ENGINEERING GEOLOGY OF THE JOHN DAY AREA, GRANT COUNTY, OREGON

STATE OF OREGON
DEPARTMENT OF GEOLOGY AND MINERAL INDUSTRIES
R. E. CORCORAN, STATE GEOLOGIST

1975

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In cooperation with

Grant County
Board of County Commissioners
and
the City of John Day, Oregon

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ENGINEERING GEOLOGY OF THE JOHN DAY AREA, GRANT COUNTY, OREGON

by

Herbert G. Schlicker and Howard C. Brooks

INTRODUCTION

The surface of the earth is not nearly as stable and unchanging as it is commonly imagined to be. The geological processes which have shaped the land continue to modify its surface. In most places the changes result from the imperceptably slow but constant weathering and erosion which produce a gradual downhill migration of soil and rock fragments. More dramatic are the effects of floods and large landslides.

When natural geologic processes interfere with the works of man, they become hazards. Since most areas have geologic conditions that could be hazardous to certain types of development, an understanding of those hazards is essential to efficient land use planning and land development.

The safe and economical development of land for urban use requires a thorough understanding of the engineering properties of the soil and the geological processes that have combined to give the land its present form.

Failure to evaluate soil and subsurface conditions can lead to improper development of the land and a financial loss to the owner or developer. Building site selection, particularly for homes, is often based chiefly on aesthetic considerations, whereas suitability of the land should be of primary concern. "Land with a view" is not necessarily safe for development.

Purpose and Scope of Report

The purpose of this report is to provide basic information on soils, geology, and related hazards so that the engineer, developer, planner, government official, and private citizen will have a better understanding of the relationship to and effect of geology on land use. Since geologic processes continue to modify the land in ways which conflict with man's attempt to use it, an understanding of the geologic hazards will result in fewer development problems and better land use.

It should be emphasized that this study is general in scope. The scale of mapping and the time available for the investigation did not permit the delineation of every small area where potentially hazardous conditions might exist. Therefore planners and developers should be aware that problems could be present even though they are not indicated on the map.

Implementation of the Report

The John Day area is endowed with wide variation in landforms, soils, and rocks. For this reason each potential building site presents a peculiar combination of slope, soil, and subsurface conditions which must be evaluated. It is the responsibility of the planning department to be aware of possible hazards to development and to advise the engineer and developer when it becomes necessary to require engineering and geologic studies.

One method for planners to apply the information on geologic hazards is to prepare hazard maps on transparent overlay sheets to fit the geologic or other base map. Each type of hazard should be on a separate sheet and rated by using three screen tones or patterns to denote the degree of hazard. For example, a flood-hazard map would have light shading for areas that seldom flood, medium-density shading for areas that flood occasionally, and darkest shading for areas that flood frequently. By stacking the transparent overlay sheets, the planner can interpret the total intensity of hazards for any one area; clear or lightly shaded areas will have the fewest hazards, and progressively darker areas will have an increasing number or severity of hazards.

When analyzing the data for a particular land use, those hazard sheets that are not pertinent to the use should be removed.

Overlay maps are especially helpful in planning and zoning studies. A more detailed description of this method is given by McHarg (1969).

Grading regulations can be prepared by planners from data developed by engineers and geologists. These regulations generally reflect chapter 70 of the Uniform Building Code but may be more specific relative to local conditions. The regulations should specify when an engineering or geological report will be required, and provide guidelines for the design and construction of cut slopes and embankments, construction of drainages, and other items deemed important.

Acknowledgments

The geologic interpretations presented in this report are based largely upon the work of T. P. Thayer and C. E. Brown, who, having devoted many years to the subject, are the foremost authorities on the geology of the John Day region. Their maps and reports which were referred to during the preparation of this report are listed in the bibliography. A summary of the geologic history based on their work is presented in a pamphlet entitled "The geologic setting of the John Day Country," published by the U. S. Geological Survey.

Gene Dyksterhuis and Don Wallenmeier of the Soil Conservation Service in Canyon City provided a map and soils data. Dr. Harold Enlows provided information on the petrography of the Rattlesnake Formati

Ron Burgman, U.S. Forest Service, read the report critically and made helpful suggestions.

Acknowledgment is made to Grant County and the cities of John Day and Canyon City for financial assistance in the study. We would especially mention Grant County Judge Francis F. R. Cole and Blen Holman, County Planning Director; Mayor John R. Moreau, and Treasurer Ruth Crim of John Day for their interest and help in the preparation of the report.

GEOGRAPHY

Population

The 1974 census figures for John Day and Canyon City were 1,770 and 640, respectively. Comparative figures for 1960 were 1,520 for John Day and 654 for Canyon City. Together, the two towns comprise the largest population center in Grant County. Total Grant County population was 7,450 in 1974 and 7,726 in 1960.

The economy of John Day and Canyon City depends mainly on the lumber and cattle industries. Tourism also is an important and increasing source of income.

In recent years there has been increasing demand for homesites, partly because the Hines Lumber Company has been closing out sawmill operations at Bates and building a new mill at John Day. The demand could not be accommodated totally within the corporate boundaries due to limitations in water supply and sewage collection systems. Several new homes have been built a mile or two outside the city boundaries.

Climate and Vegetation

The climate of the project area is semi-arid with moderate mean annual temperatures, relatively severe seasonal temperature extremes, low humidity, and fairly low precipitation. Average temperatures in Grant County for January and July are 35.8°F and 66.5°F respectively. Temperatures typically vary between 10° and 100° during the year (Winningham and Keil, 1975). Precipitation averages 12.1 inches (Winningham and Keil, 1975). Natural vegetation is sparse on hillside slopes and the upland benches (see accompanying photographs). During hot, dry periods of summer there is danger of range fire. Cottonwood trees and a variety of willows and brush grow along the banks of the John Day River and Canyon Creek. Water from the John Day River is used for irrigation of forage crops on the flood plain.

Geographic Setting

The project area includes the towns of John Day and Canyon City, which are located near the center of Grant County, Oregon. Canyon City is the County seat. The city limits of John Day encompass the junction of U. S. Highways 26 and 395 and the confluence of Canyon Creek with the South Fork of the John Day River. Canyon City is on Canyon Creek and centered about 2 miles south of the John Day city center. Highway 395 follows Canyon Creek through Canyon City. Although the valley of Canyon Creek is highly developed between John Day and Canyon City, there is unincorporated land between the two towns.

The John Day River flows generally westward in a broad valley, which is roughly half a mile across in the vicinity of John Day. The floor of Canyon Creek is less than a quarter of a mile wide in most places. The elevation is 3,065 feet at John Day city center and 3,199 feet at Canyon City. Hill slopes within the corporate boundaries are fairly steep, rising to elevations of about 3,600 feet within a distance of half a mile from the Creek. Above 3,600 feet, on both sides of Canyon Creek, dissected benchlands slope gently upward to elevations of 4,500 feet within a distance of about 2 miles. The benchlands are dissected by seasonally active streams which parallel Canyon Creek. To the south, beyond the benchland the terrain becomes steep and mountainous.

North of the John Day River a basalt terrain slopes southward at a moderately steep angle. A large hummocky landslide area extends eastward for about a mile and is bounded on the north and east by a steep, talus-covered scarp. Elevations of the terrain range from about 3,100 feet at river level to just over 4,000 feet about a mile to the north.

Photo 1. A view northward of the John Day valley with a large landslide area beyond. Columbia River Basalt rimrock caps the upland areas.

Photo 2. Looking east at the John Day River valley with its level flood plain and slumped valley walls.

The John Day River valley is a structural trough which divides the Strawberry-Aldrich Mountains to the south from the unnamed ridge and gulch terrain to the north.

The present configuration of the surface is the result of the interplay between the complex tectonic forces (which folded, buckled, and broke the Earth's crust to form the mountains and the valley) and the effects of erosion, which tend to wear the mountains down and fill the valleys with alluvium.

Uplift of the mountains began in Pliocene time. While the mountains were rising, alluvial debris (soil, sand, and gravel) was deposited on the valley floor, in places to depths of more than 1,000 feet. About six million years ago, while the Pliocene gravels were accumulating, a violent volcanic eruption spread a layer of ash more than 100 feet thick across the valley. As alluvial deposition decreased, an extensive, broad, gently sloping surface was formed on top of the valley fill. This surface forms the benchlands along the south side of the John Day River. The airport is located on this surface. In recent geologic time the John Day River, Canyon Creek, and their many tributary streams have been slowly dissecting the high benches and river terraces and depositing sediments on the valley floor.

GEOLOGIC TIME CHART

STRATIGRAPHIC DIVISIONS			TIME	DOMINANT LIFE	
ERA	SYSTEM OR PERIOD	SERIES OR EPOCH	Estimated ages of time boundaries in millions of years	ANIMALS	PLANTS
CENOZOIC	QUATERNARY	Holocene Pleistocene	2-3	Man	Flowering trees and shrubs
	TERTIARY	Pliocene	12	Mammals, birds, bony fish, mollusks, arthropods and insects	
		Miocene	26		
		Oligocene	37-38		
		Eocene	53-54		
		Paleocene	65		
MESOZOIC	CRETACEOUS	Upper (Late) Lower (Early)	136	Dinosaurs and Flying and swimming reptiles	Conifers, Cycads, Ginkgos and Ferns
	JURASSIC	Upper (Late) Middle (Middle) Lower (Early)	190-195		
	TRIASSIC	Upper (Late) Middle (Middle) Lower (Early)	225	Ammonites	
PALEOZOIC	PERMIAN	Upper (Late) Lower (Early)	280	Giant insects, Primitive reptiles & Amphibians	Scale trees, Cordaites, Calamites, and Tree ferns
	Carboniferous: PENNSYLVANIAN	Upper (Late) Middle (Middle) Lower (Early)			
	Carboniferous: MISSISSIPPIAN	Upper (Late) Lower (Early)	345	Crinoids and Blastoids	
	DEVONIAN	Upper (Late) Middle (Middle) Lower (Early)	395	Sharks & Lungfish	Primitive scale trees and tree ferns
	SILURIAN	Upper (Late) Middle (Middle) Lower (Early)	430-440	Corals,	Lycopods and Psilophytes
	ORDOVICIAN	Upper (Late) Middle (Middle) Lower (Early)	500	Brachiopods, and	Algae and Fungi
	CAMBRIAN	Upper (Late) Middle (Middle) Lower (Early)	570	Trilobites	
PRECAMBRIAN (More than 80% of earth's estimated 4.5 billion years falls within this era)	Informal subdivisions such as upper, middle, and lower; or upper and lower; or younger and older may be used locally.		3,600+	Beginning of primitive plant and animal life	

Adapted from U.S. Geological Survey and other sources.
Ages of oldest rocks and fossils from T. W. Stern, U.S.G.S. Isotope Branch, March 1970.

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Photo 3. View looking northeast from south end of airport runway. Permian meta-sediments exposed in foreground, overlain by thin rocky soil. Tree-dotted area in middle distance lies east of Canyon Creek. Columbia River Basalt rimrock is north of John Day valley, east of John Day.

Photo 4. Steeply dipping vesicular basalt cropping out in roadcut on road to John Day airport.

GEOLOGY

Summary of Geologic Units

Rocks of Paleozoic, Mesozoic, and Cenozoic Eras are exposed in the map area (see accompanying geologic time chart). They have been divided into the following units from oldest to youngest: marine sedimentary and volcanic rocks (Pal) of Permian age; serpentinite and other mafic and ultramafic rocks (Sp) of Early to Middle Triassic age; Columbia River Group of basaltic lava flows and local sedimentary interbeds (Tcr) of Miocene age; Rattlesnake Formation fanglomerate and gravel deposits (Tr) of Pliocene and Pleistocene age; and a layer of welded tuff (Trt) of Pliocene age that is included in the Rattlesnake Formation. These units are overlain locally by landslide debris (Qls) and recent unconsolidated sedimentary deposits which, because of differing engineering characteristics, are divided into the following categories: (1) terrace deposits (Qtg); (2) flood-plain deposits (Qal); (3) placer-mine tailings (Qp).

The description of each geologic unit is followed by a summary of the engineering characteristics which may have an adverse effect on certain types of development. More detailed discussions are presented in the section "Summary of Geologic Hazards."

Pre-Cenozoic Rocks

Sedimentary and volcanic rocks, partly metamorphosed (Pal)

General description: This unit consists mainly of deformed and metamorphosed volcanic and volcaniclastic rocks, chert, and argillite with some interbedded siltstone and graywacke of Paleozoic age. Some of the volcanic rocks are very fine-grained, highly altered lava flows and tuffs. Because they are fine grained and siliceous, they are often mistakenly identified as chert. Local metamorphism has converted the more basic volcanic rocks to schistose greenstones and hornblende schists, the cherts to large rock masses, and the siltstones to phyllite. The rocks are so complexly deformed that major structural features are unmappable.

The unit represents a thick accumulation of land-derived sediments and submarine volcanic debris that was laid down in a shallow marine environment during the Permian Period of geologic time about 250 million years ago.

Engineering characteristics: The engineering characteristics of the Paleozoic rocks differ according to rock type. Since rock type can vary within a few feet, a single rock face may contain both hard rock and soft decomposed rock. When quarrying these rocks for aggregate, the poor material should be selectively wasted. In general, these older rocks are not very durable and other sources should be utilized if available.

Foundation strength is considered adequate for light loads imposed by single-family dwellings, but heavier foundation loads will require more extensive testing and appropriate design. Permeability of the rocks is generally low and where they are overlain by thin soils, drainage fields are in most instances ineffective for disposal of waste water. The need for central sewerage systems will depend upon the density of housing and the results of appropriate studies for each site.

Ultramafic and mafic rocks of the Canyon Mountain Complex (Sp)

General description: Rocks included in this unit are chiefly serpentinite with some associated gabbro, peridotite, and dunite. These rocks are representative of the Canyon Mountain Complex which was named by Thayer (1963) for exposures on Canyon Mountain. Exposures of similar rocks are widely distributed elsewhere in the Blue Mountains. The plutonic complex appears to have intruded and deformed

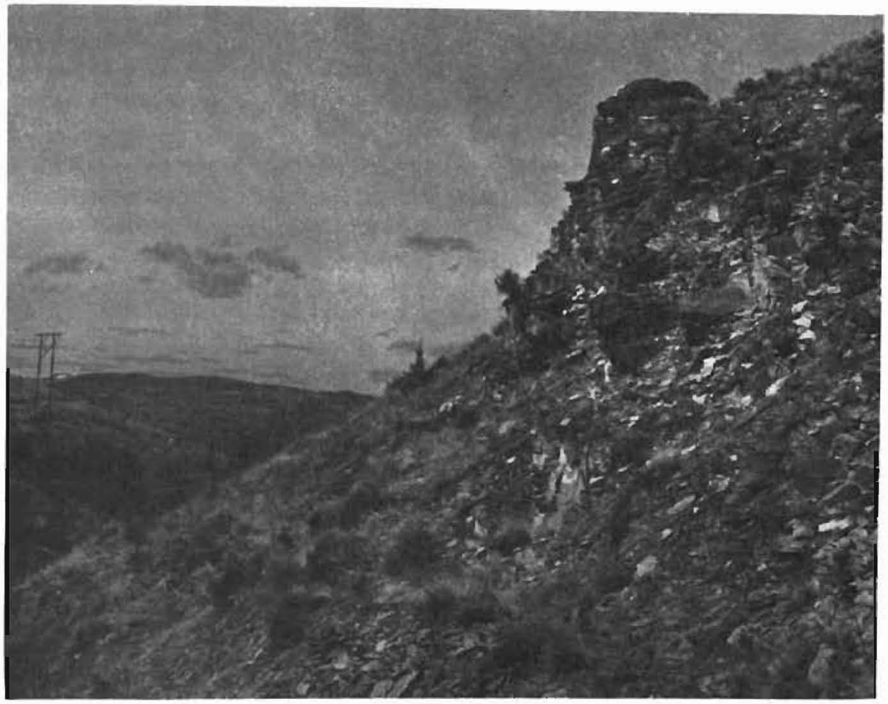

Photo 5. Looking northwest; welded tuff rimrock of the Rattlesnake Formation exposed east of Canyon Creek between John Day and Canyon City.

Photo 6. View north toward water tank. Note Rattlesnake welded tuff rimrock exposed in slope at right. Below rimrock is colluvium composed of angular blocks of welded tuff mixed with gravel. Upper slopes are Rattlesnake gravel.

the Paleozoic rocks during an Early or Middle Triassic orogenic episode. In several places in eastern Oregon, rocks of this complex are overlain unconformably by volcanic and sedimentary rocks of Late Triassic age.

Engineering characteristics: Ultrabasic rocks such as peridotite and dunite are fairly competent and can be used for road construction. However, severe tectonic activity has altered much of the rock to serpentinite, a less competent material. Weathering has reduced part of the rock to clayey soils. The altered and weathered material is generally unstable and is susceptible to landslide. It makes poor foundation for structures, and, unless overlain by at least 6 feet of loamy soil, it may be unsatisfactory for septic tank drain fields.

The soil derived from ultrabasic rocks contains appreciable clay which is sensitive to moisture changes. Upon drying, the soil shrinks and forms deep cracks, but with addition of moisture the soil swells. This alternate shrink and swell action causes soil creep on hillsides and can result in damage to buildings from vertical movement of the foundations. The approved engineering designs for a proposed structure should adequately compensate for geologic hazards determined to be present at the site.

Cenozoic Rocks

Columbia River Group (Tcr)

General description: This unit consists mostly of dark-gray to medium-gray, olivine-bearing basalt flows. In places, water-laid rhyolitic tuffs and thin gravel beds are interlayered with the basalt flows. Individual flow thicknesses range up to about 20 feet. Flows typically show a blocky joint pattern and are reddish at the base and vesicular to scoriaceous at the top. Montmorillonite clays, zeolites, calcite, and secondary silica minerals are common alteration products along fractures and in vesicles.

The basalt flows in the Charollais Heights area dip about 12° southward. These flows appear to have formed the north limb of the structural trough in which the Pliocene Rattlesnake Formation was deposited.

The basalt is part of the floods of basalt which spread over much of the northwestern United States during middle Miocene time. The basalt was deposited on a surface of considerable relief which had formed as the result of erosion during a great span of geologic time. Intervals of time between lava flows were generally sufficiently long for weathering to occur and soil zones to develop on the surface of the flow prior to the next extrusion of lava.

Following deposition of the basalt, which probably once covered the entire map area, there was another period in which the Earth's surface was deformed and much of the basalt was stripped away by erosion.

Radiometric ages of similar flows in other areas range from about 13 million years to about 19 million years. Most isotopic ages are about 13 to 16 million years. Basalt of approximately the same age is included in the basalt sections of Strawberry Mountain and Picture Gorge.

Engineering characteristics: In most areas, basalt flows can be considered excellent foundation support. Heavy foundation loads can be placed directly on the basalt after the overlying soil and weathered rock has been removed. Small structures with light foundation loads can be placed on the soil after shallow excavation of a foot or so below the surface; settlement will be within allowable limits.

Layers of weathered rock and soil between lava flows create zones of weakness within the basalt unit. In places where the lavas dip in the direction of the slope of the ground, such as in the wall of a canyon, a slip plane can develop parallel to the bedding and cause a landslide. This type of landslide can be induced by excavating and steepening the slope, by moving material onto the slope and overloading it, or by adding moisture to the soil interbed through improper construction of storm drains, roadside ditches, and drainage from housing developments.

Examination of proposed hillside developments should be made to determine the dip of the lava flows and the nature of the soil interbeds. The presence or lack of slope failure in adjacent parts of the slope is significant.

The lavas are usually an excellent source of ground water. Because of the permeability of the rock, however, waste water could cause contamination and should be prevented from entering the ground.

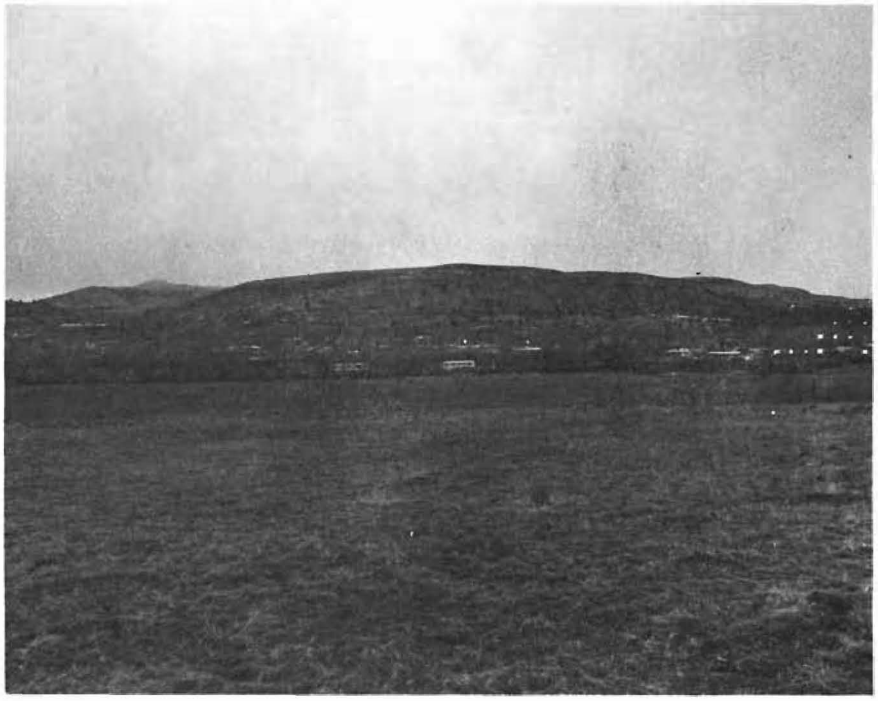

Photo 7. View south toward John Day with Canyon Creek in notch at left center. Nearly level terrace in foreground will seldom flood; flat area being grazed is river flood plain.

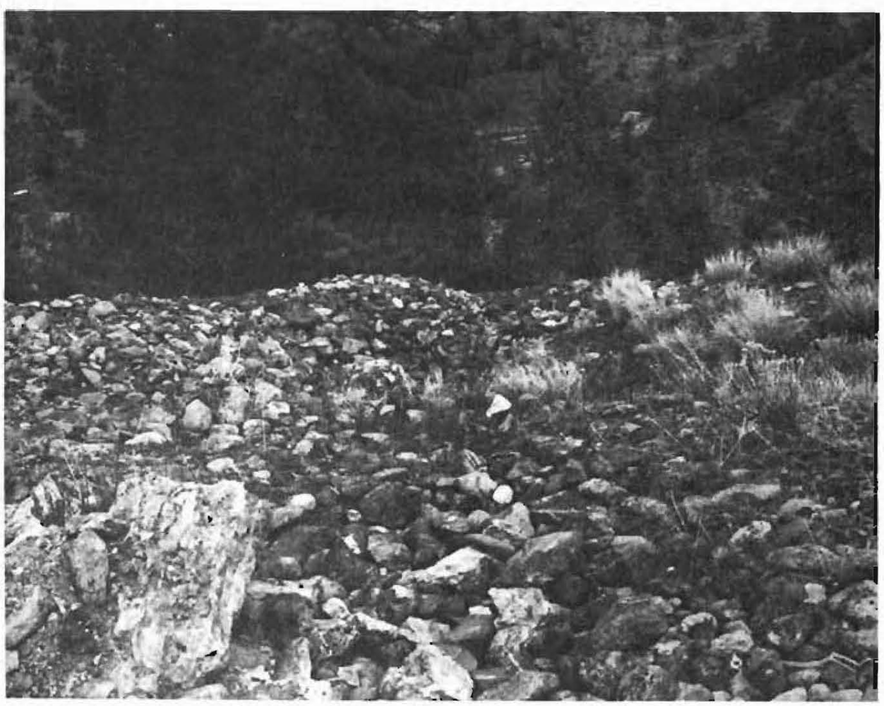

Photo 8. "Old Humboldt Diggings" produced this bouldery bench along the west flank of Canyon Creek valley.

Rattlesnake Formation - sediments (Tr), tuff (Trt)

General description: The Rattlesnake Formation is the youngest, most widely exposed unit of Tertiary age in the map area. It is best developed in the John Day valley and was named by Merriam (1901) for exposures along Rattlesnake Creek approximately 4.5 miles west of Dayville. Exposures of Rattlesnake Formation near John Day have been mapped and described by Thayer (1956) and Brown and Thayer (1966). The maximum observed thickness of the unit, 700 feet, is exposed in the John Day structural trough just southeast of Dayville.

In the John Day area, the Rattlesnake Formation consists of alluvial fans composed of river gravels, poorly sorted finer sediments, and a welded rhyolite tuff member near the middle of the Formation. In this area, the Rattlesnake Formation is thickest south of the John Day River and it feathers out against the pre-Tertiary rocks along the foothills of the mountains.

Welded tuff member: The welded rhyolite tuff member forms prominent rimrocks along the John Day River valley between John Day and Picture Gorge and is well exposed locally in the map area. Here the unit is more than 100 feet thick with only the upper part densely welded. At most exposures, only the upper 30 to 40 feet of the tuff unit is exposed. The tuff is composed mainly of annealed glass shards enclosing fragmented crystals of anorthoclase with minor quartz and green augite (Enlows, in press). Angular fragments and rounded pebbles of basalt and other rock types are subordinate constituents. The tuff represents a volcanic ash flow that spread out over the land surface as a red-hot, highly inflated mixture of minutely fragmented volcanic glass and volcanic gases. As the material cooled and the gases were expelled, the glass particles were compressed and "welded" together. The rock is fairly soft, easily worked, and resists weathering. A radiometric age of 6.4 million years was determined for the tuff unit by Evernden and James (1964). On the basis of trace elements, the tuff is correlated with the upper ash-flow tuff of the Danforth Formation (Beeson, 1969) for which Davenport (1970) reports an age of 6.1 million years. Middle and late Pliocene mammals have been recovered from the gravels beneath the tuff, but the upper part of the formation may extend into early Pleistocene.

Fanglomerate (gravelly sediment): The sedimentary phase, or fanglomerate as it is called, was deposited both before and after the welded tuff was emplaced. The slopes above the tuff are gently rounded and extend back to the mountain fronts. Exposures below the tuff member are much steeper than elsewhere and large areas have failed by landslide.

The sediment consists of semi-consolidated mixtures of clay, sand, and bouldery gravel which washed into the John Day valley from highlands to the south. The gravel is composed of an assortment of well-rounded pebbles, cobbles, and boulders up to 2 feet in diameter representing a wide variety of rock types loosely embedded in a mixture of clay, silt, and sand. Lenses of clean gravel are rare. Most of the rocks in this area were derived from rock units of pre-Cenozoic age, including chert, gabbro, ultramafic rocks, diorite, greenstone, and graywacke. Fragments of basalt and rhyolite typical of younger formations are locally abundant.

Colluvium, a mixture of soil and clastic material, has accumulated at the foot of the slopes, masking the Rattlesnake Formation in those areas. Colluvium differs from a landslide in that no slide plane or obvious slope failure is involved. The material moves downslope as a result of freeze and thaw, thermal expansion, and slope wash combined with the force of gravity.

Engineering characteristics: Steep slopes beneath the Rattlesnake tuff member should be regarded as potentially unstable. Landslides commonly occur on slopes where soft rocks are overlain by more resistant rocks. Because the Rattlesnake tuff member is more resistant to erosion, the slopes on underlying Rattlesnake sediments tend to become oversteepened to the extent that the tuff and overlying sediments fail and slide downward. The scattering of small blocks of tuff among hummocky masses of alluvial debris downslope from undisturbed exposures of the tuff unit is good evidence of this characteristic of the Formation.

Since the gravelly soil is composed of an abundance of granular material (silt through cobbles), it has very little capacity for water storage and cannot adequately accommodate septic tank and storm-sewer drainage. On hillside properties the effluent could spread rapidly and seep out onto the surface of the ground, creating a health hazard. The addition of significant amounts of precipitation can cause the slope

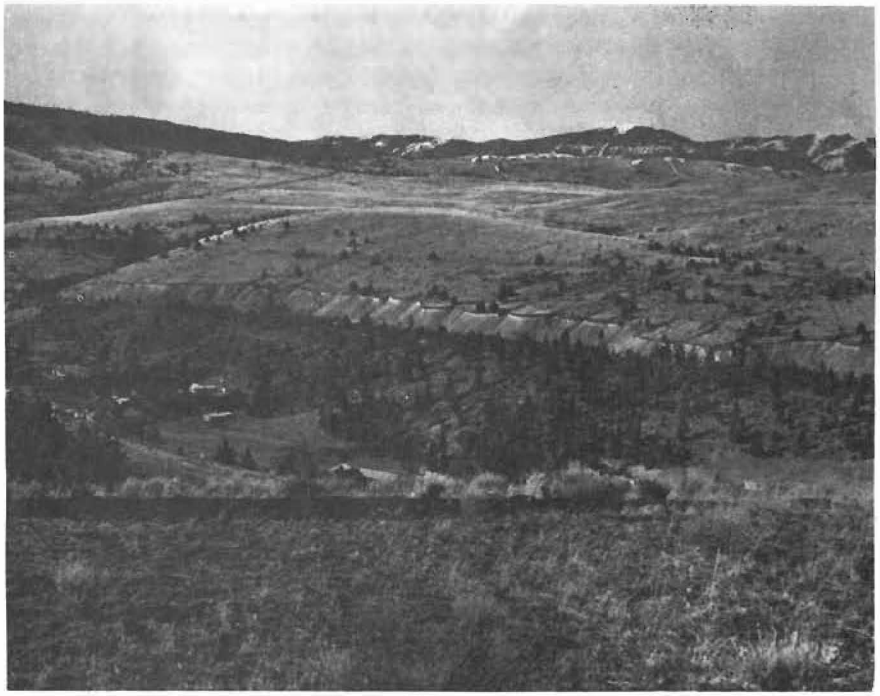

Photo 9. View southwest showing the extent of "Old Humboldt Diggings" at Canyon City and upper bench lands. Before either area is developed, sewer systems should be installed.

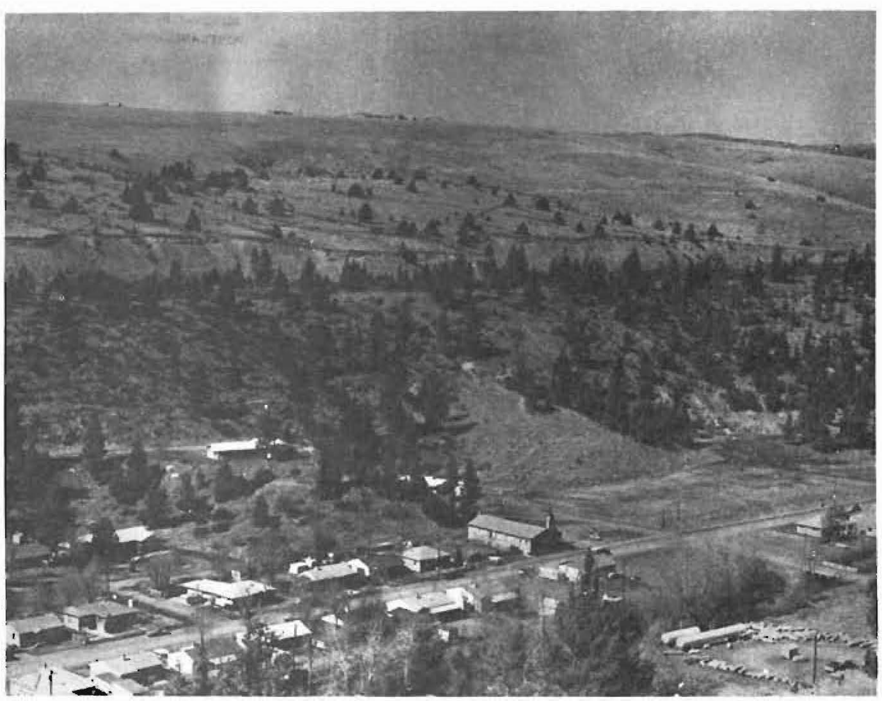

Photo 10. Continuation of Humboldt placer below John Day airport, which is located on surface of large bench area. Other than a few widely spaced houses, the placer ground will be difficult to develop.

to fail by landslide, particularly if a number of housing units are built and each contributes water to the slope. The density of houses should, therefore, be limited to about one per each 10 acres unless engineering and geologic studies indicate otherwise or public sewers are installed.

Because of a deficiency of clay, unconfined embankments constructed from this material will be difficult to compact. Erosion of the side slopes of the embankments could be rapid and excessive if not protected.

Unconsolidated Units

Terrace deposits (Qtg)

This unit includes small patches of old alluvium which represent former levels of Canyon Creek and the John Day River. The deposits are remnants of earlier flood plains which were left behind as erosion deepened the stream channels to their present levels.

The deposits consist of unconsolidated clay, silt, sand, and gravel. The poorly defined and discontinuous bedding typical of flood-plain deposits is observable in places in fresh-cut banks.

Engineering characteristics: The terraces are very limited in extent. Their location and nearly flat to gently sloping surfaces have made them attractive sites for building. Possible geologic hazards include low permeability and shrink-swell in clay-rich zones, compressible soils, and high water table.

Since low areas on terraces and the strip adjacent to the hillside may have a high water table and a greater clay content than other parts of the terrace, these areas should be adequately tiled. Greater density than about one house per 5 acres will usually require a sewerage system to prevent contamination of the ground water from excessive septic-tank drainage.

Thick unconsolidated alluvial sediments will compress and cause uneven settlement under moderate to heavy foundation loads. Structures which cannot tolerate a certain amount of uneven settlement will need foundation investigation and design by engineers familiar with this speciality.

Flood-plain deposits (Qal)

This map unit represents the deposits of clay, silt, sand, and gravel that underlie the flood plains of the John Day River and Canyon Creek. The alluvium on Canyon Creek contains an abundance of coarse gravel. The flood plain of the John Day River is composed of interstratified gravel, sand, silt, and clay deposited by floods and stream migration during recent geologic time. Alluvial deposits occur locally in the bottoms of tributary streams and gulches in the project area, but most of the deposits are too small to show on the map. These deposits were derived from adjacent slopes primarily by flash floods.

Engineering characteristics: The flood-plain deposits are unconsolidated, and heavy foundation loading may cause uneven settlement. Light foundation loads commonly result in some settlement but usually within tolerable limits for small buildings.

Flood plains, as their name implies, are subject to flooding, and their use as building sites should be avoided. The construction of dikes or large fill areas on a flood plain in an attempt to protect a development from flooding will only restrict the escape of flood water and cause it to rise higher.

As development of the John Day bottomland continues and the lowlands are gradually built up by random filling, the ability for flood water to escape will decrease. At some time in the future, if construction on the flood plain is allowed to continue, flooding problems could become serious.

Placer-mined areas (Qp)

Practically all of the bottom lands that lie within the corporate boundaries of John Day and Canyon City were placer mined for gold in the early days. Much of the land has been leveled and reclaimed for urban and commercial use.

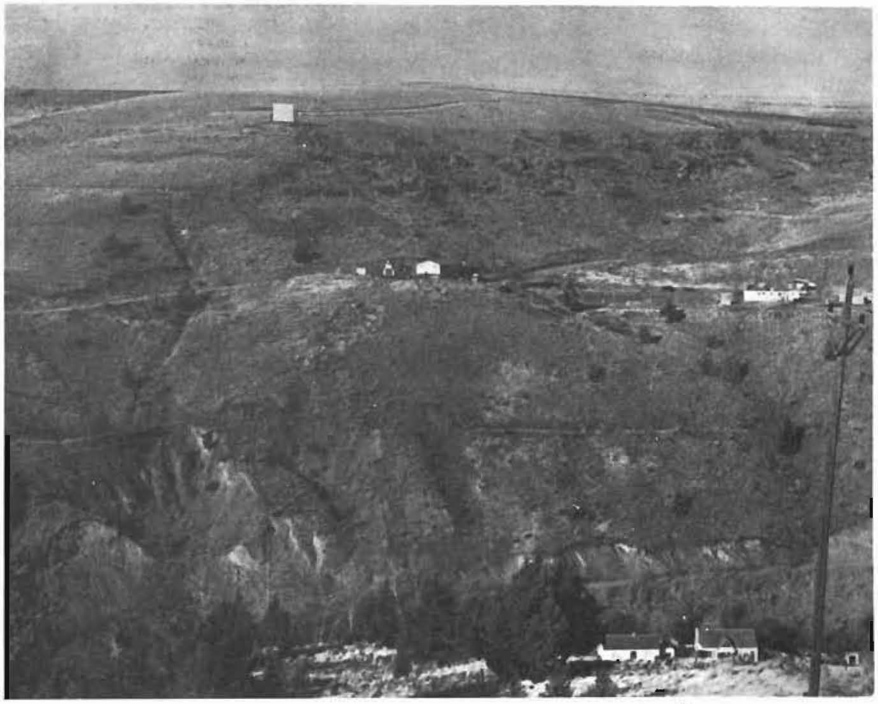

Photo 11. View looking west at slopes above Canyon Creek with Crisp Heights in right center. Rock exposed near top of slope is old landslide scarp. Oversteepened slopes in lower left have failed; older scars below the house show as darker areas.

Photo 12. Recent scarps on steep slopes indicate the need for properly engineered cuts and drainage installation.

John Day placer: The John Day valley area was placered by a large gold dredge and the sediments were worked to about 15 feet in depth. In the process, most of the fines were washed out; therefore, the permeability from the surface to the ground-water level is probably excessive.

Placer tailings on bottomland can be developed provided they are determined to be flood free, but, because they have excessive permeability, septic tanks and disposal of industrial waste water should not be permitted. Any urban expansion areas or extensive rural developments should be required to install sewerage systems.

Old Humboldt diggings: The Humboldt hydraulic placer worked terrace gravels on the wall of the canyon west of Canyon City. Lindgren (1901, p. 719) reported that "a strip of ground half a mile long and several hundred feet wide has been washed, leaving a bank 80 feet in height. The bedrock is formed by coarse, cemented gravel; the pay is said to be concentrated in the first 4 feet overlying the bedrock. The exposed bedrock is nearly level but is said to dip gently westward." Because the gold-bearing alluvium is far less firmly consolidated than the underlying gravel and is finer textured, it is assumed to be considerably younger and to have been deposited by Canyon Creek.

The placered area is cut into a steep valley wall, is only one lot wide, and lacks adequate space for streets. These characteristics, together with the bouldery nature of the ground and the need for a sewer system, make this area unattractive to develop from both economical and engineering standpoints.

Since there are already a number of landslides along the slope, there is no assurance that the impact of some type of development would not cause additional landslides. Any plans to develop this property should be carefully evaluated before a permit is issued.

Structure of Bedrock Units

The pre-Cenozoic rocks of the John Day area were deformed and metamorphosed during the Late Jurassic Nevadan orogeny. Probably they were also affected by some of the earlier periods of deformation which are postulated by Dickinson and Vigrass (1965) for the nearby Suplee-Izee area.

The contact between Cenozoic and pre-Cenozoic rocks represents a major erosional and structural unconformity. Many millions of years of erosion occurred between the time the Paleozoic and Mesozoic rocks were deformed and basaltic lavas of the Columbia River Group poured out.

The structural attitude of basalt flows and tuffs of the Columbia River Group is highly variable and indicates that these rocks were folded and faulted before the Rattlesnake Formation was deposited. There is very little evidence of post-Rattlesnake deformation in the project area.

Several faults within the project area were mapped by Brown and Thayer (1966), but there is no evidence that any of them have been active in recent geologic time.

Photo 13. Flat bench in photo center is old slumped area. Note Rattlesnake tuff in bulldozer cut (lower right of center) has moved downslope from elevation of water tank. Basalt is exposed behind building at left.

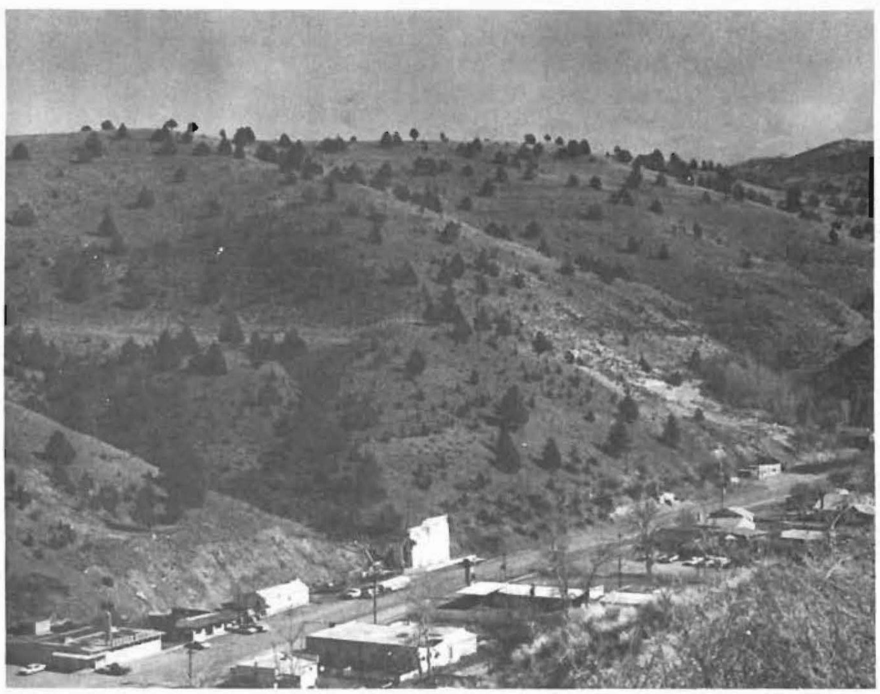

Photo 14. View southeast across Canyon Creek. Rattlesnake welded tuff is exposed in right center and overlain by gravel above. Note slopes are generally steeper below the tuff.

ECONOMIC MINERAL RESOURCES

Ground Water

The availability of ground water varies with each area depending upon the type of rock, its structure, and the related land form. Thick gravel alluvium in the valleys is the most dependable source for well water. Gravelly interbeds in sequences of basaltic lava are also good sources in areas where the attitude of bedding is favorable.

Pre-Cenozoic rocks are generally unfavorable sources for moderate to large supplies of ground water, although some wells in these rocks produce a few gallons per minute from fractured zones. If a local water source is required, the water should be developed and assured before construction is begun.

In places where the ground water flowing on top of an impermeable layer intersects the surface of the ground, a spring is formed. In most instances the water is absorbed by a thick mantle of soil and rock which may produce a swampy area supporting a green vegetation during even the dry months. Although the spring may not be large enough to produce a small creek or stream, proper development of the seepage area may provide an ample domestic water supply.

The distribution of ground water in areas of disrupted strata, such as large landslides or faulted areas, is unpredictable and may be abundant in some areas and absent nearby.

Construction Aggregate

Construction in and around John Day and Canyon City appears to be active. A growing community needs an adequate supply of construction aggregate, and it is imperative that local government observe proper planning and zoning to assure the availability of this resource for present and future needs.

Previous studies have shown that there is a direct relationship between population and gravel needs, ranging between 10 and 15 tons per capita annually. According to Huntzicker (1970), every new housing unit generates a need for 176 cubic yards of concrete. Aside from that used for the house, concrete is needed to build roads, utilities, schools, and other public buildings to serve the growing community.

Most small urban areas are experiencing a population growth of about 1.2 percent per year. Assuming the population of the John Day area will grow at this rate and that the need for aggregate will be 12 tons per capita, the total aggregate requirement for that area will reach 33,800 tons annually by 1985. Therefore, the total amount needed between 1975 and 1985 would approach 320,000 tons.

The major source for aggregate in the John Day area is gravel in the John Day River valley. If properly processed, the gold dredge tailings near the city provide the most easily accessible source of gravel in large amounts. Because of the abundance of cobble-size material the rock will require crushing.

If haul distances of river gravel exceed economic limits of 15 to 20 miles, local sources, most likely rock quarries, should be developed. The Columbia River Basalt makes excellent crushed aggregate where available. Of less desirable quality, but still satisfactory, are coarse-grained rocks such as granite and gabbro. Unweathered rocks such as greenstone, peridotite, and dunite can be used for construction aggregate if other sources are not readily available. Serpentinite and schistose rocks generally do not meet specifications for construction aggregate.

Rattlesnake and colluvial gravel is generally too dirty for aggregate production, and in many areas the ratio of rock to soil is less than 50 percent, making recovery of aggregate uneconomical. In addition, some undesirable rock types such as serpentinite, tuff, chert, and schist may be present in appreciable quantities.

Photo 15. View northeast beyond the city of John Day of a large old landslide area formed in Columbia River Basalt. Note the flat upland area of basalt beyond the talus-covered landslide scarp.

Photo 16. Road to airport passes through a slumped area. Excessive cuts and uncontrolled drainage could cause parts of the area to become unstable.

SUMMARY OF GEOLOGIC HAZARDS

Landslides

General discussion

The following was taken in part from Schlicker and Deacon (1974).

The term "landslide" denotes downslope movement of natural slope-forming materials. Movement may occur abruptly and with catastrophic speed, or it may be slow and spasmodic, continuing over days, weeks, or even years. A slope which has not failed by landslide but which could fail through natural geologic processes or man's activities is called an unstable slope or potential landslide. Landslide, or mass wasting, is a normal process of slope development. Old landslide terrain is widespread in the project area.

Active landslides are easily recognized, but ancient landslide surfaces, areas of slow creep, and unstable slopes may not be apparent except to the experienced geologist.

Even minor landslides have a disastrous effect on structures or land developments. Because of the high cost of corrective procedures which may be only partially effective, areas of unstable slope and landslide should be avoided whenever possible.

The stability of a natural slope depends upon the character of the soil and bedrock of which the slope is composed, the steepness of the slope, and the climate. Slopes developed on any given material will remain intact only so long as the natural angle or repose of that material is not exceeded. A slope will fail whenever the forces of gravity exceed the strength of the material. The effect of gravity can be increased by increasing the slope angle at or near the foot either by erosion or by man-made excavations. It can also be increased by addition of weight to the upper part of the slope, either by adding moisture to the soil or by placing an embankment at the upper part of the slope.

The strength of the material in a slope decreases gradually over a long period of time. Weathering softens the rock and forms clays; water percolating through the ground dissolves and removes the agents that cement the soil grains together; water in the pore spaces exerts an outward force on the soil; and certain clay materials which absorb moisture will expand, forcing the soil apart.

Landslides can occur on steep slopes or very gentle slopes and exhibit certain characteristics depending upon their age, size, and type of movement. The topography of landslides ranges from highly irregular to gently rolling. Tilted or bent trees, curved fence lines, sag ponds, and large displaced blocks of rock can be observed on the surface of a landslide area. Contour maps having a scale large enough to show the landslide may exhibit closed contours, irregular contour lines, a general decrease in slope relative to adjacent slopes, and a lobate or triangular-shaped area of deformation.

It is imperative that all landslides, potential landslides, and unstable slopes be identified in an area where development or construction is to take place.

Most large, active landslides will cost more to stabilize than the property will be worth afterwards. Such areas should be left undeveloped. If the original cause of the landslide is still in effect, such as stream erosion at the toe of the slide, future sliding will probably occur.

The stability of old landslides, which are recognizable by features such as bent trees and water-filled sag ponds, should be viewed with caution. Some old landslides move very slowly and intermittently, up to a few inches per year, and motion can be detected only by surveyors' instruments. This type of movement can cause continual damage to structures, and maintenance costs can in time force abandonment. Added moisture from housing developments placed on old landslides often causes the rate of slide movement to increase

In contrast to old landslides, ancient landslides are those having no historical movement but which exhibit a subdued rolling topography; sag ponds are now drained, large trees are straight (if present), and the slope is less than that of the adjacent areas. If an ancient slide area can be identified as being stable and distinguished from an "old landslide" which may still have movement, certain uses can be made of the land.

Landslides in the John Day area

Landslides have been an important factor in the development of the slopes along the John Day River and Canyon Creek. Other slopes may yet fail as a result of modifications associated with the construction of roads and buildings.

The largest landslides and several small ones have occurred either where basalt overlies weathered tuffaceous rocks or where the Rattlesnake welded-tuff unit is underlain by poorly consolidated Rattlesnake alluvium. Both situations involve a stronger unit over a weaker one. Some landslides involve only the surficial blanket of loose soil and rock fragments that have accumulated on hillsides as the result of recent erosion and weathering.

The large landslide area north of the John Day River and east of Charollais Heights consists of jumbled blocks of basalt and tuffaceous sedimentary rocks of the Columbia River Group (Tcr). Prior to development of the slide, the basalt and sedimentary rocks were interlayered and formed a slope that probably was somewhat steeper overall than now. Layering within the section dipped southward in the direction of slide movement. As weathering and erosion of the slope progressed, the poorly consolidated clay-rich tuffaceous rocks became water saturated and thus provided planes of slippage within the section. As movement occurred, the material was broken up into many independent and disoriented blocks. Topography developed on this old landslide is characterized by an irregular jumble of coalescing, smoothly rounded surfaces known collectively as hummocky ground. Even though modified by later erosion, many of the individual slump blocks are discernible; the depressions between them are disconnected and there is no well-defined drainage system.

This slide appears to be very old and one which is no longer active. Development in this area may be feasible; however, certain precautions must be taken. Characteristic of landslide masses, the subsurface rocks have been severely disturbed and the thickness, attitude, and extent of the basalt at any one place is unpredictable. The presence of ground water is likewise unpredictable. Some slide areas may be easily reactivated. For these reasons housing density greater than about one per 10 acres should be served by a sewer system.

From John Day westward for about 3 miles and extending south from the floor of the valley for half a mile or more, the sloping land is almost entirely old landslide. This ground is hummocky and rolling and is composed of large disoriented blocks of Rattlesnake tuff rimrock which have moved down the slope. Here the resistant Rattlesnake tuff member has been undermined by erosion of the underlying Rattlesnake sediments to the extent that blocks of the tuff and overlying sediments break loose and become unsystematically scattered and mixed on the slopes below.

This slide area is steep and it is likely that some parts are still active. Development is not recommended; however, if development is eventually permitted it should be widely spaced and cautiously located.

On the steep slopes of Canyon Creek, several small slides are recognizable as indented terraces with concave scarps which interrupt the general contour of the slope. The bench-like surfaces of slides of this type make attractive building sites but should be avoided unless the slide has stabilized. Any type of development which could reactivate the slide or create new ones on adjacent slopes should not be permitted.

The housing development known as the Crisp Heights addition is on one of these landslide terraces. There has been a very small amount of localized movement within this landslide block in recent years. Mild structural damage has occurred to a single property. Several factors probably were involved in causing the movement, including the addition of moisture to the ground from septic tanks and lawn watering, the disruption of natural drainage by excavations, and the oversteepening of slopes by road cuts. Landslides or slope failures rarely, if ever, can be attributed to a single cause. The final triggering mechanism can be compared to the proverbial single straw that broke the camel's back.

Another small landslide is situated on the east wall of Canyon Creek just south of the John Day water tank, and several others are shown on the accompanying map.

The larger landslides contain areas that are topographically suitable for home sites. Limited development may be feasible provided that movement has ceased and all possible measures are taken to enhance the stability of the ground. Until proven otherwise by an extended period of observation and testing, it should be assumed that parts of old landslides are still in a critical state of stability and that the improper location and construction of roads and buildings, the disruption or overloading of the natural surface, or the blocking of the natural drainages could reactivate the landslide. If construction is allowed, heavy structures should not be placed on critical parts of slopes. Cuts and embankments should be minimized, and they should be sloped and compacted to engineering specifications. Surface and subsurface drainage should be designed so that water from sources such as septic tanks, storm sewers, roof drains, and lawn and garden irrigation will not cause a buildup of moisture in the ground. Where roads cross natural drainages, culverts should be large enough to handle maximum runoff. Undersized culverts could impound a large volume of water which, if released by fill failure, would cause downstream flooding and perhaps the failure of stream banks.

Flooding

High water

Numerous residences, commercial and industrial establishments, and public buildings are located within the flood plain of Canyon Creek. Damaging overflow of Canyon Creek occurred on May 11, 1901, March 19, 1932, March 30 and April 17, 1943, and December 22, 1964. The May 1901 flood was caused by a thunderstorm. The other floods were from a combination of rain and snowmelt. It is likely that similar and possibly more damaging floods will occur in the future.

Canyon Creek drains an area of about 116 square miles. The drainage area is mainly a high, rugged, mountainous terrain with steep slopes and deep canyons. Elevations above sea level range from over 8,000 feet on the mountain tops to 3,050 feet at the confluence of Canyon Creek and the John Day River.

The flood plain of Canyon Creek ranges from 400 to 800 feet in width. Stream velocities in Canyon Creek are consistently high because of the steep gradient, about 55 feet per mile through Canyon City and John Day. During flood periods, stream-channel velocities of 4 to 7 feet per second are common. Overflows and damages in the flood plain area occur when velocities exceed 600 cubic feet per second in Canyon Creek at Canyon City. The principal obstructions to flood flows are the bridges, the trees and brush that line the channel, and some buildings adjacent to the channel.

The cost of complete and effective flood-control measures would be prohibitively expensive for local taxpayers. Therefore, major flood protection must be in the form of flood-plain management to enforce adequate zoning and building regulations. Prospective purchasers or leasees of property should be made aware of potential flood problems.

For additional data on the character and extent of past and potential flooding in the John Day-Canyon City area, the reader is referred to reports by the U. S. Army, Corps of Engineers (1969, 1971 and 1974). These reports include maps, drawings, and photographs which will help identify flood dangers. This information should be used in developing plans for avoiding or minimizing flood damage.

Flash flooding

Flash floods are the result of torrential rain storms, which often are called "gully washers" or "rain spouts." Such rain storms commonly are localized and of only a few minutes duration, but they are capable of producing a devastating flow of water, mud, and rock in gulches and ravines that may ordinarily be dry except during periods of spring runoff. Large piles of rock at the mouths of some of the gulches are evidence of past flash flooding and the high flood potential in the area. Therefore, structures should not be placed directly in line with potential flood channels.

High Water Table

Water that saturates the rocks and soil beneath the land surface is ground water. The upper surface of the water-saturated zone is called the "water table." To the developer, the term "high water table" means that the water table is near the surface and may adversely affect certain uses of the land. Parts of the flood plains along the John Day River and Canyon Creek are subject to seasonally high ground-water levels. Marshy areas and ponded water in depressed areas and shallow excavations are evidence of high

Photo 17. Low, flat ridge tops east of John Day and south of the river could be developed if water and sewerage systems are considered. Basalt mesas are north of the John Day River.

Photo 18. View toward Strawberry Mountain across gently sloping broad-topped ridges. This terrain appears to have few hazards; however, utilities will be essential to development.

water table. Springs and marshy areas on hillsides and upland benches are evidence of locally high or "perched" ground water. In areas where soils are saturated, basements may be subject to flooding, septic tanks may fail to function, or the effluent may be forced to the surface. Hydrostatic water pressure can force empty storage tanks out of the ground. It can crack walls and floors of swimming pools and basements and cause uneven settling of foundations.

Maximum water-table elevations should be considered in the planning and design of structures. Septic tanks generally should not be installed where the water table rises to within 6 feet of the ground surface. Buildup of hydrostatic pressure may be prevented by the placing of gravel mats and drain tile beneath storage tanks and concrete slabs.

Adverse Soil Conditions

Swelling clay

Some soils in the project area contain bentonitic clay minerals. This is particularly true of soils developed on serpentine and ultrabasic rocks, on the Rattlesnake alluvium, and on colluvium derived from those formations. Bentonitic clay zones may also be found in the alluvium of the present flood plains and old terrace deposits.

Bentonitic soils have a high shrink-swell factor which derives from the tendency of the clay minerals to swell as they absorb water, then shrink and crack as the water content is reduced. This reaction of clay to water can promote failure in cut slopes and cause foundations of buildings to rise or settle. As a result, concrete floors, foundations, and wall plaster can crack and plumbing can be damaged. It is important, therefore, that the presence of swelling soil be recognized by engineers before developments are designed.

Hardpan

Hardpan is a common name for impermeable clay layers that develop a few feet below the surface in certain soils. Soils developed on Rattlesnake Formation are particularly prone to this condition. Although hardpan layers may be only a few inches thick they are an impermeable barrier to downward movement of water. As a result, water tends to move along their upper surface and saturate the overlying soil. On moderate to steep slopes, the concentration above the hardpan of water from septic tanks, irrigation, or surface drainage could result in slope failure.

Low permeability

Soils that have low permeability can create a hazard to development in that septic tank and other waste water cannot pass beyond the drain field, causing the water to back up in the houses as well as run out on the surface of the ground. Sloping ground with impermeable surface soils have nearly 100 percent runoff, and erosion on such surfaces could be severe.

Excessive permeability

Coarse granular soils are highly permeable and allow waste water and effluent to move rapidly to the water table and cause contamination of the ground water.

Sand and silt soils are quickly plugged by septic-tank and waste water, especially that containing detergent, and become impermeable. Drain fields in this type of soil must be excessively large, but even so, the life of the drain field is short. Density greater than 5-acre spacing is not advised.

Compressible soils

Most soils are unconsolidated and will compress under load. Normal soils 2 feet below the surface will support light foundation loads of about 2,000 lb. per square foot, which is that of a normal house. If greater loads are to be supported, such as a water tower, warehouse, or large public building, foundation

Photo 19. Hill southeast of John Day business district is mostly basalt and basalt talus at north end. Farther south it is overlain by Rattlesnake tuff and gravel. Note old landslide north of the river.

Photo 20. Blue Gulch area west from Canyon City is underlain by serpentine and metasediments and has gravel on ridge tops and side slopes; there is moderately thick soil in canyons. Area can be developed only where slopes are gentle and water and sewer systems have been installed.

studies must be made to determine whether or not soil of adequate bearing strength is present at a reasonable depth, whether piling is necessary, or if some other type of foundation should be used.

Certain soils such as peat, organic muds, or clay having a chain structure may settle excessively even under light loads. Foundation designs for this type of material will require exploration and design by a foundation engineer.

Frost heave

Frost heave is caused by the growth of ice layers or lenses in the ground. It does greatest damage to flexible pavements (asphalt), but rigid concrete slab surfaces may also heave and crack.

Damage due to frost heave occurs in two phases. In the first phase, the surfaces heave vertically as a result of freezing. In the second phase, melting causes oversaturation and a loss of strength. If traffic is allowed during the melting phase, vehicle wheels will break through the pavement and churn up the soft soupy layers of the subgrade soil, and soon the road will become impassable (Spangler, 1951).

In order for frost heave to occur, the soil must encounter freezing conditions, water must be present, and the soil must have characteristics that favor rapid capillarity from the water table to the upper soil. Silt soils are most prone to frost heave.

Frost heave can be minimized by eliminating some of the causes. One method is to lower the water table by drainage. The installation of tile which lowers the water table at least 6 feet below the frost line is sufficient to stop most capillarity and therefore prevent frost heave. Another method is to replace soil having capillarity and occurring in the freeze zone with coarse gravel or crushed rock. This will interrupt the upward flow of water and prevent the formation of ice layers.

Photo 21. Cut in sidehill, upper left edge of photo, is part of "Old Humboldt Diggings." Slopes below are steep; numerous slope failures are present, indicating that excavations could result in landslides.

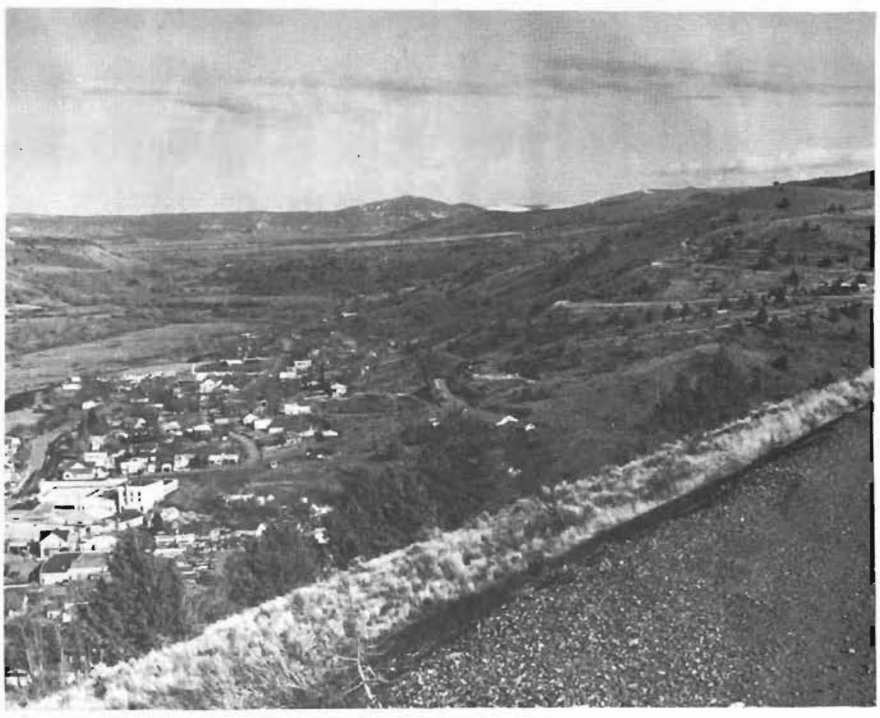

Photo 22. View east from John Day. Note hummocky topography in the south slope as a result of old landslides.

SUMMARY OF LANDFORMS AND ASSOCIATED HAZARDS

A variety of landforms exist in the project area, but the larger categories are: upland benches, steep slopes, and valley floor. All three possess one or more potentially adverse characteristics which should be considered by the developer.

Upland Benches

The prevalent landform in the project area is the bench-like terrain south of the John Day River. The large gently sloping "flats" are remnants of Pliocene-Pleistocene alluvial fan deposits (Rattlesnake Formation) that have been dissected by many narrow, steep-sided gulches. The flats range up to several hundred acres in size. One of the largest, occupied by the John Day airport, is probably the only area large enough to handle high-performance general aviation aircraft. Other flat areas, ranging from 30 to 160 acres, occur within 3 miles of John Day at elevations between 3,400 and 3,650 feet.

The bench area is underlain by rocks of Paleozoic and Mesozoic age, basalt of the Columbia River Group, and gravel and welded tuff of the Rattlesnake Formation. The pre-Cenozoic rocks had a surface of considerable relief prior to deposition of later formations. They are exposed, or lie beneath a thin soil cover, in gullies and on the surface of the upland benches near the mountains to the south.

Rattlesnake gravels thicken northward and extend to the valley floor just south of the John Day River. The welded tuff unit forms the rimrock high on the valley sides.

The bench areas can be intensively developed providing the geologic hazards have been recognized and the structures built on them properly engineered. Although the use of septic tanks at 10-acre spacing may appear to be satisfactory in some areas, most places are not favorable because of the proximity of impermeable pre-Cenozoic bedrock or the presence of hardpan layers several feet below the surface in the Rattlesnake Formation or in overlying soils.

Foundation problems exist in most areas due to the presence of bentonite. Soils containing bentonite tend to shrink and swell with changes in moisture content. If possible, these soils should be excavated and removed; if they are left in place, the foundations and adjacent areas must be engineered to remain at a constant moisture content. Care should be taken to prevent moisture buildup in the ground from sprinklers, roofs, or storm drains.

Water supply for single dwellings may be difficult to develop because of the low ground-water content of the rocks in this area. If a successful well is drilled, it is likely to produce less than 5 gallons a minute. The water requirement for a denser development will no doubt require a centralized water system in which water would be obtained from the John Day River or possibly from wells adjacent to the river or from a dammed mountain stream farther south in the mountains.

Steep Slopes

Between John Day and Canyon City the slopes of Canyon Creek generally are very steep, rising abruptly to about 500 feet above the valley floor within a distance of half a mile. In places the slopes are covered by colluvial material that is composed of volcanic ash, clay and abundant cobble gravel. The steepest slopes, as much as 45 degrees, have either thin soil or no soil cover and are underlain by basalt, serpentinite, or metamorphic rocks. From the mouth of the canyon at John Day southward for a distance of about 2 miles, five landslides covering from 15 to 30 acres each have been identified in addition to several smaller slides. These slides occur on both sides of the canyon. The existence of the slides indicates that the slopes are very nearly critical and that increases in either slope angle or moisture content could trigger landslides.

High-density development of the steeper slopes of Canyon Creek would be impractical. Most of the areas which are flat enough to be attractive for home sites are the upper surfaces of landslides. High steep cuts and embankments necessary for leveling building sites and road beds could cause overloading and oversteepening of already critically steep slopes.

Since septic tanks generally will not function properly in thin soils on steep slopes, installation of sewer and water systems would require considerable excavation of hard bedrock.

Valley Floor

The valley floor is composed of low terraces, flood plains, and gold-dredge tailings. Hazards to building on the flood plains are flooding, high water table, frost heave, low-strength foundation soil for moderate to heavy loads, and poor drainage. Placing landfills or constructing dikes on the flood plain could block the drainage area sufficiently to raise the level of flood water.

Development on dredge tailings may be feasible provided they are flood free and a sewer system is installed.

Narrow stream valleys or canyons could be hazardous sites for development because of the danger of flash floods. The valley sides cannot generally be developed past the first row of houses.

Relation of Hazards to Geologic Units and Landforms

Degree of hazard: ● High ◒ Moderate ○ Low None	High water table	Floods	Frost heave	Permeability	Thin soil over bedrock	Steep slopes	Heavy clay	Hardpan	Shrink and swell	Unstable slope	Require sewerage system	Require water supply	Hazard to development
Rattlesnake Formation - high bench gravel over hard bedrock			○	●	◒	○	◒	◒	◒	○	◒	◒	◒
Pre-Cenozoic rocks - serpentinite and argillite			○	◒	●	○	◒	○	●	○	◒	●	○
Basalt bedrock: Miocene lavas - moderate slope			○	○	○	○	○		○	○	●	○	◒
Basalt scarps						●							●
Colluvium: Slope wash-gravels and soils			◒	◒	○	●	○	●	◒	◒	●	●	●
Placer tailings: Humboldt placer benches			○	○	◒	○		◒	◒	◒	●	●	●
Landslide areas	○		◒	◒	○	●	◒	○	◒	●	●	●	●
Dredge tailings in alluvial gravels	◒	◒			●						●	◒	◒
Terraces	○		○	○					○		◒	○	○
Bottom land	●	●	○	◒			○				●	◒	●

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GLOSSARY

albite granite - a granite with albite feldspar replacing some of the orthoclase feldspar.

alluvium - clay, silt, sand, and gravel of recent origin deposited by running water.

anorthoclase - alkali feldspar found in granitic rocks.

argillite - mudstone or shale that has undergone a small amount of metamorphism, or structural change at depth.

augite - a black or greenish-black mineral found in many basic igneous rocks.

bentonitic clay - a colloidal clay containing montmorillonite which absorbs large quantities of water accompanied by enormous increase in volume; swelling clay.

chert - a hard, extremely dense siliceous sediment.

clastic - sediment composed principally of broken fragments derived from pre-existing rocks or minerals.

colluvium - a heterogeneous mass of soil and rock fragments deposited at the base of a steep slope.

dunite - an igneous rock composed almost entirely of olivine.

flow breccia - a breccia that is formed as the result of movement of a lava flow.

gabbro - a coarse-grained basic intrusive rock containing labradarite feldspar and dark accessory minerals.

graywacke - dark-gray or black, indurated, coarse-grained sandstone containing quartz, feldspar, and rock fragments.

greenstone - compact, dark-green, altered basalt or other dark igneous rock.

hazard (geologic) - natural geologic process that interferes with the works of man.

hornblende - a black, dark-green or brown mineral found in many acid and intermediate rocks such as granite and diorite.

igneous - solidified from molten or partly molten material.

mafic - made dark-colored by mineral content.

metamorphosed - altered by heat in pressure deep in the Earth's crust.

montmorillonite - a group of expanding lattice clay minerals; a swelling clay.

orogenic - mountain-building crustal movements.

peridotite - a coarse-grained plutonic rock composed chiefly of olivine.

phyllite - a layered metamorphic rock intermediate between slate and schist in degree of alteration. Generally has silky sheen.

<u>plutonic</u> - a deep-seated intrusion of magma that forms coarse-grained igneous rock, such as granite.

<u>quartz diorite</u> - a granitic rock containing plagioclase feldspar and quartz.

<u>rhyolitic tuff</u> - a light-colored rock composed of acid volcanic ash.

<u>schist</u> - a foliated crystalline rock formed by intense metamorphism.

<u>scoriaceous</u> - coarsely vesicular, clinkery volcanic rock.

<u>serpentinite</u> - a greenish rock composed of serpentine minerals, formed by the alteration of peridotite.

<u>siltstone</u> - a sedimentary rock composed of silt-sized particles.

<u>tectonic</u> - pertaining to the forces involving crustal movement and deformation.

<u>tuff</u> - a rock composed of volcanic ash and pumice.

<u>ultramafic</u> - igneous rock composed chiefly of magnesium and iron minerals such as augite and olivine.

<u>vesicles</u> - containing thick-walled bubble chambers formed by gas in volcanic rocks.

<u>volcaniclastic</u> - sedimentary rock composed of volcanic fragments.

<u>welded tuff</u> - volcanic rock composed of ash and pumice welded together by heat from hot gases and the weight of the overlying material.

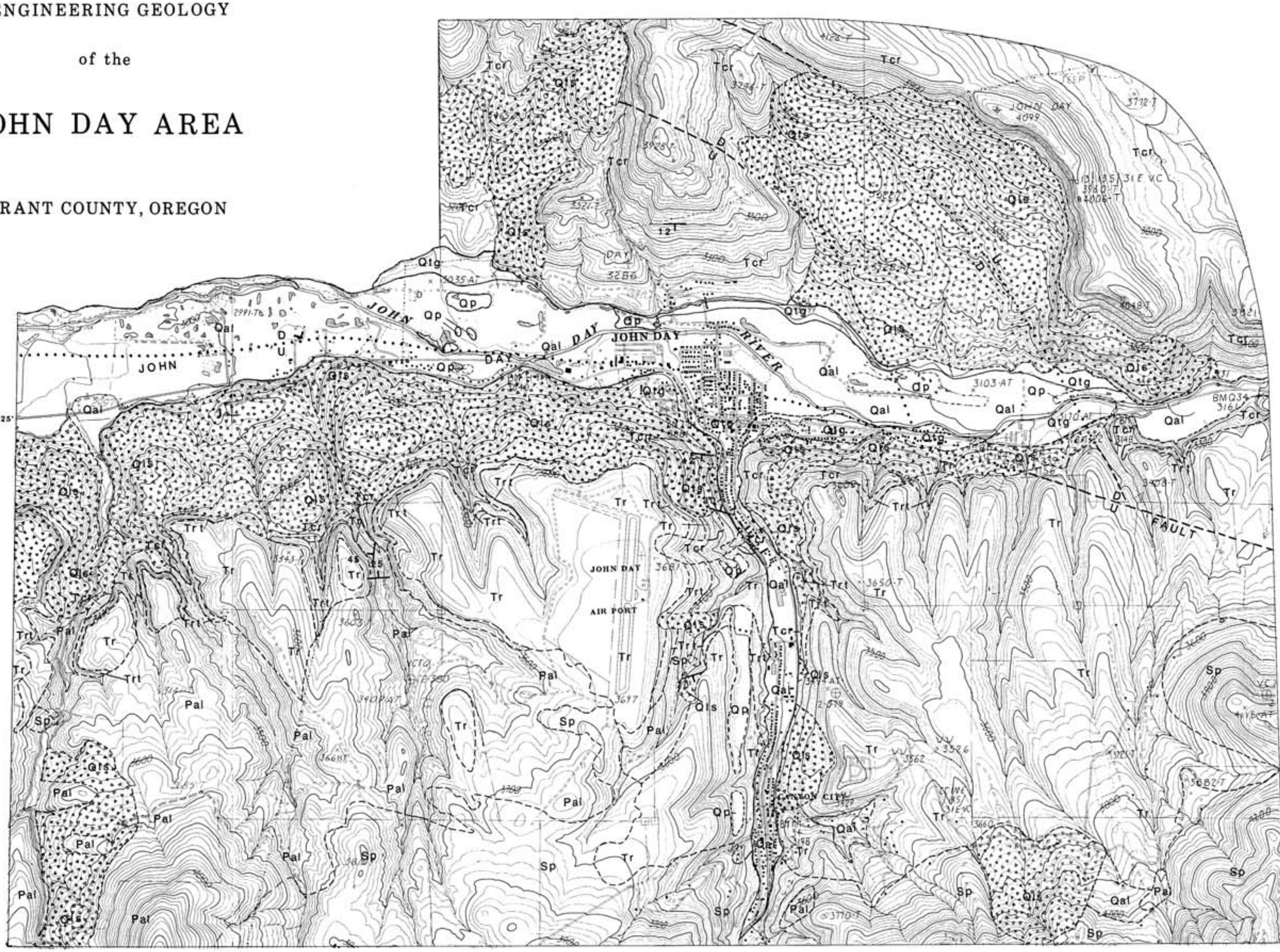
<u>zeolite</u> - a group of light-colored, hydrous silicate minerals of secondary origin found in cavities and fractures in igneous rocks.

ENGINEERING GEOLOGY

of the

JOHN DAY AREA

GRANT COUNTY, OREGON



STRATIGRAPHIC TIME CHART

ERA	PERIOD	EPOCH	
CENOZOIC	QUATERNARY	Holocene	Qls, Qal, Qp
		Pleistocene	Qtg
	TERTIARY	Pliocene	Tr, Trt
		Miocene	Tcr
MESOZOIC	TRIASSIC		Sp
PALEO	PERM.		Pal

EXPLANATION

- **Qp** Placer-mine tailings and excavations
- **Qls** Landslide deposits
- **Qal** Alluvium – Flood-plain and river-channel deposits composed of clay, silt, sand, and gravel
- **Qtg** Terrace gravels – Ancient river flood-plain and channel deposits at elevations above the present flood plains
- **Tr**, **Trt** Rattlesnake Formation – Poorly sorted and poorly consolidated fanglomerate and river gravels (Tr); includes rhyolitic ash-flow tuff member which grades from densely welded to non-welded (Trt)
- **Tcr** Columbia River Group – Mainly basalt flows, separated in places by thin layers of water-laid tuff and gravel
- **Sp** Canyon Mountain Complex – Mostly serpentinite, with some dunite, peridotite, and gabbro; most contacts with unit (Pal) are faults
- **Pal** Metamorphic rocks – Deformed and metamorphosed volcanic rocks, chert, argillite, and minor graywacke

GEOLOGIC SYMBOLS

- Contacts – solid where definite, dashed where approximate
- Strike and dip of beds or flows

BASE MAP FROM USGS PRELIMINARY MANUSCRIPT

QUADRANGLE LOCATION

SCALE 1:24 000

CONTOUR INTERVAL 20 FEET
DOTTED LINES REPRESENT 5-FOOT CONTOURS
DATUM IS MEAN SEA LEVEL

UTM GRID AND 1963 MAGNETIC NORTH DECLINATION AT CENTER OF SHEET

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H. C. BROOKS

STATE OF OREGON
DEPARTMENT OF GEOLOGY AND MINERAL INDUSTRIES
R. E. CORCORAN, STATE GEOLOGIST