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FUSED QUARTZ

by

Raymond B. Ladoo*

Fused quartz is a glass made by the fusion of very pure silica. There is some confusion in terminology but in the trade today "Fused Quartz" generally refers to the perfectly transparent colorless product made from rock crystal while "Fused Silica" is a white, translucent product made from silica sand. Vitrified silica is the term preferred by purists for all quartz glass, but it lacks the definiteness of the trade terms. Since the raw materials, methods of production, and properties of the finished products are different for the two types, the trade terms are to be preferred.

As fused quartz is amorphous, its physical properties differ greatly from those of quartz crystal. Lacking crystallographic directions and having no piezo-electric properties, fused quartz, of course, has no value for the making of radio oscillator plates; but it does have other most valuable and unique properties. Perhaps the best known and most useful properties are its extremely low coefficient of expansion and its ability to transmit very short-wave ultraviolet radiant energy.

Crystal quartz not only has an average coefficient of expansion greater than that of fused quartz but the coefficient varies with crystallograph direction. Also when crystal quartz is heated and cooled it passes through the several states of alpha and beta quartz, tridymite, and cristobalite with varying densities and coefficients of expansion. Thus when crystal quartz is heated to say 900° C. and rapidly cooled, strains develop which shatter it.

Fused quartz has the lowest coefficient of expansion of any mineral or metal (at least among those accessible to industry), far lower than iron, copper or tungsten, porcelain or glass. A fused quartz rod may be heated to redness and plunged into ice water without damage. While in recent years special glasses with low expansion coefficients have been developed, none yet equals fused quartz in this respect. Furthermore these glasses are not as resistant to chemical action as fused quartz; they have much lower softening and melting points; and they have inferior electrical properties. Fused quartz is one of the almost unique materials that is a good electrical insulator at elevated temperatures, as well as at very high frequencies.

Its ability to transmit a wide range of radiant energy from below 1850 Angstroms in the ultraviolet to over 70,000 Angstroms in the infrared make it of great value for optical purposes. There is no glass which covers this wide range, nor which has as great efficiency of transmission in a much narrower range. Fluorite transmits shorter ultraviolet waves than quartz, but is physically not suitable for making irradiation tubes, cells, lamps, etc.

This combination of physical and chemical properties makes fused quartz absolutely essential for certain highly critical technological uses, for which there literally are no substitutes. Due in part to the difficulties of manufacture and in part to the high

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prices which must be charged for quartz ware, production, and use have been limited. Up to World War II our domestic needs for clear fused quartz were supplied by only three domestic producers, none of whom made a full line of products, plus imports chiefly from one English company. There was not a single producer of clear fused quartz of really optical quality. One producer made small lens and prism blanks but they contained many bubbles, had relatively low transmission value, were optically non-homogeneous, and were too greatly strained optically to meet critical standards.

During the war there arose an urgent need for better fused quartz in quantity for several applications. One of these was for the making of new, highly efficient vaccines and serums by an ultraviolet irradiation process developed by the Michael Reese Research Foundation of Chicago under a grant from the Medical Research Committee of the Office of Scientific Research and Development and sponsored by the National Institute of Public Health. These vaccines and serums are up to 100 times as potent as those previously available. The key to the new process was irradiation by extremely short (1849 Angstrom) ultraviolet wave lengths. It had been generally assumed that these extremely potent bactericidal wave lengths could not be used practically, since published data showed 1850 A. as the "cut-off" point for commercial fused quartz, below which there is zero transmission. But Dr. Franz Oppenheimer of the Michael Reese Foundation had seen and used some fused quartz made by an expert quartz technician and inventor named Berthold F. Nieder. This fused quartz would transmit 1849 A. wave lengths in usable volume.

Eventually the Office of Production Research and Development made a contract for the development of Nieder's process and for the construction of equipment by which this high quality quartz might be made in quantity. The author was charged with the direction of this project.

Fused quartz production methods in no way resemble those used in making or forming glass. Quartz has a very high melting point - about 1750° C. as against 400° to 800° C. for various glasses. Furthermore molten silica never becomes really liquid, but remains a highly viscous mass at highly elevated temperatures. Near the softening point of around 1450° C. silica begins to volatilize and this continues at an increasing rate as temperature is increased. So fused quartz cannot be melted and cast, blown or pressed as is done with glass. Special production methods must be used.

The earliest fused quartz was made by laboriously fusing together small fragments of quartz in an oxygen-illuminating gas blowpipe flame. Even today much of the finest fabricated quartz used for ultraviolet lamps is still made by hand methods. Pre-calcined and water-quenched quartz is crushed and screened to particles ranging between 40- and 100-mesh. Quartz workers, seated at benches with oxygen-illuminating gas or oxyhydrogen burners in front of them, heat a quartz starting "bait" in the flame to the softening point, roll it in quartz powder, reheat until completely fused, roll again in powder, re-fuse and so on until the quartz nucleus has grown to sufficient volume for the object to be made. If a hollow tube is needed the starter "bait" is a short length of previously made tubing fused into hollow tube holders at each end, long enough for the worker to hold comfortably by each end. One end of the tube is plugged with a cork. To the other end is attached a mouth blowpipe tube. As the heated section grows in volume the worker gently blows and pulls, gradually elongating and increasing the diameter of the tube, but maintaining uniform wall thickness. Such tubing forms the starting point for making all types of hollow ware. Obviously the size of the piece which can be worked in this way is limited by the ability of the worker to support it in his hands, and by the volume of heat which can be concentrated on the object.

Mechanical methods of fused quartz production were introduced by General Electric Company about 25 years ago. By their process fused quartz slugs or blanks made in graphite crucibles form the starting point for making tubing, rods, lens, blanks, etc.

The raw material for all high-grade clear fused quartz is Brazilian rock crystal. This crystal quartz must be of the highest quality from the standpoint of impurities. It must be water clear and entirely free from all specks, feathers, and inclusions, but optical or electrical twinning is not detrimental. Hence the selected discards from the quartz oscillator plate program made perfectly acceptable melting grade quartz.

Quartz sand, no matter how pure, cannot be used for making clear fused quartz because the films of air adsorbed on the surface of the grains and occluded gas cannot be removed in fusing, and a milky, non-transparent quartz, full of bubbles results.

In the General Electric process the quartz lumps as received are first inspected, lump by lump, removing all visible contaminated pieces, then washed in water, then soaked in hydrofluoric acid, again washed and inspected, then dried. The quartz lumps and chips are then packed as tightly as possible in thin-walled, straight-sided graphite crucibles of the size and shape needed. Thus lens and prism blanks are made in shallow crucibles, and slugs for making rod and tubing are made in tall narrow crucibles, 1½ to 2 inches in diameter by 8 to 10 inches or more tall. The charged crucibles, one at a time, are placed in carbon-resistance, vacuum furnaces, and the charge melted. Vacuum is relied upon to pull off most of the air and occluded gases. When the charge is fully melted and it is judged that no more gases can be withdrawn, the vacuum is cut off and nitrogen under high pressure is introduced. This compacts the molten slug and squeezes the remaining gas bubbles down to microscopic size. At the end of the cycle the current is shut off. The furnace is allowed to cool, and the crucible is removed. After further cooling the crucible is broken away and the finished blank or slug removed.

Rod is made by local heating of solid slugs and pulling in a vertical pulling machine. For making tubing the solid slug must first be pierced to make a hollow slug. The slug is placed in a crucible in another type of carbon-resistance furnace, heated to 1800 or 1900°C. and pierced longitudinally by forcing a slender carbon spike down through its center. The hollow slug is then pulled into tubing in the pulling machine.

Although it is possible to make tubing up to 1¼-inch diameter or a little more by this method, good tubing of uniform diameter and wall thickness not much over three-fourths inch in diameter can be made in this way. This is due to the impossibility of maintaining uniform high temperatures localized in the critical pulling zone and to the effect of impurities in the tubing. Carbon from the graphite crucibles reduces the SiO_2 to metallic silicon and also forms silicon carbide. These form hard zones which melt at higher temperatures and form lumpy, uneven tubing.

Tubing of larger diameter is made by blowing up smaller tubing by hand or semi-machine methods. In this way tubing up to 4- or 4½-inch diameter with walls up to 4 mm thick can be made with difficulty. The work is very slow, tedious, and expensive. Small diameter tubing is also used to make all types of hollow ware such as flasks, beakers, casseroles, and the like.

In the new Nieder process clear fused quartz slugs, the starting point for making tubing and rod, are made by building up from quartz powder, grain by grain, as in the hand process described, but it is done mechanically. The crude quartz crystal is washed, acid-treated, and inspected, as in the other processes. Then the lump quartz is heated to redness in a closed muffle, then rapidly withdrawn and quenched in water. This process changes the quartz into opaque, white, fragile lumps which are very readily crushed to a granular powder. The powder is screened into fractions between 50- and 100-mesh, oversize is reground, and fine dust is discarded.

The quartz slugs are formed in a "slug machine", which resembles a lathe but in which both heads revolve at the same very slow speed. A starting "bait" of fused quartz rod, about five-eighths inch in diameter, is secured between the head and tail chucks. A sliding carriage, like the tool-rest carriage of a lathe, carries a burner-box assembly. Above and below the starter bait are oxygen-illuminating gas burners set so that the hottest flame zone impinges on the rod. Above the upper burner is fixed a container for the screened quartz powder which flows down from the container through a quartz tube and an accurate measuring orifice into a nozzle which is part of the upper burner. In operation the quartz powder drops through the heating zone of the upper burner on to the revolving bait where part of it sticks long enough to be completely fused in by the lower burner. The whole burner-box assembly moves slowly and mechanically along the bait to the end of the run where the motion is automatically reversed and a run is made in the opposite direction. This process is continued until the volume of the slug is so great that the burners can no longer supply enough heat to keep the surface of the slug completely fused and the slug becomes lumpy. In practice, at this stage of development, good slugs about 8 inches long by 1 inch in diameter, weighing about a half a pound each, can be made in $3\frac{1}{2}$ to 4 hours. Larger, but shorter, slugs of the same weight can also be made. By speeding up the machine these slugs can be made in much shorter time - say down to $1\frac{1}{2}$ hours - but at the expense of quality, that is, they contain many more bubbles.

The finished slugs are made into rod and tubing by the methods previously described.

By this means water-clear, virtually bubble-free quartz slugs can be made, of much higher quality than have ever been made before. The process sounds simple, but at each stage of manufacture, from the handling of the crude quartz to the treatment of the finished slugs, there are many technologic difficulties which have required many months of experimenting to solve. The making of larger slugs seems to depend largely upon solving refractories problems. More burners or larger burners can be used but the quantity and intensity of the heat generated is such that it is difficult to find materials for making the burners and burner box which will stand up.

Considerable work has been done on methods for producing large blanks and rectangular slabs. Small trials have been successful but the problem in general has not yet been solved, largely because of difficulties with refractories.

The Nieder process slugs show unusually high transmission of very short-wave ultraviolet and there has been much interest in this material for all types of ultraviolet irradiation and optical use. Irradiation lamps and cells made from this quartz for bactericidal work are now in actual use. Some lenses, prisms, and windows for optical use, as in spectrometers, have been made but important commercial production has not yet resulted. Although this quartz is unusually homogeneous and free from strain optically, yet larger blanks must be annealed for critical uses. More work has to be done on annealing procedure to determine the best type of equipment and operating conditions.

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SO YOU WANT A HOMESTEAD?*

by

Clarence W. Ogle, Register
District Land Office, Lakeview, Oregon

I have lived in Oregon 37 years, have been register of the District Land Office at Lakeview, Oregon, twelve years. I have seen very few homesteaders make a success of their undertaking. The biggest portion of the good land, agricultural in character, outside of reclamation districts has been taken up - years past, even before my time.

The Act of June 28, 1934, known as the Taylor grazing act, eliminated the stock-raising homestead, which was for 640 acres of grazing land. These same lands outside of grazing districts may be leased under Section 15 for grazing purposes.

There will be land opened up in almost every state, under its reclamation act for soldier's preference right; but we don't know when, and the only drawback is, there will be so few homesteads for the thousands of boys who want them. The law is so strict as to farming experience and money, that very few boys will have a chance. When a portion of land is opened up, there will be so many filings on the same piece of land, that each one will have to draw. The person who has the most farming experience as an irrigated farmer, or money, and equipment, equivalent to money will be the winner.

I am not trying to discourage you, I am only telling you my experience. I have not used my homestead right, although I was raised on a farm and have always liked the farm life. I bought a 320-acre ranch 26 years ago and still live on and operate the same.

My advice to you is, if you are not eligible for a reclamation homestead and you can buy a farm in the right location for its purpose, do so. You will be better off.

*From Agriculture Bulletin, March 1946, published by Oregon State Department of Agriculture.

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BAKER COUNTY DEVELOPMENT

Extensive development of Bourne mines on the Columbia lode, one of the principal mineral veins of the Baker region, was forecast with announcement of the merger of Ellis Mining company, lease holder on the properties, with Consolidated Mining and Smelting company of Canada.

The contract covers the North Pole, E. & E., Tabor Fraction and Columbia mines, Senator Rex Ellis, treasurer of the Ellis company, reported. He, with C. C. Curl of Pendleton, president, and Bruce Hurdle, assistant manager of Consolidated, was here this week to complete the transaction.

The new company, Solar Development Company, Inc., a subsidiary of Consolidated, will initially examine, survey and study geology of the mines at Bourne, located north of the former mining boom town of Sumpter. The announced objective is to reopen the mines as one operation, said Ellis, with a tunnel planned to drain the workings 1000 feet below previous levels.

Bourne mines produced heavily in gold prior to 1915. Cracker Creek Gold Mining company was formed in 1938, consolidating the five separate ownerships on the lode, and ownership of the property remains with this company. Ellis entered the field shortly thereafter, taking a lease and erecting a mill about the time war priorities quieted gold mine operations.

Most recently gold production was prior to the war when a half-dozen small leasers mined high-grade ore which was shipped via Sumpter and Baker direct to the smelter at Tacoma.

Oregon Journal, July 13, 1946.

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O.S.C. MINING PROFESSOR LEAVES

Dr. A. W. Schlechten, head of the Mining Engineering department of Oregon State College, has resigned to accept the position of Chairman of the Department of Metallurgy at the Missouri School of Mines, Rolla, Missouri. The Department of Mining Engineering was re-established at Oregon State College just before the war, and Dr. Schlechten came from the University of Minnesota to take charge. Because of war conditions organization of the department was postponed and Schlechten was granted a leave of absence in order to do metallurgical work for the U.S. Bureau of Mines at Albany, Oregon. The new position at the Missouri School of Mines is a great compliment to Dr. Schlechten's training and ability.

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PROMINENT SCIENTIST ON INDUSTRY STUDY*

Possibilities of establishing an artificial abrasives manufacturing industry in the Portland area are to be studied this summer by R. B. Ladoo of Newton, Massachusetts, specialist in non-metallic minerals, who has been engaged as consultant by the Industries department of the Portland chamber of commerce, Industries manager Chester K. Sterrett reports.

Ladoo previously has worked in Portland on special projects for the Aluminum Company of America in preparing market surveys for use of lime and limestone, and has been a consultant to the Pacific Power and Light company.

Production of silicon carbide and fused alumina to be made up into grinding wheels and similar products is the goal of this study which is in line with the department's policy of encouraging, where practical, establishment of factories here for goods at present shipped in from other sections.

Ladoo is the author of a number of standard technical books on non-metallic minerals.

*From Commerce, June 29, 1946, published by the Portland Chamber of Commerce.

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RECONNAISSANCE GEOLOGY OF THE LOWER ROGUE RIVER

CURRY COUNTY, OREGON

by

Ewart M. Baldwin*

Larry Lucas, well-known guide and resort owner of Agness at the so-called head of navigation on the Rogue River, found a remarkably fine ammonite near Agness. This trip was made mainly to search for fossils at this locality. At the same time notes on the reconnaissance geology of the lower Rogue River were taken.

Dr. Warren D. Smith, head of the department of geography and geology at the University of Oregon, who had previously visited the area to search for fossils and who wished to make a more thorough search, was accompanied by the writer. The trip from Gold Beach was made by power boat which leaves about 8:30 a.m. and arrives at Agness about 11:00 a.m. At this time of the year the water is unusually low and the boat had difficulty in crossing many of the riffles.

The geology of part of this area was mapped by J. S. Diller of the U.S. Geological Survey and published as the Port Orford Geologic Atlas in 1902. Since that time little additional mapping has been done in adjacent areas although the units as defined by Diller may be traced southward throughout the Gold Beach area. G. M. Butler and G. J. Mitchell, 1916, published a reconnaissance geologic map of Curry County.

Serpentine crops out in the vicinity of Gold Beach. Mesozoic conglomerate, sandstone, and shale, presumably of upper Jurassic or lower Cretaceous age, crop out between Gold Beach and the mouth of Lobster Creek. These beds are steeply folded, broken by many faults, and well indurated.

The unconformable contact between the Mesozoic sediments and underlying Colebrooke schist lies a short distance west of the mouth of Lobster Creek. This schist formation is the predominant rock type between this point and Agness. It is a contorted phyllitic schist with numerous thin lenticular quartz veins. Slates and graphitic schists occur in places. Diller assigned this mass a pre-Devonian age because of the resemblance to schists in northern California that lie beneath Devonian strata.

On the eastern edge of the schistose highland, steeply dipping Mesozoic strata lie in faulted contact against an intervening lens of serpentine. The sediments are very much like those in the vicinity of Gold Beach and a limited fauna consisting of species of ammonites and pelecypods was found. The Mesozoic sediments are exposed along the Illinois River and abundant shellbeds consisting largely of species of Aucella were found about a mile upstream from Oak Flats. The numerous lenses of conglomerate in the steeply folded Mesozoic sediments stand out as peaks such as Sign Butte and Pebble Hill.

The contact of the Mesozoic sediments with Eocene sediments trends northward and southward from Agness and both the Rogue and Illinois rivers parallel this contact for several miles. The Eocene sediments are predominantly well-bedded sandstone and sandy shale but conglomerate beds which resemble the Mesozoic sediments are common near the base. The sediments are steeply dipping but less indurated than the Mesozoic sediments. Coal is known to occur along Shasta Costa Creek near the base of the section. Fossils are relatively scarce but some oyster beds have been found; one of these beds lies a short distance below the summit along the road above Illahe.

The summits of the hills lie about 3000 feet above sea level and are generally accordant. Diller called this erosion surface the "Klamath peneplain." The region is in a youthful stage of dissection, and most of the valleys are steep-walled and narrow except where the erosion has occurred along belts of less resistant sediments. There has been some oscillation in sea level as shown by the well-developed gravel-covered terrace that stands about 200 feet above

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*Associate Geologist, Oregon Department of Geology and Mineral Industries.

river level and 300 feet above sea level at Agness. Later erosion has modified this terrace and it is generally obliterated throughout the lower gorge.

The lower Rogue River valley has been cut beneath sea level as have the other coastal rivers along the Oregon Coast but this relatively narrow valley has long since been filled by the rivers' load and the tide has little effect upon river level upstream from the mouth.

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ST. JOHNS BRIDGE

Steelways, published by the American Iron and Steel Institute, New York, in its July issue, contains an interesting article by David B. Steinman on famous steel bridges with emphasis on their beauty of architecture. Prominent among those described is Portland's St. Johns Bridge. The author of the article writes of St. Johns Bridge and steel bridges in general as follows:

> "The setting for the St. Johns Bridge at Portland, Ore., challenged the designer to produce a span of matching beauty against the colorful panorama of city, river and valley below, and peaks beyond. The selection of the suspension type, with its naturally graceful cable curve and harmonic composition, was the first step. Then in the lofty steel towers, the bracing naturally yielded a pointed arch high above the roadway, the lines of the arch harmonizing with the curving lines of the cables. The portal openings in the towers frame colorful views of green trees, blue sky and white clouds. The finial spires, carrying the aviation beacon lights, blend with the evergreen spires of the tree-tops in the background.
>
> "In this example of architecture in steel, beauty was secured without concealment, camouflage or ornamentation. Not a pound of metal was wasted. The structural steel itself was planned for beauty of line, proportion, surface relief, light and shadow. And to all this was added color, the steel being painted a pleasing shade of verde green.
>
> "The bridge designer of this era has to be both engineer and artist combined. To a thorough understanding of structural design and function he must add a strong feeling, both innate and trained, for beauty of form, line and proportion. Architects, before they can help the engineer, must learn to understand and appreciate this new material - steel - and not regard it merely as a skeleton to be clothed in some foreign raiment.
>
> "In bridge after bridge, design engineers have now demonstrated that beauty can be secured without sacrificing utility or economy. They are directing their efforts toward producing the most beautiful designs in the steel itself, by developing forms that express the spirit of this metal - its strength, power and grace.
>
> "I think that no one, unless he is completely without feeling, can remain unmoved at the sight of a beautiful bridge. The arching span of steel, at once so delicate and strong, summons an ancient dream in the heart of man - the dream of flight. It is as if the bridge itself lifted wings and soared from shore to shore."

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CLEARING HOUSE

CH-87: Two service men wish to install and operate small mill, either concentrating or amalgamation, on mine with some milling ore developed. Will not develop mine beforehand or build roads, but will enter into agreement on a percentage basis with owner of property to mill the ore which the owner mines or furnishes. If interested write Lowell W. Tyler, 137 South Montgomery, Bremerton, Washington.

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CURRENT MINING NOTES

Golden Dredging Company, a partnership among George England, Harry Morse, Thomas Harris, Frank Kendall, and Jenkins Pryse, has moved its plant from Pine Creek in Baker County to the Middle Fork of the John Day River near Caribou Creek. Equipment consists of conventional $1\frac{1}{2}$-yard dragline and washing plant.

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Associated Dredging Company has moved equipment from lower Burnt River, Baker County, to Vincent Creek northeast of Austin in eastern Grant County. Equipment includes a 3/4-yard Lima shovel and floating washing plant. This company is a partnership composed of W.A. Hilliard, Ira Pound, J.D. Oscar, Elwood Welch, and Harry Welch. The ground on lower Burnt River is still being retained by the company and is currently doing further testing work by drilling.

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The Double H mine, formerly the Lucky Boy, located about 2 miles north of the town of Rogue River in Jackson County, is being explored by a group headed by G.S. Holmes and R. J. Howard. John Johnson, Grants Pass, is superintendent.

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WILLAMETTE VALLEY LIMESTONE

Farms of the Willamette Valley continually require a large quantity of limestone to neutralize acidity and to provide calcium for crops. The amount of limestone which a farmer can use depends mainly on cost and one of the principal factors in this cost is transportation. Most of the limestone used in the Willamette Valley is now brought in by railroad from deposits in eastern and southern Oregon, because these deposits are much higher grade than known Willamette Valley deposits. If high-grade limestone could be found in the Willamette Valley, transportation cost would be lowered and farmers could use more of the needed limestone.

These facts together with descriptions of Willamette Valley deposits are discussed in a short report just issued by the State Department of Geology and Mineral Industries entitled "Reconnaissance Geology of Limestone Deposits in the Willamette Valley, Oregon." It is No. 15 of the series of G.M.I. Short Papers. The author is John Eliot Allen, geologist of the Department staff.

The report is available at the office of the Department at 702 Woodlark Building, Portland, and the field offices at Baker and Grants Pass. Price postpaid 15¢.

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PUBLICATIONS

GEOLOGIC MAP SERIES	Price postpaid
1. Geologic map of the Wallowa Lake quad.,1938:W.D.Smith & Others(also in Bull.12)	$ 0.45
2. Geologic map of the Medford quadrangle,1939:F.G.Wells & Others	0.40
3. Geologic map and geology of the Round Mountain quad.,1940:W.D.Wilkinson & Others)	0.25
4. Geologic map of the Butte Falls quad.,1941:W.D.Wilkinson & Others	0.45
5. Geologic map and geology of the Grants Pass quad.,1940:F.G.Wells & Others. .	0.30
6. Preliminary geologic map of the Sumpter quad.,1941:J.T.Pardee & Others . . .	0.40
7. Geologic map of the Portland area, 1942:Ray C. Treasher	0.25
8. Geologic map of the Coos Bay quad.,1944:Allen & Baldwin (sold with Bull. 27)	----
9. Geologic map of the St. Helens quad.,1945:W.D.Wilkinson,W.D.Lowry,&E.M.Baldwin	0.30
MISCELLANEOUS PUBLICATIONS	
The Ore.-Bin: issued monthly by the staff as medium for news items about the Department, mines, and minerals. Subscription price per year	0.25
Oregon mineral localities map	0.05
Landforms of Oregon: a physiographic sketch, (17 by 22 inches) 1941	0.10
Index to geologic mapping in Oregon, 1944	Free
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