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MAGNETIC DECLINATION IN OREGON

By
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To Lili from the declining magnet.

Anyone who uses a compass for surveying or prospecting must take into account the effect of variations in the earth's magnetism on the compass needle. There are only a few places on the earth where the compass points truly north, and even there the direction is not constant for very long. In Oregon the compass points between 18° and 22° east of true north, with local variations of from 5° west to nearly 33° east. This deviation of the compass needle, or angle between magnetic north and true north, is known as magnetic declination.

Vagaries in the earth's magnetic field cause the declination to be constantly changing with time. Thus there is no fixed angle of declination anywhere on the surface of the earth and anyone using a compass for obtaining precise direction must either measure the declination at a particular location or refer to the latest magnetic observations of the U.S. Coast and Geodetic Survey.

Isogonic charts

One of the services of the U.S. Coast and Geodetic Survey is to provide information on magnetic declination in the United States (see bibliography). The Survey makes frequent observations at regular intervals and maintains magnetic charts (Figures 1 and 2, opposite page 49) which are revised and published every decade.

A chart of magnetic declination is known as an isogonic chart (isogonic meaning "equal angle"). It is a map, in this case of the United States, on which isogonic lines are drawn. Each isogonic line passes through places having approximately the value of declination specified. Because of natural local disturbance (anomaly), which is nearly everywhere present to some degree, the chart value is not usually the actual value of declination. Rather it is the average value for an area within a surrounding 10-mile radius. According to the Coast and Geodetic Survey, there is perhaps an even chance that the chart value will agree with the actual value within half a degree; occasionally it differs by many degrees, and in such places the compass is not very reliable.

The isogonic chart has an auxiliary set of lines showing equal annual change. These lines are called isopors and allow for applying a correction for secular change (gradual change in declination over a long period of time). Isopor lines should be used only if the desired value of declination is for a date within a few years before or after that of the chart.

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Figure 1. Magnetic Declination in Oregon in 1955 (Adapted from U.S. Coast and Geodetic Survey Isogonic Chart of the United States for 1955). Solid lines show equal magnetic declination. Dashed lines show equal annual change westward. Isolated numbers are abnormal observed values caused by local magnetic disturbances.

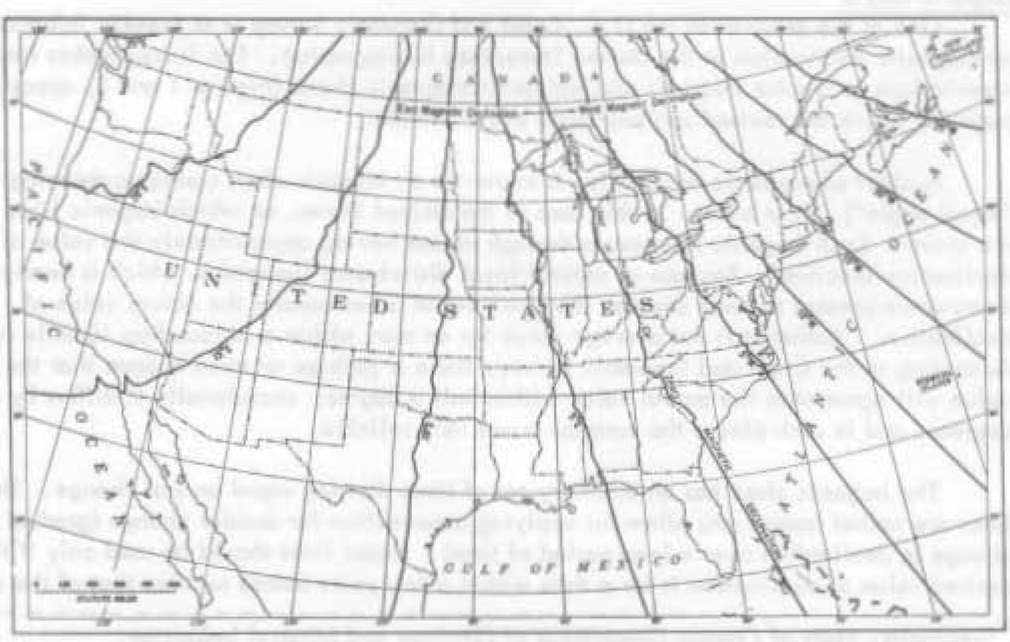

Figure 2. Isogonic Chart of the United States for 1945 (U.S. Coast and Geodetic Survey). Map shows lines of equal magnetic declination in 5-degree intervals.

The accompanying maps (Figures 1 and 2, on opposite page) were reproduced from Coast and Geodetic isogonic charts. By comparing the position of the 20° isogonic line on these two maps, one can see that its position has changed in the 10-year interval, 1945 to 1955. In Oregon the eastward declination has decreased nearly half a degree since 1945; and in the United States as a whole, the north end of the compass needle has been slowly moving westward with time.

History of geomagnetism*

The modern science of geomagnetism had its beginnings in ancient superstitions about the curious behavior of a variety of iron ore known as lodestone. The property of the lodestone to attract iron was explained by a Greek writer of the seventh century B.C. as "a certain appetite or desire of nutriment that makes the lodestone snatch the iron."

In the Middle Ages it was believed that there were fatal mountains of lodestone which broke up ships at sea by drawing the nails out of them. It is not known just when the directive property of the magnet was discovered or when this knowledge resulted in its use as an instrument, but literature of the 12th century tells of mariners using a crude floating compass as a last resort when all other means of finding direction failed.

Early charts of the Mediterranean coasts made in the 14th and 15th centuries were oriented by compass in total disregard of magnetic declination. Failure of the compass to point exactly north was believed at that time to be due to imperfections in the instrument. Gradually, however, makers and users of compasses became convinced that the needle did not point true north and that the angle of declination changed from place to place.

The prevailing opinion of the times was that the compass was being drawn toward a "point attractive" such as a magnetic mountain or island. In 1851 Robert Norman of London devised a type of compass needle that measured the dip or inclination. With this instrument he was able to show that the needle was not attracted but rather directed toward a point and that this point was not above the horizon but below it.

In 1600 Dr. William Gilbert of England published his famous work "De Magnete," in which he presented his important theory that the earth itself is a great magnet. He devised a spherical lodestone and showed how the dip of a compass needle on such a sphere would change from zero at the equator to 90° at either pole.

It had long been supposed that declination, although different from place to place, was fixed and invariable at any one place. But in 1634, Gellibrand, a mathematics professor at Gresham College, England, made the discovery that magnetic declination changes with time. By observing declination at places which had been measured 50 years earlier by previous mathematicians he was able to show that considerable change had occurred. His discovery of secular change was of great significance to the mariner and surveyor who could no longer feel confident in using the old values of declination observed by previous navigators or surveyors. Since Gellibrand's time, observations have shown that not only declination but also dip and intensity of the earth's magnetic field are changing with time.

Magnetic charts came into use around 1700. The earliest were for the Atlantic Ocean and showed lines of equal magnetic declination. The name "isogonic line" was adopted.

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* Condensed from Chapter 6, "Origins of geomagnetic science," U.S. Coast and Geodetic Survey Serial 663, 1945.

For a long period it was supposed that secular change was the only time change that occurred in declination. But eventually transient changes from day to day and from hour to hour were noted. This led to further investigation and the discovery of changes due to solar flares, cosmic rays, and magnetic storms.

In 1832 a German mathematician and physicist by the name of Gauss developed an instrument capable of measuring declination and intensity known as a magnetometer. With this instrument he was able to prove what had been earlier suspected, that the magnetic field originated inside the earth. His magnet was 3 feet long, weighed 25 pounds, and was suspended on a fiber 17 feet long. By way of contrast, the modern magnetometer has a magnet about half an inch long suspended on a filament less than 6 inches in length.

Gauss was responsible for stimulating interest in the field of magnetics among scientists in other countries. He succeeded in promoting international cooperation to the point where magnetic observatories were established at widely separated places to secure simultaneous data regarding variations of the earth's magnetism.

In 1843 the making of magnetic observations became one of the functions of the U.S. Coast and Geodetic Survey. These observations were at first confined to the coasts, but were later extended to the interior of the United States. Since 1947, the Survey has been charged with the responsibility of collecting results of magnetic observations from the entire world.

In recent years the study of the earth's magnetism has become one of the important fields of geophysical science. Besides the work of the Coast and Geodetic Survey, programs of research are carried on by the Carnegie Institution of Washington and the U.S. Geological Survey. Other organizations and certain universities are conducting laboratory and field investigations in some aspect of terrestrial magnetism. In spite of the abundance of research and the number of attractive theories advanced, however, no one has as yet been able to account satisfactorily for the existence of the earth's magnetism and its change with time.

Properties of the earth's magnetism

The earth can be thought of as a large magnet surrounded by a magnetic field. It is like the common bar magnet in that it has a north-seeking pole and a south-seeking pole. It is also similar to a spherical magnet in that at the magnetic poles the dip needle stands vertically and direction cannot be determined; as one goes away from the poles the dip increases until at the magnetic equator it is zero. Unlike the ordinary magnet, the earth has a magnetic field that is highly irregular and constantly changing.

Measuring the earth's magnetism at any one place consists of determining the direction and intensity of the field. By means of a dip needle and a compass needle the three magnetic elements - declination, dip, and horizontal intensity - can be measured and from these the total intensity and direction computed.

The axis of the earth's magnetic field is tilted in relation to the axis on which the earth rotates so that the magnetic north and south poles are many miles away from the geographic north and south poles. The magnetic poles, which, incidentally, are known to be moving, are by definition at the surface of the earth, but if a powerful bar magnet were placed within the earth so as to give an external field as nearly like the earth's actual field as possible, this magnet would have to be quite short and near the center of the earth. Its terminations or poles would be thousands of miles from the magnetic poles as we interpret them. Thus the magnetic poles are only surface manifestations of the earth's magnetic field. A popular misconception about the magnetic poles is that they control the action of the compass. The Coast and Geodetic Survey emphasizes that the compass points only in the general direction of the magnetic poles.

Observations have shown that the magnetic pole is not a point but a rather large area in which the compass direction cannot be determined because the dip of the needle is vertical. According to the latest estimate by the Coast and Geodetic Survey, the position of the north magnetic polar region is latitude 74° N., longitude 101° W.; and the position of the south magnetic polar region is latitude 68° S., longitude 144° E.

Variations and anomalies in the earth's magnetism

1. Secular change. The causes of secular change (change over a long period of time) are obscure but are believed to lie deep within the earth. Although no one has been able to account for the earth's magnetism or its change with time, a number of theories have been advanced to explain it. W.M. Elsasser, physicist, in 1939 was the first to suggest how movements in a liquid core might explain the changing field. It is now generally assumed by physicists (Inglis, 1955) that the earth's core consists of fluid metal which surrounds a solid inner core. Heat within the core is sufficient to establish convection currents. Theories to account for the complicated flow pattern in the earth's interior that would induce the magnetic field observable at the surface are admitted by physicists to be based largely on conjecture.

It is believed that the magnetic pattern of the earth is shifting slowly westward, continually changing in form but drifting as a whole (Runcorn, 1955-b). This change seems to be regional in that the rate is much greater in some parts of the world than in others.

2. Annual change. The amount of secular change in one year is known as annual change. In Oregon at the present time the annual change averages about $2\frac{1}{2}$ minutes westward per year. That is, the north end of the compass needle is gradually shifting westward by that amount. At Salem, Oregon, for example, the declination is about 21 degrees E. and the annual change westward is 2.5 minutes (Figure 1, opposite page 49); in 10 years the angle of declination will have decreased about 25 minutes so that in 1966 the declination at Salem will presumably be about $20\frac{1}{2}$ degrees E. But since the future course of secular change is unknown, annual change cannot be predicted very far in the future.

3. Daily change. Declination varies significantly during the day time, but there is little change during the night. Daily change in the earth's magnetism is believed to be due to a system of electric currents in the upper atmosphere or ionosphere.* The current system remains more or less fixed with respect to the position of the earth and sun, while the earth rotates beneath it.

In the northern latitudes there is an easterly motion of the north end of the compass needle until 8 to 9 a.m.(local time);this is followed by a westerly motion of the needle

* A regular and pronounced diurnal variation in the low-frequency range of electromagnetic activity was studied by Philip A. Goldberg of the Physics Department of the University of Oregon and students at an isolated location in Lake County during the summer of 1955. Variations were believed due largely to world-wide thunderstorm activity.

until 1 or 2 p.m.; and finally an easterly motion. From dusk until early morning there is little change. Daily variation is significant when using a compass, as the north end of the needle points about 10 minutes more to the west at 1 p.m. than it does at 8 a.m.

4. Magnetic storms. Magnetic storms are associated with sun spots and characterized by auroral displays and pronounced disturbances to radio wave transmission. A magnetic storm may last many hours or even several weeks, and the most severe affect the whole earth. During a magnetic storm a stream of electrical charges is sent from the sun into the upper atmosphere of the earth. The change in declination during a magnetic storm may be as much as 4° in the United States.

5. Local magnetic anomalies. In most places the change in declination is gradual enough so that a surveyor can use the same declination throughout a small area. In some regions, however, there are large differences within a small area - sometimes as much as several degrees in a hundred feet. These effects are due to local disturbances or anomalies. If caused by works of man they are artificial; otherwise they are natural.

Artificial: Artificial magnetic disturbances affecting the compass needle can be caused by iron in buildings, fences, buried pipes, power lines supported by steel towers, and electric railways with grounded rails. Objects on the observer's clothing such as knives, belt buckles, and zippers also affect the compass needle. Some brass contains iron and is magnetic.

Natural: Minor natural irregularities in declination are normal, and almost everywhere the declination at two points 100 feet apart can differ by a few minutes. Natural anomaly thus limits the value of a compass as a surveying instrument.

Natural anomalies of several degrees are usually due to the presence of iron ore or magnetite, but other ores and certain geologic formations also cause irregularities in the magnetic field. It is known that sedimentary rocks do not usually contain enough magnetic minerals to produce noticeable distortion in the earth's field. In fact the sedimentary rocks tend to have a blanketing effect. According to the Coast and Geodetic Survey (correspondence), if it were not for the depth of sedimentary rock that covers the basement structure in most regions of the United States, it is likely that severe anomaly in the magnetic field would be quite commonplace.

Volcanic rocks, on the other hand, particularly basaltic lavas, contain considerable amounts of magnetite and are known to cause marked distortion in the earth's field when exposed at or near the surface. In Oregon, lava flows, volcanic plugs, dikes, sills, and certain basaltic intrusions are possible causes of local irregularities in the magnetic field.

A group of abnormal observed values in declination is shown in southeastern Oregon in the vicinity of Steens Mountain (Figure 1, opposite page 49). A variation in this region of from 5.7° W. to 32.4° E. has been recorded by the Coast and Geodetic Survey. A compass would not be reliable in this area. So far as is known, no one has attempted to interpret these magnetic anomalies, but they are presumably associated with the basic Tertiary lavas of the region.

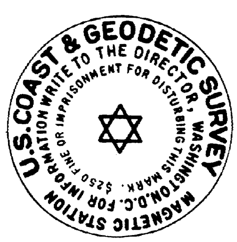
The Isogonic Chart of the United States for 1955 shows only two closures of isogonic lines, and both closures occur in Oregon (see the 20° and 21° lines in Figure 1). These closures reflect the natural anomalies of the area. It is probable that if the number of magnetic stations were increased in Oregon a great many more anomalies would be observed.

Natural magnetic anomalies play an important part in the location of ore bodies and in the mapping of geologic structures. In magnetic prospecting, knowledge of the vertical intensity of the earth's field is more useful than knowledge of declination. Exploration is done with a magnetometer which detects the intensity of the magnetic field. Iron, nickel, cobalt, chromite, and ferruginous bauxite, as well as oil structures are sometimes located in this manner.

The airborne magnetometer, developed as a submarine detector during World War II, has come into wide use in geophysical exploration for minerals (Knoerr, 1946). Aeromagnetic surveys are being conducted by the U.S. Geological Survey in search of iron ores in various parts of the country. The aerial survey is generally followed by ground surveys of the most promising anomalies.

Magnetic determinations

U.S. Coast and Geodetic Survey. Observations of magnetic declination by the Coast and Geodetic Survey are available for about 7000 places in the United States, 236 of which are in Oregon. The place where the observations are made is called a magnetic station and it is marked by a stone or concrete post with a bronze disk set in the top (as figured). In general, the stations are placed in or near county seats where they are readily accessible to local surveyors and engineers, and the locations are generally selected where natural or artificial disturbances are at a minimum.



Declination is measured by determining the true and magnetic meridians. The true meridian is obtained by observations with a theodolite on the sun or the stars. The magnetic meridian is determined by a magnet free to turn in a horizontal plane, and since accurate readings are desired a magnetometer is used. Horizontal intensity is determined with a magnetometer by means of timing the oscillations of the magnet as it swings. Dip is generally measured by means of an earth inductor. The method involved in making its determinations is described in U.S. Coast and Geodetic Survey Serial 618. Values of the magnetic elements determined at each station are given in Serial 667.

Observations are repeated about every 5 years by the Coast and Geodetic Survey at selected stations. At five observatories (Cheltenham, Maryland; Tucson, Arizona; San Juan, Puerto Rico; Sitka, Alaska; and Honolulu, Hawaii) continuous photographic records are maintained to show fluctuations in direction and intensity of the earth's magnetic field at those places.

Compass determinations. Declination may be determined also by compass if the instrument is in good adjustment and the observer free of iron and steel objects. If the true meridian is not known, it may be determined by making observations on Polaris with either the surveyor's transit or with a plumb and peep sight. (Methods for obtaining the azimuth of Polaris are described in U.S. Coast and Geodetic Serial 664.) Declination can then be measured with a compass. Observations should cover half an hour or more with readings at intervals of 5 or 10 minutes and should be made over several days, between 5 and 6 o'clock when declination is near the mean value and nearly stationary.

Paleomagnetic declination

Certain igneous, sedimentary, and metamorphic rocks have remanent magnetization that was caused by the earth's magnetic field at the time they were formed. Rocks having magnetization contain grains of magnetic iron in the form of iron oxide minerals such as hematite and magnetite. The magnetized grains act like tiny compass needles and record the declination and to a certain extent the inclination or dip of the magnetic field existing when the rock formed. In strongly magnetized rock such as basic lavas, remanent magnetization can be determined with a compass, but for weakly magnetic rocks a more sensitive instrument such as an astatic magnetometer is required (Runcorn, 1955-a). Hydrothermal alteration and weathering tend to destroy remanent magnetization.

Magnetization of lava is believed to occur when hot molten magma cools below the Curie point, above which it is nonmagnetic. Below the Curie point it becomes magnetized by the local geomagnetic field and its magnetism is not thereafter affected by changes in the field. Sedimentary deposits acquire a remanent magnetization if the already magnetized grains of iron oxide minerals orient themselves in the direction of the earth's field as they settle. Currents and eddies may affect the direction taken by these particles. The origin of remanent magnetization in metamorphic rocks is much more complicated.

It has been observed in recent years that certain rocks are reversely magnetized. The explanation of this condition has given rise to two opposing theories among students of geomagnetism: one that the earth's magnetic field reversed itself every so often (Runcorn, 1955-a); and the other that the iron oxide grains in the rock reversed their magnetic directions during the process of cooling, independently of the earth's field (Balsley and Buddington, 1956). Both theories have their staunch supporters.

Reversed magnetism is rare in sedimentary rocks but common in lava flows, particularly those of Tertiary age. Columbia River basalts in Oregon and Washington have been studied by Campbell and Runcorn (Runcorn, 1955-a) and found to have alternating zones of normal and reversed magnetizations. Further results of their work await publication.

Bibliography

Balsley, J. R., and Buddington, A. F., 1956, Correlation of reverse remanent magnetism and negative anomalies with certain minerals: Geophysical Abstracts 163. U. S. Geol. Survey Bull. 1033-D, p. 221, 1956.

Inglis, D. R., 1955, Theories of the earth's magnetism: Reviews of Modern Physics, vol. 27, no. 2, p. 212-247, April 1955.

Knoerr, Alvin W., 1946, A new aid to geophysics: Engineering and Mining Journal, vol. 147, no. 6, June 1946.

Runcorn, S. K., 1955-a, Rock magnetism -- geophysical aspects: Advances in Physics, vol. 4, no. 14, p. 244-291, April 1955.

____________, 1955-b, The earth's magnetism: Scientific American, vol. 193, no. 3, p. 152-162, Sept. 1955.

U. S. Coast and Geodetic Survey

Magnetism of the earth: Serial 663, 1945

Magnetic declination in the U.S. 1945: Serial 664, 1946

U.S. Magnetic tables and magnetic charts for 1945: Serial 667, 1948

Practical uses of the earth's magnetism: Serial 618, 1949

Magnetic Surveys: Serial 718, 1949

Magnetic poles and the compass: Serial 726, 1949

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ODM ANNOUNCES STAND ON STRATEGIC MINERALS

Late last month Office of Defense Mobilization Director Flemming presented to the Senate Interior Subcommittee on Minerals, Materials, and Fuels ODM's stand on strategic minerals procurement. Continuance of the domestic purchase programs by General Services Administration was indicated for metallurgical chromite, block and film muscovite mica, beryl, metallurgical manganese, metallurgical fluorspar, and antimony, and a recommendation was made that legislation be passed to assist the producers of chrysotile asbestos, acid-grade fluorspar, and tungsten. A review is to be made on mercury to ascertain whether there is any need for extension or intensification of the present program.

In discussing metallurgical chromite, Flemming stated "From the standpoint of stockpile objectives, it is clear that this program could be continued for a long period beyond June 30, 1957 (termination date of chrome purchase program). The question . . . is whether the program, if continued, would utlimately provide us with a mobilization base that would justify the expenditure. . . . The Interior Department has been requested to explore the matter further and submit an early report on the question of whether a meaningful mobilization base might be supported in the light of domestic reserves of metallurgical chrome and the feasible production from such reserves in time of emergency. ODM feels that if there is a reasonable doubt as to whether or not the program would ultimately provide us with a meaningful mobilization base, the doubt should be resolved in favor of a continuation of the program."

If ODM honestly wants to continue the metallurgical chrome-mining industry in the United States, they had better get on the ball and make a definite announcement rather than indulge in double-talk. As it is now, the only chrome mining is where ore has already been developed. Exploration work necessary to keep the program alive just isn't being done. If ODM waits until next year to announce the continuation of the purchase program, they will find the present mines closed down, the miners in other branches of industry, and the operators with little taste to once again reopen their mines in response to a government agency that doesn't seem to understand or care about the difficulties of operating a mine.

In his testimony, Flemming stated ODM's position in regard to the strategic minerals program as follows: Ample authority exists to procure materials for the national defense; procurement authority should be kept "flexible" to permit immediate action to support a vigorous defense program; measures which are primarily for economic relief should not be handled as part of the defense program; bills that would give specific guarantees for individual materials have not been supported. This statement of policy has long been awaited by the domestic mining industry and the Senate Subcommittee, for reportedly it was on advice from ODM that the bill to increase purchase goals passed by the first session of the 84th Congress was vetoed. Until ODM had stated its position, the future of the present bills on extension of the minerals programs was unknown. Quite obviously only the minerals recommended as needing legislation by ODM now stand a chance of being favorably reported out of the Senate Subcommittee. This means that S. 3504, which would have provided for continuation of the existing chromite purchase program, is in all likelihood dead.

H.M.D.

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EASTERN OREGON ENGINEER DIES

John Arthur, Sumpter, Oregon, mining engineer, died June 13, 1956. Mr. Arthur, who was on the Lindgren survey of the Blue Mountains in 1900, has long been identified with mining in eastern Oregon. His formal schooling in engineering was obtained at the Colorado School of Mines and the Massachusetts Institute of Technology. He was a registered professional engineer. Mr. Arthur was born May 8, 1872, in Illinois.

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NEW URANIUM PURCHASE PLAN ANNOUNCED

The U. S. Atomic Energy Commission announced May 24 establishment of a new domestic uranium procurement program for the period from April 1, 1962, through December 31, 1966, and an extension of the initial production bonus for uranium ore from February 28, 1957, its present expiration date, through March 31, 1960.

The new domestic procurement program provides a guaranteed market for all uranium concentrates produced by domestic mills from domestic ores. The price established is $8.00 per pound of U_3O_8 contained in normal mill concentrates or precipitates. The initial production bonus, which has been in effect since 1951, is paid on the first 10,000 pounds of uranium oxide in ore delivered from an eligible mining property to an authorized buying station or mill. The bonus ranges from $1.50 per pound of uranium oxide in ore assaying 0.10 percent uranium oxide to $3.50 per pound of uranium oxide in ore assaying 0.20 percent uranium oxide and above.

Concerning the off-Plateau procurement program, Mr. Elton A. Youngberg, Acting Assistant Manager of AEC's Grand Junction Operations office wrote the Department:

> ". . . This program has been under study for several months and, at this time, we are not issuing contracts of this type. An announcement will be made when a decision has been reached.
>
> "This does not mean that producers in Oregon do not have a market. We will purchase their amenable ores under our regular procurement contracts and pay haulage at 6 cents a ton mile up to 100 miles. You should also realize that the initial production for the first 10,000 pounds of contained U_3O_8 is eligible for a bonus equivalent to the base price. With the assistance of the haulage allowance and the bonus, I believe you will find that producers that have ores of minable grade can ship their production to Salt Lake City and realize a profit."

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PURCHASE PROGRAM BILLS

Legislation to extend the purchase programs of strategic minerals not taken care of by ODM was passed by the Senate Interior Committee in mid-June. The bill, S.3982, calls for the following quota limits and purchase prices: Tungsten, 1¼-million ton units at $55, and small producers - 1,000 units per year and less - will get a bonus rate of $63 per unit; asbestos, 2,000 tons of No. 1 and 2, and 2,000 additional tons of No. 3 if delivered along with No. 1 and 2, at the market price; acid-grade fluorspar, 250,000 tons at about $52.50; and columbium-tantalum - this provision was thrown in to give producers added assurance but no additional Government purchases are expected since the defense stockpile goal for this mineral has been reached.

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LAND DETERMINATION AREAS IN OREGON

The U.S. Bureau of Land Management and Forest Service notified the Department this month that the following areas will be examined this summer for determination of surface rights under Public Law 167. These areas are in addition to the ones noted in the May 1956 Ore.-Bin.

U.S. Bureau of Land Management - T. 37, 38, and 39 S., Rs. 5 and 6 W. All public domain land including O&C lands will be examined. The O&C lands will be examined under provisions of the law that have been in effect prior to passage of Public Law 167.

U.S. Forest Service - Quartzville area, most of the southern part of T. 11 S., Rs. 4, 5, and 6 E., and most of the northern part of T. 12 S., Rs. 4, 5, and 6 E.

Little North Fork area of the Santiam River, most of T. 8 S., Rs. 4 and 5 E., and secs. 3, 4, and 7 of T. 9 S., R. 6 E.

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