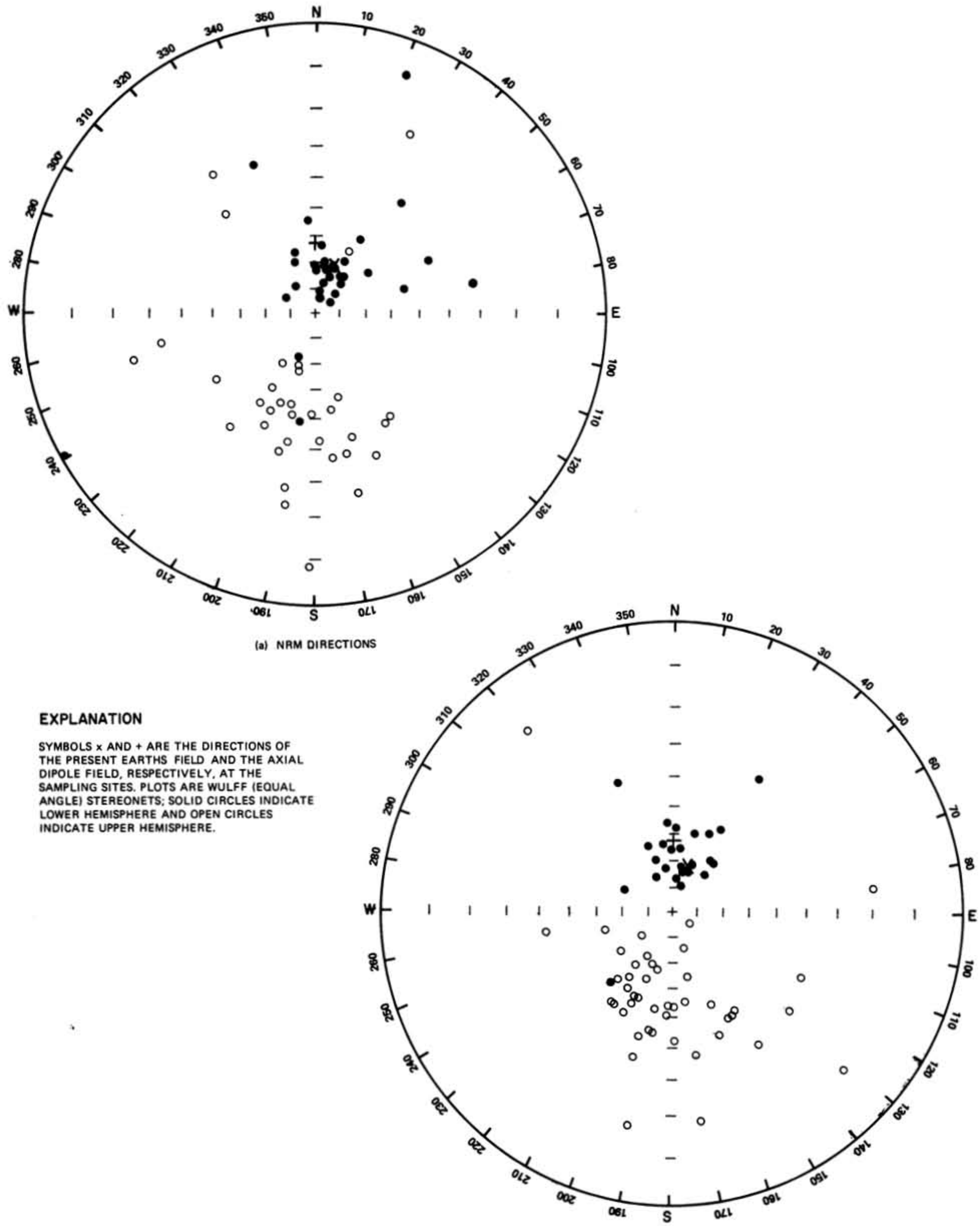


Figure 6. Stereonet plots of magnetization directions at Ringold Formation section.

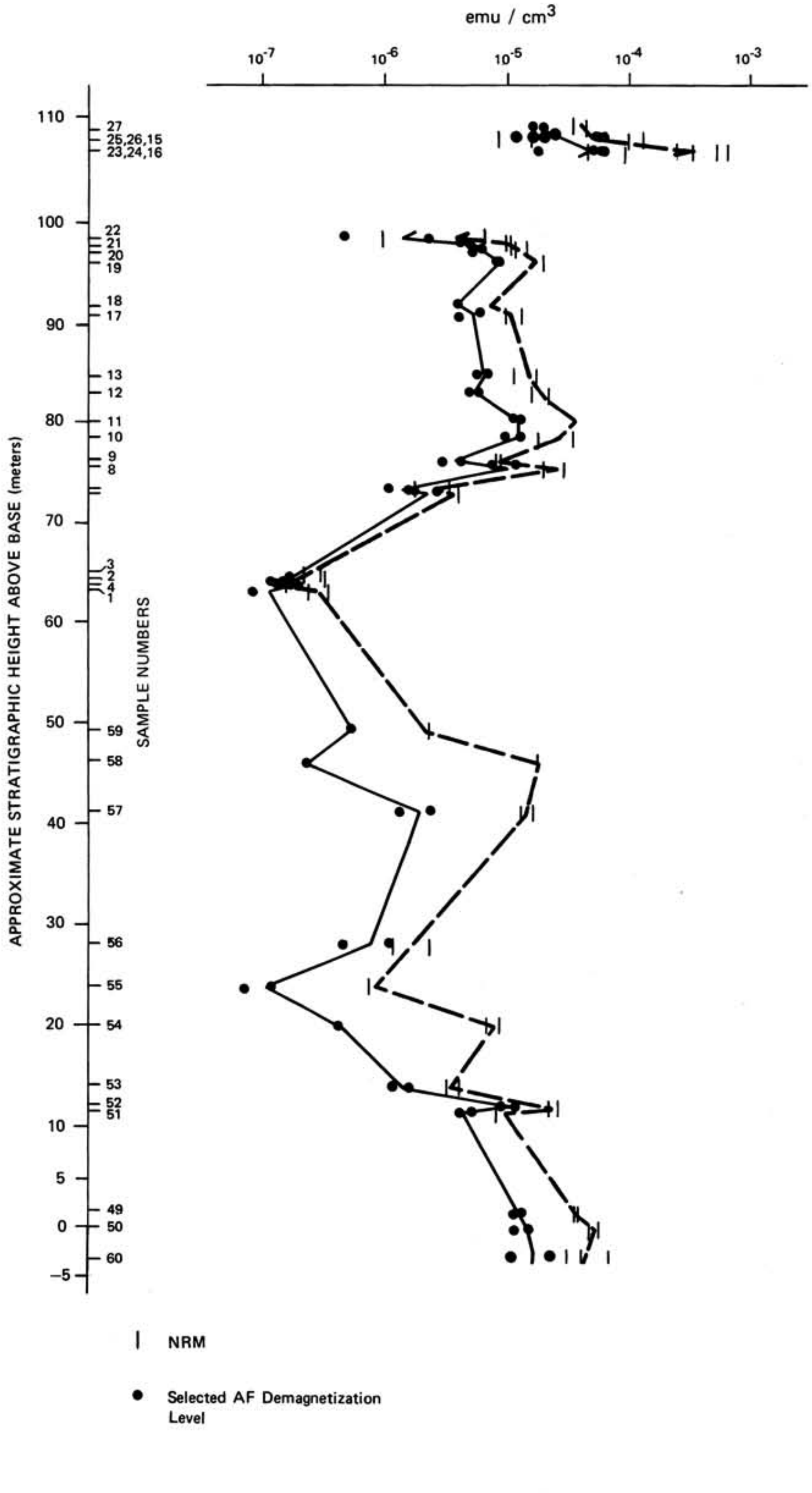


Figure 7. Intensity versus stratigraphic height at Ringold Formation section.

The magnetic polarity for this section of the Ringold Formation is shown in Figures 8 and 9. Figure 8 is a plot of the VGP (Virtual Geomagnetic Pole) latitude versus stratigraphic height above the base with magnetic polarity, and Figure 9 presents the magnetic polarity with a schematic section. The section consists of a loess unit with normal magnetic polarity overlying a reversed magnetic polarity section of the Ringold Formation, which extends from approximately 100 to 25 m (330 to 80 ft) above the base. A possible polarity transition occurs between 25 and 20 m (80 to 65 ft). Below 15 m (50 ft) above the base to a sand lens in the conglomerate, approximately 3 m (10 ft) below the base, the magnetic polarity is normal.

Only three stratigraphic sampling levels were collected between 30 and 60 m (100 to 200 ft), which is inadequate to assess fully the magnetic polarity of this section. However, on the basis of three samples between 40 and 50 m (130 to 160 ft), it is probable that the part of the section between 30 and 60 m (100 to 200 ft) is also of reversed magnetic polarity.

Sample level 22 has apparently normal magnetic polarity. This sample was collected at the top of the reversely polarized part of the Ringold Formation. Samples of the Ringold Formation and caliche cap collected several hundred feet laterally and a few feet stratigraphically above sample 22 have normal magnetic polarities. Further samples from this and adjacent sections at closer spacings will be required to determine whether or not a normal polarity exists at the very top of the exposed Ringold Formation in this section.

Craigs Hill loess deposits

Previous paleomagnetic work has shown that the loess deposits that overlie the Naneum conglomerate on Craigs Hill have reversed magnetic polarity (R.D. Bentley, personal communication). Based on direction and intensity change during AF demagnetization, magnetic stability of samples from 11 stratigraphic levels from this site was good. One sample level, level 38, showed a large secondary magnetization component, and samples from level 40 had some secondary magnetization. This secondary magnetization was removed at approximately 100 oersteds. The inclination and declination of these samples versus approximate stratigraphic height above base are shown in Figure 10. The directions of magnetization of these samples are shown also on a stereonet plot in Figure 11. A comparison of the grouping of directions at NRM and after AF demagnetization shows the good magnetic stability after removal of secondary magnetization components. The NRM intensity of magnetization of these samples ranges from 2×10^{-5} to 1×10^{-4} emu/cm^3 after AF demagnetization (Figure 12).

The VGP latitude and polarity of samples from the Craigs Hill loess section are shown in Figure 13. Approximately the lower 3 m (10 ft) of the section has reversed magnetic polarity, and the portion of the section above approximately 4¼ m (14 ft) has normal magnetic polarity. At this location, at least three loess depositional units have been mapped (R.D. Bentley, personal communication). However, on the basis of examination during collection, it was not possible to distinguish more than an upper and lower unit. A photograph of the lower portion of the upper unit is shown in Figure 14. The lower unit, which represents the lower 3 m (10 ft) of the section, has reversed magnetic polarity.

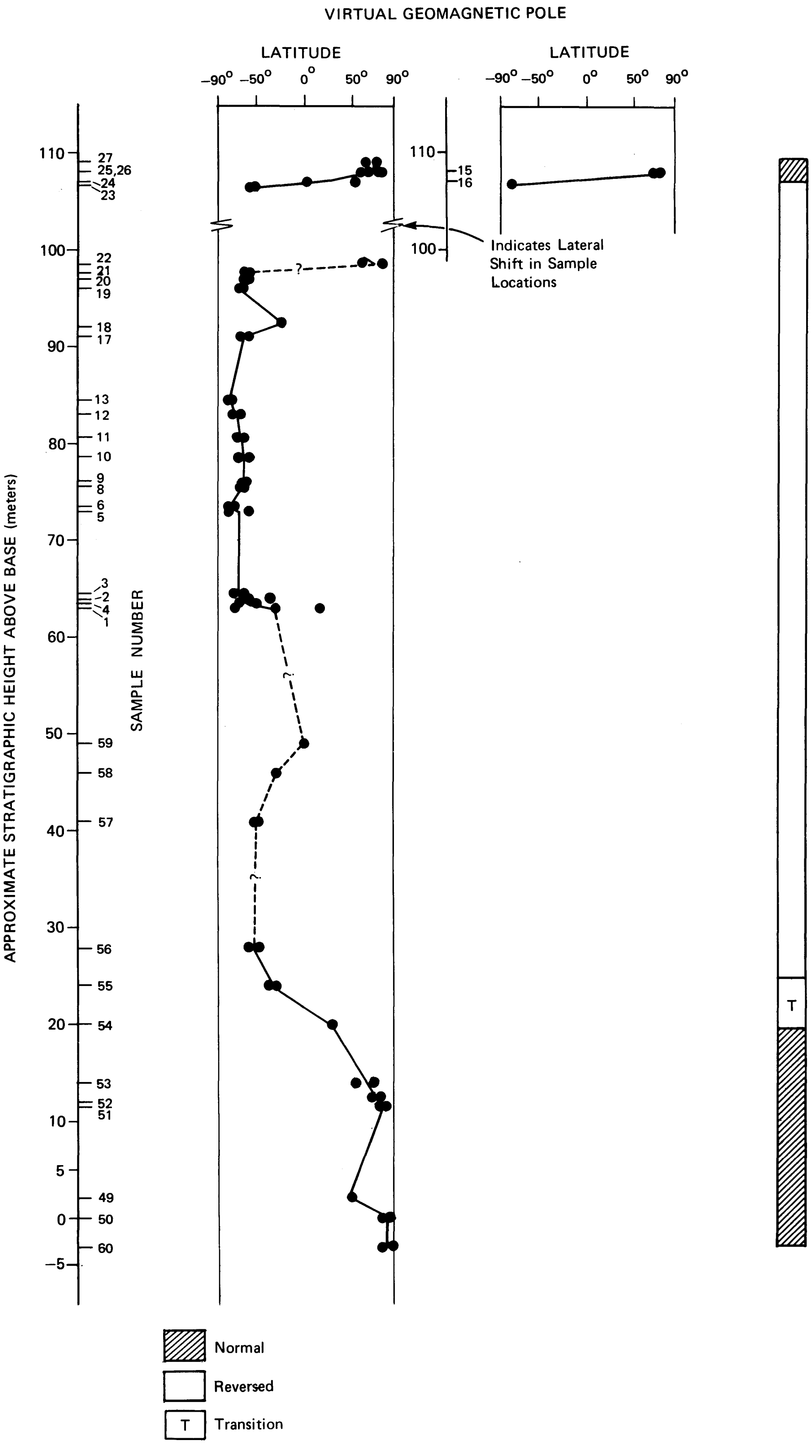


Figure 8. VPG latitude and magnetic polarity versus stratigraphic height at Ringold Formation section.

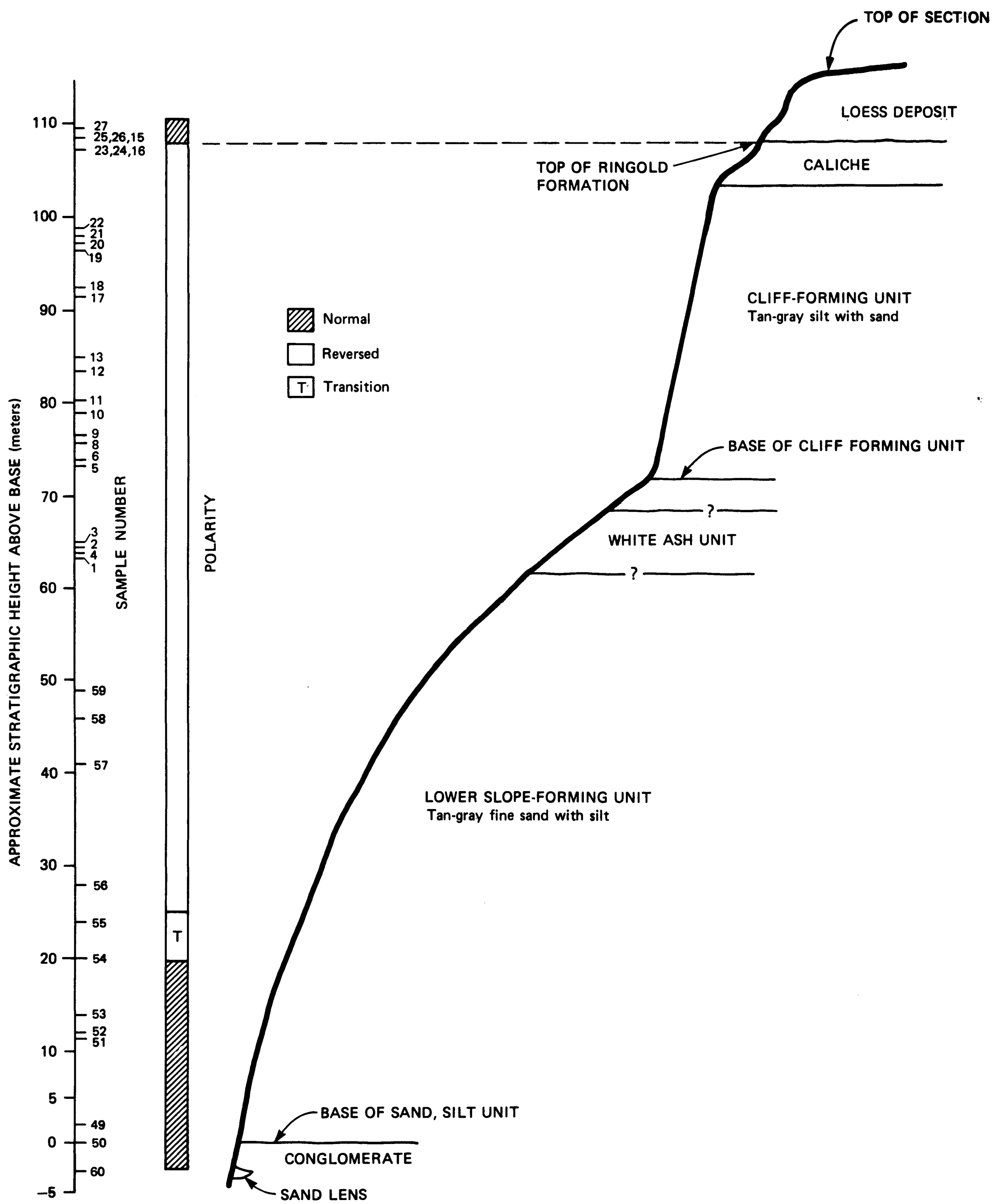


Figure 9. Schematic section with magnetic polarity at Ringold Formation.

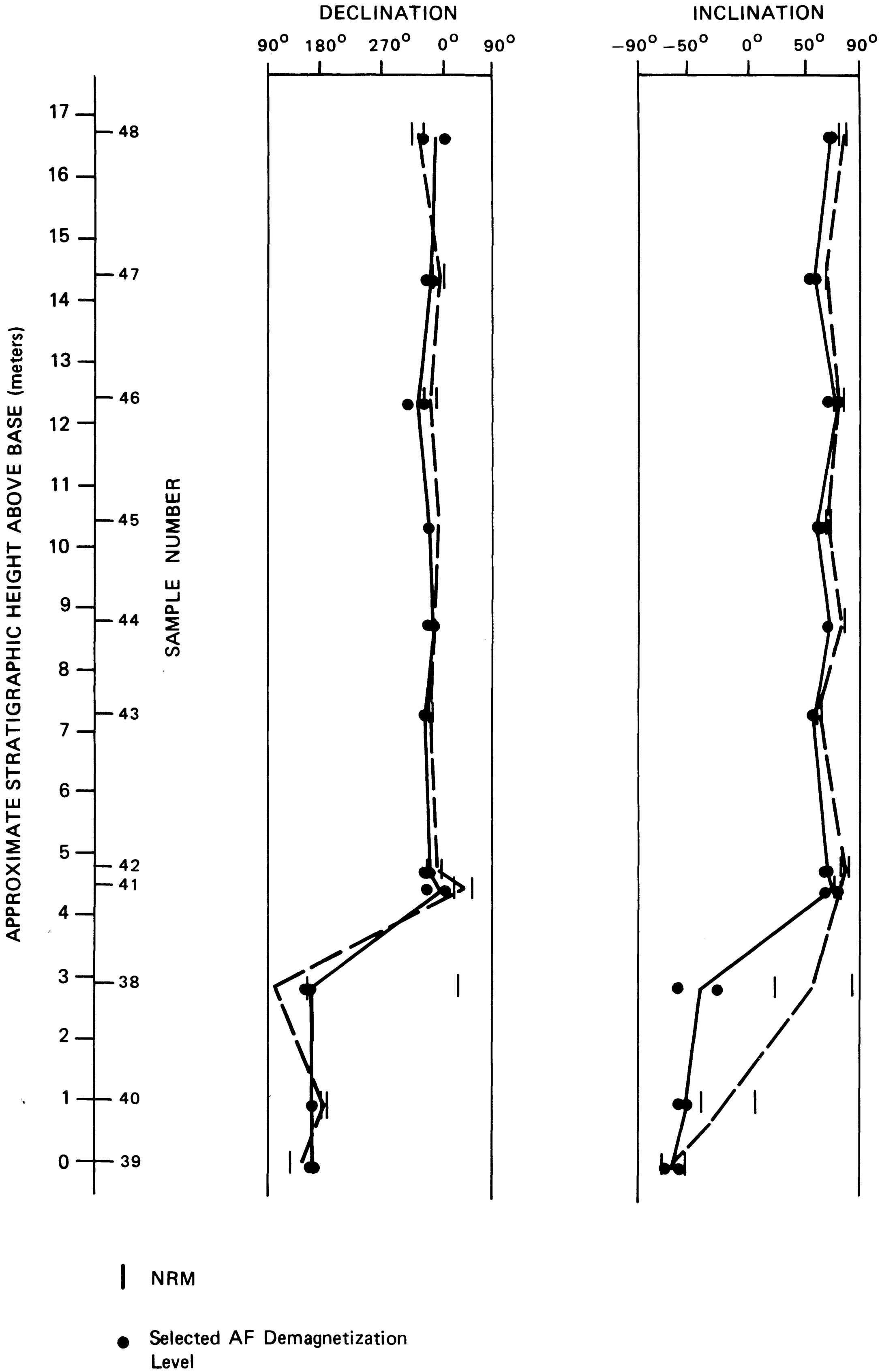


Figure 10. Declination and inclination versus stratigraphic height at Craigs Hill loess section.

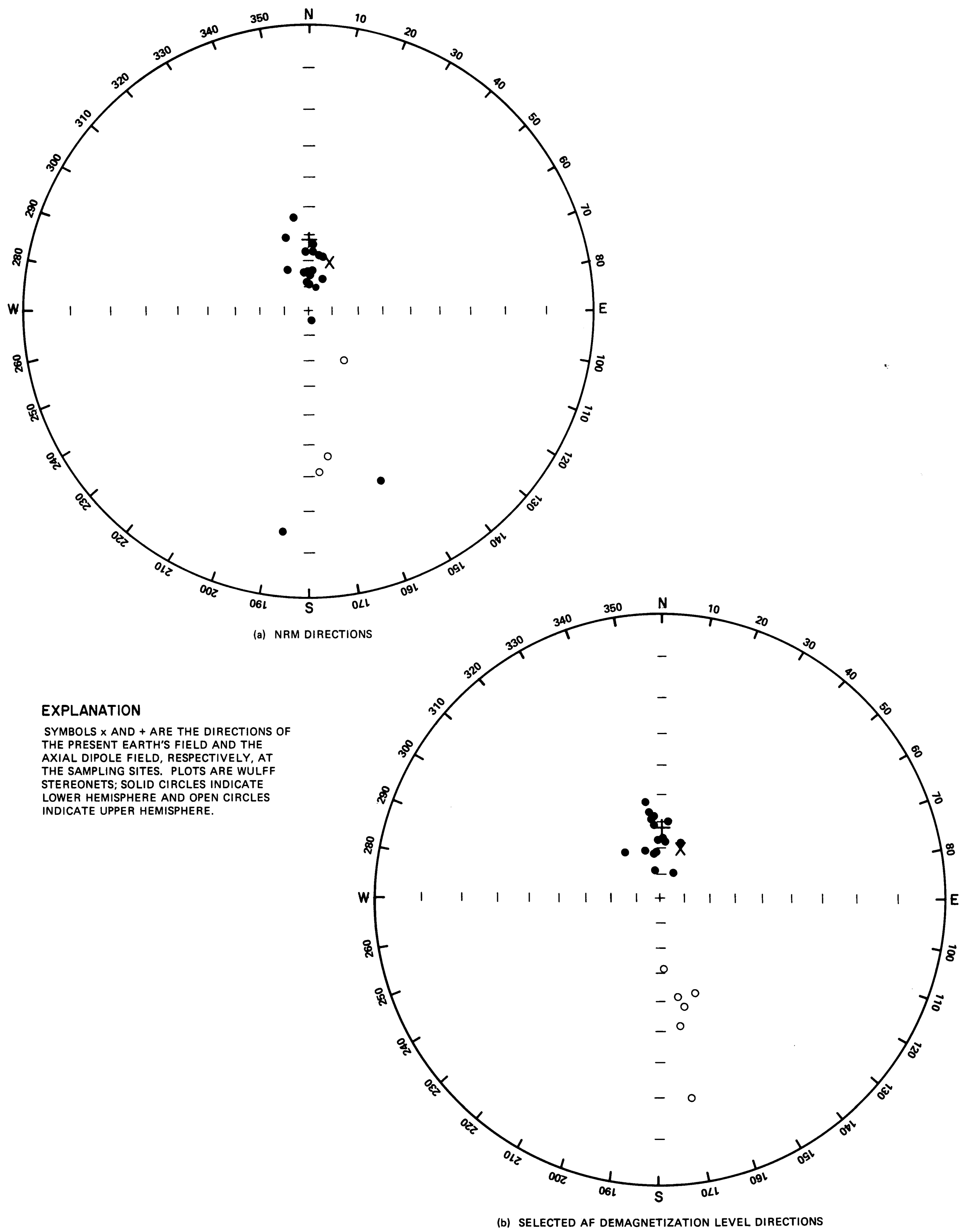


Figure 11. Stereonet plots of magnetization directions at Craigs Hill loess section.

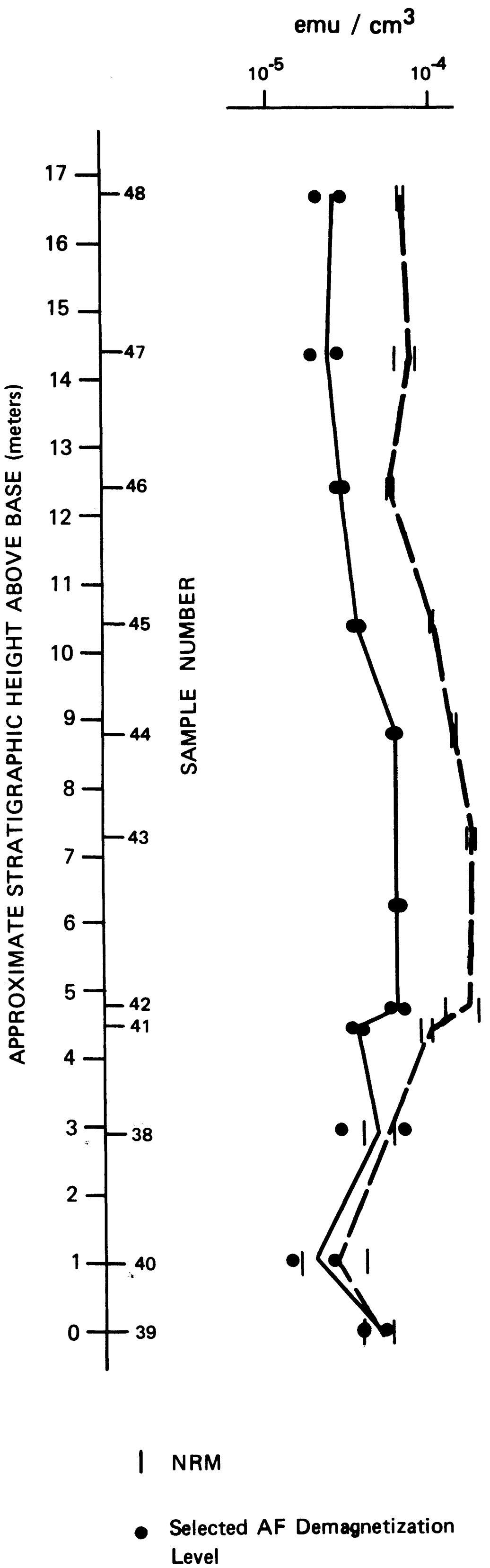


Figure 12. Intensity versus stratigraphic height at Craigs Hill loess section.

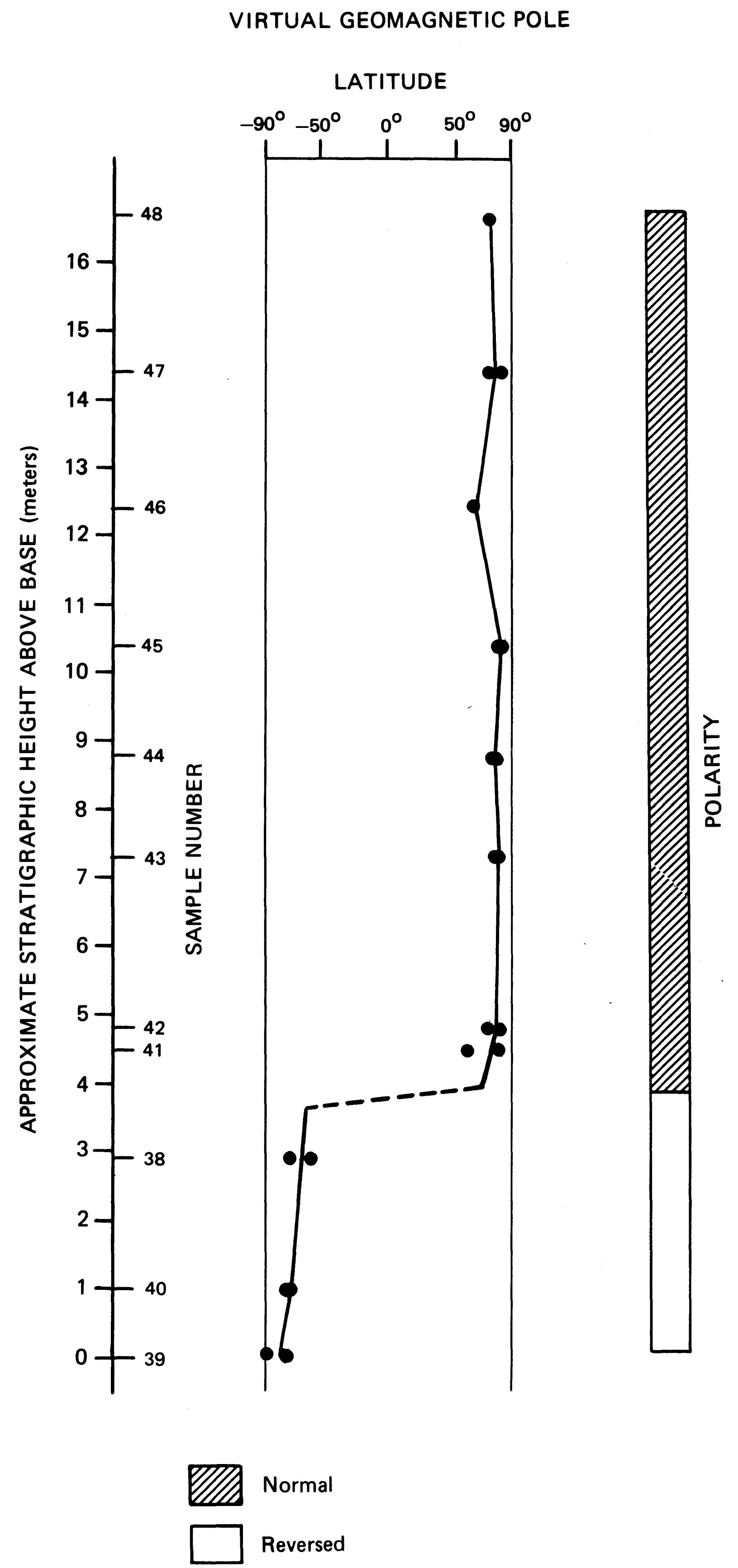


Figure 13. VPG latitude and magnetic polarity versus stratigraphic height at Craigs Hill loess section.

Figure 14. Part of Craigs Hill loess section. Arrows indicate location of oriented blocks collected for samples 41 (lowest), 42 (middle), and 43 (top). Sample 38, the uppermost sample with reversed magnetic polarity, is approximately 1.6 m (5.3 ft) stratigraphically below sample 41.

CONCLUSIONS

Ringold Formation

On the basis of these preliminary studies, the Ringold Formation exposed in White Bluff has been shown to be magnetically stable and to contain a polarity sequence suitable for correlation and possible age dating. The stratigraphically thick, magnetically reversed section confirms that the age of the Ringold Formation is older than 700,000 years.

Craigs Hill loess deposits

The loess deposits overlying the Naneum conglomerate on Craigs Hill have good magnetic stability. The lowest loess unit, approximately 3 m (10 ft) thick, was deposited during a time when the earth's magnetic field was reversed. On the basis of this magnetically reversed section, the deposits in the lower portion of the section are older than 700,000 years.

REFERENCES

Bonhommet, N., and Babkino, J., 1967, Magnetisme terrestre sur la presence d'aimantations inversees dans la Chaine de Puys: C.R.H. Aca. Sci., Ser. B, v. 264, p. 92-94.

Cox, A., 1969, Geomagnetic reversals: Science, v. 163, p. 237-245.

Dalrymple, G.B., 1972, Potassium-argon dating of geomagnetic reversals and North American glaciation, *in* Bishop, W.W., and Miller, J.A., eds., Calibration of Hominoid Evolution, Scottish Academic Press, Edinburgh, Scotland, p. 107-134.

Gromme, C.S., and Hay, R.L., 1971, Geomagnetic polarity epochs: Age and duration of the Olduvai normal polarity event: Nature, v. 10, p. 179-185.

Kawai, N., Yaskawa, K., Nakajima, T., Torii, M., and Horie, S., 1972, Oscillating geomagnetic field with a recurring reversal discovered from Lake Biwa: Proceedings of Japan Academy, v. 48, p. 186-190.

Kukla, G.J., and Koci, A., 1972, End of the last interglacial in the loess record: Quaternary Research, v. 2, p. 374-383.

Morner, N.A., Lanser, J.P., and Hospers, J., 1971, Late Weichselian paleomagnetic reversal: Nature, v. 234, p. 173-174.

Noel, M., and Tarling, D.H., 1975, The Laschamp geomagnetic "event": Nature, v. 253, p. 705-707.

Opdyke, N.D., 1972, Paleomagnetism of deep-sea cores: Review of Geophysics and Space Physics, v. 10, p. 213-249.

Smith, J.D., and Foster, J.H., 1969, Geomagnetic reversal in Brunhes Normal Polarity Epoch: Science, v. 163, p. 565-567.

Watkins, N.D., 1968, Short-period geomagnetic polarity events in deep-sea sedimentary cores: Earth and Planetary Science Letters, v. 4, p. 341-349. □

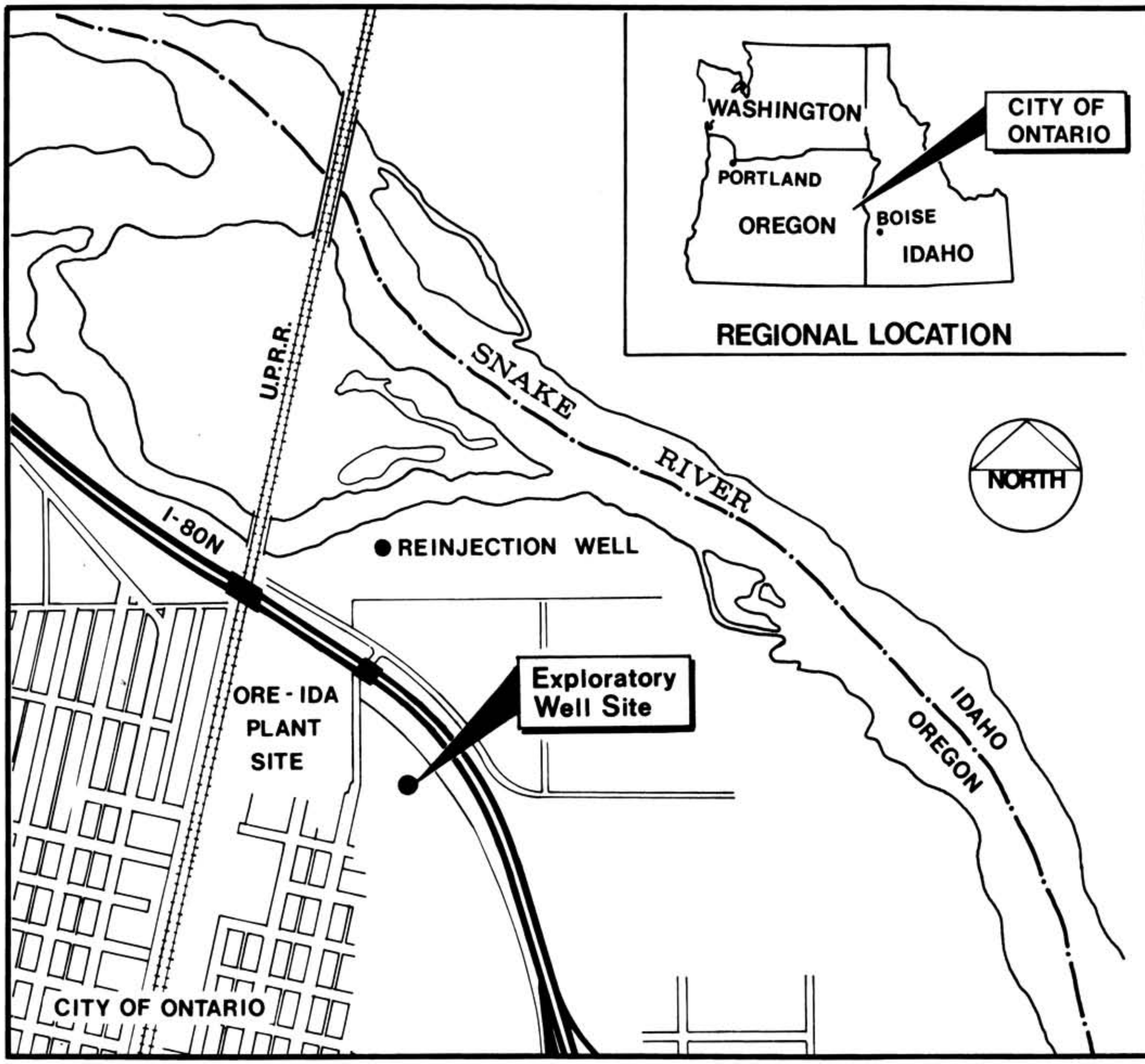
Ore-Ida to begin geothermal exploration

Earlier this year, Ore-Ida Foods, Inc., and the U.S. Department of Energy agreed to jointly participate in a geothermal resource project to use geothermal fluid to substitute for fossil fuel at Ore-Ida's Ontario, Oregon, plant. A contract was signed by Ore-Ida and Perryman Drilling Company, Inc., of Sacramento, California, for drilling a geothermal well in Ontario.

The first exploratory well will be drilled on Ore-Ida property, east of the frozen-food processing plant and northeast of the city. After extensive geologic surveys and analyses, the site was selected as having the necessary heat potential. The temperature of the geothermal fluid is expected to be about 300° to 320°F.

The drilling, set to begin in mid-July, is expected to be completed by late August or early September. "If initial drilling indicates a suitable resource availability, one to two additional wells will be drilled, and equipment at the plant will be mechanically retrofitted to use the geothermal water," said Bob Rolf, Program Manager for Ore-Ida.

Perryman Drilling Company, Inc., was chosen from five bidders on the project. Technical aspects of the program are being managed by CH2M Hill, located in Boise, Idaho. Development of the entire geothermal energy system will occur over a three-year period. □



Locating yourself with the PP&L power pole numbering system*

For years, geologists and other people roaming both on and off the beaten track have used the pole numbering system of Pacific Power and Light Company (PP&L) to find their ways through the hinterlands or to locate specific places on maps. An article in last month's *Oregon Geology* (v. 41, no. 7, p. 108) used a power pole number to indicate the location of a limestone outcrop.

Although this method may not be as precise as some of the more sophisticated navigational techniques now available, it still makes it possible to locate a PP&L pole (and yourself) to within a few hundred feet on any survey map by the information given on the yellow pole tag, which is found within a few feet of the bottom of the pole.

The PP&L pole numbering system is based on the U.S. Public Land Survey Township and Range System, in which a square 6 mi on a side forms the basic unit, called a "township." Townships are laid out north and south from an east-west base line, and east and west from a north-south principal meridian. Parallel lines at 6-mi intervals north and south of the base line are called "township lines"; parallel lines east and west of the principal meridian are called "range lines."

For Oregon and Washington, the base line is the Willamette Base Line, at 45°31′ latitude; the principal meridian is the Willamette Meridian, at 122°44′ longitude. These two lines intersect in Portland's West Hills at the Willamette Stone, which is the point from which early-day surveyors laid out the Oregon and Washington land survey system. In Oregon, township lines are described as north or south of the Willamette Base Line; range lines are east or west of the Willamette Meridian.

These lines intersect to form townships. Each township is divided into 36 sections, each 1 mi square. Sections are numbered consecutively, beginning with 1 in the upper right-hand corner, then going from right to left in the first row, left to right in the second row, and so on, with odd-numbered rows going from right to left and even-numbered rows going from left to right. The last number, 36, is in the lower right-hand corner.

PP&L further divides each section into a grid whose lines form 100 squares, each one-tenth of a mile (528 ft) on a side. The last numbers on a power pole show its position within the square.

The PP&L power pole tag number gives the township, range, section, PP&L grid square, and pole number within the grid square.

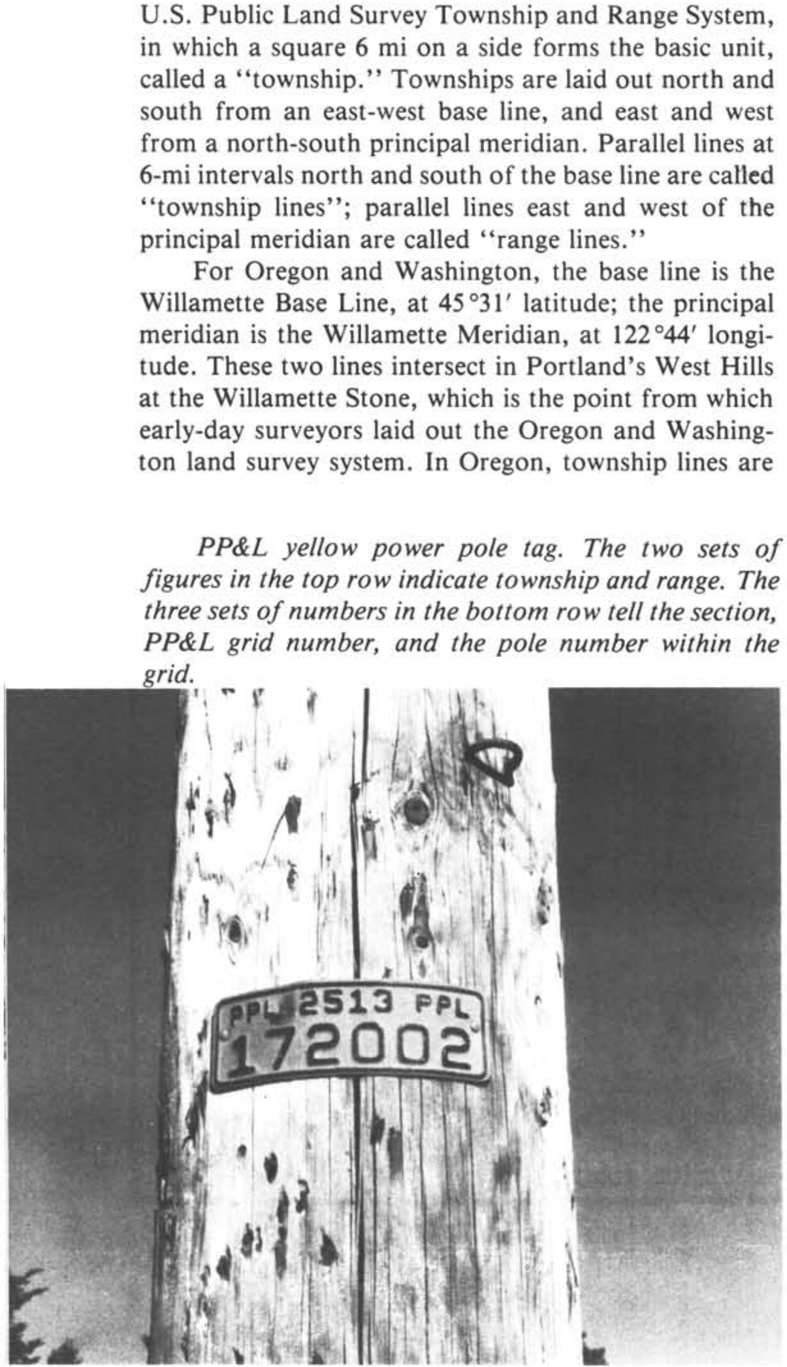
How does the system work? The pole number is in two rows, with four digits in the top row and six in the bottom. As an example, assume the top row reads "2513" and the bottom row "172002" and the pole is southwest of Portland in the town of Coos Bay.

The top row tells the township and range. Because the pole is south of the Willamette Base Line and west of the Willamette Meridian, we know already that the township will be south and the range will be west. The 25 means Township 25 South, telling us that the pole is 25 townships or 150 mi (25 townships multiplied by 6 mi per township) south of the Willamette Base Line. The 13 indicates Range 13 West, meaning that the pole is 78 mi (13 ranges multiplied by 6 mi per range) west of the Willamette Meridian. This combination of township and range occurs in Oregon only in the western part of the town of Coos Bay.

In the bottom row, the first set of two numbers, 17, tells the section within the township where the pole is located. The second set of two numbers, 20, gives the PP&L grid number. Units in the grid are numbered both horizontally and vertically from 0 through 9, beginning in the bottom left-hand corner. The first number in the second set of numbers indicates the horizontal side of the grid; the second number gives the vertical side. Grid number 20 means the third square to the right of the starting point in the 0 (bottom) row. The final two digits, 02, show the actual pole number within the grid.

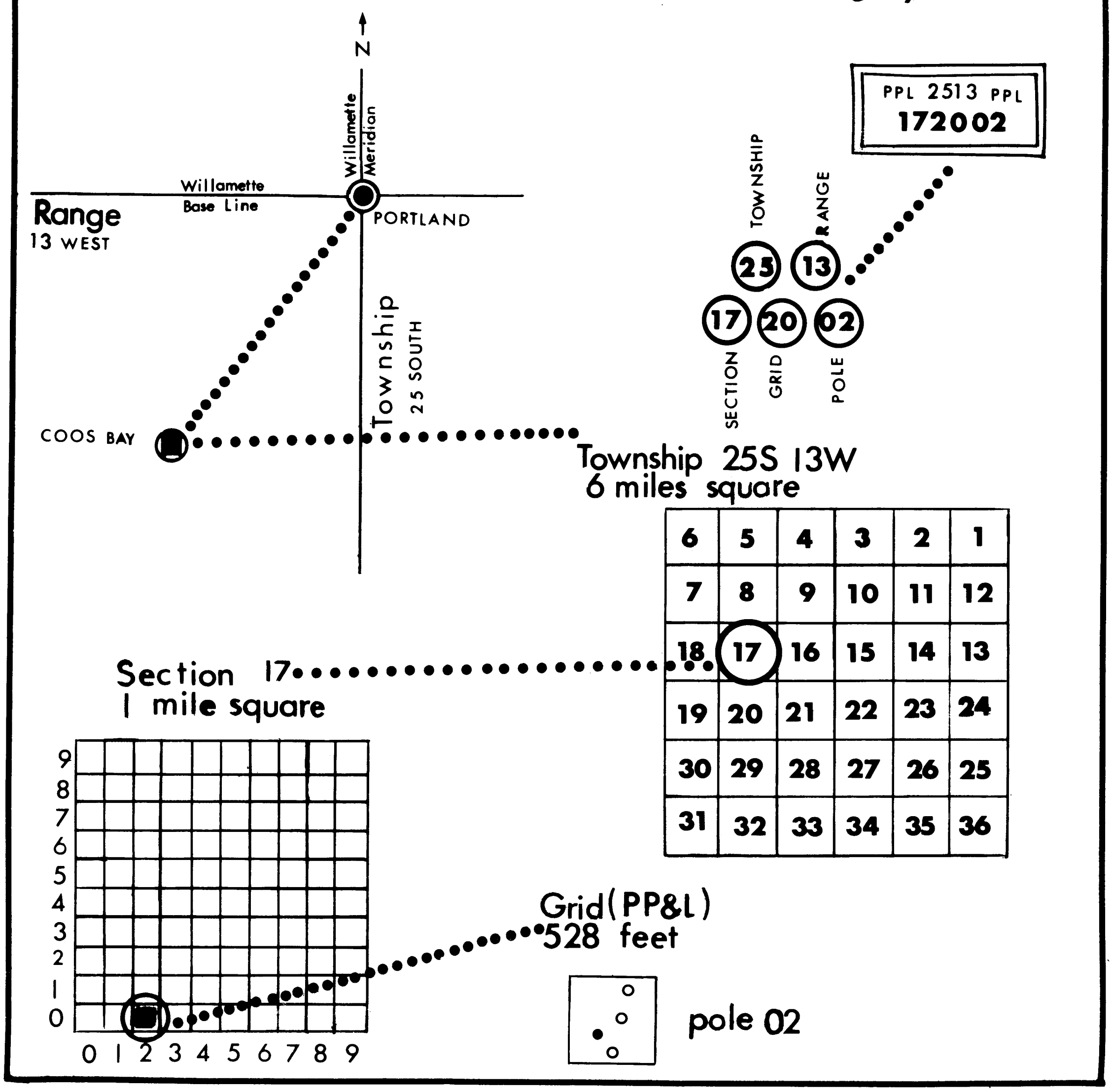
On a foggy morning, after locating an important outcrop next to a PP&L pole with no landmarks in sight, how can you use this system to find yourself on a map?

PP&L yellow power pole tag. The two sets of figures in the top row indicate township and range. The three sets of numbers in the bottom row tell the section, PP&L grid number, and the pole number within the grid.



*Source: Pacific Power and Light Company, 920 S.W. 6th, Portland, Oregon 97204. For more information write or call Leonard Bacon, (503) 243-4763.

Pacific Power & Light Company's Pole Numbering System



First, you should know if you are east or west of the Willamette Meridian and north or south of the Willamette Base Line. Note the township, range, and section numbers on the pole, then locate yourself on an appropriately marked county, U.S. Geological Survey, or U.S. Forest Service map. Once you have identified the section you are in, divide it with 10 horizontal and 10 vertical lines into 100 equal squares. Then, after you have determined which square in the PP&L grid you are in, you have located yourself in a block that is 580 ft on a side.

If you are ever lost but are fortunate enough to be near a PP&L power pole, walk down the line of poles and watch the numbers change. Within a few poles, the grid number will change, thereby giving the direction. For example, if grid number 20 changes to 21, you are walking north, because 21 is the number of the next square north of 20. If the grid number changes to 30, you are headed east; 10, west. Moving south, however, you will see the entire bottom line of numbers change, because the section number will also change. The pole number will now show section 20, grid number 29, and the individual pole number within the grid.

The one exception to this pole numbering system in the six-state PP&L service area is the former California-Oregon Power Company (COPCO) area of southwest Oregon. COPCO's system of numbering poles is still in use in that area, which extends from the Roseburg-Sutherlin area to Yreka, California, and west from Klamath Falls to the Pacific coast.

Some confusion can also arise if you are close to the Willamette Meridian or Willamette Base Line. The pole numbers will not tell you if you are east or west of the meridian or north or south of the base line. But given time and a map, a good geologist or an experienced outdoorsperson should be able to determine that. □

A petrified walnut preserved along with a small stem and a leaf in a specimen from the Clarno Formation. This photograph by Thomas J. Bones is on the cover of the Atlas of Fossil Fruits and Seeds from North Central Oregon.

Book review

by Ralph S. Mason, former State Geologist

ATLAS OF FOSSIL FRUITS AND SEEDS FROM NORTH CENTRAL OREGON, by Thomas J. Bones, OMSI Occasional Papers in Natural Science, No. 1, 1979, 23 p., plates. A compilation of 39 genera of Eocene age fruit and seed specimens collected in the world-famous Clarno Nut Beds. The specimens are distributed through 23 families, many of which are now extinct, with others related to plants now living in the forests of southern Asia.

Specimens of the fruits and seeds, many of them visible only with the aid of a hand lens, were collected since 1943 by Thomas Bones, a layman, now living in Vancouver, Washington. Large quantities of his collected material are now in the National Museum of Natural History, Smithsonian Institution, Washington, D.C. A permanent display is also housed at the Cant Ranch Visitors Center in the John Day Fossil Beds National Monument near Dayville, Oregon.

Identification of the Clarno flora is an ongoing project with R.A. Scott of the U.S. Geological Survey, assisted by Elso Barghoorn of Harvard and Marjorie Chandler of the British Museum. The *Atlas* contains 69 pictures of the fruits and seeds, but no detailed descriptions are included. The specimens, unlike so much fossil material collected elsewhere, are largely undeformed and appear in the round. Many specimens have been silicified, and nuts with opalized meats are not uncommon.

The Clarno flora provides an insight into the tropical and sub-tropical climate, the volcanic activity, and the physical conditions that existed in north central Oregon during late Eocene time. □

Columbia County No. 1 well records for 1977 to be released

The Department will release 1977 well records of the Reichhold Energy Columbia County No. 1 gas exploration hole on September 5, 1979.

The hole was drilled in 1977 in the NW¼ sec. 11, T. 6 N., R. 5 W., Columbia County. Redrilling in 1979 resulted in the discovery of the Mist gas field.

Oregon statute requires that all records remain confidential for 2 years after abandonment or completion of a well. Records of the redrilling will not, therefore, be released until 1981.

Records of the original drilling include: well history, litholog, dip log calculations, induction electric log, acoustic velocity log, and well samples (cuttings).

When facilities have been arranged, the samples will be displayed for inspection. Meanwhile, anyone wanting to see them should call Vern Newton, (503) 229-5580.

Copies of the logs can be examined at the Department's Portland, Baker and Grants Pass offices after 9 a.m., September 5. Companies selling the information are: Munger Oilgram, P.O. Box 45738, Los Angeles, California 90045, phone: (213) 776-3990; M.J. Systems, P.O. Box 9098, Bakersfield, California 93309, phone: (800) 525-5951; Petro-Well Libraries, Inc., 150 Security Life Building, 1616 Glenarm Place, Denver, Colorado 80202, phone: (303) 892-5513; Rocky Mountain Well Log Service, 1375 Delaware Street, Denver, Colorado 80204, phone: (303) 825-2181; and Petroleum Information Log Services, P.O. Box 9279, 4300 Easton Drive, Bakersfield, California 93389, phone: (805) 327-5393.

The following table summarizes all the drilling done by Reichhold and partners in Oregon.

Summary of Reichhold Drilling in Oregon					
Permit Number	Company	Well Name	Location	Total Depth (ft)	Status
65	Reichhold	NNG-Crown Zellerbach No. 1	NE¼ sec. 22, T. 2 S., R. 10 W. Tillamook Co.	5557	Abandoned August 1975
66	Reichhold	NNG-Finn No. 1	SW¼ sec. 17, T. 6 S., R. 4 W. Polk Co.	7258	Abandoned October 1975
67	Reichhold	NNG-Merrill No. 1	SW¼ sec. 24, T. 8 S., R. 4 W. Marion Co.	5282	Abandoned October 1975
68	Reichhold	Crown Zellerbach No. 2	NW¼ sec. 8, T. 4 N., R. 3 W. Columbia Co.	5805	Abandoned November 1975
69	Reichhold	Columbia County No. 1	NW¼ sec. 11, T. 6 N., R 5 W. Columbia Co.	3111	Suspended September 29, 1977
69RD	Reichhold	Columbia County No. 1	NW¼ sec. 11, T. 6 N., R. 5 W. Columbia Co.	3105	Completed May 1979; 1690 MCF/D
71	Reichhold	Dia-Shamrock Columbia County No. 2	NE¼ sec. 14, T. 6 N., R. 5 W. Columbia Co.	2780	Abandoned July 1978
72	Reichhold	Dia-Shamrock Columbia County No. 3	NE¼ sec. 10, T. 6 N., R. 5 W. Columbia Co.	2932; redrilled to 2993	Completed June 1979; 4000 MCF/D
73	Reichhold	Dia-Shamrock Longview-Fibre No. 1	SW¼ sec. 11, T. 6 N., R. 5 W. Columbia Co.	3088	Abandoned October 1977
86	Reichhold	Columbia County No. 4	NE¼ sec. 15, T. 6 N., R. 5 W. Columbia Co.	2936	Completed May 1979 900 MCF/D
87	Reichhold	Columbia County No. 5	NW¼ sec. 10, T. 6 N., R. 5 W. Columbia Co.	3116	Abandoned July 1979
88	Reichhold	Grimsbo No. 1	SE¼ sec. 9, T. 6 N., R. 5 W. Columbia Co.		Location ready
89	Reichhold	Libel No. 1	NW¼ sec. 15, T. 6 N., R. 5 W. Columbia Co.		Location ready
91	Reichhold	Columbia County No. 6	SW¼ sec. 10, T. 6 N., R. 5 W. Columbia Co.		Drilling
92	Reichhold	Columbia County No. 7	SE¼ sec. 4, T. 6 N., R. 5 W. Columbia Co.		Location ready

New Oregon heat flow publication available

Special Paper 4, *Heat Flow of Oregon,* by D.D. Blackwell, D.A. Hull, R.G. Bowen, and J.L. Steele, is now available at the Oregon Department of Geology and Mineral Industries. This 42-page book, with map, describes the results of an 8-year project to investigate the geothermal features of Oregon. The abstract from the paper is printed below.

ABSTRACT

An extensive new heat flow and geothermal gradient data set for the State of Oregon is presented on a contour map of heat flow at a scale of 1:1,000,000 and is summarized in several figures and tables. The 1:1,000,000 scale heat flow map is contoured at 20 mW/m^2 (0.5 HFU) intervals. Also presented are maps of heat flow and temperature at a depth of 1 km averaged for $1° \times 1°$ intervals. Histograms and averages of geothermal gradient and heat flow for the State of Oregon and for the various physiographic provinces within Oregon are also included.

The unweighted mean flow for Oregon is 81.3 ± 2.7 mW/m^2 (1.94 ± 0.06 HFU). The average unweighted geothermal gradient is 65.3 ± 2.5 °C/km. The average heat flow value weighted on the basis of geographic area is 68 ± 5 mW/m^2 (1.63 ± 0.12 HFU), and the average weighted geothermal gradient is 55.0 ± 5 °C/km.

On the basis of the data, the State of Oregon can be divided into 4 heat flow provinces. The first of the heat flow provinces occupies the western third of the state and includes the Coast Range, Willamette Valley, Klamath Mountains, and Western Cascade Range provinces. The mean heat flow for these provinces is 41.8 ± 1.3 mW/m^2 (1.00 ± 0.03 HFU), and the average gradient is 26.4 ± 1.0 °C/km. Heat flow values within these provinces are relatively uniform, but low, with no evidence of extensive convective heat transfer.

The second group of provinces includes the Deschutes-Umatilla (Columbia) Plateau and Blue Mountains provinces in the northeastern third of the state. The mean heat flow for these two provinces is 65.2 ± 2.6 mW/m^2 (1.56 ± 0.06 HFU), and the average gradient is 43.7 ± 2.5 °C/km. This heat flow is considered anomalously high as the crust contributes very little to the surface heat flow and mantle heat flow value is 50-55 mW/m^2 (1.2-1.3 HFU). There is ubiquitous water motion along flow contacts in the Columbia River Basalt. However, the water motion appears to be relatively slow and has only a minor effect on the measured heat flow values.

The third group of provinces occupies the southeastern third of the state and includes the High Lava Plains, Basin and Range, Owyhee Upland, and Western Snake River Basin provinces. The mean heat flow is 98.4 ± 3.8 mW/m^2 (2.34 ± 0.08 HFU), and the mean gradient is 89.1 ± 3.4 °C/km. The heat flow and geothermal gradient are extremely high and are related to the extensive volcanism and tectonism characteristic of these provinces within the past 15-20 m.y. Disruption of conductive heat transport both by regional ground water systems and by hydrothermal convection systems is common, resulting in large scatter in the observed heat flow values. Large scale crustal effects on the heat flow are also observed. Because of the high geothermal gradient and high heat flow, this area of the state probably has the greatest potential for geothermal development for both high and moderate temperature geothermal systems.

The fourth area of the state includes the High Cascades Range. Reliable heat flow data are not available for the central and eastern parts of this area of extensive young volcanism; however, heat flow values along the northwestern boundary average 105.1 ± 8.5 mW/m^2 (2.51 ± 0.20 HFU) and the geothermal gradient averages 61.3 ± 3.4 °C/km. More data are needed for the High Cascade Range in order to properly evaluate its heat flow and geothermal potential. However, based on the heat flow data along the northwestern boundary, the young volcanism, and the existence of many hot springs along the western boundary, the geothermal potential of this province is undoubtedly large.

Thus, the overall heat flow pattern in the state consists of subnormal heat flow values in the western one-third of the state separated by the High Cascade Range from slightly high to very high heat flow values in the eastern two-thirds of the state. The pattern is related to the effect of Cenozoic plate tectonic activity in the Pacific Northwest and to subduction of the Juan de Fuca plate beneath the Pacific Northwest during the past few tens of millions of years.

The complete report, with map, costs \$3.00. Address orders to the Oregon Department of Geology and Mineral Industries, 1069 State Office Building, Portland, Oregon 97201. Include payment if your order is for less than \$20.00. □

PUBLICATIONS ORDER

Omission of price indicates publication is in press. Minimum mail order 50¢. All sales are final. Publications are sent postpaid. Payment must accompany orders of less than $20.00.

Fill in appropriate blanks and send sheet to Department (see address on reverse side).

YOUR NAME ______________________

ADDRESS ______________________

______________________ Zip__________

Amount enclosed $__________

OREGON GEOLOGY

____ Renewal ____ Subscription ____ Gift

____ 1 Year ($4.00) ____ 3 Years ($10.00)

NAME ______________________

ADDRESS ______________________

______________________ ZIP __________

(If Gift, From: ______________________)

ORDER FORM - CUT ON DASHED LINE

Available publications

MISCELLANEOUS PAPERS	Price	No. Copies	Amount
1. A description of some Oregon rocks and minerals, 1950: Dole	$ 1.00	_____	_____
4. Laws relating to oil, gas, and geothermal exploration and development in Oregon			
Part 1. Oil and natural gas rules and regulations, 1977	1.00	_____	_____
Part 2. Geothermal resources rules and regulations, 1977	1.00	_____	_____
5. Oregon's gold placers (reprints), 1954	.50	_____	_____
6. Oil and gas exploration in Oregon, rev. 1965: Stewart and Newton	3.00	_____	_____
7. Bibliography of theses on Oregon geology, 1959: Schlicker	.50	_____	_____
Supplement, 1959-1965: Roberts	.50	_____	_____
8. Available well records of oil and gas exploration in Oregon, rev. 1973: Newton	1.00	_____	_____
11. Collection of articles on meteorites, 1968 (reprints from *The Ore Bin*)	1.50	_____	_____
13. Index to *The Ore Bin*, 1950-1974	1.50	_____	_____
14. Thermal springs and wells, 1970: Bowen and Peterson (with 1975 supplement)	1.50	_____	_____
15. Quicksilver deposits in Oregon, 1971: Brooks	1.50	_____	_____
16. Mosaic of Oregon from ERTS-1 imagery, 1973	2.50	_____	_____
18. Proceedings of Citizens' Forum on potential future sources of energy, 1975	2.00	_____	_____
19. Geothermal exploration studies in Oregon—1976, 1977	3.00	_____	_____
20. Investigations of nickel in Oregon, 1978: Ramp	5.00	_____	_____
GEOLOGIC MAPS			
Geologic map of Galice Quadrangle, Oregon, 1953	1.50	_____	_____
Geologic map of Albany Quadrangle, Oregon, 1953	1.00	_____	_____
Reconnaissance geologic map of Lebanon Quadrangle, 1956	1.50	_____	_____
Geologic map of Bend Quadrangle and portion of High Cascade Mountains, 1957	1.50	_____	_____
Geologic map of Oregon west of 121st meridian, 1961	2.25	_____	_____
Geologic map of Oregon east of 121st meridian, 1977	3.75	_____	_____
GMS-3: Preliminary geologic map of Durkee Quadrangle, Oregon, 1967	2.00	_____	_____
GMS-4: Oregon gravity maps, onshore and offshore, 1967 (folded)	3.00	_____	_____
GMS-5: Geologic map of Powers Quadrangle, Oregon, 1971	2.00	_____	_____
GMS-6: Preliminary report on geology of part of Snake River Canyon, 1974	6.50	_____	_____
GMS-7: Geology of the Oregon part of the Baker Quadrangle, Oregon, 1976	3.00	_____	_____
GMS-8: Complete Bouguer gravity anomaly map, Cascade Mountain Range, central Oregon, 1978	3.00	_____	_____
GMS-9: Total field aeromagnetic anomaly map, Cascade Mountain Range, central Oregon, 1978	3.00	_____	_____
GMS-10: Low- to intermediate-temperature thermal springs and wells in Oregon, 1978	2.50	_____	_____
OIL AND GAS INVESTIGATIONS			
3. Preliminary identifications of foraminifera, General Petroleum Long Bell #1 well	2.00	_____	_____
4. Preliminary identifications of foraminifera, E.M. Warren Coos County 1-7 well, 1973	2.00	_____	_____
5. Prospects for natural gas production or underground storage of pipeline gas	5.00	_____	_____
MISCELLANEOUS PUBLICATIONS			
Landforms of Oregon (17 × 12 inches)	.25	_____	_____
Mining claims (State laws governing quartz and placer claims)	.50	_____	_____
Geological highway map, Pacific NW region, Oregon-Washington (published by AAPG)	3.00	_____	_____
Fifth Gold and Money Session and Gold Technical Session Proceedings, 1975	5.00	_____	_____
Sixth Gold and Money Session and Gold Technical Session Proceedings, 1978	6.50	_____	_____
Back issues of *The Ore Bin*	25¢ over the counter; 50¢ mailed	_____	_____
Colored postcard, *Geology of Oregon*	10¢ each; 3 for 25¢; 7 for 50¢; 15 for 1.00	_____	_____

OREGON GEOLOGY

1069 State Office Building, Portland, Oregon 97201

Second Class Matter
POSTMASTER: Form 3579 requested

Available publications (continued)

BULLETINS	Price	No. Copies	Amount
33. Bibliography (1st supplement) geology and mineral resources of Oregon, 1947: Allen	1.00		
36. Papers on Tertiary foraminifera: Cushman, Stewart and Stewart, 1949: v. 2	1.25		
39. Geology and mineralization of Morning Mine region, 1948: Allen and Thayer	1.00		
44. Bibliography (2nd supplement) geology and mineral resources of Oregon, 1953: Steere	2.00		
46. Ferruginous bauxite deposits, Salem Hills, 1956: Corcoran and Libbey	1.25		
49. Lode mines, Granite mining district, Grant County, Oregon, 1959: Koch	1.00		
53. Bibliography (3rd supplement) geology and mineral resources of Oregon, 1962: Steere and Owen	3.00		
57. Lunar Geological Field Conference guidebook, 1965: Peterson and Groh, editors	3.50		
62. Andesite Conference guidebook, 1968: Dole	3.50		
63. Sixteenth biennial report of the Department, 1966-1968	1.00		
64. Mineral and water resources of Oregon, 1969 (unbound, without maps and tables)	2.00		
65. Proceedings of Andesite Conference, 1969: (copies)	10.00		
67. Bibliography (4th supplement) geology and mineral resources of Oregon, 1970: Roberts	3.00		
68. Seventeenth biennial report of the Department, 1968-1970	1.00		
71. Geology of selected lava tubes in Bend area, Oregon, 1971: Greeley	2.50		
72. Bedrock geology of the Mitchell Quadrangle, Wheeler County, 1971	3.00		
76. Eighteenth biennial report of the Department, 1970-1972	1.00		
77. Geologic field trips in northern Oregon and southern Washington, 1973	5.00		
78. Bibliography (5th supplement) geology and mineral resources of Oregon, 1973: Roberts	3.00		
79. Environmental geology inland Tillamook and Clatsop Counties, 1973: Beaulieu	7.00		
81. Environmental geology of Lincoln County, 1973: Schlicker and others	9.00		
82. Geologic hazards of Bull Run Watershed, Multnomah, Clackamas Counties, 1974: Beaulieu	6.50		
83. Eocene stratigraphy of southwestern Oregon, 1974: Baldwin	4.00		
84. Environmental geology of western Linn County, 1974: Beaulieu and others	9.00		
85. Environmental geology of coastal Lane County, 1974: Schlicker and others	9.00		
86. Nineteenth biennial report of the Department, 1972-1974	1.00		
87. Environmental geology of western Coos and Douglas Counties, 1975	9.00		
88. Geology and mineral resources of upper Chetco River drainage, 1975: Ramp	4.00		
89. Geology and mineral resources of Deschutes County, 1976	6.50		
90. Land use geology of western Curry County, 1976: Beaulieu	9.00		
91. Geologic hazards of parts of northern Hood River, Wasco, and Sherman Counties, Oregon, 1977: Beaulieu	8.00		
92. Fossils in Oregon (reprinted from *The Ore Bin*), 1977	4.00		
93. Geology, mineral resources, and rock material of Curry County, Oregon, 1977	7.00		
94. Land use geology of central Jackson County, Oregon, 1977: Beaulieu	9.00		
95. North American ophiolites, 1977	7.00		
96. Magma genesis: AGU Chapman Conference on Partial Melting, 1977	12.50		
97. Bibliography (6th supplement) geology and mineral resources of Oregon, 1971-75, 1978	3.00		

SPECIAL PAPERS	Price	No. Copies	Amount
1. Mission, goals, and purposes of Oregon Department of Geology and Mineral Industries, 1978	2.00		
2. Field geology of SW Broken Top Quadrangle, Oregon, 1978: Taylor	3.50		
3. Rock material resources of Clackamas, Columbia, Multnomah, and Washington Counties, Oregon, 1978: Gray	7.00		
4. Heat flow of Oregon, 1978, Blackwell, Hull, Bowen, and Steele	3.00		

SHORT PAPERS	Price	No. Copies	Amount
18. Radioactive minerals prospectors should know, 1976: White, Schafer, Peterson	.75		
19. Brick and tile industry in Oregon, 1949: Allen and Mason	.20		
21. Lightweight aggregate industry in Oregon, 1951: Mason	.25		
24. The Almeda Mine, Josephine County, Oregon, 1967: Libbey	3.00		
25. Petrography, type Rattlesnake Formation, central Oregon, 1976: Enlows	2.00		
27. Rock material resources of Benton County, 1978: Schlicker and others	4.00		