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STEENS
MOUNTAIN



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MAY 03 1976

STEENS MOUNTAIN, OREGON

Ernest H. Lund* and Elton Bentley**

Steens Mountain, in Harney County, is Oregon's highest and scenically grandest fault-block mountain (Figure 1). It extends in a northeasterly direction for about 50 miles and rises at its highest point to 9,733 feet above sea level. Burns, the nearest city, is situated about 50 miles to the north.

A round trip of about 245 miles, starting and ending at Burns, will take one completely around the mountain. To make this trip, drive east from Burns on Oregon Highway 78 about 2 miles, then south on Oregon Highway 205, crossing part of the Malheur National Wildlife Refuge, and continue south through the small settlement of Frenchglen into Catlow Valley. Here the road changes to a good rock-surfaced road. Continue south along the face of Catlow Rim to Long Hollow, then east across the southern end of the Steens to Fields. From Fields, turn north on the rock-surface road and follow the base of the Steens escarpment northward to Oregon Highway 78. Turn northwest and return to Burns.

To reach the top of the Steens for spectacular views of this great fault block mountain and its glaciated valleys, take the Steens Mountain summit loop road from Frenchglen (see map). At the time of this writing, the loop road was improved only as far as Fish Lake.

Physiographic and Structural Setting

The Great Basin, which occupies Nevada and parts of adjacent states and extends into southeastern Oregon, is characterized by fault-block mountains and intermountain basins. Steens Mountain is the most prominent of the fault blocks in the northern part of the Great Basin.

The Steens Mountain block was uplifted and tilted gently toward the west along a major set of faults that determines the northeasterly trend of the mountain. The block itself is cut by many smaller faults, one set parallel to the major faults and another set trending northwesterly at nearly right angles. Displacement along the northwesterly-trending faults has separated

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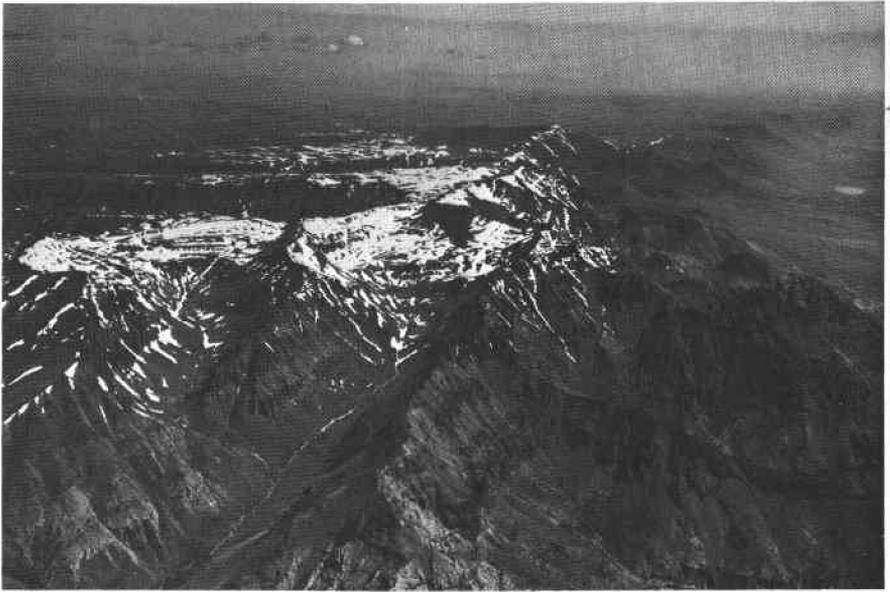


Figure 1. High Steens viewed from the south. Wildhorse Canyon and Little Wildhorse Canyon are in lower-left quarter of photograph. (Conkling photo)



Figure 2. Central part of High Steens with Northern Steens in the distance. A small fault block lies east of and parallel to the Northern Steens. Note dike in center of photo. (Ore. Hwy. Div. photo by Kinney)

the mountain into three distinct topographic units known as Northern Steens, High Steens, and Southern Steens (Fuller, 1931, p. 23).

The Northern Steens (Figure 2) extends for a distance of more than 25 miles and is bounded on the east by a steep, continuous scarp trending N. 30° E. At its southern end, the scarp rises nearly 3,000 feet above the valley floor; toward the north it diminishes in height, finally merging with the hilly terrain southeast of Malheur Lake. The west side of the Northern Steens slopes gently toward the valley of Donner und Blitzen River, which lies along the hinge line of the fault block. East of the scarp, a long narrow valley occupies the hinge line of a low fault block that parallels the Northern Steens. This valley contains a number of shallow, intermittent lakes. Mann Lake, near the south end of this valley, is a permanent lake fed by creeks that originate just below the crest of the scarp.

The High Steens (Figure 3), which forms the central segment of the mountain, is about 15 miles long. It rises along a north-south scarp about 5,500 feet above the floor of the Alvord Desert and reaches an altitude of 9,733 feet. Bounded on the north and south by northwest-trending fault scarps, the High Steens stands about 2,000 feet above the other two segments of the mountain. Its back slope, between the crest and the Donner und Blitzen River 20 miles to the west, has an inclination of about 3°. The steep eastern scarp has been shaped into spectacular valleys and sharp ridges by glaciation and stream erosion. Streams originating high on the scarp, some in small cirque basins just below the rim, have built prominent alluvial fans along the base of the scarp, as at Alvord Creek, Pike Creek, and Indian Creek.

The Southern Steens is separated from the High Steens by a prominent northwest-trending fault scarp that decreases in height toward the west owing to a greater amount of tilt in the High Steens block. On the west, the Southern Steens is bounded by Catlow Rim (Figure 4), a prominent fault scarp which at its highest part rises about 2,000 feet above Catlow Valley. Thus the Southern Steens, bounded on both the east and west sides by fault scarps, is a horst.

Another fault scarp, trending about N.60°W. with the downfaulted block to the south, divides the Southern Steens into two parts. The northern and larger part, known as Smith Flat (Figure 8), is a structural sag which controls the northwest-trending course of the Blitzen River. In the other part, south of Smith Flat, numerous faults have produced a very irregular terrain through tilting of the blocks and subsequent erosion by running water. Some of the blocks have been elevated to heights above the less rugged Smith Flat.

To the south, Steens Mountain merges with the Pueblo Mountains, and the boundary between the two is not sharply defined either structurally or in terms of rock types. However, a topographic break northwest of Fields, marked by a gap in the mountain and by Long Hollow, can be considered the southern end of Steens Mountain.

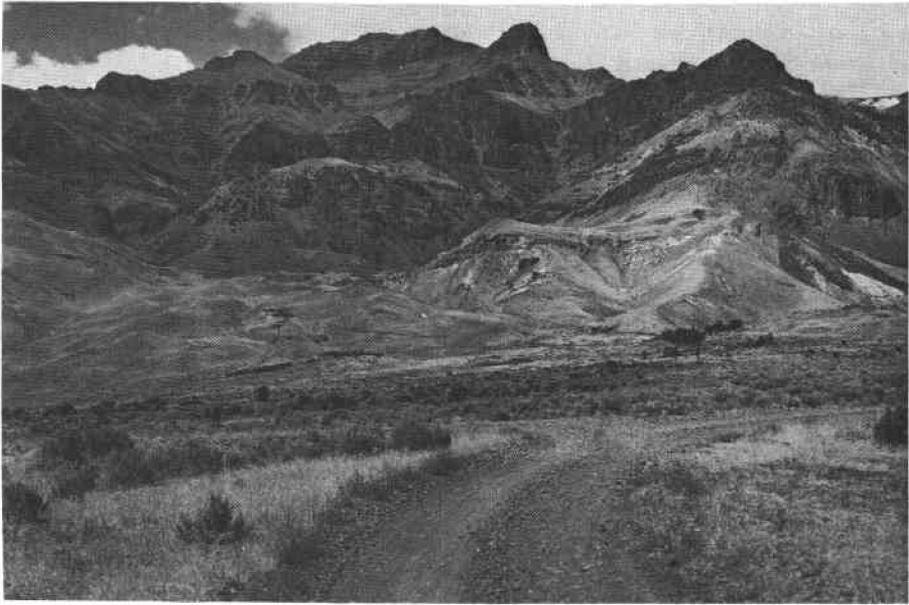


Figure 3. High Steens from the Alvord Ranch. Alvord Creek beds make up the foothills and are overlain by the Steens Mountain Andesite Series. (Ore. Hwy. Div. photo)

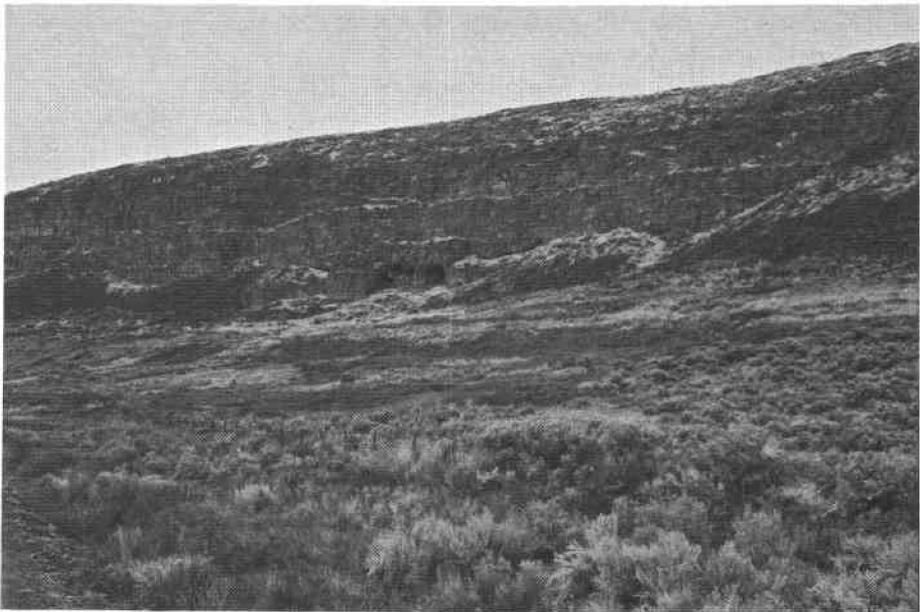


Figure 4. Catlow Rim near Roaring Springs Ranch. Caves near the base of the scarp were once occupied by Indians.

Rock Sequence

The bedrock exposed in Steens Mountain is mostly flow lava, but bedded pyroclastics and intrusive bodies are also exposed in the east scarp of the High Steens. The scarp provides the thickest exposed section in the southeastern part of the State, and rocks as old as Oligocene (Walker and Repenning, 1965) crop out at the base. Fuller (1931) made a comprehensive study of the rocks of Steens Mountain, and the more recent work by Walker and Repenning has led to modifications of Fuller's interpretation of the volcanic sequence. The following descriptions of the rock units are drawn principally from these two works. For detailed lithologic descriptions, the reader is referred to Fuller and for mapped distributions to Walker and Repenning.

Alvord Creek beds

Fuller applied the name Alvord Creek beds to light-colored tuffs that crop out at a number of places in the lower thousand feet of the scarp (Figure 3) between Cottonwood and Toughy Creeks, a distance of more than 5 miles. The unit consists of stratified acidic tuffs. The color is predominantly white, but brownish and greenish varieties of altered tuff are common. North of Alvord Creek, two thick andesite flows are interlayered with the sediment, and north of Little Alvord Creek the beds are intruded by a 200-foot-thick basalt sill. A rhyolite intrusion in the form of a laccolith has uparched the sedimentary beds and sill and has altered them locally.

Although the Alvord Creek beds appear to be at the base of the Miocene rock sequence in the east scarp of Steens Mountain, there is disagreement on the age and distribution of the unit. A study of plant fossils in the Alvord Creek beds by Chaney (in Fuller, 1931, p. 51) led him to conclude that the unit was equivalent to the late Miocene Mascall Formation in the John Day Valley. Axelrod (1944, p. 225) assigned an early Pliocene age to the beds on the basis of composition of the fossil flora and its geographic and climatic implications. Possibly, rock units of similar lithology occurring in Pliocene structural terraces as well as beneath Miocene volcanic rocks are being mapped as Alvord Creek beds by different workers.

The fossil flora includes species of fir, spruce, pine, juniper, maple, aspen, cottonwood, willow, beech, Oregon grape, service berry, mountain mahogany, Christmas berry, cherry, rose, mountain ash, sumac, madrona, chaparral, and pondweed. Axelrod concluded that this flora denotes a region of moderate topographic diversity with an annual rainfall of 20 to 30 inches and temperatures ranging from below freezing in winter to high in summer and that these conditions are intermediate between the moister and milder climate of the Miocene and the drier and colder climate of the region today.



Figure 5. Pike Creek Formation at the mouth of Pike Creek Canyon. (Ore. Hwy. Div. photo)

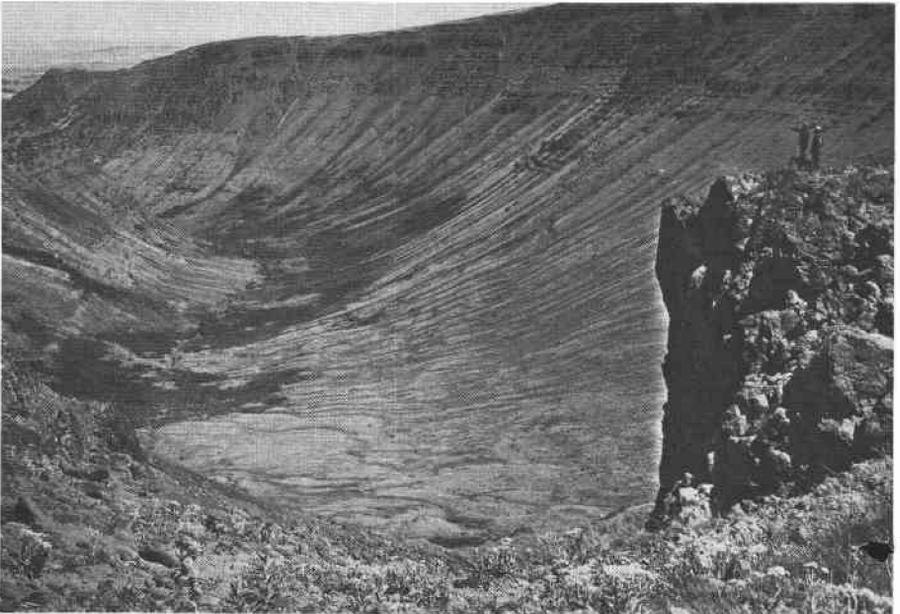


Figure 6. Kiger Gorge. Steens Basalt flows are well displayed in the canyon walls. (Ore. Hwy. Div. photo)

Pike Creek Volcanic Series

Fuller gave the name Pike Creek Volcanic Series to a thick series of acidic flows and stratified tuffs that are best exposed in Pike Creek Canyon (Figure 5). The aggregate thickness totals more than 1,500 feet. The lower 1,000 feet of the series consists of two tuff members interlayered with two rhyolite flows, each unit 200 to 300 feet thick. The lowermost tuff unit is intruded by five basalt sills ranging from a few inches to 15 feet in thickness. A 40-foot layer of tuff overlies the uppermost rhyolite, and this is in turn followed by two biotite-dacite flows, the lower of which is about 200 feet thick and the upper ranging from 200 feet to 500 feet. Walker (Walker and Repenning, 1965) renamed this series the Pike Creek Formation, to which he assigns an age of Oligocene and Miocene.

Steens Mountain Andesitic Series

This series consists of an andesite flow up to 200 feet or more in thickness at the base and capped by a stratified tuff unit up to 20 feet thick, a unit called the "great flow" with a maximum thickness of about 900 feet, and a series of alternating thin layers of andesite breccias and platy flow-andesite with a maximum aggregate thickness of more than 600 feet. Pyroclastic deposits marking sites of small volcanic cones are related to the upper andesite series.

The "great flow" is a prominent unit in the Alvord Creek locality, where it is about 900 feet thick. Joint columns measure as much as 5 feet across and rise 300 feet above the talus. The unit thins to about 500 feet in the valley of Cottonwood Creek, a mile to the north. Fuller did not identify the unit with certainty north of there, though he reports that similar rock with exposed thickness of about 400 feet crops out at Mann Creek, about 7 miles north of Cottonwood Creek. South of Alvord Creek the flow is exposed only in scattered outcrops.

Steens Mountain Basalt

The Steens Mountain Basalt (name shortened to Steens Basalt) (Figure 2), a series of thin flood or plateau basalt, constitutes the bulk of the mountain and extends into Pueblo Mountain to the south and to Abert Rim to the west. It makes up the upper 3,000 feet of the east scarp and is the rock exposed along the glacial valleys on the back slope of the mountain. Except where covered locally by a younger ash flow, it is the bedrock over most of the western slope.

The maximum original thickness of the Steens Basalt is not known, for much of it has been removed from the High Steens by glacial erosion, and it is only on the east scarp of this part of Steens Mountain that the base is exposed. Wilkerson (1958) measured 3,280 feet of section on the west rim



Figure 7. View east up Little Blitzen Canyon. Alvord Desert in far right distance. (Ore. Hwy. Div. photo by Kinney)

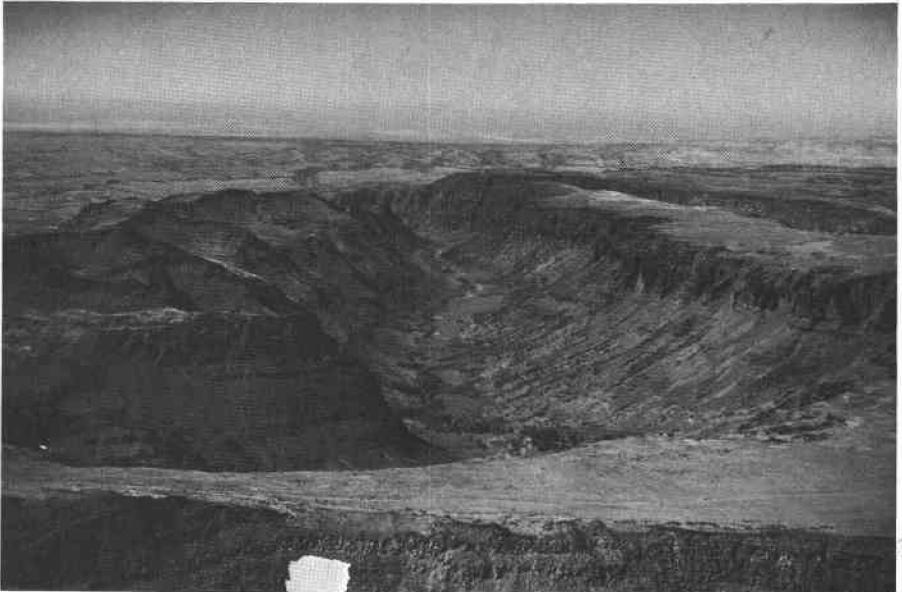


Figure 8. Narrow wall separates east scarp from Big Indian Canyon (white patch in foreground is snow clinging to east scarp). Smith Flat in background. (Ore. Hwy. Div. photo by Kinney)

of Wildhorse Canyon but believed the formation was much thicker. Individual flow units range from less than a foot to more than 70 feet in thickness but average about 10 feet.

Most of the flows, despite their thinness, are of totally crystalline rock, predominantly a fairly basic olivine basalt. Textures of rock in the series range from fine grained, in which a few or no individual grains can be discerned, to porphyritic, in which plagioclase plates are as much as 4 centimeters long. In some porphyritic varieties, the plagioclase crystals are clustered in a radiating or stellate arrangement. Many of the flows are diktytaxitic, a textural term proposed by Fuller (1931, p. 116) for a porous texture in which plagioclase laths are in a netlike arrangement with empty space between. Numerous dikes (Figure 2) believed to be feeders cut the flows.

Based on potassium-argon ages obtained by Evernden and co-workers (1964, p. 164, 190, 194), the formation is assigned the age of middle and late Miocene. Ages of 14.5 m.y. and 14.7 m.y. were obtained from a unit high in the series on Steens Mountain, and an age of 14.6 m.y. was obtained from sediments interbedded with Steens Basalt on Beatys Butte west of Catlow Valley.

Ash-flow tuff (Danforth Formation)

Numerous small isolated patches of Pliocene welded tuff are scattered over Smith Flat, and an extensive sheet veneers the Steens Basalt on the lower slopes of the High Steens and the Northern Steens. The rock consists of glass shards, crystal fragments, and fragments of pumice and other rock all welded together. In places where the rock is only lightly welded, it is soft and erodes easily. Where welding is intense, the rock is compact and has a glassy or porcelaneous appearance.

From its patchy distribution over Smith Flat and other parts of the mountain, it appears that welded tuff was originally widespread and likely formed a veneer over all the Steens Basalt on the west slope of the mountain but was later eroded from most of the High Steens by glacial ice and running water. The distribution of welded tuff around the Harney basin and over Steens Mountain suggests that it was emplaced before the onset of block faulting. Potassium argon ages average 9.2 m.y. (Green, 1973, p. 3). This would place the beginning of the Steens uplift at about 9 to 10 million years ago. Movement likely continued into the Pleistocene, but the mountain had acquired most of its height before glaciation.

Glaciation

Erosional features

Running water, glacial ice, and other agents of erosion have not severely changed the mountain's gross block-fault form, but they have



Figure 9. Large cirque on the east scarp at the head of Alvord Creek. A narrow ridge, an *arête*, separates it from Wild-horse Canyon (lower right corner). (Ore. Hwy. Div. photo)



Figure 10. Small cirques around the upper edge of the large cirque at the head of Alvord Creek. Alvord Desert, a playa, is in the distance. (Ore. Hwy. Div. photo by Kinney)

effected marked changes in the surface configuration of both the long, gentle back slope and the steep eastern scarp. The east scarp has retreated an estimated mile and a half from its original position (Williams and Comp-ton, 1953, p. 34), and the western slope has been sculptured by glacial ice that has shaped lake basins and cut deep, U-shaped canyons.

Ice has been the main sculpturing agent on the upper part of the High Steens and on the adjacent parts of the Northern and Southern Steens into which glaciers originating in the High Steens flowed. Kiger Gorge (Figure 6) and the canyons of Little Blitzen River (Figure 7), Big Indian Creek (Figure 8), Little Indian Creek, Wildhorse Creek, and Little Wildhorse Creek were all gouged out by valley glaciers that originated within a few miles of the summit of the mountain and flowed down former stream valleys. The heads of the glaciated canyons lie within a distance of about 6 miles of each other and are accessible by short hikes from the rough and rocky Steens Loop road and side roads. Few places offer such an opportunity to view the heads of so many glacial valleys in such a short distance and with the exertion of so little physical energy.

Glaciers on the east side of the Steens Mountain extended about half-way down the scarp (Figure 9), and below that the valleys have stream valley features. Smaller glaciers extended only a short distance down the scarp, and their positions are marked by small cirque basins just below the rim of the mountain (Figure 10). As the glaciers on the east scarp eroded into the mountain, the crest of the rim shifted westward. At the same time, glaciers on the west slope extended their valleys headward into the mountain. Only thin walls (Figure 8) separate the heads of Little Blitzen and Big Indian Canyons from cirques east of the rim. At Kiger Gorge the rim was breached where the head of Kiger glacier met the head of a glacier in the valley of Cottonwood Creek on the east scarp. Where the two glaciers "got their heads together" is a gap in the mountain rim known as a col. The Big Nick, a gap in the east rim of Kiger Gorge, is a col where a glacier on the east scarp intersected the side of Kiger glacier.

Narrow, and in places sharp, ridges separate the heads of Big Indian and Little Indian Canyons on the west from the south-trending Wildhorse and Little Wildhorse Canyons. A col marks the place where the glacier in Little Wildhorse met the glacier in Little Indian Canyon (Figure 1). A sharp ridge, an arête, separates Wildhorse Canyon from the large cirque at the head of Alvord Creek.

Lake basins on the High Steens were formed by glaciation and are of two types. Fish Lake (Figure 11) and other smaller lakes nearby are in depressions dammed at the west end by moraines. Wildhorse Lake (Figure 12), in the cirque of Wildhorse Canyon, and the small lake in the cirque of Little Wildhorse Canyon are glacially eroded depressions in the bedrock.



Figure 11. Fish Lake and the smaller lake above it are impounded by glacial moraine. (Ore. Hwy. Div. photo by Kinney)



Figure 12. Wildhorse Lake occupies a bedrock depression in the cirque at the head of Wildhorse Canyon. (BLM photo)

Glacial advances

Glaciation on Steens Mountain occurred in two major advances and a minor one. The first was in the form of an extensive ice cap named the Fish Lake Advance (Bently, 1970, p. 21) for the glacial deposits on the lower west slope of the mountain. The ice cap covered an area of approximately 115 square miles and left an extensive mantle of till. Around the lower margin, ice was channeled along several major valleys. In one of these, the Little Blitzen Canyon, the ice left a set of moraines which have since been so severely dissected by running water that not much besides weathered boulders remains.

During the Fish Lake Advance, ice extended down the east side of the mountain to levels about 2,500 feet above the floor of Alvord Desert. These glaciers left cirques along the scarp of the High Steens, such as the large one at the head of Alvord Creek.

The second major advance has been named the Blitzen Advance (Bentley, 1970, p. 67) for deposits at the mouth of Little Blitzen Canyon. The Blitzen glacial advance covered less than 50 square miles, and the ice occupied mainly the canyons. During this stage, cirques were formed on the canyon rims and around the headwalls, and cirque glaciers formed on the east scarp.

The moraines of the Blitzen Advance are relatively intact, and the till is not much weathered. Its grayish color distinguishes it from the weathered buff-colored till in the moraine of the Fish Lake Advance. The two materials are further distinguished by cementation and leaching in the Fish Lake till and the absence of these in the Blitzen till.

Both the Fish Lake Advance and the Blitzen Advance were in two stades (a stade formerly was referred to as a substage). Two moraines at the mouth of Little Blitzen Canyon were formed during the Fish Lake stades, and another pair was formed during the Blitzen stades.

The third glacial advance, referred to only as post-Blitzen, was of minor extent and is suggested by tired cirques on certain canyon walls. Some of the small "pocket" cirques along the rim on the east side may belong to this latest glaciation.

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GEOHERMAL CONFIDENTIAL RECORD PERIOD EXTENDED

From a starting date of July 1, 1975, geothermal well records are now kept confidential for a period of 4 years following completion or abandonment, doubling the 2-year period granted in the 1971 law. The legislature granted the extension after hearing testimony from exploration firms that the time lag in putting a geothermal field into production made the longer period mandatory.

* * * * *

OREGON MINER ROY RANNELLS DIES

Oregon lost one of its best old-time miners with the death of Roy Rannells on March 28, 1976 at the age of 87. Rannells helped explore and develop the Hanna nickel deposit on Nickel Mountain in Douglas County and later discovered and developed the Quartz Mountain silica deposit for use in the nickel smelter process. His knowledge and experience significantly benefited the mining industry of southwestern Oregon.

* * * * *

URANIUM PAPER REPRINTED

The Department's Short Paper 18, "Radioactive Minerals the Prospector Should Know," has been published in its 4th revision. Author is Norman V. Peterson, geologist with the Department's Grants Pass office. The new edition is for sale by the Department at its offices in Portland, Grants Pass, and Baker. Price is 74 cents.

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- 4. Prelim. identifications of foraminifera, E. M. Warren Coos Co. 1-7 well: Rau 2.00

MISCELLANEOUS PUBLICATIONS

- Landforms of Oregon: 17" x 22" pictorial relief map 0.25
- Mining claims (State laws governing quartz and placer claims) 0.50
- Oregon base map (22" x 30"). 0.50
- Geologic time chart for Oregon, 196110
- Postcard - geology of Oregon, in color 10¢ each; 3 - 25¢; 7 - 50¢; 15 - 1.00
- The ORE BIN - Annual subscription (\$8.00 for 3 yrs.) 3.00
- Available back issues, each 25¢; mailed 0.35
- Accumulated index - see Misc. Paper 13

GOLD AND MONEY SESSION PROCEEDINGS

- Second Gold and Money Session, 1963 [G-2] 2.00
- Third Gold and Money Session, 1967 [G-3] 2.00
- G-4 Fifth Gold and Money Session, Gold Technical Session 5.00