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STATE DEPARTMENT OF GEOLOGY AND MINERAL INDUSTRIES
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# GEOLOGY OF THE JOHN DAY COUNTRY, OREGON*

By
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## Introduction

The first person to recognize the significance of the fossil mammal remains in the John Day Country was Thomas Condon, at that time pastor of the Congregational Church at Fort Dalles (The Dalles, Oregon). In 1861 a company of soldiers returning to Fort Dalles from the Crooked River Country, brought back fossilized bones and teeth, including a fine rhinoceros jaw. Thomas Condon saw the fossils and, having considerable knowledge of and interest in geology and paleontology, recognized the importance of the find and decided to take the first opportunity to visit the locality. The following year, 1862, he obtained permission to join a company of soldiers taking supplies to Harney Valley. On the way the company visited the Crooked River fossil locality, and on the return trip they came by way of Bridge Creek where Condon made his first collections in the John Day Country. The following summer he returned to collect again at Bridge Creek, and in 1864 saw for the first time the large exposures of John Day beds in the John Day River valley north of Picture Gorge.

Summer after summer he returned to this area, which he called Turtle Cove, to collect specimens and study them. Having little in the way of scientific books for identifying the material, he sent specimens of fossil horse teeth to Professor Marsh at Yale. This find made him discoverer of the Oligocene horse. Almost immediately he received a request from Marsh to guide an expedition into the field. Other groups of scientists, hearing about the find or seeing the specimens, began coming to the John Day fossil beds, conducted there at first by Condon. Much material was sent to Smithsonian Institute, American Museum of Natural History, and various universities for identification.

In 1876 Thomas Condon was made the first Professor of Geology at the University of Oregon where he taught for many years. During this time he wrote a number of reports on the geology of various parts of the State, including the John Day Country. These were later compiled into a book entitled "The Two Islands," (Condon 1902), which was the basis for all future geological study in Oregon.

On May 29, 1954, in appreciation for Professor Condon's contribution to knowledge of geology and paleontology of the John Day Country, the John Day Fossil Bed State Park was renamed "Thomas Condon State Park," and an inscribed plaque was placed by members of the Geological Society of the Oregon Country at the roadside park facing the spectacular outcrop of John Day beds in Sheep Rock.

## Location

The John Day Country is generally considered to be the mountainous territory drained by the John Day River and its tributaries lying between the Cascade Range and the Blue Mountains.

The area shown on the accompanying map is the portion of the John Day Country that is most easily accessible and most frequently visited. It is bounded roughly by the towns

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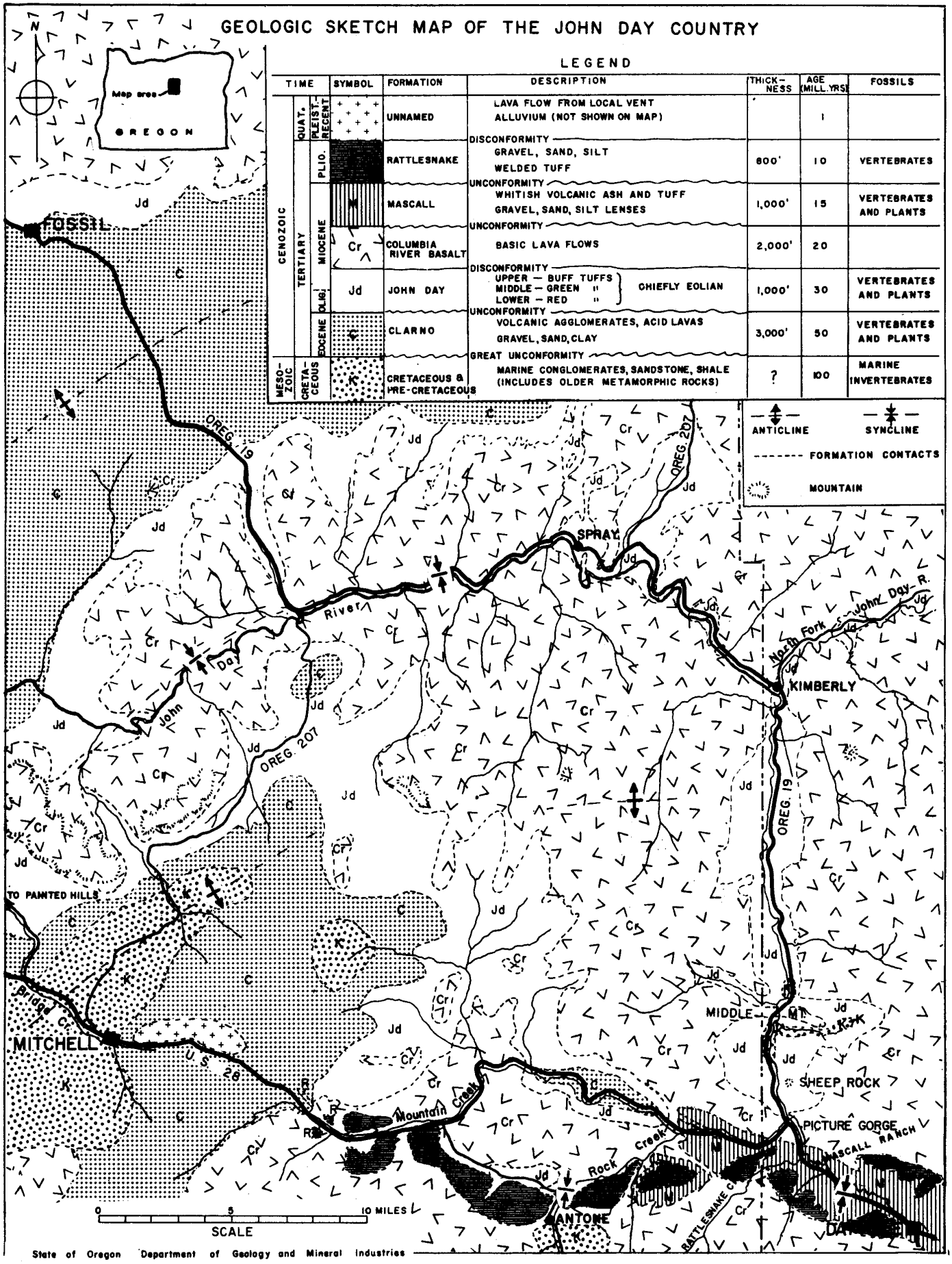
# GEOLOGIC SKETCH MAP OF THE JOHN DAY COUNTRY




State of Oregon Department of Geology and Mineral Industries

of Mitchell, Fossil, and Dayville, and includes Picture Gorge and the John Day fossil beds. Highways crossing the map area follow the valleys of the John Day River and its tributaries. These streams in their downward carving through successively older rocks have exposed to the traveler a hundred million years of geologic history.

Because the accompanying geologic sketch map was compiled from a number of published and unpublished sources of varying accuracy, it should be regarded only as a reconnaissance map subject to changes.

## Geologic History

### Pre-Cretaceous and Cretaceous rocks

Very ancient, metamorphosed rocks of probable Paleozoic and lower Mesozoic age underlie the John Day region and crop out in a few places; but so extreme was the squeezing and folding of these strata that in their meager outcrops the record of life and accompanying geologic events has been almost entirely destroyed.

The oldest rocks of the John Day region in which fossils are sufficiently well preserved to make possible an age determination are late Mesozoic (Cretaceous) sediments. In Cretaceous time, one or more great seaways covered most of the State of Oregon, and ammonites and other forms of shell life were abundant. Dark gray shales and slates bearing these marine fossils crop out along U.S. Highway 28 in the Ochoco Mountains a few miles west of Mitchell. Conglomerates and sandstones also comprise a large part of the Cretaceous sediments and represent the old shore line of the Cretaceous sea. About 2 miles north of Picture Gorge an indurated conglomerate believed to be of Cretaceous age crops out on either side of the John Day River for a distance of about 1 mile along State Highway 19. A few poorly preserved fossil leaves have been found in this material (Coleman 1949).

At the close of the Mesozoic era, the land was uplifted and the rocks steeply folded. The sea withdrew far to the west, beyond what is now the Cascade Range, and never again invaded the John Day Country. The uplifted land underwent a long period of erosion, and the formations of the Cenozoic era which followed were laid down as terrestrial or land deposits on this old erosion surface. A marked unconformity exists where rocks of the two eras are seen in contact.

### Clarno formation

Accumulation of terrestrial volcanic material began in late Eocene time when numerous explosive volcanoes in the John Day Country and elsewhere covered the land with volcanic debris. These volcanic rocks attained a thickness in some places of nearly 3000 feet. They crop out over wide areas in the John Day region and have been named the Clarno formation after exposures near Clarno Bridge on the John Day River west of Fossil.

The early products of the Clarno volcanoes were basalt flows, agglomerates, breccias, and tuffs; later the material changed to acid lava flows (rhyolite). During quiet intervals between volcanic eruptions, normal processes of erosion in streams and lakes worked over the volcanic rocks and redeposited them locally as gravels, sands, and muds. Where the environment was suitable, plant and animal life became established. Subsequently all was buried under volcanic extrusions. Thus we see conglomerates, sandstones, and shales interbedded in the Clarno volcanics, particularly in the lower part of the formation, and some of the finer sediments contain fossil plant material. That the climate was warm and humid in Clarno time is indicated by the presence of fossil fruits and the leaves of semi-tropical plants. Although fossil plants are fairly abundant in the sedimentary layers of the Clarno formation, fossil animal remains appear to be extremely rare.

The typical appearance of the Clarno formation where it crops out in the map area is that of rounded stony hills of a reddish hue.

The Clarno and older formations were subjected to folding and considerable erosion at the end of the Eocene so that all later formations lie unconformably on these folded and eroded rocks.

John Day formation

Beginning in late Oligocene and continuing until middle Miocene another period of volcanism took place during which ash was carried away from exploding volcanoes by the wind and deposited frequently over the land to form the colorful and fossiliferous John Day beds. It was originally believed by Condon and other geologists who early studied the area that these were lake beds. Today, however, it is generally accepted that the sediments are aeolian and that waterlaid tuffs occur only in small pockets near the base of the formation. Most geologists believe that the chief source of this material was from volcanoes in the young Cascade Range and that the volcanoes which deposited the Eagle Creek formation in the Columbia Gorge also contributed ash to the John Day region.

The intervals between ash falls were long enough for plant and animal life to become re-established many times over. The beautifully preserved leaf imprints near Bridge Creek in the Painted Hills State Park north of Mitchell is an example of the flora of the John Day formation. Other similar flora are found at various places in the lower part of the John Day formation, two of which occur in the area shown on the sketch map: one near the mouth of Deer Gulch just south of Middle Mountain on the east side of the John Day River; the other in the bluff behind the High School in Fossil. On the basis of leaf count, the dominant trees of the John Day Country in late Oligocene time were Metasequoia, birch, and alder.

More than 100 species of fossil mammals have been recognized in the John Day beds from the area along the John Day River between Picture Gorge and Spray. These include many extinct forms of cats, dogs, camels, rodents, and rhinoceroses. The primitive three-toed horse, Miohippus, was also present. Most common animals were the oreodonts -- cud-chewing, piglike beasts, long extinct, whose fossilized skulls were collected in large numbers as curios in the early days by settlers in the region.

Three divisions have been recognized in the John Day beds and described in detail by Coleman (1949), namely Lower, Middle, and Upper. The Lower John Day formation of upper Oligocene age is composed predominantly of red tuffs and contains much fossil plant material but only a small amount of vertebrate remains. The Middle John Day formation, which is predominantly green tuff, and the Upper John Day formation, which is chiefly buff-colored tuff, are of lower Miocene age and contain abundant vertebrate fossils. A thick flow of welded tuff from some local vent forms a distinct line of demarcation between the middle and upper members of the John Day formation. A complete section of the Upper John Day formation, together with the welded tuff beneath it, is exposed on the west face of Sheep Rock.

The bright colors of the John Day formation are caused by the chemical action on iron minerals in the tuff during periods of weathering between showers of ash. Reds and yellows are due to various degrees of oxidation of these minerals to form hematite and limonite, while the greens are due to reduction and hydration of the iron minerals under conditions of low oxygen and the presence of organic material to form ferro-ferric iron compounds.

The fantastic castellated shapes one sees in the John Day beds are due to the differential erosion of hard and soft layers of the rock, and are particularly characteristic of the green and buff members of the formation. The lower, red member, where exposed at the surface, tends to weather down into low, rounding hills. The John Day formation is easily recognized by its bright colors, tuffaceous texture, and oddly eroded appearance.

Following the deposition of the John Day beds, the formation was warped slightly and then underwent a short period of erosion resulting in a highly dissected topography.

Columbia River basalt

In middle Miocene time Oregon, Washington, and Idaho were the scene of the most extensive accumulation of basic lavas in the world. The whole region of the John Day Country was turned into a desolate waste by tremendous flows of lava known as the Columbia River basalt. This welled up out of many fissures in the earth and spread over all earlier formations like a black pavement. Early flows filled in topographic irregularities on the eroded John Day formation, as at Picture Gorge where the basalt apparently filled a low area in the old erosion surface.

As many as twenty-three distinct layers of basalt can be counted in Picture Gorge, and these are generally interpreted as representing twenty-three flows of lava. In the opinion of Dole,* however, there were only fourteen flows. Pseudo-layers, he believes, were produced in certain flows by a cooling phenomenon as follows: heat escaping upward through the lava caused a critical temperature to be reached about midway in the flow. At this level, tension was such that a sharp line of demarcation occurred between top and bottom of the flow. The top, cooling rapidly, fractured in an irregular manner, while the bottom, which cooled more slowly, fractured in columns, thus producing the appearance of two flows where actually only one existed.

In Picture Gorge at least 1500 feet of basalt can be seen. In other regions outside the map area, lava sections have been measured that are more than 5000 feet thick. In some places, carbonaceous soil layers occur between flows, indicating that here was a short period of quiescence before the land was again covered by a great flood of lava.

The Columbia River basalt is a dense, fine-grained olivine rock that is nearly black on fresh exposure. It is very resistant to erosion and forms the dominant topographic features of the region. Although somewhat warped into regional folds, locally it appears nearly horizontal and is seen as prominent flat surfaces, table mountains, hog backs, rim rocks, and narrow, steep-sided canyons. The basalt acts as a protective capping layer on top of the soft John Day beds, thus retarding erosion. A small remnant of basalt on Sheep Rock prevents the soft tuffs beneath from being washed entirely away.

Mascall formation

In upper Miocene time the flows of Columbia River lava gave way to intermittent showers of ash from volcanoes. A down warping of the Columbia River basalt south of Picture Gorge formed a syncline in which wind- and water-laid ash, together with lesser amounts of silt and gravel, accumulated to a maximum depth of at least 1000 feet. This series of nearly white ashy deposits was named the Mascall formation for the typical exposure near the Mascall Ranch on the John Day River south of Picture Gorge.

Fossil leaf imprints of the Mascall flora are well preserved in the white ashy shale in various outcrops east of Dayville. According to Chaney (1948), Metasequoia, characteristic of the Lower John Day formation, occurs only in small numbers in the Mascall formation, the dominant conifer being swamp cypress. Oak and beach are abundant. Fossil bones of mammals and fish have been found in the Mascall formation.

The close of the Miocene epoch was marked by considerable folding and faulting over much of Oregon. A series of large folds developed trending northeast to east across the John Day region as shown on the sketch map. It was during this period of deformation that the Cascade Mountains were greatly uplifted to form a climatic barrier between western and eastern Oregon.

Rattlesnake formation

Erosion of the faulted and tilted strata in the vicinity of Picture Gorge resulted in the deposition of about 800 feet of gravel, sand, and silt on top of the Mascall formation. A single flow of welded tuff (ignimbrite) from some local vent is interbedded in this series

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*Dole, H. M., Geologist, Oregon Department Geology and Mineral Industries, oral communication.

of sediments. The flow is about 50 feet thick and can be traced for many miles along the John Day valley south of Picture Gorge. It is composed of a hard glassy material showing flow structure and containing aligned and flattened pumice fragments (Taubeneck 1950). At the top and bottom of the flow the glassy texture grades into a porous tuff.

The origin of this peculiar tuff was for many years a matter of considerable speculation, but was generally regarded as a flow of rhyolite. In recent years observations of extrusions from active volcanoes have given rise to the theory that this is a form of nuée ardentes (fiery cloud). Such volcanic outbursts are erupted as a glowing gaseous cloud of incandescent particles, the whole mass moving at great speed. The entire phenomenon is one of exceedingly short duration, perhaps only a matter of a few days. After extrusion the hot plastic particles adhere to one another till they are welded together, while the larger fragments are flattened under the weight of the mass.

Thus the welded tuff of the Rattlesnake formation was extruded in a few days' time, while the sands and gravels, which comprise most of the formation, continued their slow accumulation, finally covering the tuff flow. Along the north side of the John Day valley between Picture Gorge and Dayville, recent erosion has removed the upper gravels so that the resistant welded tuff stands out conspicuously as a horizontal buff-colored rim rock above the white, tilted Mascall formation.

Fossil bones of camels, antelopes, and grazing horses discovered in the sediments near Rattlesnake Creek (type locality of the Rattlesnake formation) date the deposit as Pliocene in age.

### Pleistocene and Recent rocks

The course of the John Day River was established near the end of Pliocene time and was controlled by structural features. The synclinal basin south of Picture Gorge had filled with sediments of the Rattlesnake formation to an elevation that covered the Columbia River lavas at Picture Gorge. Continued aggrading of the floor of the basin raised the stream level to a point where drainage found an outlet through the anticline to the north by way of a local north-trending syncline (not shown on the map) near Middle Mountain (Coleman 1949). Thus the John Day River, as it cut down through the Mascall and Rattlesnake formations, became superimposed on the Columbia River basalt at Picture Gorge. Farther to the north, the course of the stream swung westward in the east-west syncline near Kimberly.

In more recent times, the John Day River and its tributaries have enlarged and deepened their valleys by erosion and removal of the rocks encountered. Where the formations are soft the valleys widen out, and where the rocks are hard the streams are confined to narrow canyons. East of Mitchell a local lava flow, probably related in age to the intracanyon flows of the Deschutes and Crooked rivers area (Hodge 1942), filled part of one of the valleys tributary to the John Day River.

## Ancient Man in the John Day Country

On the west wall of Picture Gorge, a type of fossil art in the form of crude drawings, from which the Gorge derived its name, have intrigued the imagination of many a passer-by. These markings, called pictographs (Cressman 1937), were painted on the basalt walls with a pigment made from red iron oxide mixed with a resinous substance. Now weathered and dull almost beyond recognition, they are believed to be at least 5000 years old. Similar paintings and carvings on rock walls have been found in many places in Oregon and all are located near lakes or rivers where the aboriginal Indians came to fish and hunt. Living Indians disclaim any knowledge of the origin of the drawings. Whether they had some important symbolic meaning or whether they were done for the artist's own amusement will probably never be known.

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## BAKER COUNTY LATEST LIMESTONE PRODUCER

National Industrial Products Corporation, Durkee, Oregon, is the name of the wholly-owned subsidiary of the Morrison-Knudsen Company which has brought into production the newest limestone operation in the State. The quarry is located about 4 miles southeast of Durkee in Baker County, and 28 miles southeast of Baker on the main line of the Union Pacific Railroad. Extensive exploration was carried on by Morrison-Knudsen interests before the plant was installed. Diamond drilling was employed as was also sampling by bulk carload shipments to several different potential markets. This exploration work showed that high-calcium limestone satisfactory for the various market demands could be produced in large quantity. The company installed large-capacity crushing, conveying, and storage facilities, and built a railroad spur and siding which has a sufficient capacity for more than twenty railroad cars per day. Present production averages about 500 tons a day. The deposit occupies the greater part of 820 acres. Depth of stone available as shown by drilling is at least 160 feet. Exploration

so far has proved 15 million tons. The company plans to serve heavy chemical and metallurgical industries with sized material as required. Contracts have already been entered into with several sugar mills in southwestern Idaho and southeastern Oregon. Operations are directed by Mr. J. V. Otter, Box 450, Boise, Idaho.

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## NEW PURCHASE PROGRAM FOR QUICKSILVER

The government has set up a purchase program for quicksilver in which it will buy 200,000 flasks at a guaranteed price of $225 per flask, it was announced on July 6. Under the program General Services Administration will buy 125,000 flasks of domestic quicksilver and 75,000 flasks of Mexican metal. The guaranteed price will be in effect until December 31, 1957. GSA may enter into private contracts with foreign producers, especially in Canada, over and above the 200,000 flask total. It was reported that reaction to the news was mixed but the price for quicksilver was unchanged during the week of July 8, remaining at $280-285 per flask. Demand was quiet. It was the feeling of users of the metal that the program will bring out more quicksilver, especially if the government pulls out of the European market, as seems probable.

The E&MJ Metal and Mineral Markets, New York, issue of July 15, reports that feeling in the industry is that the price will eventually decline to approximately $225 per flask. However, spot metal during the preceding week developed further market strength. Prices from $285 to $290 per flask, a new high, were paid.

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## STATE GEOLOGIC MAP WORK SPEEDED UP

Work on the State Geologic Map is being pushed by both cooperating agencies, the State Department of Geology and Mineral Industries and the U.S. Geological Survey. Hollis Dole, geologist of the Department, is mapping in the western Cascades east of Eugene. N. S. Wagner and Max Schafer, geologists with the Department, have been finishing up in the Umatilla County mapping project. Dr. Francis Wells with an assistant is now in southwestern Oregon where he is conferring with Dr. Ralph Imlay and Dr. Roland Brown, paleontologists of the Survey. They together with Hollis Dole have planned an investigation of problems in the Upper Elk River area of Curry County and in central Douglas County for the immediate future. Dr. Ewart M. Baldwin of the University of Oregon, working for the U.S. Geological Survey during the current field season, is mapping in the lower Siuslaw area of Lane County. Mr. Linn Hoover of the U.S. Geological Survey is mapping in the Drain and Anlauf quadrangles of Douglas County. Dr. Aaron Waters, professor of geology at Johns Hopkins University who is doing State Geologic Map work for the U.S. Geological Survey, is mapping in central Oregon, at present in Deschutes and Crook counties.

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## SUCCESSFUL EXPERIMENTS REPORTED BY HARVEY

According to the Salem Statesman, the Harvey Aluminum Company at its Salem experimental plant has been successful in developing processes for the treatment of Salem bauxite. The company reported on June 30 that the plant on Cherry Avenue has been doing research on Salem laterite for several months and believes that alumina can be successfully produced from the Salem material. It was also stated that aluminum sulphate might be a by-product. The company announced that a pilot plant to go into active production will be built, and predicted that later a larger plant along the same lines would be built in the same general area.

The Salem plant, now operated by Harvey, was built during the war in order to develop a process invented by the Chemical Construction Company of New York to produce alumina from high-alumina clays. The process was not fully tried out because the government shut off funds for such work after the submarine menace was overcome and there was then no shortage of bauxite. The Harvey Company purchased the plant from the government for $325,000. A. W. Metzger is in charge of the Salem work.

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