SAN JUAN COUNTY

San Juan County is an area of 175 square miles comprised entirely of a group of islands lying between the Strait of Juan de Fuca and the Gulf of Georgia. The bedrock of the county is pre-Tertiary in age and for the most part of metamorphic type. Quartzites, argillites, and greenstones predominate, and cutting these are various igneous intrusives. Small islands in the extreme north, and a little of the northern edge of Orcas Island, are composed of Cretaceous sediments. These are much indurated, though hardly metamorphosed, and include thin-bedded shales interstratified with sandstone. Lack of workable thickness as well as low plasticity renders the Cretaceous shales of little economic value. In the neighboring islands of British Columbia efforts have been made with slight success to work similar shales. Data on this, quite applicable to the San Juan Islands, may be found in reports of investigations by Ries[1].

Any residual clay which may have formed from the decay of the bedrock has been scoured off by glacial action, so that unaltered rock, commonly striated, crops out on all the islands. The retreat of the ice, however, left deposits of glacial clay that are ample to care for the needs of the county in brick material and allied ware.

On San Juan Island, at Roche Harbor, are extensive beds of the blue glacial clay. They occur, here, horizontally stratified and interbedded with sand. The same type of clay occurs in several places on Orcas Island, and at one time a deposit was worked for common brick. The yard was in sec. 21 (37-1 W), where an extensive body of clay is available. Similar Puget Sound glacial clays are found in large deposits on Lopez Island. About 3½ miles from the town of Lopez, at the north end of the island, the clay crops out along the beach and is exposed for 200 feet or more to a thickness of 25 to 30 feet.

The results of chemical analyses of these clays are included in appendix 2. No physical tests were made, as the material is nearly identical with clays of similar origin occurring in King and neighboring counties. Reference to the glacial clays of King County (p. 151) will indicate the properties of the San Juan County clays.

SKAGIT COUNTY

Skagit County is in northwestern Washington and has an area of 1,774 square miles. The topography varies from broad areas of lowland to rolling hills and high mountains, as the county reaches from tidewater to the summit of the Cascade Range. Geologic conditions here are different from those of the

[1] Ries, Heinrich, Clay and shale deposits of the Western Provinces: Canadian Geol. Survey Mem. 25, pp. 77-81, 1912; Mem. 47, pp. 56-61, 1914; Mem. 65, pp. 17-21, 1915.

other mainland counties in western Washington, in that the Tertiary formations occur in very minor amount. Paleozoic and Mesozoic rocks extend across the county, decreasing in elevation from the high Cascades to Puget Sound and then beyond to form islands to the west. These rocks are nearly all metamorphosed, and mostly to an advanced degree. They consist in general of schists, quartzites, argillites, and some limestones, together with a younger series of unaltered igneous rocks. The shales that belonged to these formations are so indurated as to be almost valueless for ceramic purposes; and any clays that may have developed, as from the decomposition of such rocks as the granodiorite of the eastern part of the county, have been swept away by the active erosion to which that mountainous area is subjected.

The Chuckanut formation, an isolated extension of the Whatcom County beds, occurs in a small area in the vicinity of McMurray, in the southwestern part of the county. It underlies also at least part of the delta of the Skagit River and crops out through the alluvium and glacial sediments in a few places. Other relatively small areas of these rocks are at Cokedale, to the southeast near Cumberland Creek, and at Higgins Mountain. The shales of this formation are suitable for ordinary red and brown structural wares and form beds of such thickness as to be readily mined and, in some places, even quarried.

Puget Sound glacial clays are abundant in the western part of the county and are well exposed in the terraces bordering the larger streams. Of very similar physical properties are the fluviatile and estuarine clays that form thick beds in the Delta region. The glacial clays are being worked at present at Concrete for the manufacture of Portland cement and estuarine clays at Tiloh for drain tile, hollow block, and common brick.

Some of the older metamorphic rocks are well exposed along the Skagit River road between Van Horn and Sauk. A representative sample was taken of the great beds of argillite here, not so much for data on this particular outcrop as to throw light on the general physical properties of such highly indurated shales. The rock is thin-bedded and is made up of alternating layers of sandstone, altered nearly to quartzite, and hard argillite that only lacks well-developed cleavage to be termed slate.

Sample No. 191 includes both sandstone and argillite. The latter is very dark gray in color, is very hard and tough, and breaks across the bedding with a sharp, hackly fracture.

Plastic and dry properties Sample No. 191

Plasticity	Weak	Volume shrinkage	7.5% dry volume
Shrinkage water	3.7%	Linear shrinkage	2.6% dry length
Pore water	11.9%	Linear shrinkage	1.9% wet length
Water of plasticity	15.6%	Dry condition	Weak

Fired properties Sample No. 191

Cone	Color	Condition	L.S.%d.l.	T.L.S.%d.l.	V.S.%d.v.	Abs.	A.Por.
08	Buff-brown	Soft, weak	1.2	3.8	3.7	16.9	32.2
06	Red-brown	Hard, good	....	....	....	16.7	31.5
01	Dk. red-brown	Vitreous surface scum	6.4	9.0	18.0	1.9	4.5

Remarks: Best firing range: 06-02. Cone fusion: 2. Weak plastic and dry strength; low fusion.

Class of ware: Dark-brown structural wares or a possible natural glaze.

In the north part of the town of McMurray, a road cut about 150 feet long has been made in Tertiary sediments. It exposes thin-bedded shales to a depth of about 10 feet. These have a dip of 10° S. The material is broken and stained from surface weathering but resembles the gray shales which occur in this formation in other places. There is very little overburden; so the bed could be easily worked.

Sample No. 189, from here, is rather light gray in part but is irregularly stained to a buff color and shows dark brown where crusts of limonite have formed along joints. The material is medium hard and slightly sandy, although some portions are quite "fat".

Plastic and dry properties Sample No. 189

Plasticity	Good	Volume shrinkage	24.8% dry volume
Shrinkage water	14.5%	Linear shrinkage	9.0% dry length
Pore water	17.5%	Linear shrinkage	6.8% wet length
Water of plasticity	32.0%	Dry condition	Good strength

Fired properties Sample No. 189

Cone	Color	Condition	L.S.%d.l.	T.L.S.%d.l.	V.S.%d.v.	Abs.	A.Por.
010	Lt. red-brown	Weak, soft	2.9	11.9	8.4	25.7	42.0
05	Lt. brown-red	Good, hard	6.7	15.7	18.8	16.4	31.2
01-1	Brown-red	Good, S.H.-	10.3	19.3	27.9	10.9	22.1
3-4*	Brown-red	Good, S.H.	10.5	19.5	28.2	12.0	25.1
6-7*	Brown-red	Vesicular, black cored, S.H.	....	....	....	14.0	23.8
12*	Black	Vesicular softened, S.H.	7.0	16.0	19.6	14.8	31.2

Remarks: Best firing range: 06-2. Cone fusion: 8-9. Needs reduction in shrinkage.

Class of ware: Red and brown structural wares.

Glacial clay occurs in thick terrace deposits on the sides of Skagit Valley and is utilized in the manufacture of cement at Concrete on Skagit River. In the clay quarry of the old Washington Portland Cement Co. a 50-or 60-foot face is exposed, and a continuation of these beds is being mined by the Superior Portland Cement Co. to the west across the Baker River. The clay is horizontally bedded and is, in part, very smooth. The bedding is distinct, owing to the presence of sandy phases; and fine sand on the bedding planes causes the clay to separate easily into blocks. An overburden of gravel and boulders covers the clay to a depth of from 10 to 20 feet. In mining, the clay is caved onto a long covered trap beneath which cars are drawn for loading.

Sample No. 192 shows this clay to correspond with other aqueoglacial clays. It is light bluish gray when dry. The texture is fine and uniform, although different strata vary in the content of sand, some being rather silty, while others are "fat".

Plastic and fired properties Sample No. 192

The clay developed a good plastic strength when mixed with 38.2 percent water. The best firing range was between cones 06 and 02. Fusion was reached at cone 2. The clay is suitable for dark red-brown structural wares.

Similar clays occur a considerable distance back from the Skagit River and indicate the extensive ponding during Pleistocene time that allowed these finely assorted sediments to accumulate.

Sample No. 192-A, sent in to the Division, was taken from sec. 8, (35-9 E) on Jackman Creek at an elevation of over 1,000 feet above sea level. It is a typical glacial clay, light gray when dry, that is very fine-grained and free from sand or silt.

Plastic and dry properties Sample No. 192-A

Plasticity	Good	Volume shrinkage	49.7% dry volume
Shrinkage water	29.9%	Linear shrinkage	20.5% dry length
Pore water	18.5%		
Water of plasticity	48.4%		

Fired properties Sample No. 192-A

Cone	Color	Condition	L.S.%d.l.	T.L.S.%d.l.	V.S.%d.v.	Abs.	A.Por.
07	Lt. red-brown	Good, S.H.-	3.8	24.3	10.9	18.0	31.5
02	Dk. red-brown	Scum, good, S.H.	13.8	34.3	35.9	0.0	0.0
3-4*	Dk. red-brown	Vesicular, fused, S.H.	3.7	24.2	10.5	....	....

Remarks: Best firing range: 07-02. Cone fusion: 2.

Class of ware: Needs reduction in shrinkage for red and brown structural wares. The low fusion point may make the clay useful for glazing.

Just south of Hoogdal, a station on the Northern Pacific Railway 4 miles north of Sedro Woolley, a cut has been made for over a quarter of a mile through a low hill of glacial clay. The exposed section is about 25 feet high at its maximum, the upper 15 feet being uniformly a light buff color when dry, while the unweathered lower clay is bluish gray. The only overburden is a thin soil. Although two or three small quartzite pebbles were noted in the body of the clay, they do not appear to be common.

Sample No. 196, of the upper buff-colored clay, is very fine-grained and, in general, free from grit. It is a compact material that becomes jointed and very brittle when dry.

Plastic and dry properties Sample No. 196

Plasticity	Good	Volume shrinkage	43.0% dry volume
Shrinkage water	25.8%	Linear shrinkage	17.1% dry length
Pore water	23.7%	Linear shrinkage	6.5% wet length
Water of plasticity	49.5%	Dry condition	Strong

Fired properties Sample No. 196

Cone	Color	Condition	L.S.%d.l.	T.L.S.%d.l.	V.S.%d.v.	Abs.	A.Por.
010	Buff-brown	Good, hard	2.2	19.3	6.5	21.5	36.9
05	Red-brown	Good, hard	....	....	....	16.0	32.7
04	Red-brown	Good, S.H.	10.5	27.6	28.2	9.0	18.9
01-1	Red-brown and black	Vitreous, good, S.H.	12.2	29.3	32.2	0.2	0.5
3-4*	Red-brown and black	Fused, swelled, S.H.	9.4	27.1	25.6	0.3	0.6

Remarks: Best firing range: 06-01. Cone fusion: 2. Excessive plastic material.

Class of ware: Mix with nonplastics for red and brown structural wares.

Sample No. 197, from the lower unweathered portion of the exposure, resembles the general run of unoxidized glacial clays. It is uniform in texture, medium fine, and somewhat silty. The depth to which this clay extends is unknown; but an immense amount is in sight, and similar material may be seen in many road cuts throughout this part of the county.

Plastic and dry properties Sample No. 197

Plasticity	Good	Volume shrinkage	29.7% dry volume
Shrinkage water	7.0%	Linear shrinkage	11.1% dry length
Pore water	26.9%	Linear shrinkage	4.7% wet length
Water of plasticity	33.9%	Dry condition	Strong

Fired properties Sample No. 197

Cone	Color	Condition	L.S.%d.l.	T.L.S.%d.l.	V.S.%d.v.	Abs.	A.Por.
08	Buff-brown	Weak, soft	1.4	12.5	4.1	20.7	35.4
04	Lt. brown-red	Good, hard	4.5	15.6	13.0	12.7	24.3
03	Lt. brown-red	Good, S.H.	....	....	....	5.5	11.7
01-1	Dk. red-brown and black	Vitreous, good, S.H.	11.9	23.0	31.5	0.0	0.0
3-4*	Brown and black	Fused, S.H.	6.3	17.4	17.8	0.0	0.0

Remarks: Best firing range: 06-02. Cone fusion: 3. Needs a reduction in shrinkage.

Class of ware: Red and brown structural wares.

At Tiloh, a station of the Northern Pacific Railway 4 miles east of Mount Vernon, a clay similar in properties to glacial clay is being mined by the Knapp Brick & Tile Co. This deposit, however, is of Recent lacustrine sediments that accumulated in a lake or brackish estuary that formerly filled the valley. An open pit, some 200 feet across, exposes the horizontally bedded clay to a depth of 10 feet under a thin overburden of humus. It is said that a drill hole showed the deposit to continue to a depth of about 30 feet more. The areal extent coincides with the valley floor.

Sample No. 190, of this clay, was blue when damp and fresh; it dried to a light gray with irregular buff discolorations. Fine sandy partings mark the bedding planes, but otherwise the clay is uniformly fine textured and free from grit. It is compact and brittle. Numerous minute holes, formed by rootlets when the clay was being deposited, traverse the clay.

Plastic and dry properties Sample No. 190

Plasticity	Sticky	Volume shrinkage	38.6% dry volume
Shrinkage water	21.5%	Linear shrinkage	15.0% dry length
Pore water	20.3%	Linear shrinkage	10.0% wet length
Water of plasticity	41.8%	Dry condition	Good

Fired properties Sample No. 190

Cone	Color	Condition	L.S.%d.l.	T.L.S.%d.l.	V.S.%d.v.	Abs.	A.Por.
010	Buff-brown	Good, hard	1.9	16.9	5.7	19.2	34.2
06	Lt. red-brown	Good, hard	....	....	....	13.4	25.0
05	Red-brown	Good, S.H.	....	....	....	12.3	24.1
02	Red-brown	Good, S.H.	12.7	27.7	33.5	0.3	0.8
1+	Deep red-brown	Fusion started, S.H.	10.6	25.6	28.4	1.3	2.3
3-4*	Dk. red-brown	Fused, S.H.	7.6	22.6	21.1	0.2	0.4

Remarks: Best firing range: 07-02. Cone fusion: 3-4*. High shrinkage.
Class of ware: Mix with more nonplastic material for red-brown structural wares.

Knapp Brick & Tile Co.—In working this deposit, the clay is dug by drag-line scraper and carried to a trap where a car is filled. This is pulled by cable a short distance to the plant. There the clay goes through disintegrator rolls to a combination pug mill and auger machine equipped with an automatic tile cutter. The ware is dried in the open air and then goes to one 28-foot round down-draft periodic kiln. Water-smoking requires 48 hours and a burn is completed in another 24 hours. Oil burners are used and the temperature of the kiln is maintained as closely as possible between cone 07 and 08 during the actual firing. Various sizes of drain tile and hollow block are the only product made, though formerly some brick and even flower pots were made here. The present output is about 600 tons per year.

Glacial clay occurring near Bay View, on Padilla Bay, was formerly used by a yard located there for drain tile, hollow block, and common brick. Another small yard operated near Anacortes a few years ago, making common brick; the pit was a small one in the ordinary glacial clay. A yard ran for several years at Alger near the south end of Samish Lake. Here, clay was taken from extensive deposits of lacustrine material in the valley bottom, similar in origin and character to the Tiloh clay (see sample No. 190, p. 222).

A material is found about 7 miles east of Sedro Woolley that has been called fire clay but that is in reality a water-laid deposit of powdery talc with some clay intimately mixed throughout. It occurs over many acres on the south side of the Skagit River and was sampled by boring at several places. The purest material was found in the S½ sec. 30, (35-6 E), where it occurs in a flat under 6 inches of soil and may be seen in a plowed field near the road. The deposit is irregular in thickness, ranging from 3 to 6 feet, and has a 6-inch parting of humus where drilled. Talc schists and soapstone occur in the region, and this "clay" deposit owes its origin to the erosion of such rocks and the deposition of the finest sediment in a swampy lake. Because of the local idea concerning the material, two samples were taken for testing as clay.

Sample No. 193 is light gray in color and is somewhat stained in part to yellow. It is very fine-grained and free from noticeable grit.

Plastic and dry properties Sample No. 193

Plasticity	Good	Volume shrinkage	16.9% dry volume
Shrinkage water	9.8%	Linear shrinkage	6.0% dry length
Pore water	21.8%	Linear shrinkage	4.5% wet length
Water of plasticity	31.6%	Dry condition	Strong

Fired properties Sample No. 193

Cone	Color	Condition	L.S.%d.l.	T.L.S.%d.l.	V.S.%d.v.	Abs.	A.Por.
04	Red-brown	Weak, soft	3.3	9.3	9.6	20.4	34.6
01-1	Dk. red-brown	Near vitreous, good, S.H.	10.2	16.2	27.6	7.1	14.6
3-4*	Dk. red-brown	Vitreous, S.H.	15.2	21.2	39.1	0.0	0.0
6-7*	Brown-black	Fused, S.H.	11.6	17.6	31.0	0.0	0.0

Remarks: Best firing range: 02-2. Cone fusion: 5.

Class of ware: Red and brown structural wares.

Sample No. 194 was taken in the same flat about 300 yards west of No. 193. The talcose material has a greater thickness (6 feet) here and is much purer. When damp it is bluish white and dries to a very light silver gray. Lumps are easily crushed to powder between the fingers and have the greasy feel characteristic of talc.

Plastic and dry properties Sample No. 194

Plasticity	Weak	Volume shrinkage	21.0% dry volume
Shrinkage water	16.0%	Linear shrinkage	7.6% dry length
Pore water	39.9%	Dry condition	Weak
Water of plasticity	55.9%		

Fired properties Sample No. 194

Cone	Color	Condition	L.S.%d.l.	T.L.S.%d.l.	V.S.%d.v.	Abs.	A.Por.
03	Lt. brown-buff	Very soft	....	....	....	39.0	52.8
01-1	Lt. brown-buff	Very soft	4.9	12.5	13.9	34.8	49.8
3-4*	Buff-brown	Soft	7.1	14.7	19.7	31.2	48.5
6-7*	Dk. gray-brown	Good, hard	10.5	18.1	28.3	20.6	36.0
12*	....	Fused	....	....	....	....	....

Remarks: Best firing range: 6-9. Cone fusion: 11-12. Weak dry strength, excessive pore space. Short firing range at high temperatures.

South of Prairie, a quarter of a mile, a nearly black clay occurs in ditches along the grade of the Northern Pacific Railway. It is a sedimentary deposit probably very similar in origin to the talcose clays mentioned above but derived from a graphitic rather than talcose schist. The extent is unknown but may be considerable.

Sample No. 195, of this clay, is very dark gray and has much the appearance and feel of graphite, owing to a considerable content of this mineral and probably some talc. The clay is soft, has a very uniform fine texture, and is free from grit.

Plastic and dry properties Sample No. 195

Plasticity	Good	Volume shrinkage	18.3% dry volume
Shrinkage water	11.0%	Linear shrinkage	6.5% dry length
Pore water	22.4%	Linear shrinkage	4.3% wet length
Water of plasticity	33.4%	Dry condition	Good

Fired properties Sample No. 195

Cone	Color	Condition	L.S.%d.l.	T.L.S.%d.l.	V.S.%d.v.	Abs.	A.Por.
08	Buff-brown	Scum, very soft	0.6	7.1	1.8	26.5	41.3
06	Lt. red-brown	Scum, good, S.H.-	8.0	14.5	22.1	12.6	24.5
02	Deep red-brown	Good, S.H.	15.5	22.0	39.7	0.2	0.5
01-1	Red brown-black	Vitreous, fusion started, S.H.	12.1	18.6	32.0	0.1	0.2
3-4*	Brown-black	Fused, S.H.	9.4	15.9	25.7	0.0	0.0

Remarks: Best firing range: 07-02. Cone fusion: 6. Shrinkage excessive. Change in volume is very rapid.

Class of ware: Red and brown structural wares.

SKAMANIA COUNTY

Skamania County is a high rugged area of 1,685 square miles lying in the Cascade Mountains, in the southern part of the State. The rocks are mostly of basic extrusive type—basalt, andesite, and pyroclastic variants. Clay, other than a common red-firing type, would not be expected from such rocks, and what did form would be prevented from accumulating in any great amount by the erosion characteristic of an area of such great relief.

In the extreme southern part of the county, along the Columbia River and short tributary valleys, are soft, structureless clays that would be available for common brick and drain tile in case a local market developed. These are partly colluvial, formed from the decomposition of the basalt and carried onto the lower areas by landslides and surface wash, and partly Pleistocene terrace deposits. All are low-fusing, red-firing materials not unlike the related deposits in Clark and Cowlitz counties.

SNOHOMISH COUNTY

Snohomish County, in northwestern Washington, has an area of 2,664 square miles. For some distance east from Puget Sound the land is low and rolling, but the eastern part of the county lies in the Cascade Mountains and is high and extremely rugged. Oligocene sediments form the surface exposures in four or five relatively small isolated areas in the western part of the county. The shales are similar to those cropping out in the vicinity of Seattle and would be usable for ordinary red-firing structural wares. Characteristic exposures occur near Cathcart and just east of Snohomish. Elsewhere the bedrock for many miles east of Puget Sound is deeply covered by alluvium and glacial sediments.

The central and eastern part of the county is composed of Mesozoic and Paleozoic rocks. These include granodiorite, which might be weathered to form excellent clay deposits but for the rapid erosion to which it is subjected, and great areas of metamorphic rocks that are not usually important as clay-forming materials. These various formations have their extensions or equivalents in Skagit County and are also discussed under that heading.

The clay resources are practically confined to those deposits occurring in the Puget Sound glacial sediments. They are suitable for common red-fired ware and structural materials but not for products of higher grade. Fortunately, such clay is of widespread occurrence and may be developed near any of the towns. For many years glacial clay has been used in Everett for making common brick and other products. The beds crop out in the sides of the Snohomish River Valley and have great thickness and areal extent. Like other deposits of this type in Washington, some are very smooth and uniformly free from sand, while others have alternate beds of clay and sand or grade laterally from one into the other. Only one yard is operating here at present.

This company, the Everett Brick Yard, has its plant in the southeastern part of Everett at 39th Street and Rockefeller Avenue. The clay is taken from a quarry-pit in the hill 400 feet southeast of the plant. The working face is about 50 feet high and some 125 feet across. The clay is distinctly stratified, varved in part, and horizontally bedded. Some boulders occur on the surface and are stripped off, but the beds as a whole are free from gravel except for an occasional pocket. The bluish color of the damp glacial clay is apparent in all but the upper 8 feet, where surface oxidation has changed it to a buff color. The bottom of the workings is well above drainage level and is in a 4-foot stratum of loose sand. Below this is more of the thin-bedded clay and sandy clay. An immense amount of material is available and may be mined with a minimum of expense.

Sample No. 388 was taken of the ground clay as used in the plant.

Plastic and dry properties Sample No. 388

Plasticity	Good	Volume shrinkage	16.3% dry volume
Shrinkage water	10.5%	Linear shrinkage	5.8% dry length
Pore water	19.9%	Dry condition	Good
Water of plasticity	30.4%		

Fired properties Sample No. 388

Cone	Color	Condition	L.S.%d.l.	T.L.S.%d.l.	V.S.%d.v.	Abs.	A.Por.
010	Buff-brown	Weak, soft	0.6	6.4	1.6	19.3	33.0
05	Buff-red	Little scum, good, hard	5.1	10.9	14.4	15.5	30.1
01	Dk. red-brown	Vitreous, slight sticking, S.H.	9.7	15.5	26.4	0.2	0.4

Remarks: Best firing range: 06-02. Cone fusion: 2. Could use a little more sand to advantage and reduce shrinkage.

Class of ware: Now used for red-brown common brick.

Everett Brick Yard.—The clay is taken "run-of-pit" and loaded by drag-line scraper, by means of a trap, into a side-dumping car. The haul to the plant is by cable. There the clay passes by gravity through one pair of disintegrator rolls, a pug mill, and an auger machine. The ware is cut by a hand side-cutter, and dried in a 4-tunnel steam drier. Firing is carried on in a continuous ring kiln. The capacity is 25,000 common brick per day. The 1936 output consisted of 1,400,000 common and

100,000 rough-textured face brick, 10,000 hollow block, 36,000 drain tile, and 8,000 square feet of roofing tile.

A small yard formerly operated in the northwest part of Snohomish, manufacturing an excellent grade of common brick and drain tile. The clay occurs in a low bench just north of the plant site and is a buff-colored horizontal thin-bedded Recent flood-plain deposit overlying a pebbly blue glacial clay. The only overburden is 1 foot of soil which was used with the clay. The working face varied from 6 to 10 feet in height, the pit bottom being determined by the drainage level and the top of the blue clay.

Sample No. 389 is a general one of the clay used. It is buff in color, except where leaching has rendered it gray. Though not uniform throughout, it is soft, sandy, and mostly fine-textured. Peculiarities of the clay are: fine sandy partings along the bedding planes, an abundance of minute root-hair holes, and concretionary columns, still soft, that are forming about worm borings.

Plastic and dry properties Sample No. 389

Plasticity	Good	Volume shrinkage	19.4% dry volume
Shrinkage water	11.3%	Linear shrinkage	7.0% dry length
Pore water	18.2%		
Water of plasticity	29.5%		

Fired properties Sample No. 389

Cone	Color	Condition	L.S.%d.l.	T.L.S.%d.l.	V.S.%d.v.	Abs.	A.Por.
010	Buff-brown	Weak, soft	0.3	7.3	0.8	17.8	31.1
05	Buff-red	Very good, hard	4.7	11.7	13.3	13.4	25.4
02	Deep brown-red	Very good, S.H.	8.7	15.7	23.8	3.3	7.8
1	Dark red-brown	Vitreous, badly stuck, S.H.	8.9	15.9	24.4	0.4	1.1

Remarks: Best firing range: 06-02. Cone fusion: 4-5. Color is especially good.

Class of ware: Used for common brick and tile.

At the State Reformatory at Monroe, all the common brick used in the buildings were made on the site. Some 4 feet of clay overlies the glacial till or "hardpan" at this particular place, and in improving the grounds much of this clay was available. It was put through disintegrator rolls and standard auger-machine equipment; the bricks were dried on pallets in the open air and burned in a scove kiln. The yard was run during the summer months for 5 years, during which time about 4,000,000 common brick and several thousand feet of 6-inch drain tile were made.

The glacial clay that crops out so generally in the bluffs along the shore of Puget Sound was utilized until recently at Meadowdale, about 15 miles north of Seattle, for the manufacture of flower pots. Many seams of clay occur here interstratified with sand, but only two beds were worked; these are 6 and 4 feet thick, respectively, with 2 feet of sand between.

Sample No. 387, a general one, was taken. It is bluish gray in color and is fine-grained but rather silty, so the lumps are soft and easily broken. Some carbonaceous matter is disseminated throughout the clay.

Plastic and dry properties Sample No. 387

Plasticity	Good	Volume shrinkage	19.0% dry volume
Shrinkage	12.2%	Linear shrinkage	6.8% dry length
Pore water	23.8%		
Water of plasticity	36.0%		

Fired properties Sample No. 387

Cone	Color	Condition	L.S.%d.l.	T.L.S.%d.l.	V.S.%d.v.	Abs.	A.Por.
06	Buff-red	Weak, soft	3.9	10.7	11.1	20.2	36.0
02	Red-brown	Vitreous, good, S.H.	11.9	18.7	31.6	0.9	2.3
1	Dark brown	Vitreous, good, near fusion, S.H.	13.0	19.8	34.1	0.1	0.2

Remarks: Best firing range: 05-02. Cone fusion: 6.

Class of ware: Used for flower pots.

Meadowdale Pottery.—The Meadowdale Pottery, now closed, was particularly interesting, not only because it operated steadily for many years when other more pretentious plants, for various reasons, started and failed, but also, because the plant was almost entirely hand-made, and one man with the aid of a horse carried on the entire process. Clay, in ample quantity to run the small shop, was hand-picked from the horizontal beds by following them along the bluff and not disturbing the immense overburden. It was wheeled the few yards to the shop in a barrow and there put into a soak-pit. Tempering was in a vertical pug mill, and the clay was screened while plastic to remove any hard lumps. The one jigger-wheel was operated by a small gasoline engine and, by using different molds, various sizes of flower pots were made. The ware was partially dried on racks and then put into the kiln. The latter was 6 feet wide, 8 feet long, and 5 feet high (inside measurement), and was of the semimuffle type. It held some 10,000 pots of 4-inch size or their equivalent. As the average daily run was between 800 and 1,000 flower pots, the kiln was filled and burned only once in 3 weeks. Operation was continuous throughout the year and about 100,000 pots of assorted sizes, together with novelty and garden ware, found a ready market in Seattle, Everett, and other Sound markets.

SPOKANE COUNTY

Spokane County is an area of 1,756 square miles on the eastern border of the State. It is made up of rolling stream-incised plains and rounded hills that merge into mountains.

Extensive deposits of both ordinary red-firing clays and high-quality light-firing clays occur in the county and in smaller areas immediately adjoining in Stevens and Whitman counties. Some of the materials available in this region are white kaolins suitable, after treatment, for china clay, others are very high-grade plastic refractories, and many deposits contain stoneware, pottery, and terra cotta clays. In a State where the better clays are relatively scarce, these so-called "Spokane-Clayton" clays are particularly important. So it is entirely natural that the ceramic industry in the general vicinity of Spokane should be well founded and that certain continued development will give permanent value to the clay deposits.

LATE GEOLOGIC HISTORY

Three factors have been chiefly responsible for the accumulation of the better clays: first, the predominant rock here is granitic, a type whose decomposition products are high in alumina and low in iron and other fluxes; second, the physiographic maturity of much of the area is such that weathering has progressed faster than erosion, allowing clays to accumulate; and third, drainage has been interrupted at different times in the Cenozoic era, so sedimentary deposits have formed. A brief discussion of these points and their bearing on the clays may serve to explain the occurrence of the various clay types and aid in their prospecting.

The oldest known rocks in this region are quartzites, slaty argillites, and schists. Their age is not known with certainty, for as yet no fossils upon which to base conclusions have been found in this immediate vicinity. The series is lithologically similar to certain supposedly unfossiliferous rocks of Stevens and Pend Oreille counties, where recent investigations by the Division of Geology have shown the presence of a Paleozoic fauna. So a Paleozoic age appears more probable for the metamorphic sedimentary rocks of the Spokane region than does an Archean or, as suggested by some earlier workers, an Algonkian age contemporaneous with the Belt series of Idaho. A few deposits of usable clays have been derived from the decomposition of these rocks, but such occurrences are rare.

Intruding these ancient rocks, and now through erosion forming the principal rock throughout much of the region, is granite which is doubtless an extension of the Mesozoic Loon Lake batholith of Stevens County. It shows a great many textural and mineralogic variations, and it has been the source of numerous smaller intrusive bodies. The most common form for the main mass is a moderately coarse-grained biotite-hornblende granite; in some places, however, it merges into syenite and in others into diorite. Gneissic phases are very common; they appear to be merely localized border effects primary to the original mass, but some investigators have thought they represented a far older metamorphosed granite of which only isolated remnants are now left.

Textural extremes are represented by fine-grained aplites and similar intrusives and by very coarse-grained pegmatites. Feldspar phenocrysts more than 2 inches long occur in the gneiss of the southeast slopes of Little Baldy, east of Hillyard; pegmatites are abundant on the north and south slopes of Mica Peak, particularly near the Idaho line; and an outstanding example of magmatic differentiation is shown by a quartz hill covering several acres 1½ miles southwest of Wayside. This granite and the related rocks are the chief source of the high-quality clays of the region.

In Miocene time the Columbia River lavas invaded the area and eventually reached an elevation of from 2,400 to possibly 2,600 feet. This basalt is only the fringe and upper part of the series of flows that produced the great Columbia basalt plains. Here, in the Spokane region, it filled pre-existent valleys, covered practically contemporaneous sediments, and finally inundated all surfaces that had an elevation less than approximately 2,500 feet. The flat-topped "prairies" (Moran, Pleasant, Five Mile) are remnants of these upper thin flows resting on the older granitic rock or on Miocene sediments. South and west of the Mica Peak-Silver Hill area basalt predominates throughout many counties, and in only a few places, as near Medical Lake and along the Idaho line, do older rocks remain uncovered.

On all these rocks weathering has been active and clays have formed from their decomposition. The products of rock decay have been removed by active erosion from the areas of greater relief, and there the soil cover is scant and outcrops of rock are plentiful. However, much of the region has a relief that is under 1,500 feet, and locally far less. This and the general physiographic maturity of the country have caused erosion to lag behind weathering in many places, and residual clays have accumulated.

Some of these deposits were doubtless forming before the advent of the lava, as suggested by the depth of decomposition shown locally and by residual clay and disintegrated granite underlying basalt. But in most of the area steepness of slopes aided in sweeping away clays and other products of weathering.

The basalt flows interrupted drainage so that many ponds and lakes were formed both in front and on top of the basalt [1]. In these water bodies were deposited sediments of various kinds, depending on local conditions, and among them were some of the light-firing clays that have become commercially so important. These sediments were covered by later flows, forming new drainage obstructions. The process was repeated many times, so that now throughout the Columbia basalt plain and particularly near its margins, clays and sands are interbedded with the flows in thicknesses ranging from inches to 100 feet, while exceptional deposits may be many times as great. In the vicinity of Spokane, according to Pardee and Bryan [2], there is no interbedding of sediments and basalt in the 1,500-foot formation which they called the Latah.

In Pleistocene time glaciation again interrupted drainage and another series of sands, gravels, and clays was deposited. As these clays are of little value, it is fortunate for the ceramic industry that the glacial deposits are mostly thin and do not extend far south of Spokane.

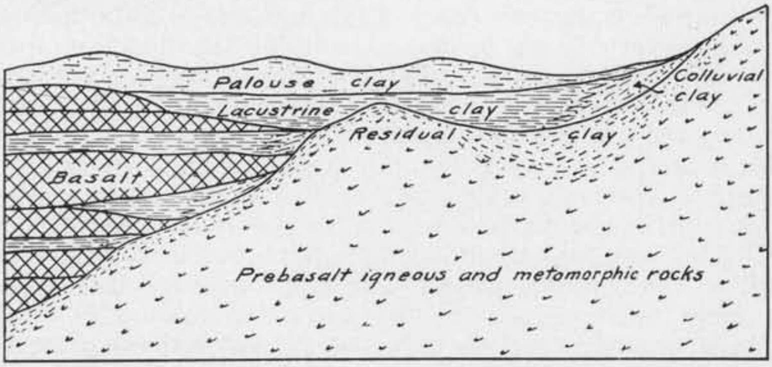

FIGURE 2.—Section to illustrate the occurrence of clays in the Spokane region.

OCCURRENCE OF CLAY GROUPS

From this brief review of late geologic history, it is apparent that some of the Spokane clays occur in protected places in the higher hills, but that these regions are mostly barren of usable deposits. Out in the area covered by basalt an excessive overburden prevents the economic working of any interbedded clays that may exist. So the line of contact between basalt and older rock may be taken as approximately determining the location of the workable clay beds and should govern prospecting. In some

[1] Russell, I. C., A reconnaissance in southeastern Washington: U. S. Geol. Survey Water-Supply Paper 4, p. 55, 1897.

[2] Pardee, J. T., and Bryan, Kirk, Geology of the Latah formation in relation to the lavas of the Columbia Plateau near Spokane, Washington: U. S. Geol. Survey Prof. Paper 140-A, 1926.

places this clay belt is narrow, and the deposits are small; in others, it may have a width of several miles, and deposits, consequently, are extensive.

The elevations of known light-firing deposits range from about 1,800 feet (Milan clay) to 2,600 (Freeman clay). The beds may be expected to extend to elevations of about 3,000 feet, and long gentle slopes in the granite hills are most favorable for occurrences. Of particular promise are the following areas: Mica Creek Valley and Manito vicinity, California Creek Valley, Saltese Creek Valley, the eastern edge of Pleasant Prairie, and throughout the lower slopes of Mount Spokane.

Derived from feldspathic rocks commonly pegmatitic, the clays are light gray in color and without special treatment range from buff to nearly white when fired. By washing certain of the high-kaolin varieties, such as occur at Freeman, a white-firing china clay can be obtained. Some of the deposits are residual, but more show the slight assorting and even the rude stratification of colluvial clays—those which, through surface creep caused by rain wash and frost action, have moved a short distance from their source. Some of the high-grade clays belong to the sedimentary Latah formation, notably the Sommer, Fuher (Deadman Creek), and probably Deer Park-Clayton clays, but it is only where these beds were derived from granitic rock alone, that they are low in fluxes and iron.

Most of the widespread Latah clays are nonrefractory and red firing. They contain abundant volcanic ash [1], and are sufficiently high in iron oxide to weather to shades of brown and yellow. They are well stratified and characteristically have leaf fossils on the bedding planes. The more argillaceous members may have the compactness and laminated feature of shales. Fissile structure, however, does not extend noticeably beyond the outcrop into the damp underground clays and, of course, is absent in weathered shales. Typical Latah strata are best seen in railroad cuts near the southwest city limits of Spokane, though extensive exposures below the basalt are found north of the city and elsewhere.

One other clay common to much of this region is the Palouse clay, described in detail under the heading of Whitman County (see pp. 327-332). It is a useful material for ordinary structural wares, but, as it overlies better grades of clay, it hinders their prospecting. In some places it is residual and grades from reddish-brown sticky clay through disintegrated rock to unaltered basalt. In most places, however, the Palouse clay is partly or wholly eolian in origin and may occur at elevations not reached

[1] Pardee, J. T., and Bryan, Kirk, op. cit., pp. 4-8.

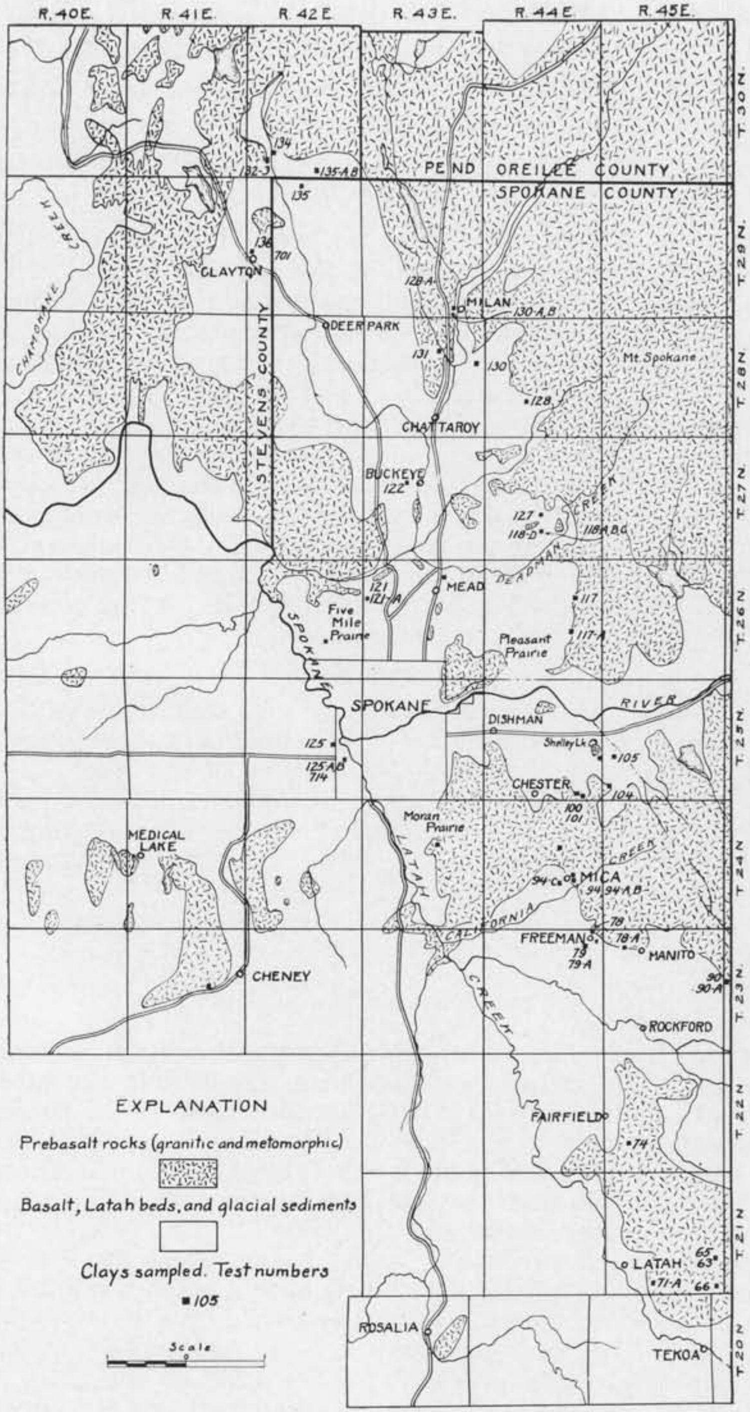

FIGURE 3.—The Tekoa-Spokane-Clayton region and location of clays sampled.

by the basalt. Deposits may be very thick, as in the brick-clay pit at Freeman, where a 40-foot bed of almost structureless reddish-brown to yellowish loess overlies stratified sands, gravels, and other clays without any basalt appearing in the section.

LIGHT-FIRING CLAYS

The color of a clay after firing is a useful indication of certain characteristics of the clay, such as the relative amount of iron oxide and alumina present, whether the clay is a low-, medium-, or high-fusion type, and of course, whether the clay is suitable for certain ware. In general, those clays which are light firing acquire some shade of buff or gray, or they may be white or nearly so. It is convenient, therefore, to make a broad division on the basis of fired color when considering a large group of clays, having both light- and dark-firing characteristics, in a given region. This division is made of the Spokane County clays. It holds in general for the clays mentioned specifically and for the districts in which these clays occur. It should be understood, however, that a light-firing clay may have dark-firing phases or may be associated with dark-firing beds.

DISTRICTS

The geology of certain areas may be such that the clays, there, have distinctive characteristics. This would permit the grouping of clays on a basis of location. A division of this kind may be made for parts of Spokane County, but district designations are chiefly for convenience in considering together the clays of a certain locality. Accordingly, the light-firing clays of the county are described from the following districts:

Tekoa-Fairfield	Moran	Deadman Creek
Manito	Cheney-Medical Lake	Five Mile Prairie
Freeman	Chester	Milan
Mica	Pleasant Prairie	Deer Park

Tekoa-Fairfield district.—A group of prominent rounded hills, composed of quartzites, quartz schists, fine friable sandstones, and sandy shales occupies a considerable region in the extreme southeastern corner of Spokane County. Thin tongues of basalt have reached into some of the lower valleys but the elevation is, in general, higher than that attained by the lava. The contact between the older rocks and the lava roughly extends from Tekoa, in Whitman County, along Latah Creek to Waverly, thence northeastward through Fairfield to a point about 2 miles south of Rockford where it swings eastward into Idaho.

Alluvial clays, derived from the older rocks, probably have been deposited quite generally at the base of the hills, but Palouse clay conceals them except in some road cuts and excavations, as in the broad valley lying east of Tekoa Mountain and again on the lower western slope.

A road in the center of the N½ sec. 25, (21-45 N), about 4 miles north of Tekoa, cuts an extensive bed of dark-red, ocherous clay. This exposure is large; similar clay is reported 30 feet thick in a well 2 miles to the south, and so a great quantity of this material appears to be available.

Sample No. 65, taken at the road cut, is brick red in color except for abundant small bluish-gray masses, distributed irregularly throughout. The texture is mostly fine but is nonuniform and sandy. Lumps of the clay when dry are compact and brittle.

Plastic and dry properties Sample No. 65

Plasticity	Good	Volume shrinkage	30.7% dry volume
Shrinkage water	15.6%	Linear shrinkage	11.5% dry length
Pore water	15.5%	Linear shrinkage	7.0% wet length
Water of plasticity	31.1%	Dry condition	Good

Fired properties Sample No. 65

Cone	Color	Condition	L.S.%d.l.	T.L.S.%d.l.	V.S.%d.v.	Abs.	A.Por.
08	Bright buff-red	Weak, soft	1.1	12.6	4.0	22.7	39.1
05	Light buff-red	Good, S.H.-	3.8	15.3	11.0	11.1	22.0
01	Bright buff-red	Good, S.H.	8.4	19.9	23.1	3.8	8.9
3-4*	Bright brown-red	Good, S.H.	10.2	22.7	27.5	4.0	9.2
12	Brown and black	Vesicular, S.H.	8.9	20.4	24.3	8.0	18.3

Remarks: Best firing range: 06-8. Cone fusion: 17. High shrinkage.

Class of ware: Reduce excessive shrinkage with nonplastics for brown and red structural wares.

White clay, 15 feet thick, is reported to underlie the red clay in the well mentioned above and is said to occur in many other places in the Tekoa region. It is exposed in a ditch in a swale near the center of sec. 36, (21-45 E), where indications point to an extensive deposit.

Sample No. 66, taken from material removed from the ditch, is light gray in color, and parts are smooth and unctuous. The texture, however, is not uniform, and some portions are harsh from the content of fine quartz sand. It is very compact and brittle when dry.

Plastic and dry properties Sample No. 66

Plasticity	Good	Volume shrinkage	20.7% dry volume
Shrinkage water	10.1%	Linear shrinkage	7.4% dry length
Pore water	10.4%	Linear shrinkage	6.8% wet length
Water of plasticity	20.5%	Dry condition	Good

Fired properties Sample No. 66

Cone	Color	Condition	L.S.%d.l.	T.L.S.%d.l.	V.S.%d.v.	Abs.	A.Por.
08	Cream	Weak, soft	-0.1	7.3	-0.4	15.6	29.0
04*	Cream	Good, hard	-2.4	5.2	-6.9	15.2	28.3
02	Light buff	Good, hard	-3.4	4.0	-9.9	12.1	22.4
6-7*	Light buff	Good, hard	-3.6	3.8	-10.4	10.7	20.4
12*	Brown-buff	Good, S.H.	1.0	6.4	+3.1	9.8	8.6
15	Brown	Good, S.H.	3.2	4.2	9.1	8.6	17.3

Remarks: Best firing range: 04-15. Cone fusion: 26.

Class of ware: Buff-colored pottery ware if sand is removed. Needs a high temperature for strong structural wares.

In order to ascertain the physical properties of what is probably a pre-Tertiary sandy shale occurring in this vicinity, a sample was taken from a large exposure along the road just south of the clay sampled as No. 65. This material is coarse-grained and friable and readily weathers to soil. Two prominent color phases occur, one light gray, the other bright buff.

Sample No. 63, of the buff rock, is compact, moderately hard, and is well jointed.

Plastic and dry properties Sample No. 63

Plasticity	Weak	Volume shrinkage	4.4% dry volume
Shrinkage water	2.3%	Linear shrinkage	1.5% dry length
Pore water	14.8%	Linear shrinkage	1.0% wet length
Water of plasticity	17.1%	Dry condition	Weak

Fired properties Sample No. 63

Cone	Color	Condition	L.S.%d.l.	T.L.S.%d.l.	V.S.%d.v.	Abs.	A.Por.
08	Buff-brown	Weak, very soft	-1.7	-0.2	-0.5	21.9	35.9
07	Brown-red	Weak, soft	0.2	1.7	0.7	17.2	29.5
04*	Bright buff-red	Good, hard	0.8	2.3	2.5	11.3	22.8
02	Bright buff-red	Good, hard	2.1	3.6	6.2	11.0	21.8
6-7*	Brown-red	Good, S.H.	5.3	6.8	15.0	6.0	12.9
10	Dk. gray-brown	Vitreous, good, S.H.	6.5	8.0	18.3	1.6	3.4
12*	....	Fused	....	....	....	....	....

Remarks: Best firing range: 05-8. Cone fusion: 12.

Class of ware: Needs more plastic strength for auger machine work. Red and brown structural and facing wares.

Years ago a pottery operated on the clays taken from the W½ sec. 33, (21-45 E), about 2 miles southeast of Latah, where the topography indicates a large body of similar sedimentary material. An overburden of Palouse clay, however, effectually conceals the subsurface in most places. In some respects, the clay is similar to sample No. 65 but not so highly colored with iron oxide. The products made were dark buff in color and included the common kinds of stoneware.

Sample No. 71-A was taken from a dump at the old workings, where a tunnel had evidently been driven into the hillside. The material is mottled brick red and very light gray, has a high sand content, and is of nonuniform texture. The sample is probably not representative of what could be obtained here by selective mining.

Remarks: Too much plastic material causes a high shrinkage, making the commercial use of this clay alone inadvisable. It would be useful as a bond clay for dark or buff-brown structural wares, or as a No. 3 refractory brick; the cone fusion is cone 23-26.

In a road cut 2½ miles southeast of Fairfield, in the NW¼ SW¼ sec. 29, (22-45 E), is exposed a partly decomposed shaly material which no doubt exists in large quantities. Five feet of Palouse clay covers the deposit where sampled.

Sample No. 74, of this deposit, is a nonuniform mixture of soft fine-grained white shaly material and coarse very sandy hard shale. Abundant sericite in the finer portions gives a smooth, talc-like texture that might easily be mistaken for the unctuous feel of many kaolins.

Plastic and dry properties Sample No. 74

Plasticity	Fair	Volume shrinkage	11.8% dry volume
Shrinkage water	9.0%	Linear shrinkage	4.1% dry length
Pore water	13.3%	Linear shrinkage	2.4% wet length
Water of plasticity	22.3%	Dry condition	Fair

Fired properties Sample No. 74

Cone	Color	Condition	L.S.%d.l.	T.L.S.%d.l.	V.S.%d.v.	Abs.	A.Por.
08	Buff-brown	Weak, soft	-0.6	3.5	-1.7	18.9	34.5
06	Red-buff	Weak, soft	0.3	4.4	0.8	17.6	31.2
04*	Bright brown-red	Good, S.H.	1.3	5.4	3.9	12.7	24.8
6	Brown-red	Good, S.H.	3.7	7.8	10.7	6.6	13.3
15	Gray-brown	Vitreous, good, S.H.	7.2	11.3	20.0	1.2	2.8

Remarks: Best firing range: 04-15. Cone fusion: 20-23. Long firing range.

Class of ware: Red and brown structural wares.

Manito district.—White and red clays are exposed southeast of Saxby Station in a cut on the Chicago, Milwaukee, St. Paul & Pacific Railway where it crosses the State line. An exposure near the west center of sec. 18, (23-46 E), is about 200 feet long and 15 feet high and is composed of residual clays overlain by a small amount of Palouse clay. Several kinds of material occur here, but predominant is a sandy brick-red clay derived from the decomposition of gneiss. Cutting the other rocks is a feldspathic dike, nearly vertical and striking S. 20° E., about 3 feet in width, that has altered to a mass of yellowish-white kaolin.

Sample No. 90-A, of the red clay, is coarse and uneven and has abundant quartz grains disseminated throughout. Fragments of slightly altered feldspar and flakes of muscovite are also numerous. Sufficient clay substance is present to make dry lumps of this material very firm and compact.

Plastic and dry properties Sample No. 90-A

Plasticity	Good	Volume shrinkage	20.1% dry volume
Shrinkage water	11.7%	Linear shrinkage	7.2% dry length
Pore water	19.2%	Dry condition	Good
Water of plasticity	30.9%		

Fired properties Sample No. 90-A

Cone	Color	Condition	L.S.%d.l.	T.L.S.%d.l.	V.S.%d.v.	Abs.	A.Por.
06	Bright buff-red	Weak, soft	1.1	8.3	3.4	24.7	41.5
02	Bright buff-red	Weak, soft	4.9	12.1	14.0	19.2	35.4

Remarks: Best firing range: 1-8. Cone fusion: 16.

Class of ware: Mix with a less plastic clay for red and brown facing and structural wares.

Sample No. 90, of the kaolin, has a slightly yellowish color when damp but dries almost pure white. The texture is very fine and even; grit is detected only when a fragment is tested between the teeth and then in small amount. The clay has a soapy feel and in lumps is very compact and brittle. Considerable iron oxide has leached from the adjoining red clay, staining the kaolin near the contact. This cuts down the available white clay, but if the deposit were prospected to a little depth below the surface, a sufficient width of clean material might be developed to be of value.

Plastic and dry properties Sample No. 90

Plasticity	Good	Volume shrinkage	29.2% dry volume
Shrinkage water	17.4%	Linear shrinkage	10.9% dry length
Pore water	18.3%	Dry condition	Lamination cracks from auger
Water of plasticity	35.7%		

Fired properties Sample No. 90

Cone	Color	Condition	L.S.%d.l.	T.L.S.%d.l.	V.S.%d.v.	Abs.	A.Por.
07	Light cream	Weak, soft	4.6	15.5	13.2	23.1	38.5
04*	Light cream	Hard	5.9	16.8	16.6	17.3	32.6
02	Light cream	Steel hard	10.0	20.9	27.1	14.8	30.3
3	Light cream	Steel hard	11.1	22.0	29.8	11.2	22.1
6-7*	Light cream	Steel hard	....	....	....	9.3	19.3
10	Mottled buff and gray	Cracked, S H.	....	....	....	4.2	10.0
12*	Cream	Good, S.H.	15.0	25.9	38.7	2.3	5.4

Remarks: Best firing range: 04-20. Cone fusion: 30-31. Needs non-plastic material.

Class of ware: Refractories; buff-colored pottery and terra cotta ware; buff-colored facing and general structural wares.

In the valley of Lake Creek (south fork) poorly assorted gray clays and quartzose sands occur under a variable overburden of Palouse clay. Drill holes in sec. 36, (24-45 E) show these sediments to have thicknesses of at least 40 feet in favorable places. The clays are apparently colluvial, grading into both residual and transported types. They are doubtless buff firing. Indications of similar nearly white clay were at the bottom of a 15-foot railroad cut just west of Hagen Station in the west center sec. 1, (23-45 E).

Very extensive deposits of gray and nearly white sedimentary clays occur in the vicinity of Manito Station in the NW¼ sec. 9, (23-45 E). Just north of the depot the grade cut exposes an overburden of Palouse clay and sand from 4 to 10 feet thick, a bed of stained, reddish-brown plastic clay from 8 to 10 feet thick, and a lower white sandy clay 8 feet thick with base concealed. Test borings elsewhere near the station gave the following section: Palouse clay, 2-15 feet; yellow ocher, 1 foot; light-gray clay, 3 feet; and dark-gray very fine-grained clay, 0-10 feet.

A few carloads of the white clay from north of the station were used at one time by the Washington Brick, Lime & Sewer Pipe Co. Samples tested by Wilson[1] showed that the clay, after the usual purification, could be used satisfactorily in a whiteware mixture to produce a good cream-colored body. This general region south of Mica Peak is particularly favorable for the occurrence of these clays and excavations have proved their presence. The deposits are concealed by Palouse clay, but that overburden is relatively thin and prospecting by drilling would undoubtedly show high-grade clays to underlie several thousand acres.

[1] Wilson, Hewitt, Kaolin and china clay in the Pacific Northwest: Univ. of Washington Eng. Exp. Sta. Bull. 76, p. 58, 1934.

A peculiar kind of clay is exposed in a cut on the Oregon-Washington Railway & Navigation Company's line at Lockwood Siding. Under 2 or 3 feet of overburden are beds of stratified plastic alluvial clays to a depth of probably 6 feet. These are variously colored and show different textures in the several rather thin beds. A thin layer of limonite marks the bottom of the lake or pond in which these sediments, eroded from the adjacent crystalline rocks, were deposited. Below the limonite is about 6 inches of very fine-grained clay, high in organic matter, and the rest of the exposure is a fine porous residual clay, of general bluish color, derived from some igneous rock very low in quartz, possibly on the order of andesite. The depth to which decomposition has gone, beyond the 4 feet exposed, is unknown.

Sample No. 78-A, taken from the lower material, is dark bluish green when damp and dries to a bluish-gray color with yellow and greenish phases. The material is but little consolidated, and lumps crush easily between the fingers to fine powder. No grit is apparent; yet the clay lacks the unctuous feel of ordinary smooth clays. The low specific gravity also is unusual. Under the microscope the clay shows abundant irregularly shaped yellowish masses and rounded aggregates of kaolin, minute grains of magnetite in great quantities, but no quartz.

Plastic and dry properties Sample No. 78-A

Plasticity	Good	Volume shrinkage	21.4% dry volume
Shrinkage water	12.1%	Linear shrinkage	7.7% dry length
Pore water	19.9%	Linear shrinkage	6.1% wet length
Water of plasticity	32.0%	Dry condition	Cracking

Fired properties Sample No. 78-A

Cone	Color	Condition	L.S.%d.l.	T.L.S.%d.l.	V.S.%d.v.	Abs.	A.Por.
08	Blue-gray	Weak, soft	5.5	13.2	15.5	22.6	40.4
06	Purple-gray	Hard	6.6	14.3	18.5	20.8	38.4
04*	Buff-gray	Steel hard	9.0	16.7	24.8	14.3	33.3
02	Gray	Steel hard	10.7	18.4	28.8	11.3	24.0
6	Brown-gray	Steel hard	15.4	23.1	39.4	4.2	10.5

Remarks: Best firing range: 06-15. Cone fusion: 26. Very peculiar gray colors; bad cracking at all temperatures; high shrinkage.

Class of ware: Add nonplastic material for structural wares.

The usual light-gray clays are of widespread occurrence in this vicinity, as they are at Manito. Samples are difficult to obtain without boring, as the material underlies the Palouse clay. On the Thompson place in the $E\frac{1}{2}SW\frac{1}{4}$ sec. 5, (23-45 E) white clay was struck in a well and later obtained in a pit. Other occurrences have been reported from various places between Lockwood Siding and Freeman, and it is reasonable to expect much of the region to have high-quality clays under a variable amount of overburden.

Freeman district.—The clay deposits at Freeman, in sec. 1, (23-44 E), are among the best known in the State, for they have produced a very large tonnage in the past 40 years. The location is near the northern border of the low, rolling plains at approximately 2,600 feet elevation, where the basalt thins out and granitic rock becomes predominant. Here are found residual clay from the decomposition of granite and gneiss, well-stratified alluvial clays, and Palouse clay.

PLATE 9

RESIDUAL CLAY PIT AT FREEMAN.

A 24-foot face of clay is mined after stripping the scant overburden of Palouse clay. See samples No. 78 and 80.

Freeman pit.—Just north of Freeman Station the residual clay is well exposed in a pit about 250 feet in diameter that extends back into one of the spurs leading to Mica Peak. Below a variable overburden of Palouse clay and gravel, from 6 to 15 feet thick, residual granitic clay is exposed for 25 feet above the pit floor and for 20 feet below it. The feldspars have entirely altered to kaolinite, and the whole mass, although retaining the original rock texture, is rendered nearly as soft as sand. The depth to which decomposition extends is unknown, but there is no change in the 40 feet or so worked and test drilling is said to show a depth of at least 150 feet.

Cutting the sandlike material are numerous bodies which were once dikes and irregular masses of pegmatite. These vary greatly in size, their thickness ranging from a fraction of an inch to several feet. They have decomposed as has the original granite, the only difference now being in size of grain. The quartz masses may be as much as 2 inches across; "books" of muscovite may be equally large; and the powdery, chalk-like kaolinite forms the matrix and a large proportion of the entire body. Many of the smaller dikes were apparently entirely feldspar and so appear as veinlets of kaolinite in which quartz and mica are absent, but these may owe their origin to the deposition of the powdery kaolinite by ground water in fractures and joints of the original disintegrated rock. Unaltered granitic gneiss, with a texture similar to coarse sandstone and cut by pegmatite intrusions making up 40 percent of the rock, are exposed in road cuts 4 miles north of Freeman in the south center of sec. 10, (24-44 E).

Sample No. 78 was taken of the uniform medium-grained material forming the bulk of the Freeman deposit. It is light gray in color and consists of subangular grains of friable quartz, abundant fine muscovite, and a groundmass of white powdery kaolinite. It is virtually a loose, clayey sand.

Plastic and dry properties Sample No. 78

Plasticity	Good	Volume shrinkage	18.6% dry volume
Shrinkage water	9.3%	Linear shrinkage	5.6% dry length
Pore water	12.4%	Linear shrinkage	4.0% wet length
Water of plasticity	22.1%	Dry condition	Good

Fired properties Sample No. 78

Cone	Color	Condition	L.S.%d.l.	T.L.S.%d.l.	V.S.%d.v.	Abs.	A.Por.
6	Cream	Weak, soft	1.7	7.3	4.9	20.6	36.4
9	Cream	Weak, soft	2.0	7.6	6.0	19.9	35.6
10	Cream	Weak, soft	2.2	7.8	6.4	19.6	35.4
12	Cream	Good, hard	2.9	8.5	....	....	35.0
15	Cream	Good, hard	3.4	9.0	9.8	18.6	34.3

Remarks: Best firing range: 12-18. Cone fusion: 30-31.

Class of ware: When washed, it has a possible use for whiteware. At present it is used for siliceous clay refractories.

The pit is operated by the Washington Brick, Lime & Sewer Pipe Co., the clay being shipped to their plant at Clayton where it is mixed with local plastic clay and made into fire brick and other refractory products. In mining, the overburden is stripped off and the underlying residual material is caved onto the pit floor, no effort being made to sort the different phases. It is loaded by hand into a car which is drawn up an incline and emptied into gondolas on the railroad above. Similar residual clay was taken for a short time from another pit opened to the west of the main Freeman pit. A working face of 10 feet or so was developed for about 150 feet along the railroad right-of-way.

A plant of the Washington Brick, Lime & Sewer Pipe Co., for manufacturing common brick, was formerly located south of the railway at Freeman. The clay used was the ordinary Palouse type so common in southeastern Washington (see pp. 327-332 for description and the results of tests), but underlying that material is an unknown thickness of stratified alluvial clays that doubtless belongs to the same series of sediments as those exposed at Manito Station and elsewhere south of Mica Peak. A test hole in the pit floor gave data for the following section:

Section at brick-clay pit, Freeman

	Feet
Palouse clay, reddish and yellowish brown, in part sandy, used for brick	40+
Pit floor	
Sand and clayey sand	8
Boulders and gravel	2
Clay, stratified, very plastic, fine-grained, blue. (Sample No. 79)	3
Clay, similar to above but more sandy	14+

Sample No. 79, of the underlying blue clay, is very plastic and smooth when damp and then has a dark-blue color. When dry it is grayish blue and is compact and very brittle. This material appears to be a kaolin that has become colored by ferrous iron.

Plastic and dry properties Sample No. 79

Plasticity	Good, strong	Volume shrinkage	41.2% dry volume
Shrinkage water	27.0%	Linear shrinkage	16.3% dry length
Pore water	24.5%	Linear shrinkage	10.2% wet length
Water of plasticity	51.5%	Dry condition	Tough and strong

Fired properties Sample No. 79

Cone	Color	Condition	L.S.%d.l.	T.L.S.%d.l.	V.S.%d.v.	Abs.	A.Por.
010	Brown	Hard	5.3	21.6	15.1	29.3	46.0
07	Brown-buff	S.H.	6.3	22.6	17.7	20.2	42.7

Remarks: Best firing range: 06-10. Cone fusion: 20-23. Badly cracked; poor color; but long heat range. Too much plastic material; add nonplastics.

The extent of these or similar low-iron light-firing clays in this vicinity is doubtless considerable, as they have been reported from wells a mile south of Freeman, in the NE¼ sec. 11, (23-44 E) and presumably underlie the Palouse clay eastward to the Manito occurrences.

After the closing of the brick plant at Freeman, a kaolin-washing plant was erected on the same site. It is inoperative at the present time but in 1925-26 handled some 1,500 tons of residual clay from the pit north of the station. The installation and process are described in detail by Harby,[1] designer and former superintendent of the plant. The raw clay was trucked the short distance to the mill where it passed through disintegrating rolls to a blunging or washing apparatus that removed the coarser sand. The resulting slip of suspended finely-divided quartz, muscovite, and kaolin was further classified in a series of troughs and settling tanks until only the purest kaolin reached the open-air drying tank. About 50 tons of clay could be washed per day with a recovery of 35 percent kaolin, 50 percent coarse quartz sand, and 15 percent fine sand and muscovite. The dried clay from the summer's run was shipped in the fall or spring to the plant of the Washington Brick, Lime & Sewer Pipe Co. at Clayton.

Mica district.—In the vicinity of Mica a reentrant in the hills has allowed deep decomposition of the old granitic surface and the accumulation of excellent clays. One or more thin flows of basalt reached into this region, now drained by California Creek, and caused some ponding of water; this no doubt aided in the clay deposition. The basalt cover at the present time is largely removed, but brown residual clay remains in places, although the Palouse clay is even more widespread. In this favorable location, thick beds of nearly white clay have been extensively developed for various ceramic uses. They are known to occur northeast of Mica, and the geologic conditions supplemented by drilling data indicate an extent of more than 3,000 acres in that vicinity.

No doubt the thickness of the beds is extremely variable, for deposits of residual, colluvial, and sedimentary origin are involved. However, a number of test holes were still in white kaolin at 15 feet, and one test showed white clay to reach to a depth of 75 feet. Two miles west of Mica at least 11 feet of plastic white clay underlies a foot or so of ocher, 10 feet of gray sandy clay, and some 5 feet of Palouse clay overburden. Gladding, McBean & Co. have a plant at Mica (formerly operated by the American Fire Brick Co.) and are making a large variety of products. The clay is taken from four places: three a little distance east and northeast of the plant, and one about a quarter of a mile to the north.

Gladding, McBean & Co. pits.—The "north", or fire-clay, pit extends northward for 700 feet as an open cut and quarry along a west hillside. The width of the excavation varies from 50

[1] Harby, J. M., Clay washing: Am. Ceramic Soc. Jour. vol. 6, pp. 197-199, 1927.

to 150 feet, and the most recent working face is 30 feet high. Here 15 feet of roughly stratified sandy brown Palouse clay and some gravel covers the white clay, but in other places there is as little as 2 feet. The workings may be extended for a long distance to the north and east, while the pit floor may be lowered 25 feet or so without causing drainage difficulties; so an immense reserve of fire clay is available.

PLATE 10

A. FIRE-CLAY PIT OF GLADDING, McBEAN & CO. AT MICA.

A 15-foot face of clay is worked and about 15 feet of overburden is stripped. See sample No. 94.

B. PIT OF WASHINGTON BRICK, LIME & SEWER PIPE CO. AT MICA.

Clay is worked in two benches, an upper 40 feet of Palouse clay and a lower 25 feet of refractory lacustrine clay. Each is used in the various mixtures. Sample No. 94-C is of the lower clay.

The white clay is a modified residuum from a granitic rock particularly low in femic minerals. It mostly occurs as a massive plastic material filled with grains of quartz and muscovite. In some places are small lenses (to be measured in inches) of coarse sand composed of quartz, muscovite, and partly altered feldspar, the latter in broken crystals as much as one-half inch long. In general, there is no suggestion of stratification, though toward the south end of the openings a bedded ocherous clay and yellow-stained sand in layers several inches thick underlie the massive clay. The lack of assorting, absence of orientation of the mica plates, an angularity of all coarse grains, indicate a residual origin slightly modified by wash and settling; the clay, then, is best classified as colluvial material formed in the near proximity of water-laid sediments.

In mining, the overburden is stripped off, after which the white clay is loosened by blasting and loaded by hand into cars. These are drawn by a gas-engine locomotive a quarter of a mile to the plant, where the clay is used in all refractories manufactured here.

Sample No. 94, of the fire clay, is tough and plastic and has a bluish-gray color when damp. It dries nearly pure white and is then very compact and brittle. The abundant grains of angular quartz in general do not exceed a millimeter in diameter, and most of the particles are extremely fine. Muscovite flakes are numerous and some are over 2 millimeters across.

Plastic and dry properties Sample No. 94

Plasticity	Strong	Volume shrinkage	27.9% dry volume
Shrinkage water	15.6%	Linear shrinkage	10.3% dry length
Pore water	15.7%	Dry condition	Good
Water of plasticity	31.3%		

Fired properties Sample No. 94

Cone	Color	Condition	L.S.%d.l.	T.L.S.%d.l.	V.S.%d.v.	Abs.	A.Por.
08	Cream	Weak, soft	1.8	12.1	5.4	24.3	40.0
07	Light cream	Weak, soft	2.5	12.8	7.3	22.9	38.0
04*	Light cream	Good, hard	6.6	16.9	18.5	12.8	25.5
02	Light cream	Good, hard	7.3	17.6	20.2	11.6	23.7
6	Light cream	Good	7.5	17.8	20.9	9.6	19.3
12*	Light cream	Good, S.H.	8.8	19.1	24.2	6.5	13.9
15	Light cream	Good, S.H.	10.2	20.5	27.7	6.0	13.1

Remarks: Best firing range: 05-20. Cone fusion : 33+ (washed sample).

Class of ware: Refractories and light cream-colored structural wares. Wash for buff-colored pottery wares.

The "south" pit lies about 200 yards east of the plant and has furnished the material for sewer pipe, hollow block, and similar ware. It covers an area 300 feet north and south, and has been extended eastward to the hill a distance of 400 feet where the face is about 45 feet high. The surface mantle, of from 8 to 20 feet of Palouse clay, has been used with the underlying light-colored clays in the sewer-pipe mixtures. This practice not only eliminated the overburden problem and made a free, smooth-working body but gave to the fired ware the red color which is considered necessary for sewer pipe. Under the brown surface clay is 2 to 6 feet of iron-stained water-worn quartzite pebbles and sand. Below this is an irregular layer, 1 to 2 inches thick, of bog iron that has been deposited on a very uneven erosional surface of kaolin. The lower kaolinic material has nonuniform layers of stained and light-gray plastic clay and very sandy ocherous clay in the upper 4 feet; below that is 10 to 15 feet of sandy micaceous bluish-gray colluvial clay not unlike the fire clay of the "north" pit.

Sample No. 94-B, of the lower blue-gray clay, is slightly finer in grain and a little more plastic than the clay of the "north" pit, but it dries nearly white and in other respects closely resembles the fire clay material. The sample includes only the unstained material.

Plastic and dry properties Sample No. 94-B

Plasticity	Good	Volume shrinkage	21.0% dry volume
Shrinkage water	12.0%	Linear shrinkage	7.6% dry length
Pore water	19.6%	Linear shrinkage	5.6% wet length
Water of plasticity	31.6%	Dry condition	Lamination cracks from auger machine

Fired properties Sample No. 94-B

Cone	Color	Condition	L.S.%d.l.	T.L.S.%d.l.	V.S.%d.v.	Abs.	A.Por.
08	Light gray	Weak, soft	2.8	10.4	8.0	23.5	38.5
07	Light cream	Weak, soft	2.2	9.8	6.5	20.6	34.1
04*	Light cream	Good, S.H.	6.0	13.6	17.0	13.0	25.8
02	Light cream	Good, S.H.	....	....	....	10.7	22.0
3	Light freckled cream	Good, S.H.	8.2	15.8	22.5	8.1	16.2
6-7*	Light freckled cream	Good, S.H.	....	....	....	5.4	11.4
12*	Light cream	Good, few spots, S.H.	12.1	19.7	32.0	3.5	8.0
15	Cream	Good, S.H.	12.3	19.9	32.5	2.9	6.6

Remarks: Best firing range: 05-15. Cone fusion: 32-33.

Class of ware: Need to mix with nonplastic material for buff-colored structural wares. Terra cotta, buff pottery wares, and refractories.

A horizontal bed of white kaolin, about 12 inches thick, was very persistent in parts of the "south" pit now worked out and was unique in appearance. It resulted from the natural washing of the gritty residual clay and a consequent rather complete separation of the component kaolinite and quartz. In one part of the pit, as the face was carried back, this layer was underlain by 2 feet of loose fairly coarse light-colored sand composed of quartz and feldspar grains with flakes of muscovite. This formed the floor of the pit here and had not been penetrated to the clay which underlies it. Above the kaolin was a small amount of sand which graded upward into the gritty highly plastic bluish-gray clay. In another place the kaolin seam was underlain by plastic gray clay similar to the upper member and without the accompanying loose sand.

PLATE 11

A. NEARLY PURE KAOLIN INTERBEDDED WITH THE USUAL REFRACTORY CLAYS AT MICA.

This irregular layer, outlined in black, forms a sticky-plastic band in the pit face. Sample No. 94-A.

B. RAIN-GULLIED RESIDUAL CLAY IN A RAILROAD CUT 1½ MILES NORTH OF MICA.

A sandy refractory clay with scant overburden.

Sample No. 94-A was taken of the kaolin. It is light cream colored when damp and has about the same texture as soap. After drying, it is pure white, only slightly compact, and extremely brittle. A few small aggregates of quartz grains and flakes of muscovite occur in this sample, but except for these the material is entirely free from grit, even when tested between the teeth.

Remarks: Very sticky and gluelike when tempered in water. Cannot be molded. Fires to a gray white and does not fuse till close to cone 35.

The "plastic" pit is one recently opened about 300 yards northeast of the plant. It is in a swale where comparatively recent erosion has stripped the usual Palouse clay overburden from the white clay. The present land surface is in the yellow iron-stained sandy clay that commonly separates the Palouse clay from the high-quality lower clays. This yellow overburden, from 2 to 6 feet thick, is scraped up by a tractor-powered shovel and used in red-firing mixtures. From a smaller, inner pit 12 to 15 feet deep the underlying white clay is being used in place of that formerly taken from the "south" pit.

This white clay shows more evidence of transportation and consequent water classification than is usual on this side of California Creek Valley. Assorting is far from complete, and stratification is rude; but the pit walls show three thick beds of gray clay, in part very soft and plastic, though not free from quartz grains, separated by layers and lenses of clayey to nearly clay-free loose quartz-muscovite sands. These latter are mostly thin, but one lens has a thickness of 4 feet and length of nearly 30 feet. An interesting feature of this pit is the occurrence of a more or less horizontal layer or series of lenses of white, chalk-like kaolin much like that of the old "south" pit.

The company has opened a shallow surface pit in the Palouse clay on a hill 600 feet east of the plant. The clay is a buff-brown loess of the usual appearance and properties. It is scraped from an area 150 feet in diameter to a depth of 15 feet, carried by truck to the plant, and there used in the ordinary red-firing mixtures.

Sample No. 726 is one of two samples of the standard fire-clay mixture taken from the general ground mixtures used at the plant.

Plastic and dry properties Sample No. 726

Plasticity	Good	Volume shrinkage	28.7% dry volume
Shrinkage water	14.9%	Linear shrinkage	10.7% dry length
Pore water	10.6%		
Water of plasticity	25.5%		

Fired properties Sample No. 726

Cone	Color	Condition	L.S.%d.l.	T.L.S.%d.l.	V.S.%d.v.	Abs.	A.Por.
08	Pink-gray	Weak, soft	0.4	11.1	1.0	18.8	33.0
04*	Light cream	Weak, soft	0.5	11.2	1.5	16.1	29.0
02	Light cream	Weak, soft	0.7	11.4	2.0	15.5	29.0
3	Light cream	Weak, soft	0.5	11.2	1.6	14.5	26.7
6-7*	Light cream	Weak, soft	1.2	11.9	3.5	12.7	23.0
12*	Light cream	Good, hard	2.8	13.5	8.0	11.3	22.2
15	Light cream	Good, hard	3.0	13.7	8.8	11.2	23.5

Remarks: Best firing range: 9-15 (fire brick). Cone fusion: 31+.
Class of ware: Now used for a No. 1 siliceous fire brick.

Sample No. 736 is of the standard sewer-pipe mixture; it is partly No. 94-B or similar buff-firing refractory clay and partly Palouse clay from the overburden.

Plastic and dry properties Sample No. 736

Plasticity	Good	Volume shrinkage	26.1% dry volume
Shrinkage water	13.0%	Linear shrinkage	9.6% dry length
Pore water	11.7%	Linear shrinkage	7.0% wet length
Water of plasticity	24.7%		

Fired properties Sample No. 736

Cone	Color	Condition	L.S.%d.l.	T.L.S.%d.l.	V.S.%d.v.	Abs.	A.Por.
08	Buff-brown	Weak, soft	0.0	9.6	0.0	18.3	33.4
07	Lt. red-brown	Weak, soft	0.2	9.8	0.5	15.9	29.4
04*	Brown-red	Good, hard	0.8	10.4	2.5	11.7	22.1
01	Brown-red	Good, S.H.-	1.3	10.9	4.0	10.9	21.4
6-7*	Red-brown, black spots	Good, S.H.	2.9	12.5	8.5	8.3	16.7
10	Dark brown	White blisters, good, S.H.	3.8	13.4	11.0	6.8	13.9
12*	Dark brown	Vesicular, S.H.	3.1	12.7	8.9	2.5	5.4

Remarks: Best firing range: 05-8. Cone fusion: 20.
Class of ware: Used for sewer pipe and other structural wares.

Gladding, McBean & Co., Mica plant.—Clays in the pits are loosened by dynamite, loaded into cars by hand or by a pickup power shovel, and pulled to the plant by a gasoline locomotive. There they are piled in storage sheds, so they may be used separately or mixed, depending on the product desired. The "north" pit fire clay is used for all refractories; a mixture of one-third Palouse clay, 10 percent grog, and the rest from the Sommer (Chester) pit is used for sewer pipe; and a mixture of clay from the "plastic" or the "south" pit and Palouse clay is used for the ordinary red-fired ware.

For all brick, the clay is ground in one 9-foot dry-pan, elevated, screened, and stored in bins. From the bins it goes by automatic feeder to a combination pug mill auger machine and a 14-brick automatic cutter. Face and common brick are then ready for the coal-fired tunnel drier; fire brick are first put through a repress machine. Drying requires 4 days. For hollow ware, the raw clay goes by gravity to one of two wet-pans and then by conveyor belt to a sewer-pipe press. Drying is on a steam-heated floor. The kiln system includes one 26-foot, two 28-foot, five 30-foot, and one 32-foot round down-draft periodic kilns. Fire brick are fired for 8 days to a temperature of cone 14, sewer pipe for 7 days to a temperature of cone 3. In 1937 the output consisted of about 60,000 face and common brick and 20,000 fire brick per day, together with a considerable tonnage of sewer pipe, hollow block, and drain tile.

Washington Brick, Lime & Sewer Pipe Co.—A large clay pit of the Washington Brick, Lime & Sewer Pipe Co. is located on the west side of the valley at Mica. It is operated as a quarry cut, about 400 feet in diameter, all above drainage level in the east side of a prominent hill that rises about 100 feet above the valley floor. A railroad siding allows cars to be loaded near the pit, and the clay is taken to the company's plants at Dishman and Clayton. This clay is similar to the material mined across the valley by Gladding, McBean & Co. The top 40 feet of the total 65 feet is reddish-brown Palouse clay, very uniform in texture throughout, except for ironstained sand and small quartzite pebbles at the bottom. It is used with the underlying clay in the sewer-pipe mixture, thus eliminating a stripping expense too great to be practicable if the lower clay were to be used alone.

Underlying the Palouse clay is 20 to 25 feet of sandy gray clay and clayey sand. The indistinct stratification is essentially horizontal. The material is nonuniform, the texture varying from coarse to fine and the color from light and dark gray to yellow from iron stain. An irregular bed of white to iron-stained kaolin, 3 to 18 inches thick, is associated with loose quartz sands, as in the "south" and "plastic" pits on the east side of the valley, and indicates the former continuity of these clays, now cut by the erosion of California Creek. As would be expected, a bluish-gray tough gritty colluvial clay occurs below the kaolin, as it does in the other workings.

Sample No. 94-C was taken of the lower clay. It forms the floor of the pit and is exposed for several feet in the side. After drying, it is nearly white and corresponds closely with that occurring on the east side of the valley (see sample No. 94-B, p. 247).

Plastic and dry properties Sample No. 94-C

Plasticity	Good	Volume shrinkage	35.1% dry volume
Shrinkage water	19.0%	Linear shrinkage	13.4% dry length
Pore water	13.4%	Dry condition	Good
Water of plasticity	32.4%		

Fired properties Sample No. 94-C

Cone	Color	Condition	L.S.%d.l.	T.L.S.%d.l.	V.S.%d.v.	Abs.	A.Por.
08	Lt. pink-gray	Weak, soft	0.8	14.2	2.4	21.4	35.6
04*	Light cream, near white	Good, rough surface, hard	4.8	18.2	13.8	11.9	23.1
02	Light cream, near white	Good, rough surface, hard	5.4	18.8	15.4	10.8	21.7
6	Light cream near white	Good, rough surface, S.H. -	6.0	19.4	16.9	8.3	16.9
12*	Light cream	Good, S.H.	8.4	21.8	23.3	4.2	9.2
15	Lt. gray	Good, S.H.	9.9	23.3	26.9	3.7	8.2

Remarks: Best firing range: 05-20. Cone fusion: 32+.

Class of ware: Refractories with nonplastics. Terra cotta and buff-colored structural wares. Wash for cream-colored pottery ware.

Just north of the main workings on the west side of the valley is a shallow pit about 125 feet in diameter in a residual granitic material. This is a clayey arkose comprising angular grains of quartz, decomposed feldspar, and abundant muscovite in a binder of clay. No work has been done here for some time, but there is evidently a large quantity of clay and conditions for mining are favorable.

A similar light-gray or nearly white material is exposed in railroad cuts about a mile north of Mica. The grade has been put along a hillside so that as much as 40 feet of the harsh, gritty clay is exposed in the bank. It is like the fire clay used at Troy, Idaho, a feebly plastic, coarse granitic material. Mining conditions here are ideal for an apparently immense body of this clay. A small pit was operated for a short time in this material on the Conlan property in the NE¼ sec. 15, (24-44 E). This is beside the railroad, 1¾ miles north of Mica and 350 feet east of the highway underpass. The excavation is 75 feet long and exposes 12 feet of white clay under 10 feet of sandy clay overburden. A mile or so west of the Conlan property, at Redlin spur on the railroad, a cut exposes 15 feet of clays. These are plastic yellow, gray, and white beds under an overburden that varies from 3 to 6 feet in thickness.

Moran district.—Silver Hill is a prominent elevation lying a few miles southeast of Spokane and is a western continuation of the granitic and metamorphic rocks that form Mica Peak. Light-colored clays would be expected to occur near the 2,500-foot level in favorable localities, and in fact such deposits were exploited years ago. They have been encountered in wells on Moran Prairie, at the western foot of Silver Hill, and one boring showed 11 feet of yellowish-gray clay. Before 1900 clay was mined and shipped to potteries from pits in the NW¼SW¼ sec. 10, (24-43 E), on the Peter Myren property. To the east, on the

C. H. Stumpf property, a bored well is reported to have gone through 10 to 14 feet of Palouse clay and then about 75 feet of very sticky-plastic white clay underlain by a sandy water-bearing material. This report is unverified, but, except possibly for the unusual thickness of the deposit, the section accords with what would be expected. A possible continuation of this clay deposit occurs in the NW¼NE¼ sec. 15, (24-43 E); it is a light-gray very plastic clay, but fires to a pinkish buff at cone 04 and darker colors before fusion at cone 10.

Cheney-Medical Lake district.—A still more westerly extension of the old rocks are the low hills in the Cheney-Medical Lake region. Good clays would be expected near the contact with the basalt and have been reported in two places. One is from a well on the Wellsandt property, just south of Cheney, in the E½NW¼ sec. 23, (23-41 E). A buff-firing alluvial clay associated with lignitic material was struck under a scant soil and gravel overburden; the thickness of the deposit is not known. Another is near the north end of West Medical Lake, possibly in sec. 10, (24-40 E), where conditions are particularly favorable for the existence of light-firing clays.

Chester district.—Spokane Valley, north of Mica Peak, is filled with a thick accumulation of stream-deposited sand and gravel, so that clays formed from the near-by feldspathic rocks are effectually buried. Some are known, and others may be sought, on gentle south slopes near the border of the valley-fill. One deposit of this kind, locally known as the Chester or Vera clay, is in the SE¼ sec. 35, (25-44 E), mostly on the A. M. Sommer property. Development work was begun in this vicinity many years ago, and since then a large tonnage has been removed. One of the earliest pits to be opened was an open cut in what is probably a colluvial clay. The material is nonuniform and generally coarse in texture. Sufficient bond is present to give fair plasticity, but the clay is sandy and commonly much iron stained. It was formerly hauled 3 miles to the small Chester plant for making refractory ware.

Sommer pit.—The main Sommer pit, now being worked steadily, is some 300 yards southeast of the old fire-clay pit just mentioned. It is about 300 feet wide and has a 20- to 25-foot working face that is 400 feet long. The overburden consists of sandy, pebbly, and bouldery Palouse clay that is mostly between 1 and 5 feet thick and a discontinuous layer of bog iron not over a foot thick. This is stripped off, exposing horizontally stratified clay of the Latah formation for the 20 feet or so to the pit floor. Most of the lower clay is dark gray when damp and dries to a very light gray, but original concentrations of iron oxide and irregular staining by iron-bearing solutions have produced a yellow ocher in parts of the bed, and, because of high carbon content, the clay near the foot of the present face is nearly black. All is very fine grained and "fat", though paper-thin layers of very fine silt are present and responsible for the marked lamination of the more thinly bedded parts of the deposit. As in other deposits of the Latah, leaf imprints are plentiful on the bedding planes, and carbonized vegetal matter occurs occasionally.

The clay is loosened with blasting powder, then loaded into trucks by a gasoline pick-up shovel. It is carried to the principal users, Gladding, McBean & Co. at Mica, and the Washington Brick, Lime & Sewer Pipe Co. at Dishman, though in the long period of operation a considerable amount has been shipped by rail and truck as far as Pacific Coast points. Drilling is reported to show a maximum thickness of 45 feet, and although the total area is probably not much over 20 acres, this erosional remnant contains a large reserve.

Sample No. 100 is of the main body of clay. It is dark gray, plastic and soft when damp and becomes very light gray, compact, and brittle when dried. The texture is uniform and very fine. Only when taken between the teeth can the small amount of grit be detected.

Plastic and dry properties Sample No. 100

Plasticity	Sticky	Volume shrinkage	38.7% dry volume
Shrinkage water	21.5%	Linear shrinkage	15.0% dry length
Pore water	15.2%	Dry condition	Lamination cracks from auger machine
Water of plasticity	36.7%		

Fired properties Sample No. 100

Cone	Color	Condition	L.S.%d.l.	T.L.S.%d.l.	V.S.%d.v.	Abs.	A.Por.
012	Lt. pink-gray	Weak	....	....	....	26.3	....
08	Lt. buff	Weak, soft	2.0	17.0	5.9	23.7	39.0
04*	Lt. buff	S.H.	3.8	18.8	10.8	11.6	20.4
01	Lt. buff	S.H.	9.3	24.3	25.4	7.7	16.7
6	Buff	S.H.	10.5	25.5	28.5	2.7	6.3
10	Uniform lt. gray	Vitreous, S.H.	13.0	28.0	34.2	0.6	1.5
12*	Lt. gray	Good, S.H.	13.0	28.0	34.2	1.1	2.7

Remarks: Best firing range: 06-12. Cone fusion: 27 and 28. Too much plastic material to use alone. High shrinkage and cracking.

Class of ware: Good color and strength for use in terra cotta and other structural wares and buff-colored pottery.

Sample No. 101 was taken where impregnation by iron-bearing solutions and leaching along silty bedding planes has given a marked lamination to the soft clay. The color of this material varies through light gray, light buff, yellow and pink, with darker tones when wet. The dry clay is more compact and brittle than sample No. 100 and pieces break with a conchoidal fracture.

Like the other, this clay is practically free from grit and has a very smooth, even texture.

Remarks: Tests on this clay are practically identical with those made on sample No. 100 in all but the color of the fired pieces, the iron oxide content causing uneven mottling in reds and browns.

Tiano pit.—Adjoining the Sommer pit on the south is the old Tiano pit, 125 feet wide and 300 feet long, in the same bed of clay. It has been many years since any work was done here, and the 12- to 15-foot face has sloughed in, but apparently varied color phases were particularly common. The pit floor shows large areas of hard, brittle fine-grained claystone so high in iron oxide that it is brick red in color and classed as ocher.

To represent the decomposition products of the granitic rock along Spokane Valley, a sample was taken of sandy residual clay removed from a well in the NW¼ sec. 31, (25-45 E). Similar clays occur at other places in this section and to the north in the SW¼ sec. 30. Some may be alluvial in origin, but all appear to be rather refractory and buff firing. This particular sample is from no great depth and lies under but little overburden on a gentle slope leading south toward Mica Peak. Such loose clay would long since have been removed by erosion but for the fact that it has been protected by a thin basalt flow, remnants of which still remain as great boulders.

Sample No. 104, of this clay, is a gray and grayish-green color and very sandy. It is composed of fragments of quartz and abundant muscovite with a weak clay bond, all being derived from a rock on the order of a micaceous gneiss rather low in femic minerals.

Plastic and dry properties Sample No. 104

Plasticity	Weak	Volume shrinkage	14.7% dry volume
Shrinkage water	9.0%	Linear shrinkage	5.1% dry length
Pore water	20.5%	Linear shrinkage	4.7% wet length
Water of plasticity	29.5%	Dry condition	Moderate strength

Fired properties Sample No. 104

Cone	Color	Condition	Abs.	A.Por.
04	Light pink-buff	Good, sandy texture. Soft	26.2	38.2
03	Light pink-buff	Good, sandy texture. Soft	24.6	39.6
3-4*	Light red-buff	Good, sandy texture. Soft		

Remarks: Best firing range: 6-12. Cone fusion: 27-28.

Class of ware: No. 2 or No. 3 refractory material. Without purification, too high temperature is needed for ordinary structural wares.

In some places in this region pegmatite occurs in great masses and as dikes cutting the granite or gneiss. As excellent deposits of clay owe their origin to the decomposition of such rock on the south side of Mica Peak, they might possibly occur also on the north side, although erosion has been more active here. A coarse pegmatite containing large crystals of feldspar crops out at the head of "Saltese Lake", but the rock at this particular place is fresh and unaltered. Prospecting would doubtless reveal clays hereabout; in fact, large deposits of white clay are said to exist in the S½ sec. 4, (24-45 E). Probable occurrences should be sought throughout Saltese Creek drainage below the 2,500-foot elevation, and in favorable places up to the 3,000-foot elevation. They might exist, also, in the vicinity of Liberty Lake, though it is doubtful if there they extend much above the 2,500-foot elevation.

H. Seidel Clay Co.—This company, successor to the plant of the Standard Stoneware Co., is located at Chester. Clay is obtained from the Sommer pit and to it is added 5 or 6 percent Palouse clay from Freeman. After a preliminary soaking, the clay is ground in a small wet-pan and then made into flower pots on a power-operated jigger wheel. A hot-room is used to dry the ware, and firing is in an 8-foot round down-draft kiln. Approximately 50,000 flower pots, the only product, are made per year.

Washington Brick, Lime & Sewer Pipe Co., Dishman plant.—This company has its sewer-pipe factory at Dishman Station, about 5 miles east of Spokane, where transportation facilities and labor conditions of a large city more than offset the expense of freighting the clay to the plant. In 1937 60 percent of the raw clay was from the Sommer pit, east of Chester, and 40 percent from the company's Palouse clay pits at Freeman and Mica.

The clay is dumped from gondolas or trucks into large storage bins. From there it goes by tractor shovel and reciprocal feeder to two 9-foot dry-pans. It is then screened and elevated to overhead storage bins of 5,000 tons capacity. These feed to two 8-foot wet-pans, and the clay is then elevated to a feeder which automatically supplies the sewer-pipe press. The ware in various sizes up to 30 inches is dried on steam-heated floors from 8 to 24 days and is fired in eleven 28-foot kilns. These are all of the round down-draft type. Two days are allowed for water-soaking and 4½ days to complete the firing. The output in normal years amounts to 3,000 to 4,000 tons.

Pleasant Prairie district.—Light-gray residual and lacustrine clays occur at many places north of Spokane Valley near the contact of the basalt and the older rock. The basalt originally extended to the mountain mass of which Mount Spokane is a part and formed a thin flat floor over the lower slopes to the 2,500-foot elevation. Later the streams draining this area deeply incised the basalt plain, cutting through in so many places that now the old level is maintained by only a few flat-topped hills and benches. Five Mile, Pleasant, and other "prairies" are remnants of the old basalt surface.

The removal of the basalt has exposed underlying Latah beds in a few places, as on the south side of Little Baldy. Here, the buff-gray silty sediments crop out owing to undercutting by the Spokane River and recent road-grading operations. More extensive beds occur north and northeast of Little Baldy, as has been shown by scattered wells and a few drill holes. No samples are available, but the indications are that a large area of probably light-firing clay not unlike the Deadman Creek material (see p. 258) underlies the head of Bigelow Gulch in sec. 25, (26-43 E) and the neighboring region.

Pleasant Prairie lies near the eastern boundary of the basalt in this vicinity and close to hills of granitic rock high in feldspar. Erosion of the prairie since Miocene time has been slight, so a level area, several square miles in extent, still remains. Beneath the basalt cover and to the east of the old lava front would be a logical place to expect high-grade residual clay. Examination of wells bears this out, and samples of the clay were taken from two localities.

Sample No. 117, from the Skattum place, is from 12 feet below the surface in a partially filled well in the center of the S½ sec. 11, (26-44 E). This is the top of the white clay; the shaft extended to this depth through the disintegration product of the old basalt capping, a nonuniform mass of brown Palouse clay and rock. The depth to which the white clay extends could not be verified, but several farmers located on the prairie concur in the estimate that 30 feet is an average thickness in this district. This residual clay is gray, very plastic and unctuous, and has the subtranslucent appearance of kaolin when damp, although scattered throughout are small angular grains of quartz and a little muscovite. The dry lumps are light colored, very tough and compact. It is assumed that a grittier, more arkosic material will be found at greater depth.

Fired properties Sample No. 117

Cone	Color	Condition	L.S.%d.l.	T.L.S.%d.l.	V.S.%d.v.	Abs.	A.Por.
08	Lt. buff	Good, S.H.-	3.8	15.9	10.8	21.2	37.8
04*	Bright buff	Quartz cracks, S.H.	8.7	20.8	24.0	7.0	15.0
02	Bright buff	Quartz cracks, S.H.	9.3	21.4	25.5	4.1	9.5
3	Buff	Quartz cracks, S.H.	9.9	22.0	26.8	2.6	5.5
6-7*	Buff	Quartz cracks, S.H.	10.2	22.3	27.5	1.7	3.6
15	Brown	Quartz cracks, good, S.H.	11.1	23.2	29.6	1.9	4.2

Remarks: Best firing range: 08-20. Cone fusion: 29. Needs nonplastic material.

Class of ware: No. 2 refractories (siliceous); buff-colored structural wares; terra cotta; wash for buff-colored pottery.

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Sample No. 117-A, from the F. J. Fitzgerald place, came from under 16 feet of loose soil and gravelly material in a well located in the NE¼SW¼ sec. 23, (26-44 E). This is about 2 miles south of the Skattum well. The shaft had penetrated the residual clay for 4 feet. The clay is a light-gray gritty material—a typical arkose—composed of very coarse grains of quartz, unaltered feldspar, and muscovite. This clay is entirely interstitial so that the original granitic texture is retained. A slight amount of iron staining, derived from the Palouse clay overburden, shows in the sample. The sample was washed before testing and the residue removed on a 200-mesh screen. When tempered with 38.1 percent water, a good plastic strength was developed. Hard bodies for buff-colored structural wares can be obtained between cones 04 and 12. The washed body can also be used for buff-colored pottery. As the cone fusion was 31, the clay, if properly grogged, will have a refractory value.

The overburden in this region varies from only a thin soil to 30 feet or so. Doubtless the underlying clay, also, is variable in thickness; so extensive prospecting, utilizing a well-drilling rig, should precede any attempt to develop the deposits. The roads are good and the distance to rail connection is not great, but some drainage problems would probably arise in any pit in this area.

Deadman Creek district.—A great thickness of horizontally bedded Latah clay occurs in the sides of the valley occupied by Deadman Creek. The series shows in wells and excavations, but, owing to a thin covering of soil washed from higher elevations and a basalt cover on the hills, natural exposures are scarce. Some beds in this vicinity show the effect of localized sedimentation from the erosion of the nearby granite. Such clays are buff firing and rather refractory—characteristics at decided variance with the common properties of Latah clay-shales.

On the Fuher place, in the E½ sec. 28, (27-44 E), a prospect shaft has been sunk on the north slope of the valley. It exposes 20 feet of clay; and at least an additional 38 feet of similar clay is shown, by drilling, to underlie this. The clay is fine-grained though sandy in part. The stratification is very distinct and abundant leaf impressions occur on the bedding planes.

Sample No. 118-A was taken from the upper 4 feet of beds exposed in the shaft. It is gray in color but is slightly stained with iron oxide, the coloring matter following minute hairlike holes which extend irregularly through all the lumps. The texture is very fine and smooth, so that grit in slight amount can be detected only when tested between the teeth. The dry lumps are compact but very brittle. The following results were obtained on a mixture of samples No. 118-A and 118-B.

Remarks: When tempered with 29.4 percent water, a good plastic strength is developed. Firing range is cones 04-12. As the fired color is a good buff and the cone of fusion is 26, the clay can be used for buff-colored structural ware, terra cotta, and, when washed, for buff-colored pottery.

Sample No. 118-B was taken from the 10 feet of material exposed below No. 118-A in the shaft. The color is a little lighter gray than the upper sample, and the texture is very different. It is composed of fine siltlike sand, abundant fine muscovite, and a binder of clay, so lumps readily break to powder between the fingers and have a gritty but not very harsh feel.

Plastic and dry properties Sample No. 118-B

Plasticity	Good	Volume shrinkage	20.4% dry volume
Shrinkage water	11.8%	Linear shrinkage	7.3% dry length
Pore water	16.5%	Dry condition	Good
Water of plasticity	28.3%		

Fired properties Sample No. 118-B

Cone	Color	Condition	L.S.%d.l.	T.L.S.%d.l.	V.S.%d.v.	Abs.	A.Por.
08	Light buff	Weak, very soft	0.0	7.3	0.0	21.0	34.6
02	Light buff	Good, hard	2.3	9.6	6.6	19.2	32.9
1	Buff	Good, hard	2.7	10.0	7.7	17.8	31.4
3-4*	Buff	Good, hard	2.9	10.2	8.5	16.5	29.2
6	Buff	Good, S H.	4.3	11.6	12.3	15.0	27.8
12*	Gray-buff	Good, S H.	7.4	14.7	20.7	1.3	2.7
15	Gray-brown	Near vitreous, S.H.	8.3	15.6	22.8	....	....

Remarks: Best firing range: 02-15. Cone fusion: 28.

Class of ware: No. 2 refractory; buff-colored structural wares; terra cotta. Grind or wash for buff-colored pottery.

Sample No. 118-C, from the bottom 6 feet in the shaft, is practically identical with the middle member, the only difference being a slightly finer grain and somewhat darker color.

Plastic and dry properties Sample No. 118-C

Plasticity	Good	Volume shrinkage	30.8% dry volume
Shrinkage water	17.5%	Linear shrinkage	11.6% dry length
Pore water	16.1%	Linear shrinkage	8.2% wet length
Water of plasticity	33.6%	Dry condition	Strong

Fired properties Sample No. 118-C

Cone	Color	Condition	L.S.%d.l.	T.L.S.%d.l.	V.S.%d.v.	Abs.	A.Por.
02-01	Lt. brown-buff	Good, hard	3.2	14.8	9.3	11.7	21.8
1*	Lt. brown-buff	Good, S.H.	6.5	18.1	18.4	8.0	16.7
3-4*	Lt. buff-brown	Good, S.H.	7.5	19.1	20.9	6.1	12.8
6-7*	Lt. buff-brown	Good, S.H.	8.2	19.8	22.7	3.4	7.1
12*	Brown and black	Bloated, blistered, S.H.	4.3	15.9	12.3	2.0	3.8

Remarks: Best firing range: 03-10. Cone fusion: 20.

Class of ware: High shrinkage. Brown and buff-colored structural wares; terra cotta.

To the west of the Fuher shaft about a quarter of a mile, at nearly the same elevation, a small prospect pit has been dug. Eight feet of Palouse clay overlies a thin layer of limonite under which is a plastic gray clay to a depth of at least 4 feet.

Sample No. 118-D, of this lower clay, is a very light brownish gray and resembles, in some ways, the upper member from the shaft to the east (No. 118-A). It contains a small amount of very fine grit and some muscovite, but, in general the texture is very uniform and fine, so that the clay has a smooth, unctuous feel.

Plastic and dry properties Sample No. 118-D

Plasticity	Good	Volume shrinkage	35.7% dry volume
Shrinkage water	20.4%	Linear shrinkage	13.7% dry length
Pore water	18.7%	Linear shrinkage	9.0% wet length
Water of plasticity	39.1%	Dry condition	Lamination cracks from auger machine

Fired properties Sample No. 118-D

Cone	Color	Condition	L.S.%d.l.	T.L.S.%d.l.	V.S.%d.v.	Abs.	A.Por.
08	Light buff	Weak, soft	2.5	16.2	7.2	25.1	40.3
06	Lt. cream	Good, hard	3.7	17.4	10.7	20.3	34.4
04*	Bright buff	Good, S.H.	5.9	19.6	16.6	11.9	22.9
02	Bright buff	Good, S.H.	7.1	20.8	19.7	10.6	21.7
6	Deep buff	Good, S.H.	8.3	22.0	22.8	2.6	5.8
12*	Gray-brown	Good, S.H.	8.9	22.6	24.4	1.4	3.3
15	Gray and brown	Few blisters, good, S H.	5.8	19.5	16.4	5.0	10.0

Remarks: Best firing range: 05-12. Cone fusion: 32-33.

Class of ware: Refractories, but add nonplastic material. Buff-colored structural wares: terra cotta; buff-colored pottery.

These Deadman Creek clays are ideally situated for ease of mining, having all the advantages of a side-hill location and small amount of over-burden, but the transportation at present must be over 5 miles of ordinary country roads to rail connections.

Indications of an underlying body of light-colored clay are plentiful along the road running north through the center of secs. 27 and 22, (27-44 E). This particular location is nearly at the crest of one of the flat-topped hills, where a thin flow of basalt, since decomposed, reached at one time. A well was put down here through 10 feet of surface material and brown Palouse clay and was continued through from 15 to 20 feet of nearly white sand; below this was 5 feet of similar sand, though stained yellow, lying on bedrock.

Sample No. 127 was taken of this very light-gray, nearly white, loosely consolidated clayey sand. Lumps have a texture much like that of a medium grained sandstone, but, when pressed between the fingers, disintegrate readily, and the kaolin present whitens the fingers as does chalk. The material is probably a residual product and is composed of angular grains of quartz, practically unaltered feldspar, and much muscovite. There is enough clay substance from the kaolinization of part of the feldspar to form a weak bond for the granular material. The only other clay known to resemble this is the finer portion from the pit at Freeman where the Washington Brick, Lime & Sewer Pipe Co. obtain part of their fire-clay body. The distance from a railroad and the unknown extent of the deposit detracts from a possible value.

Plastic and dry properties Sample No. 127

Plasticity	Good	Volume shrinkage	11.2% dry volume
Shrinkage water	6.2%	Linear shrinkage	3.9% dry length
Pore water	16.4%	Dry condition	Moderate strength
Water of plasticity	22.6%		

Fired properties Sample No. 127

Cone	Color	Condition	L.S.%d.l.	T.L.S.%d.l.	V.S.%d.v.	Abs.	A.Por.
03	Lt. cream	Weak, soft	0.1	4.0	0.3	20.5	34.3
1	Lt. cream	Weak, soft	0.7	4.6	2.2	20.4	35.3
3-4*	Lt. cream	Weak, soft	1.3	5.2	3.9	17.2	29.9
6-7*	Lt. gray	Weak, soft	2.0	5.9	5.8	16.3	27.8
10	Near white	Good, hard	....	....	....	13.6	....
12*	Near white	Good, S.H.–	4.2	8.1	11.9	7.7	15.2

Remarks: Best firing range: 10-18. Cone fusion: 28+. At all cones, sandy, granular.

Class of ware: No. 2 siliceous refractory. Wash out sand for stronger buff-colored wares.

About a quarter of a mile south of the deposit just mentioned is exposed a very plastic light-gray clay in material removed from an old well. Surface clay was so mixed with this that a sample was not taken, but the occurrence is interesting as an indication of the extent of the underlying body of clay in this region.

Gray lacustrine clays, probably of the Latah formation, are exposed in a road cut northeast of Chattaroy, in the NW cor. sec. 28, (28-44 E). A face 8 feet high at its maximum point and 75 feet long indicates a probably extensive body of this clay and one which is overlain by only a slight thickness of soil and objectionable material. The stratification is horizontal and massive, and, except for being yellow stained at the base, the whole exposure is very uniform. This deposit is similar in origin and occurrence to the Deadman Creek clays and doubtless was formed in the same body of water. It lies in the valley of Deep Creek, and is a remnant that has been left well up on the valley side by the stream erosion of a once widespread series of beds.

Sample No. 128 of this clay is medium gray in color and darker when damp. It is sandy, but the texture is very fine and uniform. When dry, the lumps are soft and crush easily between the fingers to a velvety, siltlike powder.

Remarks: When tempered with 30.7 percent water, a good plastic strength is developed. Buff and brown colors are obtained when fired between cones 04 and 8. The deformation point is cone 14. Nonplastic material must be added to reduce the shrinkage.

Five Mile Prairie district.—Well-bedded clays of the Latah formation underlie the basalt capping of Five Mile Prairie and are exposed in the side slopes at a few places. Dark-firing shaly phases, from near Little Spokane River, are mentioned on page 272; a better quality of clay occurs on the opposite side of the area on the John Reshoft property, in the NW$\frac{1}{4}$ sec. 26, (26-42 E). This material crops out in a ravine a short distance above the road and is very light gray in color—more nearly white than the usual Latah clay. The texture is fine and uniform, and, as in the Sommer clay, grit can be detected only between the teeth. Nevertheless, the material is silty and very moderately compact, so that dry lumps readily disintegrate to a smooth white impalpable powder between the fingers. Leaf imprints are particularly abundant in this clay.

Preliminary tests show good plasticity and 8 percent dry linear shrinkage. At cone 04 it has 10 percent additional shrinkage and develops a steel-hard, strong body of low porosity and buff color. The large amount of this clay that is apparently available on the slopes, the scant overburden there (2 to 8 feet), and the accessibility warrant more complete prospecting and testing.

Milan district.—An interesting and possibly valuable deposit of clay has been exposed by a small landslide one-half mile southeast of Milan. This occurrence is in the north center of sec. 2, (28-43 E), on the west side of the Little Spokane River. It is ideally situated for working, as it lies practically on a railroad and has a hillside exposure. Similar clay is reported to underlie the town of Milan, and from general indications a large amount is available in this vicinity. A hill rises with moderate slope for 150 feet on the west side of the valley, and at higher levels there are outcrops of basalt. Since the deposition of the clay, a great accumulation of boulders and glacial debris has been deposited throughout this region; it is such material that would constitute the overburden of the clay and might render mining expensive. However, where sampled, the deposit carried only a thin mantle of soil, so favorable locations might be found if a little prospecting were done.

Sample No. 130-A was taken from the bottom member of the exposure, which, in all, is about 30 feet long and 25 feet high on a 30° slope. It is a dark bluish-gray clay that is residual or possibly colluvial in origin, derived from granitic rock. The material is considerably jointed, and iron-bearing solutions have worked into these cracks, staining some of the clay. The large content of angular quartz grains, ranging from 1 to 5 mm., makes the clay very gritty and harsh. The clay substance, when damp, is smooth, plastic, and unusually tough. The dried lumps are light bluish gray and are very compact. It is slightly darker in color but otherwise is very similar in appearance to clay from Mica (see sample No. 94).

Plastic and dry properties Sample No. 130-A

Plasticity	Good	Volume shrinkage	14.4% dry volume
Shrinkage water	7.8%	Linear shrinkage	5.1% dry length
Pore water	16.3%	Dry condition	Good
Water of plasticity	24.1%		

Fired properties Sample No. 130-A

Cone	Color	Condition	L.S.%d.l.	T.L.S.%d.l.	V.S.%d.v.	Abs.	A.Por.
06	Light buff	Soft	....	....	....	20.8	....
02-01	Light buff	Soft	1.2	6.3	3.6	20.2	35.9
3-4*	Light buff	Soft	4.6	9.7	13.1	16.2	29.9
6	Light buff	Soft	4.9	10.0	14.0	14.7	28.2
10	Light buff	Hard	6.8	11.9	19.0	11.2	22.8
12	Light buff	Hard	8.0	13.1	22.0	8.0	16.7

Remarks: Best firing range: 10-15. Cone fusion: 28+. Quartz cracks throughout.

Class of ware: No. 2 refractory. Grind or remove quartz and decrease the firing temperature for buff-colored structural wares.

The upper clays in this deposit are poorly exposed but are apparently of sedimentary origin. All but the top member appear to be dark colored, either yellow or brown, and resemble the soft, sandy clay-shales of the Latah formation.

Sample No. 130-B was taken of the top bed, which may be only a foot or so in thickness. It is a soft, sticky, plastic clay, very fine and even grained and of a slightly yellowish light-gray color. The small content of sand is finely divided so the clay is smooth in texture. As the bed lies just under the top soil it has been considerably stained by iron-bearing solutions and disturbed by plant roots. A detrimental feature is the close proximity of a coarse siliceous sand which would make a clean separation of the light-colored clay difficult. Further prospecting might prove a workable quantity of this clay to be available; certainly the indications and the results of laboratory tests warrant some exploration.

Plastic and dry properties Sample No. 130-B

Plasticity	Good	Volume shrinkage	31.1% dry volume
Shrinkage water	17.2%	Linear shrinkage	11.7% dry length
Pore water	16.6%	Linear shrinkage	7.0% wet length
Water of plasticity	33.8%	Dry condition	Good

Fired properties Sample No. 130-B

Cone	Color	Condition	L.S.%d.l.	T.L.S.%d.l.	V.S.%d.v.	Abs.	A.Por.
06	Cream	Good, S.H.	....	10.7	....	15.8	30.0
01	Cream	Good, S.H.	8.2	19.9	22.7	7.6	15.4
6	Light buff	Good, S.H.	10.9	22.6	29.2	5.1	11.4
15	Light gray and brown	Good, vitreous, S.H.	12.3	24.0	32.4	1.5	3.5

Remarks: Best firing range: 08-15. Cone fusion: 31-32. Needs non-plastic material to reduce shrinkage.

Class of ware: Refractories; buff-colored structural wares; terra cotta; and buff-colored pottery.

Deer Park district.—Nearly white clays underlie part, at least, of a low rolling plain many square miles in area in the vicinity of Deer Park. The clays appear to be about contemporaneous with the Miocene basalt, hence are doubtless correlatives of the Latah formation. They represent the decomposition and erosion of the Loon Lake granite and the deposition of sediments in lakes or ponds where there was very little admixture of detritus tending to impair the purity of the kaolin. The beds are concealed by a variable overburden of soil, glacial and Palouse clays, and gravels, but their extension is indicated by the physiographic relations and by well logs. They have been developed in only one place in Spokane County, at the Conner pit, though worked extensively nearby in Stevens County.

The S. M. Conner clay pit is about 5 miles from Clayton in the NE¼NE¼ sec. 4, (29-42 E). It lies in a region of low relief just a short distance south of hills of granite and metamorphic rock. The pit measures about 75 feet by 125 feet and has been excavated to a depth of about 17 feet. An overburden 3 to 7 feet thick is stripped back from the working face. This surface mantle, probably glacial, consists of loam with various-sized pebbles and cobbles; it overlies a coarse reddish-yellow clayey sand filled with water-worn pebbles and larger rocks. Between the overburden and the clay is a nearly continuous layer of bog iron about 4 inches in thickness, which carries unusual hollow spherical concretions of harder limonite containing a fine blue or yellow sand. Beneath the overburden are thick-bedded horizontal strata of light-gray and nearly white plastic clays. These have been shown by boring to extend to a depth of 30 feet, where the auger was stopped by hard material that was probably a layer of limonite. To allow for drainage, only the upper 12 feet has been used but this is, with slight exception, very high-grade material. In mining, there were encountered a pocket of rather carbonaceous dark-gray clay and a lenticular bed of clayey sand, about a foot thick but of small areal extent. The nonuniformity of strata is characteristic. Some phases are smooth and unctuous, others are very fine grained but gritty, and necessarily the alumina and silica content in different parts shows corresponding divergence. As a large quantity is available of any of these varieties, this feature is hardly a detriment and may possibly increase the adaptability of the deposit, providing care is used in mining.

The pit has not been operated since 1927; formerly the Washington Brick, Lime & Sewer Pipe Co., at Clayton, was the largest user of this clay. It was mined by pick and shovel and then hauled by truck to the plant, where it was employed as the main constituent of their terra cotta body. The lower white clay makes a very good stoneware body and was being used in increasingly large amounts by the Inland Empire Pottery Co. when they were operating.

Sample No. 135, taken from the working face of the pit, is a very light gray soft, plastic clay. When dry it is nearly pure white and is softer and less brittle than some other clays of this region. It is gritty from very finely divided quartz grains and contains considerable muscovite.

Plastic and dry properties Sample No. 135

Plasticity	Good	Volume shrinkage	23.2% dry volume
Shrinkage water	12.9%	Linear shrinkage	8.4% dry length
Pore water	15.6%	Linear shrinkage	7.0% wet length
Water of plasticity	28.5%	Dry condition	Good

Fired properties Sample No. 135

Cone	Color	Condition	L.S.%d.l.	T.L.S.%d.l.	V.S.%d.v.	Abs.	A.Por.
07	Cream	Weak, soft	-0.1	8.3	-0.4	19.8	32.4
04*	Light buff	Good, hard	0.0	8.4	0.0	....	....
02	Light buff	Good, hard	1.3	9.7	3.8	17.0	29.0
3	Buff	Good, S.H. –	2.9	11.3	8.4	11.8	21.7
12*	Light gray	Good, S.H.	8.6	17.0	23.6	1.9	4.3
15	Light gray	Vitreous, good, S.H.	....	....	....	0.1	0.2

Remarks: Best firing range: 02-15. Cone fusion: 29-30.

Class of ware: No. 2 siliceous clay refractory. This sample would need a little more nonplastic material in order for it to be used alone for buff-colored structural wares. Terra cotta and buff-colored pottery if washed or ground fine.

Plants manufacturing stoneware and pottery have operated at various times in the Spokane region and have been successful in producing a good grade of ware from the local clays. That eventually they have all closed has been due to financial and other reasons, chief of which was probably lack of adequate market, but not to unsuitability of clays. One of the most recent large-scale operations was the Inland Empire Stoneware Co. of Hillyard. That concern utilized Palouse clay from Freeman for flower pots up to 6 inches in diameter; yellow plastic clay from the A. B. pit (Stevens County), mixed with some Palouse clay, for the larger flower pots; and white clay from the Conner pit (Spokane County) for stoneware and yellow earthenware. These clays cost, laid down at the plant, approximately $4.00 per ton. The yearly output, during the best years of operation, was about 100 carloads of stoneware and 25 carloads of flower pots, shipped throughout the Pacific Northwest.

Sample No. 133-A was taken of the ground material that was used for flower pots at this plant. It is a mixture of yellow clay from the A. B. pit in Stevens County and of Palouse clay from Freeman.

Plastic and dry properties Sample No. 133-A

Plasticity	Good	Volume shrinkage	32.1% dry volume
Shrinkage water	17.5%	Linear shrinkage	12.1% dry length
Pore water	13.6%	Dry condition	Strong
Water of plasticity	31.1%		

Fired properties Sample No. 133-A

Cone	Color	Condition	L.S.%d.l.	T.L.S.%d.l.	V.S.%d.v.	Abs.	A.Por.
06	Lt. brown-red	Good, hard	2.7	14.8	7.7	13.0	14.8
02	Bright brown-red	S.H.	5.0	17.1	14.4	9.2	18.8
01	Bright brown-red	S.H.	6.2	18.3	17.5	7.1	14.6
3-4*	Bright brown-red	S.H.	7.4	19.5	20.6	5.4	11.8
6	Dk. brown-red	S.H.	7.9	20.0	21.8	3.2	7.2
12*	....	Badly fused	....	....	....	....	....

Remarks: Best firing range: 06-8. Cone fusion: 14.

Class of ware: High shrinkage for auger-machine work and structural wares. Used for flower pots.

DARK-FIRING LATAH CLAYS

Dark-firing clays and shales are, of course, abundant in the Spokane region, for those of the Latah formation are predominantly of this class, and the Palouse and glacial clays all belong here. The Latah beds formerly covered much of the area up to an elevation of about 2,100 feet. After deposition, the beds were covered by flows of basalt and in many places were cut and intruded by dikes and sills of that rock. Erosion, both before and after the coming of the basalt, has removed a great amount of these soft deposits, so exposures are mostly confined to hillsides below a protecting capping of basalt or where erosion has stripped off the cover and has had insufficient time to remove the sediments.

In the Spokane vicinity the Latah beds were laid down in lakes and ponds on the old surface of granitic and metamorphic rock; it is doubtful if the strata were interbedded with contemporaneous basalt flows, though that is the usual occurrence in extensions of the formation outside of this immediate area [1]. The detrital material, if not actually derived from the basalt, was in all but a few places so impregnated with mineral solutions from the basalt or, possibly, mixed with wind-borne volcanic ash, that the beds are relatively high in iron oxide and other impurities detrimental to most ceramic uses.

The sediments are mostly gray or buff-colored clays or silty clays; some sands occur, but gravels are uncommon. Individual members are commonly uniform in composition and texture and may form thick beds. Cross-bedding is comparatively rare. The stratification is very distinct in most exposures, and leaf impressions are abundant on bedding planes. In some places sufficient vegetal matter is present to make the clays carbonaceous or even to form thin coaly seams. Some clays of this formation are soft and plastic and the associated silts and sands are not compact, but far more commonly the sediments are somewhat indurated and so are classed as shales, sandy shales, and soft clayey sandstones. The most shaly character is developed where the beds have been intruded by basalt, or tilted.

DISTRICTS

The dark-firing Latah clays are described for convenience under the following district headings: West Spokane, Shelley Lake, Five Mile Prairie, Buckeye, and Chattaroy-Milan. These general localities contain accessible and characteristic exposures.

West Spokane district.—The shales are excellently exposed in the southwest part of Spokane on the west side of Latah (Hangman) Creek. Railroad cuts through the series in several places from one-eighth to one-fourth mile in length expose the beds to a depth of as much as 25 feet and show their relations to the basalt. The bedding is rather massive but is thin in places, and all the material is greatly jointed. The more massive portions separate into large blocks which fall to the bottom of the cuts and finally disintegrate to plastic clay. A cut of the Seattle, Portland & Spokane Railway in the SW cor. sec. 24, (25-42 E) shows 25 feet of laminated gray shale with an included lens-shaped mass of friable yellow sandstone that is 50 feet long and 3 feet thick. At

[1] Kirkham, V. R. D., and Johnson, M. M., The Latah formation in Idaho: Jour. Geology vol. 37, no. 5, pp. 483-504, 1929.

the north end of the cut the shale is underlain by a loose greenish-gray sandstone. This member is separated from the shale by a 1-inch layer of coaly matter, marking an undulatory erosional surface. Cutting the beds is a large basalt dike, which locally conforms to the horizontal bedding and tapers out between the layers as a thin sill. The adjacent shale is blackened and baked for as much as 8 inches from the contact, but in general shows no effects beyond that distance.

Sample No. 125-A was taken of shale from near the center of the above cut. It is bluish gray in color and very fine grained and uniform in texture. The moist shale when cut by a knife shows a surface with high sheen, but some sand of very fine grain is present. Microscopic examination shows that minute grains of quartz and a few poorly preserved diatoms form the chief gritty constituents.

Plastic and dry properties Sample No. 125-A

Plasticity	Good	Volume shrinkage	28.6% dry volume
Shrinkage water	33.1%	Linear shrinkage	10.7% dry length
Pore water	20.4%	Dry condition	Good
Water of plasticity	53.5%		

Fired properties Sample No. 125-A

Cone	Color	Condition	L.S.%d.l.	T.L.S.%d.l.	V.S.%d.v.	Abs.	A.Por.
08	Buff-brown	Weak, soft	3.3	14.0	9.4	32.1	54.3
06	Brown	Good, hard	10.4	21.1	28.0	26.6	41.8
04	Red-brown	Good, hard	13.8	24.5	35.8	18.1	31.0
1*	Dk. red-brown	Good, S.H.	14.7	25.4	37.9	12.2	23.2
3-4	Dk. red-brown	Good, S.H.	16.2	26.9	41.1	6.4	13.4
6	Red-brown and black	Good, S.H.	20.7	31.4	50.1	1.7	4.0
15	Dk. red-brown	Surface fused, slight deformation, S.H.	....	....	....	2.8	....

Remarks: Best firing range: 06-6. Cone fusion: 12. High shrinkage; too much plastic material; good firing range; a little scum at cones 06, 04, 1*, 3-4.

Class of ware: Red and brown structural wares.

Sample No. 125-B was from a sandier phase of the same shale at the north end of the cut. It has the same color but a slightly harsh feel from the higher sand content. It is very fine grained and uniform.

Plastic and dry properties Sample No. 125-B

Plasticity	Good	Volume shrinkage	28.6% dry volume
Shrinkage water	20.4%	Linear shrinkage	10.7% dry length
Pore water	23.3%	Dry condition	Good
Water of plasticity	43.7%		

Fired properties Sample No. 125-B

Cone	Color	Condition	L.S.%d.l.	T.L.S.%d.l.	V.S.%d.v.	Abs.	A.Por.
08	Buff-brown	Weak, soft	1.9	12.6	5.6	33.4	46.6
06	Brown	Good, hard	6.0	16.7	17.0	22.7	36.2
04	Brown-red	Good, S.H.	12.3	23.0	32.5	22.0	36.4
01	Bright red-brown	Good, S.H.	13.1	23.8	34.4	14.7	27.7
3-4	Dk. brown-red	....	....	....	....	5.7	12.0
6	Red-brown and black	Good, S.H.	15.8	26.5	40.2	0.0	0.0

Remarks: Best firing range: 06-6. Cone fusion: 12. High shrinkage; a little scum at cones 06, 04, 01, and 3-4.

A continuation of these beds is exposed in another cut about a quarter of a mile to the south. Here, sandy thin-bedded gray shales and clayey sands show for about 300 yards to a height of 18 feet. The material is uniform in texture and has no very coarse phases. A few thin iron-stained layers occur, but the usual color is either a light or dark gray. Bedding is prominent and is made wavy to contorted by intrusions of irregularly shaped masses of basalt occurring both as dikes and sills, mostly only a few feet in thickness, and some as little as 3 inches.

PLATE 12

BASALT INTRUSION IN LATAH SHALES JUST WEST OF SPOKANE.

The camera case is near the base, as exposed, of a dike; thin sills extend across the view to the left from the base and top of the dike. The shale is a part of the series sampled as Nos. 125-A, -B.

Heat, frost, plant roots, and surface water have all played a part in disintegrating the upper portion of these shales and changing them to plastic brownish-yellow clay. Such alteration is everywhere shallow, but when a large area is involved an immense tonnage of clay is available. This material is being used by one yard for common brick; and formerly a second plant, also, was located in this immediate vicinity.

Sample No. 714 is of a general mixture of such surface clay, after grinding, used at the Pioneer yard.

Plastic and dry properties Sample No. 714

Plasticity	Good	Volume shrinkage	15.2% dry volume
Shrinkage water	8.3%	Linear shrinkage	5.4% dry length
Pore water	17.0%	Linear shrinkage	3.0% wet length
Water of plasticity	25.3%		

Fired properties Sample No. 714

Cone	Color	Condition	L.S.%d.l.	T.L.S.%d.l.	V.S.%d.v.	Abs.	A.Por.
08	Lt. red-brown	Weak, soft	-0.2	5.2	-0.7	21.2	35.9
07	Red-brown	Weak, soft	0.7	6.1	1.9	19.0	33.4
04*	Dk. brown-red	Vitreous surface, good, S.H.	5.1	10.5	14.5	7.4	15.1
01	Dk. red-brown	Vitreous surface, good, S.H.	7.5	12.9	20.8	6.0	13.3
2	Dk. red-brown	Vitreous, good, S.H.	8.7	14.1	23.8	3.3	7.4
6	Red-brown and black	Vitreous, fusion started, S.H.	7.7	13.1	21.4	0.4	0.9

Remarks: Best firing range: 06-2. Cone fusion: 6-7.

Class of ware: Used for common brick. Very good color for brown-red face brick.

The Pioneer Brick Co. is located at 29th Avenue on the old Medical Lake Road, Spokane. The pit, about 100 yards in diameter and very shallow, is worked by plowing the disintegrated surface shale and wheeling it in a scraper to the plant. Owing to the extreme plasticity of the clay, loose sand from adjacent deposits is added. The mixture is ground in a 5-foot dry-pan, elevated to an 8- to 10-mesh screen, and dropped into a combination pug mill and auger machine equipped with a 10-brick rotary hand-cutter. Drying is on pallets in sheltered racks in the open air and requires about 2 weeks. The ware is fired in scove kilns. Common and rough-textured brick are made, the output being about 800,000 per year.

The shales are well exposed west of Spokane in a bank along the Rim Rock Drive just north of Highway No. 10. They show for 100 feet to a height of 10 feet and are closely associated with basalt. There is a large amount of the material available, but it is not so advantageously located as are the beds along the railroad. The deposit is rather massive but well stratified. It is composed, for the most part, of a soft gray shale that weathers to a very light color, but below a separating 1-inch limonite layer it has a greenish hue. Leaf impressions are plentiful on the bedding planes. The texture of the whole is fairly uniform except for one or two 2-inch sand layers.

Sample No. 125 is light gray and rather sandy. It is not quite as fine-grained as sample No. 125-B but is lighter in color. A few diatoms are scattered throughout as in sample No. 125-A.

Remarks: When tempered with 38.8 percent water, a moderate plastic strength is developed. The firing shrinkage is high in the best range, cones 02 and 2. Nonplastic material should be added for red and brown structural wares. Cone fusion is 7.

Shelley Lake district.—About 9 miles east of Spokane, in the center of sec. 19, (25-45 E), extensive beds of soft, silty shale crop out on the south side of the Spokane Valley a short distance above the valley floor. Basalt forms a low bench at the foot of the hill, and above this is sedimentary material, totaling probably 50 feet in thickness. This, in turn, is capped with other basalt, and it is this capping which has protected the soft beds from erosion and removal. Shale is well exposed in a short prospect tunnel and in a trench higher up the hillside. It closely resembles that occurring in the railroad cuts southwest of Spokane and particularly that sampled as No. 125-A.

Sample No. 105 was taken in the prospect hole. The inside of lumps are gray in color, but a brown stain of iron oxide has worked well toward the center from all old surfaces and fractures. The material is very compact and brittle but still is easily cut by a knife. The texture is fine and uniform; sand is present in fine grains but not in sufficient quantity to prevent the moist shale from showing a decided sheen when cut. A few tests of diatoms were noted in a sample examined under the microscope.

Plastic and dry properties Sample No. 105

Plasticity	Good	Volume shrinkage	69.0% dry volume
Shrinkage water	37.4%	Linear shrinkage	28.2% dry length
Pore water	14.3%	Linear shrinkage	13.4% wet length
Water of plasticity	51.7%	Dry condition	Cracked badly. Lamination cracks from auger machine

Fired properties Sample No. 105

Cone	Color	Condition	L.S.%d.l.	T.L.S.%d.l.	V.S.%d.v.	Abs.	A.Por.
010	Brown-red	Cracking, hard	4.3	32.5	12.2	15.7	29.3
07	Brown-red	Cracking, S H.	6.0	34.2	17.0	9.3	18.5
04	Speckled brown-red	Cracking, S.H.	9.8	38.0	26.5	2.9	6.2
02	Speckled brown-red	Cracking, S H.	10.4	38.6	28.0	1.9	4.3
6	Speckled brown-red	Cracking, S H.	12.9	41.1	34.0	1.0	2.2
10	Dark brown	Badly cracked, no fusion, S.H.	....	....	....	2.6	....

Remarks: Best firing range: 08-8. Cone fusion: 16. Too much plastic material.

Class of ware: Can not use alone, without treatement; add nonplastics for red and brown structural wares.

A continuation of these horizontal beds and the underlying basalt is exposed on the west side of the same hill in the SE¼ sec. 24, (25-44 E). This is three-quarters of a mile from the first location, and in that distance the shale has become very carbonaceous, nearly black in color, and contains numerous leaf imprints. In the expectation of finding coal, a tunnel has been driven several hundred feet into the bed. The opening shows that the underlying basalt is a sill intruded into the formation and not pre-Latah in age. From these fresh exposures it appears that the shaly lamination is a characteristic of the 15-foot surficial zone only and is probably induced by weathering processes, and that complete weathering produces structureless clay. Beyond the shaly zone the beds are massive mudstones. Still farther underground a blocky jointing becomes noticeable; this results in a rude columnar structure normal to the bedding, which, though apparent 10 feet above the contact, still may be due to heat effects from the intrusive basalt. Joints near the surface are coated with limonite; underground this is in its original condition, a paper-thin coating of brittle ankerite. The exposed beds are compacted and moderately hard and brittle. Included are: a smooth carbonaceous mudstone, low in sand, which when damp cuts like black wax; similar very dark-gray beds containing considerable sand and occasional diatom tests; partings of gray sandstone a fraction of an inch thick; and at least one bed, 2 feet or so thick, of light-gray unaltered, only slightly consolidated pumicite.

Tests on the unusual-appearing 5-foot bed of black waxlike mudstone showed it to be similar to sample No. 105 in having high shrinkage, a reddish-brown fired color, and no particular value.

Five Mile Prairie district.—Shales of the Latah formation underlie the basalt capping of Five Mile Prairie, north of Spokane. At least some parts of the series here are light firing—these are mentioned on page 262; others, as on the north side of the hill, are dark firing. Samples were taken near the Spokane Country Club from a 20-foot well on the E. R. Peterson farm in the SW¼SW¼ sec. 7, (26-43 E). Under only a little soil overburden, a horizontally bedded gray shale was encountered, underlain by a bed of black micaceous silty material. It is interesting to note that in tests made by W. T. Nightingale, then of the Washington Geological Survey, this lower stratum produced 11 gallons of shale-oil to the ton. This is the highest content of oil of any of the many Washington shales tested, although far from being a commercial quantity.

Sample No. 121, of the upper shale is bluish gray in color and has a medium-fine uniform texture. It contains considerable finely divided muscovite and angular grains of quartz. Well-preserved tests of diatoms of several varieties are present, and leaf impressions are numerous on bedding planes.

Remarks: The plastic material is excessive in this sample, causing too great shrinkage. The best firing range is between cones 05 and 3, and here a red and brown-colored body is produced. The mass fuses at cone 6-7. It should not be used alone for commercial ware.

Sample No. 121-A is of a plastic clay, probably not of the Latah formation, found also on the Peterson place. The clay is greenish gray in color, soft and plastic, but very nonuniform in texture. It is derived from the decomposition of granite and carries considerable quartz and enough mica to give the clay the smooth feel of talc.

Plastic and dry properties Sample No. 121-A

Plasticity	Good	Volume shrinkage	30.0% dry volume
Shrinkage water	16.7%	Linear shrinkage	11.2% dry length
Pore water	16.1%	Linear shrinkage	7.2% wet length
Water of plasticity	32.8%	Dry condition	Good

Fired properties Sample No. 121-A

Cone	Color	Condition	L.S.%d.l.	T.L.S.%d.l.	V.S.%d.v.	Abs.	A.Por.
08	Brown-buff	Good, hard	1.5	12.7	4.4	20.5	35.5
02	Buff-brown	Scum, good, hard	3.5	14.7	10.0	15.5	28.6

Remarks: Best firing range: 06-8. Cone fusion: 23-26.
Class of ware: Brown structural wares.

Buckeye district.—Latah shales are exposed over a considerable area in the vicinity of Buckeye. On the west line of the NW¼ sec. 16, (27-43 E), a road cut about 30 feet long and 10 feet high has been made through the sedimentary beds. This location is well above the valley floor and about three-quarters of a mile west of the Little Spokane River and the railroad. Some of these shales are fine, even-grained, and of light gray color; others are sandy and much stained by iron oxide. The stratification is distinct, the bedding planes being marked by many leaf impressions. A strike of S. 40° W. and a dip of 20° NW., apparent here, is probably due to land slide.

Sample No. 122 is yellowish gray and medium fine grained. It is sandy and poorly consolidated for a shale but is not very different from other deposits of the series where unaffected by igneous intrusions. Diatom tests are present in abundance.

Remarks: When tempered with 40 percent water, a good plastic strength is produced. When fired between cones 4 and 8, red and brown colors result. For commercial ware it will be necessary to reduce the shrinking and tendency to crack by the addition of nonplastic material. The clay deforms at cone 15.

Chattaroy-Milan district.—A mantle of glacial gravel makes prospecting difficult in the low, rolling region just east of Deer Park where clays or shales are exposed in but few places. Two miles southwest of Milan along Bear Creek is a ridge composed mostly of brown, yellow, and gray sandy shales. In grading a county road, the series has been exposed for a considerable distance in the E½ sec. 10, (28-43 E). The material is thin-bedded and lies practically horizontal. The texture is nonuniform but not very coarse. A well in this region is said to have been dug through 66 feet of these poorly consolidated shales; the whole distance showed only slight variations in material, but the color varied with the content of iron and its state of oxidation.

Sample No. 131 is slightly yellowish gray in color, but some parts are stained to a reddish brown. It is sandy, medium fine grained, and fairly uniform in texture.

Plastic and dry properties Sample No. 131

Plasticity	Good	Volume shrinkage	54.6% dry volume
Shrinkage water	26.9%	Linear shrinkage	22.3% dry length
Pore water	10.6%	Dry condition	Good dry strength
Water of plasticity	37.5%		

Fired properties Sample No. 131

Cone	Color	Condition	L.S.%d.l.	T.L.S.%d.l.	V.S.%d.v.	Abs.	A.Por.
08	Lt. red-brown	Weak, soft	0.0	22.3	0.0	20.6	33.9
06	Red-brown	Good, hard	2.0	24.3	5.9	18.9	33.0
03	Lt. red-brown	Hard	....	....	....	17.6	31.2
02-01	Lt. red-brown	Hard	....	....	....	....	....
3-4*	Red-brown	S.H.	7.2	29.5	20.0	7.8	16.1

Remarks: Best firing range: 06-7. Cone fusion: 15. Some cracking at cones 08, 06, 03, and 02-01. High dry shrinkage.

Class of ware: Needs more nonplastic material for red and brown structural wares.

South of Milan 2½ miles, near the center of the north line of sec. 13, (28-43 E), a road is graded for nearly a quarter of a mile through leaf-bearing horizontally bedded Latah clays. These occur about 2,100 feet above sealevel, within the elevation range of the clays of Deadman Creek, Deep Creek, and many other places. The Little Spokane River has cut deeply into the series, the road-side outcrops being 400 feet above the river, while similar-appearing clays show in the bank by the water's edge.

One road cut 40 feet long and 10 feet high exposes a rather thin-bedded light-gray sandy clay, very firm and uniform in texture, that is almost identical with that occurring northeast of

Chattaroy and sampled as No. 128. Interbedded with this, however, is pinkish-buff clay that contains a high percentage of diatomaceous earth. Such material is very unusual in this part of the State, though common enough in some counties. (See details of one diatomite deposit of Kittitas County, p. 165.) Occasional diatom tests have been noted in the microscopical examination of samples from many exposures of the Latah formation; an impure diatomite was encountered in a well at Mica [1]; but the material occurs in this outcrop in large quantity; and a purer, nearly white bed, said to have been uncovered at one time on the hillside to the east, has been used locally for silver polish. It indicates the localized sedimentation that accounts for the peculiar, or unusual, physical properties of the Latah beds in certain areas.

Sample No. 130 is a general one, taken from various places in the large exposure. As the bedding is rather thin and partly concealed by slides, no attempt was made to separate the clays, but it might be found by a little prospecting that either of the two principal kinds of clay could be mined singly. The textures of each are similar, and they have about the same amount of clay substance—the fine sand of one being about equal to the diatomaceous material in the other. The noticeably low specific gravity is due to the presence of the diatoms.

Plastic and dry properties Sample No. 130

Plasticity	Good	Volume shrinkage	28.2% dry volume
Shrinkage water	18.7%	Linear shrinkage	10.5% dry length
Pore water	26.8%	Linear shrinkage	5.5% wet length
Water of plasticity	45.5%	Dry condition	Good

Fired properties Sample No. 130

Cone	Color	Condition	L.S.%d.l.	T.L.S.%d.l.	V.S.%d.v.	Abs.	A.Por.
08	Buff-brown	Good, hard	3.9	14.4	11.2	21.3	34.2
04	Red-brown	Good, S.H.	....	....	....	16.6	29.2
03	Red-brown	Good, S.H.	....	....	....	8.0	17.4
3-4*	Dk. red-brown	Good, S.H.	....	....	....	0.5	1.2

Remarks: Best firing range: 06-6. Cone fusion: 11. Shrinkage too high.

Class of ware: Add nonplastic material for red and brown structural wares.

Northwest of Milan about 2 miles, in the NE¼ sec. 27, (29-43 E), is a road cut 40 feet long that has exposed the shales to a depth of 5 feet. They are overlain by 4 feet or so of unassorted glacial gravels, soil, sand, and boulders up to 3 feet in diameter.

[1] Pardee, J. T., and Bryan, Kirk, Geology of the Latah formation in relation to the lavas of the Columbia plateau near Spokane, Washington: U. S. Geol. Survey Prof. Paper 140-A, p. 6, 1926.

The deposit is very unevenly colored and much jointed and broken, but the indications are that, with depth, the clayey weathered material will grade into shales similar to those in the region to the south.

Sample No. 128-A, from this deposit, is buff to reddish buff in color, but the interior of lumps that have not been reached by the staining solutions is light gray. The texture is very uniform, fine, and smooth, so that the substance has a talc-like feel.

Plastic and dry properties Sample No. 128-A

Plasticity	Good	Volume shrinkage	38.5% dry volume
Shrinkage water	22.1%	Linear shrinkage	15.0% dry length
Pore water	14.8%	Dry condition	Strong
Water of plasticity	36.9%		

Fired properties Sample No. 128-A

Cone	Color	Condition	L.S.%d.l.	T.L.S.%d.l.	V.S.%d.v.	Abs.	A.Por.
06	Brown-buff	Good, hard	1.0	16.0	3.2	15.2	26.5
04	Light red-buff	Good, hard	4.7	19.7	13.5	13.7	25.0
01-1	Light brown-buff	Good, S.H.	5.8	20.8	16.4	10.1	20.0
3-4*	Pink-brown	Good, S.H.	7.1	22.1	19.7	8.5	17.1
6	Pink-brown	Good, S.H.	8.2	23.2	22.6	7.3	15.2
12*	Brown and black	Vitreous, good, S.H.	....	....	....	0.2	0.4
15	Gray and brown	Good, S.H.	10.2	25.2	27.5	0.2	0.5

Remarks: Best firing range: 05-10. Cone fusion: 23-26. Too much plastic material.

Class of ware: Add nonplastics for brown structural wares.

DARK-FIRING PALOUSE CLAY

Among the red- and brown-firing clays is the so-called Palouse clay, so common in the county and particularly in the region to the south.

Because of similarity in occurrence and physical properties, only the Freeman deposit is described here in detail. Other descriptions of this type of clay, a material which occurs in unlimited quantities, are given under the heading of Whitman County.

The clay is well exposed just south of the Freeman station in the pit formerly operated by the Washington Brick, Lime & Sewer Pipe Co. This excavation covers an area that is from 60 to 100 feet wide and extends 400 feet or so into one of the low-rounded hills so typical of the Palouse clay region. The clay is practically structureless, only the slightest indication of rude bedding being shown in the 40-foot working face. It is a yellow-brown material made up of wind-borne clay particles derived from weathered basalt, mixed with silt and a smaller amount of quartz sand. There is no indication of an origin from the decom-

PLATE 13

PALOUSE CLAY PIT OF FORMER FREEMAN BRICK PLANT OF WASHINGTON BRICK, LIME & SEWER PIPE CO.

A 40-foot face of clay, without overburden, was quarried. Sampled as No. 79-A. Underlying the Palouse clay is an unknown thickness of buff-firing lacustrine clay sampled as No. 179.

position, in place, of basalt flows, though some of the clay substance may be the result of more complete alteration of basalt dust or ash after the deposit accumulated.

Sample No. 79-A, of the clay formerly used at the plant, is dark brown in color when damp and dries to a much lighter shade. It is nonuniform in texture, part being "fat" and free from much grit, while other portions are very sandy. Beside rather abundant quartz, considerable muscovite in fine flakes is disseminated throughout the sandier material. The clay is rather porous; yet when dry it is very compact and more resistant to pressure than many less-porous clays.

Plastic and dry properties Sample No. 79-A

Plasticity	Good	Volume shrinkage	33.3% dry volume
Shrinkage water	16.5%	Linear shrinkage	12.6% dry length
Pore water	9.9%	Linear shrinkage	9.1% wet length
Water of plasticity	26.4%		

Fired properties Sample No. 79-A

Cone	Color	Condition	L.S.%d.l.	T.L.S.%d.l.	V.S.%d.v.	Abs.	A.Por.
08	Lt. red-brown	Weak, soft	0.0	12.6	0.0	16.6	30.1
07	Brown-red	Weak, soft	-0.3	12.3	-0.9	15.9	29.3
04*	Dk. brown-red	Vitreous surface, S.H.	4.5	17.1	12.9	7.0	14.7
02	Dk. brown-red	Vitreous surface, S.H.	6.8	19.4	19.0	4.2	9.7
2	Dk. brown-red	Vitreous surface, S.H.	....	....	....	2.3	5.2
3	Dk. brown-red	Vitreous surface, S.H.	6.8	19.4	19.0	1.5	3.3
6-7*	Dk. brown-red	Vitreous, good, S.H.	-0.3	12.3	-0.9	15.9	29.3

Remarks: Best firing range: 05-6. Cone fusion: 7. Some cracking at cones 04*, 02, 2, and 3. Dry shrinkage a little high in proportion to pore space. Cracked in drying. Add nonplastics or change by chemical means.

Class of ware: Red and brown structural wares.

In operation, as there was no overburden to contend with, the clay was merely undercut and carried by power scrapers to a trap from which tram cars, used to transport the clay to the plant, were filled. At the plant the clay was dumped into a hopper at the top of the mill. It fed through a double pair of rolls into a combination pug mill and auger machine, and the brick were cut by an automatic rotary cutter. Both steam drier and open-air racks were used in drying the ware, so advantage could be taken of the hot summer weather without being dependent upon it. The brick were fired in a long up-draft clamp scove kiln.

Two other pits in Palouse clay are operated in this general vicinity. One is at the Mica plant of Gladding, McBean & Co. and has been described under that heading (see p. 249). The other is a recent opening made by the Washington Brick, Lime & Sewer Pipe Co. immediately adjacent to the west side of their fire-clay pit at Freeman. A cut has been made for 200 feet in a hillside that is within 50 feet of the railroad tracks. In the 10- to 12-foot face is exposed a brown clay, similar to that occurring in the pit of the old Freeman brick yard. Below the clay is a bed of boulders and gravel, marking the top of residual material similar to that exposed in the fire-clay pit. The brown clay is very easily mined; it is shoveled into dump cars, and trammed the short distance to a loading platform, where the clay falls by gravity into gondolas. The decided advantage in the use of this clay in the sewer-pipe mix at Dishman is that the more clay mined the greater will be the area of fire clay uncovered and made available for future use.

DARK-FIRING GLACIAL CLAY

Pleistocene sands and gravels are abundant in the valley regions about Spokane and to the north and east. With them are occasional beds of well-stratified clays. These sediments are of glacial origin, similar to the glacial sediments of western Washington, and represent local accumulations from overcharged streams from the melting ice. Where lake conditions prevailed, considerable thicknesses of soft, silty clays have resulted, materials quite different from the cross-bedded sand-gravel deposits of general occurrence.

As these clays are derived from the erosion of a great variety of rock types, they are impure, low-fluxing, red-firing materials, usable only for very ordinary ceramic ware. They are abundant in Pend Oreille County and are discussed in detail under that heading. In Spokane County they may be confused, in places, with Latah beds, but laboratory tests, particularly for fusion, serve to distinguish them.

One description of a characteristic occurrence of the dark-firing glacial clay is considered sufficient, as the material is relatively uncommon in the county, has a general concordance in physical properties, and is only suited to the manufacture of common ware.

A brick yard 1 mile north of Mead is using such clay for making common brick by the soft-mud process. The pit is just east of the plant and is 500 to 600 feet long and 250 feet wide. It exposes an overburden of clayey sand, silt, and gravel of varying thickness up to 6 feet. This is underlain by a 14-foot bed of soft buff-colored clay containing many sandy layers. Below this is a 4-foot bed of water-bearing sand and 12 feet of light-blue clay that were exposed in digging a well. The material used in the yard is the upper soft buff clay. It is fine-grained in part but not uniform in texture. The bedding is horizontal and distinctly stratified. Apparently a large body of the clay occurs here, though lateral variations between clay and sand are common. The chief objectionable feature of the deposit is the abundance of small calcareous concretions; these if left in the clay and not finely ground are apt to swell and disrupt the ware after firing.

The following results of physical tests made on samples from this clay bed are given by Shedd [1]:

Plasticity	Fair	Total shrinkage	10%
Water of plasticity	23%	Cone 01	Nearly steel hard
Drying shrinkage	5%	Color	Dark red
Burning shrinkage	5%	Cone 4	Fused
Condition during drying	Good	Condition after firing	Good

Building Supplies, Inc.—In operating here, the company strips off some of the sand overburden and then mines the clay "run-of-pit." A dragline scraper is used with a trap to fill the clay car. The car is pulled by gasoline locomotive up an incline

[1] Shedd, Solon, The clays of the State of Washington: State College of Washington publication, p. 174, 1910.

to the plant, where the clay is dumped into bins. A soft-mud machine with a disintegrator and pug mill, is the principal equipment, and 25,000 brick per day can be made by this means. A stiff-mud machine, capacity 30,000 per day, also is available for use. Drying is on pallets in open-air roofed racks and requires about 8 days. The brick are fired in 3 clamp scove kilns of 385,000 capacity, a period of 3 days being allowed for water-smoking and 6 days for the actual firing. Wood is used for fuel. The product is chiefly common brick, and the output in 1936 was approximately 3,000,000.

STEVENS COUNTY

Stevens County includes 2,394 square miles in the hilly and mountainous northeastern part of the State. The topography and geologic formations are rather similar to those characterizing the adjoining counties on the east and west. Paleozoic metamorphic rocks such as quartzites, argillites, marbles, and schists are abundant yet contribute very little to the ceramic resources. Some of the less highly metamorphosed argillites, though low in plasticity when ground, could be used for a few purposes, especially by dry-press methods. Unfortunately, most of these rocks are high in lime or other fluxes and so are of little value.

Some shales of Tertiary age that slake and become plastic in water are known, but these are too scarce to deserve more than passing mention. One example is the fine-grained gray to greenish-gray shale associated with coal about 2½ miles southwest of Valley, in the W½ sec. 28, (31-40 E). It contains leaf impressions, is interbedded with basalt, and is similar to certain shales of the Spokane region. It probably is a correlative of the Latah formation occurring so commonly to the southeast.

Of far greater importance to the ceramic industry are the granitic rocks which occur over large areas in the county. Among these, the Loon Lake granite is outstanding. It forms the surface exposures over many square miles in the southern part of the county, and probable extensions of this rock make up much of the granite of Pend Oreille and Spokane counties. With its high content of feldspar and relatively low percentage of iron minerals it has been a source of excellent clays in the vicinity of Spokane (p. 232), and is also the source material for the valuable clays of the adjacent Clayton area of Stevens County.

LIGHT-FIRING CLAYS

The high-grade nearly white plastic clays found in the vicinity of Clayton, in the southeastern part of the county, are among the best in the State. All those opened so far have been lacustrine types, clays laid down in what were probably marshy lakes and ponds. The finer products of rock decomposition were carried by sluggish streams into these waters. This material was eroded from the adjacent granite hills to the east and north and washed into a low region in the vicinity of the present site of Clayton and Deer Park. Derived from rock low in femic minerals, the resultant clay is, as a rule, exceptionally free from iron oxide, because the extended leaching to which it has been subjected, both before and after deposition, has greatly reduced the flux content. So large deposits have accumulated of well-stratified soft, plastic clay, generally fine-grained and unctuous, although differing markedly from place to place in its silica and alumina content. The common colors are nearly white and light gray, but some phases are various shades of blue and yellow. Leaf fossils are often found on bedding planes, and limonite (bog iron) in nodules and sheets is associated with virtually all occurrences.

The limonite marks an undulatory erosion surface which forms the top of the better clays. Above this, representing later sedimentation, is an overburden of glacial origin. This upper material is derived from ice- and stream-transported debris that was deposited south of the ice front. It is mostly very sandy, if not wholly unconsolidated sand, and ice-rafted boulders are abundant. In places, as in the immediate vicinity of Clayton and to the north, it is only a few feet in thickness and so interferes but little in mining the underlying clay, but south and southeast of Clayton it is much thicker.

The high-grade clays differ markedly from the usual clays or shales of the Latah formation, though they are not so unlike the Chester (Sommer pit) beds. That they probably belong to that formation, in spite of their purity and unctuous character, is indicated by the stratigraphic relations, by the presence of a flora similar to that occurring in the Latah shales, and by their disconformity with the Pleistocene sediments.

Some of the deposits at one time were doubtless covered by basalt. Erosional remnants of what were apparently thin border flows of the Columbia River basalt are common at an elevation of 2,100 feet near Deer Park. The white clays have not been seen in contact with the lava, but drilling has shown them to be present beneath the surface of the plain over which the basalt presumably flowed. The elevation at Clayton is 2,266 feet, so the upper flows, known to have reached 2,400 feet near Milan, 13 miles to the southeast, may have originally covered the Clayton beds. Although suggested by the topography, it is doubtful if the basalt reached to the 2,300- to 2,400-foot elevations of the Conner, Neafus, and A. B. pits to the north.

DISTRICTS

The clays of the Clayton district are well known and have been worked for many years. They are sufficiently similar in origin or general properties to be described under one district heading, though some of the clay types are distinctive. Somewhat similar clays are in the Valley district and are described separately.

Clayton district.—One of the plants of the Washington Brick, Lime & Sewer Pipe Co. is at Clayton, and the pits opened at the plant are the most extensive in the Clayton district. The town is on the edge of a nearly level alluvial plain that extends for several miles to the east and southeast. Although the white clays no doubt underlie much of this flat, the overburden of sand and gravel is such, in most places, as to render working very expensive. This surface mantle thins out as the flat merges into the low hills, and it is in that part where most mining has been done.

Clayton pit.—The present working pit at Clayton covers several acres and exposes various clays, but in use it is unnecessary to recognize more than three kinds. Measurements differ from place to place, but those made at one point are indicative of usual conditions. Here, below a foot or so of soil is 5 to 8 feet of sandy yellow clay that is doubtless of glacial origin. This is not very uniform but has plasticity enough so that it may be made into a good red brick of pleasing color. Sandy pockets occur, and at times material of quite different texture and appearance from the surrounding clay is exposed in working the pit. Such variants are probably due to the

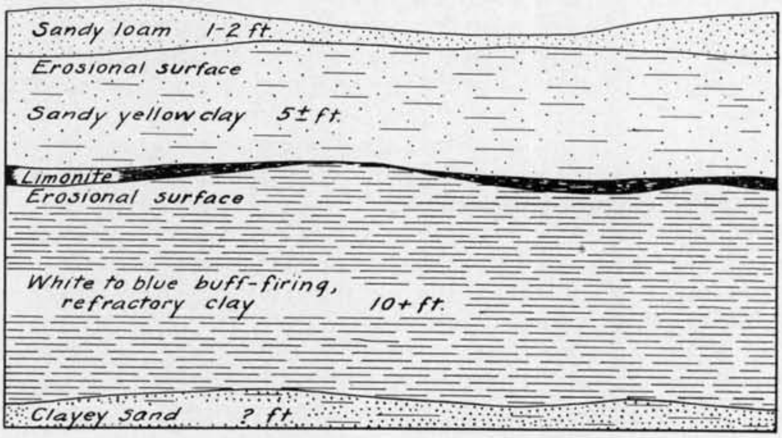

FIGURE 4.—Section of beds at the Clayton pit, Stevens County.

PLATE 14

A. BANDED LATAH CLAY OF THE CLAYTON PIT.

A refractory light-firing material sampled as No. 136. The resemblance to the varved clays of *B* is due to carbonaceous layers.

B. VARVED GLACIAL CLAYS AND SILTS AT COLVILLE.

A low-fusing dark-firing material.

decomposition of scattered granitic boulders and also to the presence of some residual clay from a projecting point of the granite which underlies the whole region and reaches the surface to the west of the main pit. Underlying the yellow material is exposed 18 feet, more or less, of very fine even grained unctuous clay, probably a correlative of the Latah clays. Horizontal stratification of this material is made distinct by dark-colored carbonaceous layers as well as by paper-thin sandy partings. The clay is dark blue and gray in color and dries to much lighter shades. It is high in alumina and so plastic as to require considerable care in use. When mixed with disintegrated granite from Freeman it makes a good grade of fire brick and is also used for face brick and as a bond clay.

Separating the blue-gray from the overlying yellow clay is a layer which varies in thickness from 1 to 12 inches, of limonite, or bog iron. This was laid down on a very uneven erosional surface, so that it is now cut and exposed as a wavy band in the face of the pit. Underlying the blue-gray member in some places is a yellowish-colored clayey sand, or sandy clay, of medium-fine grain and uniform texture. Considerable diversity in the color of the clay occurs at different places in the pits, changes occurring in the course of a few feet from dark to light blue, to yellow, and to nearly white; yet the material is used with very little sorting, as the average composition remains fairly constant. The following chemical analyses, based on those given by Shedd[1], is indicative of the general "run-of-pit" from the upper yellow member.

Analyses of clays from Clayton, Stevens County

Constituents	*I*	*II*	*Average*
Silica (SiO_2)	62.56	65.80	64.18
Alumina (Al_2O_3)	23.96	18.78	21.37
Iron (Fe_2O_3)	4.70	5.42	5.06
Lime (CaO)	....	....	....
Magnesia (MgO)	trace	2.46	1.23
Alkalies (K_2O, Na_2O)	1.12	3.39	2.25
Titanium (TiO_2)	....	....	....
Moisture (H_2O)	0.92	1.38	1.15
Loss on ignition	6.84	3.14	4.99
Total	100.10	100.37	100.23
Total fluxes	5.82	11.27	8.54

Similarly, the following is indicative of the lower or blue-gray member.

Analyses of clays from Clayton, Stevens County

Constituents	*I*	*II*	*III*	*Average*
Silica (SiO_2)	49.67	53.64	51.36	51.56
Alumina (Al_2O_3)	32.38	31.96	33.09	32.46
Iron (Fe_2O_3)	1.50	1.82	2.39	1.90
Lime (CaO)	0.25	....	....	0.08
Magnesia (MgO)	0.58	trace	0.78	0.42
Alkalies (K_2O, Na_2O)	1.35	1.17	0.08	0.87
Titanium (TiO_2)	0.51	....	....	0.17
Moisture (H_2O)	2.30	1.66	2.12	2.03
Loss on ignition	10.92	10.06	10.54	10.51
Total	99.46	100.31	100.36	100.06
Total fluxes	4.19	2.99	4.25	3.81

Sample No. 136 was of banded blue clay from the side (south) of the pit nearest the plant. When fresh, this clay has about the texture and hardness of common soap and is apparently free from sand. When a little is taken between the teeth, very fine grit may be detected. It dries compact and brittle and then is light gray in color.

[1] Shedd, Solon, op. cit., p. 205.

Plastic and dry properties Sample No. 136

Plasticity	Good	Volume shrinkage	39.6% dry volume
Shrinkage water	23.1%	Linear shrinkage	15.0% dry length
Pore water	16.3%	Linear shrinkage	9.5% wet length
Water of plasticity	39.4%	Dry condition	Tendency to crack

Fired properties Sample No. 136

Cone	Color	Condition	L.S.%d.l.	T.L.S.%d.l.	V.S.%d.v.	Abs.	A.Por.
07	Light buff	Weak, soft	....	....	....	20.5	33.0
04*	Light buff	A few cracks, otherwise good, S.H.-	3.9	18.9	11.3	15.3	26.5
02	Light buff	A few cracks, otherwise good, S.H.-	6.6	21.6	18.5	13.1	24.8
6	Light buff	A few cracks, otherwise good, S.H.-	10.6	25.6	28.6	7.2	20.1
9	....	....	....	....	....	1.4	3.9
12*	Light gray	Good, S.H.	12.8	27.8	33.8	0.2	0.5
15	Gray and brown	Good, S.H.	17.1	32.1	43.0	0.8	2.4

Remarks: Best firing range: 05-20. Cone fusion: 30-31. Too much plastic material.

Class of ware: Refractories. Add nonplastics for buff-colored structural wares, terra cotta, and buff-colored pottery.

The third clay type is exposed in the northwest part of the main pit and continues westward from there for at least the 600 feet or so that small pits have been extended. There, under a variable overburden of 1 to 10 feet of sandy glacial clay, is a residual material formed from the weathering of granite. In some places it is merely "rotten rock" and hardly disintegrated. Much of it is stained with iron oxide, but even the deeper portions, free from discoloration, are impure as compared with the low-iron refractory residuum occurring in the vicinity of Freeman, Spokane County. An interesting variation of this material is in the "sand pit" lying west of the plant, where a deposit of micaceous clayey quartz sand has accumulated as a result of partial assorting through water action. This sand has been excavated to a depth of 12 feet or so over a 300-foot area. It, like the other clays, is separated by an irregular thin layer of bog iron from overlying glacial sediments.

Washington Brick, Lime & Sewer Pipe Co., Clayton brick plant.—The Clayton pits have been worked since 1893, and an immense tonnage of clay has been removed. The main pit, a level-floored area that is 600 feet or more long by some 400 feet wide, has been carried 26 feet below the general ground surface. Formerly the clay was caved by blasting and loaded by pick and shovel into the clay cars; now a gasoline-powered shovel is used and the clay is moved by truck. The reason for this is that much less clay is mined from the Clayton pit than formerly, and the pit floor forms a convenient repository for clays from other pits. An incline connects plant and pit, and power is used to take the cars up this to raw-clay storage bins where different types of clay are kept separate.

Clay is drawn by tractor shovel from the various stock piles, depending on the ware to be made. For common brick, the Clayton clay is used, and some may be added from the A. B. pit. Face brick require similar clay and also various mixtures to obtain different effects. For fire brick, use is made of one-third each of Freeman residual, gray plastic from Mica, and A. B. clay. The mixtures go (by way of a clay drier if too damp) to a hopper which furnishes automatic feed to three 9-foot dry-pans. The clay is then elevated, screened, and fed to a combination pug mill and auger machine with a 22-brick automatic cutter. From the off-bearing belt the brick go on double-deck cars to the steam-heated drier, though they are first repressed if fire brick are being made. After an average time of 4 days in the drier the ware is ready for firing. The kilns have a capacity of 368,000 brick and include two rectangular down-draft periodic kilns, each of 90,000 brick capacity, and five round down-draft periodic kilns ranging from 20,000 to 70,000 in capacity. Three days are allowed for water-smoking, and the firing is completed in 2 or 3 days more. The average run of fire brick, common brick, and all kinds of face brick was about 600,000 per month during 1936.

Washington Brick, Lime & Sewer Pipe Co., Clayton terra cotta plant.—The terra cotta plant of this company, adjoining the brick plant at Clayton, is the only one operating at the present time in the State. The clay used for modeling is the very plastic fine-grained material from the Clayton pit, but that used for terra cotta is obtained from the company's A. B. pit. This is delivered by truck to the storage bins at the plant. A dry-floor is available when the clay is too wet. From this the clay goes to a jaw crusher and a 7-foot dry-pan. Grog in the proportion of 5 parts to 1 part clay is used, and barium carbonate is added to eliminate any possible efflorescence on the finished ware. After grinding, the clay is screened and then passed through a pug mill and auger machine in order to properly temper it and, also, to form the plastic material into blanks of convenient size for handling. To give uniformity and maximum plasticity the clay is then aged in cellars, after which it is again passed through the pug mill and auger machine. The final blanks are then ready for the regular procedure of pressing, drying, and glazing. The glaze is mixed in two Abbe pebble mills and is applied with a spray-gun.

Drying is then completed on the hot-floors. Nine round down-draft muffle kilns are available for firing the ware, but, with the present conditions of the market, only two 20-ton kilns are in use. After firing, the ware is packed for shipment throughout the Pacific Northwest.

Sample No. 701 is of the clay mixture used in the general terra cotta body.

Plastic and dry properties Sample No. 701

Plasticity	Good	Volume shrinkage	24.7% dry volume
Shrinkage water	13.4%	Linear shrinkage	9.0% dry length
Pore water	11.9%		
Water of plasticity	25.3%		

Fired properties Sample No. 701

Cone	Color	Condition	L.S.%d.l.	T.L.S.%d.l.	V.S.%d.v.	Abs.	A.Por.
04*	Light buff	Good, hard	0.7	9.7	2.2	15.5	28.1
5	Light buff	Good, S.H.	3.3	12.3	9.5	10.0	19.3
6-7*	Buff	Good, S.H.	3.7	12.7	10.5	9.8	19.1
12*	Buff-gray	Good, S.H.	7.6	16.6	21.1	2.7	6.0

Remarks: Best firing range: 2-8. Cone fusion: 26+.

Class of ware: Used for terra cotta.

A. B. (formerly the Abbott) pit.—The A. B. pit of the Washington Brick, Lime & Sewer Pipe Co. is in the NE¼NW¼ sec. 32, (30-42 E), about 7 miles by road north of Clayton. It is in a region of low, rolling hills, with higher country to the west and north, not far removed from the edge of the plain extending to the southeast. The company owns about 4½ acres here, lying on either side of the old Colville road. The pit is about 100 feet wide and 350 feet long; as the ground is sloping, a quarry face is developed that is 30 feet high at the maximum. Overburden is negligible in some places, elsewhere reaching nearly 3 feet, but a stained top phase of the underlying deposit, as much as 8 feet thick, must be stripped at the west end of the pit. The clay is of lacustrine origin and probably to be correlated with the Latah formation. It is a horizontally bedded plastic gray material that is fairly uniform in texture though containing some sandier phases. It appears massive when dry, but greater leaching along silty layers makes stratification apparent when the clay is damp. In part of the pit the gray clay grades into a variable thickness (probably averaging about 4 feet) of underlying coarser-grained yellow clay, a variation due to iron-bearing solutions percolating through a more pervious stratum and causing an irregular staining. This yellow clay contains rather plentiful leaf imprints on the bedding planes.

The clay is loosened by powder and loaded by a gasoline-powered shovel into trucks for delivery to Clayton for use in practically all the different mixes. Some, also, is shipped to buyers in other locations, and, in the 30 years or so that clay has been mined here, it has been used in refractory bodies, for face brick, for terra cotta, and for stoneware and pottery. The yellow phase was formerly hand-sorted from the gray and used by the old Inland Empire Pottery Co. for a red-firing stoneware body and for flower pots.

Sample No. 132, taken from the upper beds, is a very plastic light-gray, nearly white, clay. It is compact and brittle when dry, but contains uniformly throughout very fine sand grains and minute flakes of white mica. The texture is fine and even but between the fingers feels slightly harsh.

Plastic and dry properties Sample No. 132

Plasticity	Good (sticky)	Volume shrinkage	31.9% dry volume
Shrinkage water	17.0%	Linear shrinkage	12.0% dry length
Pore water	13.0%	Linear shrinkage	8.1% wet length
Water of plasticity	30.0%	Dry condition	Lamination cracks from auger machine

Fired properties Sample No. 132

Cone	Color	Condition	L.S.%d.l.	T.L.S.%d.l.	V.S.%d.v.	Abs.	A.Por.
08	Light cream	Weak, soft	0.8	12.8	2.4	17.9	31.4
07	Light cream	Good, hard	1.2	13.2	3.5	14.2	25.1
04	Light cream	Good, hard	3.7	15.7	10.6	12.6	25.1
02	Light buff	Good, S.H.	5.3	17.3	15.0	8.2	17.2
5	Light buff	Good, S.H.	7.6	19.6	21.0	4.4	9.6
10	Light gray	Few blisters, vitreous, S.H.	8.8	20.8	24.1	0.2	0.4
12*	Light gray	S.H.	7.2	19.2	20.0	0.9	2.4

Remarks: Best firing range: 04-8. Cone fusion: 23-26. Too much plastic material; high shrinkage.

Class of ware: Buff-colored structural wares, terra cotta, and buff-colored pottery.

Sample No. 133, of the lower yellow bed, is also compact and brittle when dry but has a clear yellow color. It is coarser than the gray clay, contains larger grains of sand and mica, and consequently has a harsher texture.

Plastic and dry properties Sample No. 133

Plasticity	Good	Volume shrinkage	31.8% dry volume
Shrinkage water	17.2%	Linear shrinkage	12.0% dry length
Pore water	18.6%	Linear shrinkage	7.5% wet length
Water of plasticity	35.8%		

Fired properties Sample No. 133

Cone	Color	Condition	L.S.%d.l.	T.L.S.%d.l.	V.S.%d.v.	Abs.	A.Por.
07	Lt. brown-red	Weak, soft	2.0	14.0	6.0	18.5	31.6
04	Bright buff-red	Weak, hard	8.0	20.0	22.2	9.6	19.7
02	Bright buff-red	Good, hard	9.7	21.7	26.3	8.5	18.6
01	Bright buff-red	Good, S.H.	10.7	22.7	28.6	6.8	15.0
3-4*	Bright brown-red	Good, S.H.	....	....	....	3.9	8.6
6	Bright brown-red	Good, S.H.	12.2	24.2	32.3	0.0	0.0

Remarks: Best firing range: 06-6. Cone fusion: 20-23. Shrinkage high.

Class of ware: Used for flower pots.

Just north of the A. B. pit, across the old Colville road, a small pit or shaft, dug some 40 years ago, has been given the name of the "Paint Pot" from the color of the exposed clay. This is a dark orange-colored clay or ocher that is deep blood-red when wet. Several other shallow pits in the surrounding 150 feet show clays variously colored to light buff, yellow, and deep red, as well as thin, hard, brittle layers of fine-grained sienna. These are either stained phases of the plastic gray clay or, as is probable in some instances, they represent original depositions of hydrous iron oxide and clay in varying proportions. From their elevation it is presumed that they are underlain by a continuation of the gray clay of the A. B. pit.

Sample No. 134 was taken from the "Paint-Pot", though the value of this material does not lie in its ceramic use but rather in its possibilities as a pigment. The ocher is devoid of grit, is very smooth and unctuous, and dries compact and very brittle.

Plastic and dry properties Sample No. 134

Plasticity	Good	Volume shrinkage	40.5% dry volume
Shrinkage water	23.3%	Linear shrinkage	15.9% dry length
Pore water	16.7%	Dry condition	Cracked
Water of plasticity	40.0%		

Fired properties Sample No. 134

Cone	Color	Condition	L.S.%d.l.	T.L.S.%d.l.	V.S.%d.v.	Abs.	A.Por.
04	Buff-red	Bad cracking, soft	....	....	....	22.5	38.8
03	Buff-red	Bad cracking, hard	....	....	....	19.5	34.9
01	Buff-red	Bad cracking, S H.	14.5	30.4	37.5	6.3	14.8

Remarks: Best firing range: 02-12. Cone fusion: 30. Too much plastic material.

Class of ware: Use as a red pigment.

Neafus pit.—The D. C. Neafus clay pit, now under lease to the Deer Park Natural Pigment Co., is about 2 miles east of the A. B. pit in the SW¼ sec. 34, (30-42 E). Prominent rounded hills of argillite, quartzite, and granite reach to within a mile of the deposit, but the immediate vicinity is only slightly rolling and is too level to permit the clay to be removed by quarry methods. The old Colville road passes through the property, giving, in common with the other pits of the Clayton district, an easy haul to the railroad, though several miles in length. Very little of this clay has been marketed, but considerable exploratory and some development work has been carried on at various times. The surface is covered with a variable overburden of glacial boulders, gravel, and sand that is as much as 15 feet thick in places. Below this is a lacustrine deposit, probably of Latah age, of horizontally bedded clays and sands. Some of this material is fine-grained, plastic, and nearly white. This apparently holds true for the upper 8 to 11 feet in most places, but there is some difference in the relative amounts of ocherous plastic clay and hard brown layers of sienna that are known to underlie the white clay. Such discrepancies are doubtless due to actual differences from place to place caused by lenticular beds and lateral variation. The company, as the result of extensive drilling over a large acreage, gives the following average section:

Section of Neafus clays	*Feet*
Overburden, soil, silt, and gravel	8
Unctuous white clay	11
Yellow ocher	6
Sienna	5
Quartz sand	32+

Wilson[1] mentions that below 8 to 11 feet of nearly white clay is from 3½ to 5 feet of ocher with which thin layers (mostly 2 to 6 inches thick) of sienna are interbedded.

In the early work on this property it was the intention to reach the clay under its overburden by means of a shallow slope, after which it would be mined by drifts along the bedding. A gently sloping tunnel was run in a N. 70° W. direction for 100 feet or so, and some clay was removed; eventually the dead weight of loose surface material proved too great for the timbering used and caused the slope to cave. Cars of clay, during the operation, were raised up an incline to a substantial bunker; from there trucks were loaded by gravity and the clay sold for buff-colored stoneware and pottery.

Sample No. 135-A was taken from clay in the bunkers. It is nearly snow white when dry, though an 11-foot auger test

[1] Wilson, Hewitt, Ochers and mineral pigments of the Pacific Northwest: U. S. Bur. Mines Bull. 304, p. 22, 1929.

hole near the tunnel produced clay that was mixed with yellow ocher. The sample is compact and brittle. The texture is fine and uniform and gives the clay a waxlike feel, the semblance being furthered by the gloss that appears where the clay is rubbed. A small amount of very fine grit can be detected when a portion is tried between the teeth.

Plastic and dry properties Sample No. 135-A

Plasticity	Good, sticky	Volume shrinkage	40.2% dry volume
Shrinkage water	22.6%	Linear shrinkage	15.8% dry length
Pore water	14.2%	Dry condition	Lamination cracks from auger machine
Water of plasticity	36.8%		

Fired properties Sample No. 135-A

Cone	Color	Condition	L.S.%d.l.	T.L.S.%d.l.	V.S.%d.v.	Abs.	A.Por.
02	Light buff	S.H.	....	....	....	7.2	15.3
01	Light buff	S.H.	....	....	....	6.4	13.9
1+	Light buff	S.H.	8.1	48.3	22.5	5.1	10.8
3-4*	Buff	S.H.	....	....	....	3.7	8.0
6-7*	Buff	S.H.	....	....	....	0.9	1.9
12*	Gray-buff	S.H.	6.6	22.4	18.6	1.1	1.8
15	Gray and brown	Vitreous, good, S.H.	5.8	21.6	16.4	2.5	5.1

Remarks: Best firing range: 03-15. Cone fusion: 30-31.

Class of ware: Refractory, but needs nonplastic material. Buff-colored structural wares; pottery; terra cotta.

Sample No. 135-B, also from the Neafus property, was taken from two shallow pits about 300 yards north of the bunkers. Some prospect work was done here, and a small amount of clay was mined. The clay is light gray in color; it is a little darker than that from the tunnel but is otherwise almost identical with it.

Plastic and dry properties Sample No. 135-B

Plasticity	Good	Volume shrinkage	46.9% dry volume
Shrinkage water	24.3%	Linear shrinkage	19.0% dry length
Pore water	11.4%	Dry condition	Lamination cracks from auger machine
Water of plasticity	35.7%		

Fired properties Sample No. 135-B

Cone	Color	Condition	L.S.%d.l.	T.L.S.%d.l.	V.S.%d.v.	Abs.	A.Por.
08	Light buff	Good, hard	1.9	20.9	5.5	16.7	30.5
07	Light buff	Good, S.H.-	3.3	22.3	9.6	14.5	27.2
04*	Light buff	Good, S.H.	5.6	24.6	16.0	7.9	17.1
02	Light buff	Good, S.H.	7.3	26.3	20.4	5.9	13.0
3	Buff	Good, S.H.	8.5	27.5	23.6	0.6	1.5
12*	Light gray	Badly blistered, S.H.	6.7	25.7	18.8	1.5	3.1
15	Brown-gray	Badly blistered, S.H.	6.8	25.8	19.0	1.6	3.4

Remarks: Best firing range: 06-8. Cone fusion: 28-29. Too much plastic material.

Class of ware: No. 2 refractory. Needs nonplastics for buff-colored structural wares, terra cotta, and buff-colored pottery.

Although the locations just mentioned are the only ones in the Clayton district known to have produced clay in commercial quantities, yet many square miles of the low country and foot hills in this vicinity and around Deer Park, in Spokane County, are underlain with the light-colored high-grade clay. It is reported from wells on many farms—in fact, wherever the formation below the surface mantle of soil, sand, and gravel has been penetrated. The samples described above may be considered to be more or less characteristic of the clays of the whole region, if dependence can be placed in reported descriptions of occurrences now inaccessible. The fact that clays high in silica appear to be more common in the northern part of the field, and that high-alumina clays generally occur to the south may be due to the fact that the drainage here is southerly. In any bodies of water the more siliceous clays with their grains of free silica would settle out first, leaving the finer aluminous material to be deposited farther south. Thus a mechanical separation would result that would be in agreement with field indications.

Valley district.—So far as known, the only exposures of high-grade white clays in Stevens County, outside of the Clayton district, are in the vicinity of Valley, where three alluvial deposits, probably of Latah age, have been reported. Conditions are favorable for additional deposits of either residual or sedimentary origin around the borders of the large areas of Loon Lake granite extending south from Springdale, so prospecting would be warranted along the valley of Chamokane Creek, particularly on the east of the Springdale-Long Lake Dam road and south of Loon Lake through T. 28 and 29 N., R. 41 E.

In the NE¼NE¼ sec. 30, (31-41 E), on the property of John Kulzer, is a bed of light-gray clay that occurs under peculiar conditions. The region is rough and hilly, and a ridge of basalt dominates the topography at this particular place. About 1910 a shaft was sunk in the basalt in an endeavor to find iron ore; instead, a "pocket" of clay was penetrated which later led to considerable development work. About halfway to the top of the ridge a tunnel entirely in basalt enters the hill in a general easterly direction for about 100 feet. A 30-foot raise has been driven at about 80 feet from the tunnel entrance and taps the clay discovered by the old shaft. A 15-foot drift on the bed exposes 5 feet of light-gray soft, plastic clay with base concealed. This member is overlain by about 1 foot of coarse brown sand, 1 to 1½ feet of gray clay, which forms the roof of the drift, and an unknown thickness of brown sand. The light-gray clay contains leaf imprints and wood fragments. Some of the vegetal material has been replaced by iron minerals, so that fossils formed of limonite occur and show the texture of the original woody matter.

No mining has been done for many years, but the workings when visited were still in good condition. The drift gives no indication of the clay pinching out. The material is contorted and slickensided, and the relations are obscure, owing to the advanced weathering and disintegration of the basalt at the contact; but no doubt the occurrence is a small lacustrine deposit interbedded between two flows of basalt. The expensive preliminary work is completed, so that the clay could be mined now very cheaply until the supply becomes exhausted.

Sample No. 138 was taken from the 5-foot stratum. It is light gray in color, slightly stained in places by iron oxide derived from limonite nodules which occur at intervals in the bed. There is a noticeable lack of uniformity, some of the clay being free from grit, while some contains considerable sand; one or two waterworn pebbles are present. In general the clay is smooth and compact, appearing not unlike the better Clayton clays.

Plastic and dry properties Sample No. 138

Plasticity	Good	Volume shrinkage	21.4% dry volume
Shrinkage water	15.6%	Linear shrinkage	7.7% dry length
Pore water	17.9%	Dry condition	Good
Water of plasticity	33.5%		

Fired properties Sample No. 138

Cone	Color	Condition	L.S.%d.l.	T.L.S.%d.l.	V.S.%d.v.	Abs.	A.Por.
06	Light buff	Good, S.H.-	3.9	11.6	11.2	12.7	24.1
04	Brown-buff	Good, S.H.	5.9	13.6	16.8	9.6	14.2
01	Brown-buff	Good, S.H.	8.3	16.0	22.9	4.5	10.0
3-4*	Brown-buff	Good, S.H.	12.2	19.9	32.2	0.0	0.0
6-7*	Brown-buff	Good, S.H.	11.9	19.6	31.6	0.0	0.0
12*	Brown and black	Blistered badly, S.H.	7.7	15.4	21.4	1.3	2.0
15	Brown and black	Vesicular, stuck	....	....	....	1.3	....

Remarks: Best firing range: 06-6. Cone fusion: 23+.

Class of ware: If high shrinkage were reduced, suitable for buff-colored structural ware, terra cotta, and pottery.

Clay was encountered in a well put down on the Zeiss farm just south of the tunnel at the foot of the ridge. No sample of this was seen, but it was reported to be similar to that in the basalt, so judicious prospecting in the vicinity might be repaid.

What is probably a very similar clay is reported by Shedd[1] about a mile to the north in the NW¼ sec. 20, (31-41 E). This, also, is a high-grade almost snow white material that apparently

[1] Shedd, Solon, Cement materials and industry in the State of Washington: Washington Geol. Survey Bull. 4, p. 126, 1913.

warrants prospecting. The extent of the deposit is not known, and development may be retarded by the distance from a railroad or market. (See analysis No. 278.)

DARK-FIRING CLAYS

Other clays of Stevens County which have been utilized in a few places are the Pleistocene and Recent alluvial deposits. These are widely distributed throughout the county along the principal rivers and mostly occur in thick well-stratified beds of smooth, plastic clay. A high flux and iron content prevent these clays from being used for anything except the common red wares, but their very fine, uniform texture has led to some being employed for slip in compounding cheap brown glazes.

DISTRICTS

For convenience the dark-firing silts and clays are described under the headings of Chewelah, Bissell-Northport, and Kettle River Valley districts.

Chewelah district.—Of the Pleistocene and Recent alluvial silts and clays, those occurring at Chewelah have been used most extensively. These clays are abundant in the Colville Valley and attain great thickness, as is shown by well borings. The deposit just north of Chewelah has been used for making common red brick and drain tile, and a pit which measured about 150 by 400 feet supplied the plant formerly located there.

A low knoll rises from the level valley floor, and clay was taken from the open pit in its south side. Care was used to allow for natural drainage, so the workings are shallow, exposing only the upper portion of the formation. The clay is laminated and separates readily along the bedding planes but is not indurated enough to be considered a shale. In general it is uniform and free from grit; however, minute layers of very finely divided sand account for the smooth parting. The chief objection to this deposit is the large amount of hard, concretionary lime nodules scattered throughout. These are of various sizes and shapes, though mostly flat and having an average diameter of about three-quarters of an inch.

Sample No. 138-A, from this pit, is a yellowish-gray clay, smooth and soft. It is very even textured and practically free from grit, but it contains sufficient calcium carbonate to effervesce briskly when tested with acid.

Plastic and dry properties Sample No. 138-A

Plasticity	Good	Volume shrinkage	21.5% dry volume
Shrinkage water	11.7%	Linear shrinkage	7.8% dry length
Pore water	14.4%	Linear shrinkage	6.5% wet length
Water of plasticity	26.1%		

Fired properties Sample No. 138-A

Cone	Color	Condition	L.S.%d.l.	T.L.S.%d.l.	V.S.%d.v.	Abs.	A.Por.
08	Buff-brown	Weak, soft	0.4	8.2	1.1	18.5	31.9
07	Buff-brown	Good, hard	....	....	....	16.3	28.2
04*	Dk. brown-red	Vitreous surface, good, S.H.	8.4	16.2	23.2	0.7	2.7
02	Dk. red-brown	Vitreous surface, good, S.H.	9.6	17.4	26.2	0.0	0.0
2	Dk. red-brown	Deformed, fused, S.H.	5.1	12.9	14.6	1.1	2.2
6-7*	Dk. red-brown	Fused	3.8	11.6	10.9	0.3	1.0

Remarks: Best firing range: 06-01. Cone fusion: 8. Shrinkage is a little high.

Class of ware: Formerly used for common, face brick, and drain tile.

Chewelah Brick Co. (abandoned).—As used at the old Chewelah Brick Co., the clay was plowed and exposed to the weather for some time. It was then carried in wheeled scrapers to the plant, where it was passed through disintegrator rolls and elevated to a hopper. The product, common brick, was made by the ordinary stiff-mud process and dried on pallets in the open yard and on covered racks. Firing was in a semi-continuous down-draft kiln, using wood and coal for fuel. An output of 3,000,000 brick was reached in some years.

Alluvial clays occurring at Colville were formerly utilized for making common red brick. The lack of demand was principally responsible for the closing down of the two plants that were located here. Varved bluish-gray soft clays have been exposed to a depth of 10 feet and more by excavations in the business district and elsewhere. One mile northeast of town a bed of grayish clay about 20 feet thick occurs with from 1 to 3 feet of overburden. Southeast of the Fairgrounds 100 yards is another deposit. A 2-acre pit here exposes about 8 feet of sandy gray clay with about 2 feet of overburden.

Bissell-Northport district.—Near Bissell, in western Stevens County, is a small deposit of alluvial clay. It is exposed just north of the road near a spring in the NW¼ sec. 3, (31-37 E). The distance from any market reduces the value of this clay, but it represents a type slightly different from other beds sampled.

Sample No. 139, taken here, is a sandy gray material somewhat stained yellow where it has been exposed to weathering.

Remarks: When tempered with 26.2 percent water, a good plastic strength is produced. It fired to scummed buff, brown, and red colors between cones 06 and 1. It could be used for brown structural wares.

From Bissell north along the Columbia are large deposits of alluvial clays where Pleistocene terrace deposits remain as erosional remnants high above the river level. These are, in places, poorly consolidated silts, such as are found so generally in the larger stream valleys in northeastern Washington, but some deposits are well-bedded clays, commonly very plastic and tenacious. The extensive deposits near Kettle Falls are characteristic of the better grade of these glacial clays. However, a high content of iron oxide and other fluxes confines their adaptability to common red-firing products. A small yard operated at the old town of Kettle Falls at one time and used these clays for common brick.

Horizontally stratified thin-bedded clays are cut by the road at the south side of the Colville River in the SW¼ sec. 35, (36-37 E). Separation occurring along thin sandy layers renders the bedding distinct. The material is very uniform and fine in texture and is free from grit except for the small amount on the bedding planes. Immense amounts are available, but trouble would be caused by a gravel overburden in some places. This particular location will be covered by water when the Grand Coulee dam is completed, but the description and the results of tests are indicative of the abundant Pleistocene clays throughout this whole region.

Sample No. 140, taken at this location, is dark blue and very plastic when fresh and damp. After drying it is compact and brittle and gray in color. The sample contains practically no grit.

Plastic and dry properties Sample No. 140

Plasticity	Sticky	Volume shrinkage	22.5% dry volume
Shrinkage water	13.6%	Linear shrinkage	8.2% dry length
Pore water	23.1%	Linear shrinkage	6.7% wet length
Water of plasticity	36.7%	Dry condition	Good

Fired properties Sample No. 140

Cone	Color	Condition	L.S.%d.l.	T.L.S.%d.l.	V.S.%d.v.	Abs.	A.Por.
06	Buff-brown	Good, hard	0.7	8.9	2.2	20.2	33.1
04	Lt. buff-red	Good, hard	6.4	14.6	18.0	14.4	26.6
02	Dark brown	Good, scum, S.H.	13.6	21.8	35.5	1.4	3.4
1	Dk. brown-red	Badly stuck, glazed, S.H.	17.0	25.2	42.7	1.1	2.5
3-4*	Dk. brown-red	Fused, S.H.	9.1	17.3	24.9	0.0	0.0

Remarks: Best firing range: 05-02. Cone fusion: 2. High shrinkage. Low fusion.

Class of ware: Add nonplastic material for red and brown structural wares.

About three-quarters of a mile north of Marcus, a cut along the Great Northern Railway exposes a clay resembling that at the old town of Kettle Falls. It is dark gray in color, fine-grained and compact. A similar large deposit occurs along the road about half a mile northeast of Evans. Other large deposits occur near Bossburg along the Columbia. They are finely stratified and vary in color from dark bluish gray when damp to light gray when dry. In common with the deposits farther south, these clays are very fine grained and practically free from all but the finest grit. They commonly show only medium plasticity and low tensile strength. One deposit here has been mined intermittently for many years; some of the clay was shipped to Clayton to the old Spokane Pottery Co., where it was used as slip for glazing stoneware, but most of the output (some 8,000 tons) was bought by smelters, formerly located at Northport and at various places in British Columbia, and used for temporary seals in furnace openings.

This particular deposit is beside the railroad, 4 miles north of Bossburg, in the NE cor. sec. 15, (38-38 E). It is held by T. R. Fitzgerald as three mining claims. The high bluff, here, above the Columbia is very steep and has undergone considerable slumping. This has left the usually horizontal clay beds tilted and broken, so that a series that is 125 feet thick at one place is exposed for only a few feet at the foot of the bluff a short distance away. The clay is easily mined, as some 125 feet of upper sandy and gravelly beds were stripped off years ago by the railroad in order to decrease the slope and eliminate slides. It occurs in thinly laminated beds, 1 to 2 inches thick, and in more massive beds, as much as 3 feet thick; the bedding is made distinct by paper-thin fine, silty partings in a clay which is otherwise almost free from detectable grit. The color is dark bluish gray when the material is damp and a medium gray when dry. The following results were obtained in tests[1]:

Water of plasticity	34.5 %	Light red and still soft at cone 010.
Linear shrinkage on drying	6.68%	Dark red and vitrified at cone 05.
Linear shrinkage on firing to cone 010	1.33%	Dark brown and completely fused at cone 1.

There was little cracking or warping, even when dried rapidly but care was required in firing to prevent swelling and distortion.

In the vicinity of Northport are extensive deposits of similar kind. The railroad cuts through one near the river, 2½ miles northeast of the town. Stratification is distinct, owing to very sandy layers being interbedded with finer-grained plastic ones that are practically free from grit. A flat bench, several hundred acres in extent, across the river from the town, is probably largely composed of these clays. They are exposed at one place where the railroad grade cuts into the series and again at the mouth of Sheep Creek. South of Northport, 2½ miles, the clays

[1] From Shedd, Solon. The clays of the State of Washington: State College of Washington publication, p. 217, 1910.

occur in a bench above the river. A very uniform bed, more than 30 feet thick, is exposed in sec. 17, (39-40 E), indicating the large quantity available. At one time a brick yard operated here, and the old opening shows stratified light-buff fine-grained clay. Samples are practically free from grit, though when dry they have a harsh, silty feel. They slake readily and have good plasticity, but have a short firing range, produce a red ware, and have a low temperature of fusion.

Kettle Valley district.—Silty clay occurs at several places along the Kettle River from its confluence with the Columbia north into Canada. A characteristic example is in the NE¼ sec. 17, (37-38 E), where a deposit, very light gray in color, covers many acres of land. It is mostly exposed in the upper levels of the hills making up the region and is of glacial origin, horizontally bedded, and of great thickness. The beds are commonly without much overburden and show white through the mantle of vegetation, especially where uncovered by the hoofs of stock and deer. Incidentally, the animals eat the clay for some salts it contains and in so doing have laid bare many patches.

Sample No. 148 was taken from the farm of C. C. Hooks at the section location given above. It is very uniform and smooth in texture and is quite free from coarse grit. It is compact and brittle when dry and is filled with irregular, branching minute holes. Several irregularly shaped limy concretions were noted where the sample was taken; these would be an objectionable feature of this clay were it ever to be utilized. Although less than a mile from the railroad, the clay is not of a quality to repay shipping, its only value coming with the development of a nearby market.

Plastic and dry properties Sample No. 148

Plasticity	Good	Volume shrinkage	28.5% dry volume
Shrinkage water	17.7%	Linear shrinkage	10.6% dry length
Pore water	23.7%	Dry condition	Good
Water of plasticity	41.4%		

Fired properties Sample No. 148

Cone	Color	Condition	L.S.%d.l.	T.L.S.%d.l.	V.S.%d.v.	Abs.	A.Por.
06	Lt. buff-brown	Light scum, soft	1.2	11.8	3.5	23.3	36.7
02	Dk. red-brown	Scum, good, S.H.	14.0	24.6	36.5	0.0	0.0

Remarks: Best firing range: 04-02. Cone fusion: 3-4. High shrinkage, short firing range.

Class of ware: Add nonplastic material for red and brown structural wares.

Great exposures of unconsolidated silt occur in benches along the Kettle River near Orient. The hills rise rather steeply from the water, and some bench remnants that have escaped erosion are found at considerable elevation. Other lower benches form flats above the present channel.

Sample No. 149 was taken from the property of Charles Rogers, where the road going east up the Orient hill crosses thick silt beds. It is a gray very fine material that shows only the slightest cohesion or consolidation in dry lumps. It immediately disintegrates to powder under pressure. Between the fingers it is velvet smooth but is gritty when tested between the teeth.

Plastic and dry properties Sample No. 149

Plasticity	Very weak, silty	Volume shrinkage	6.4% dry volume
Shrinkage water	4.0%	Linear shrinkage	2.2% dry length
Pore water	26.0%	Dry condition	Weak
Water of plasticity	30.0%		

Fired properties Sample No. 149

Cone	Color	Condition	L.S.%d.l.	T.L.S.%d.l.	V.S.%d.v.	Abs.	A.Por.
06	Buff-brown	Weak, very soft	0.0	2.2	0.0	26.8	41.8
05	Buff-brown	Weak, soft	0.0	2.2	0.0	25.8	40.3
01	Dark red-brown	Vitreous, S.H.	12.8	15.0	33.7	1.8	4.1
1+	Brown black	Fusion started, S.H.	15.3	17.5	39.3	1.3	3.1

Remarks: Best firing range: 04-01. Cone fusion: 3. Weak plastic and dry strength; short firing range; slow to develop fired strength.

Class of ware: Slip clay.

Some of the silt was mined here years ago and shipped to a pottery near Spokane, where it was used in common brown glazes on stoneware. The nearness to a railroad of this and other deposits in the vicinity makes them very accessible if a demand for such material arises.

THURSTON COUNTY

Thurston County, near the central part of western Washington, has an area of 709 square miles. The extreme eastern part is made of high hills that are outliers of the Cascade Mountains; between there and the hilly western part is a broad area of prairie and rolling lowland. Igneous extrusive rocks—basalt and andesite—of Eocene and Miocene age comprise the bedrock of a large part of the county. Extensive exposures of these are in the more inaccessible eastern area, and there, in favorable places, Cascade residual clays similar to those of La Grande may be expected to occur. It is doubtful, however, that any large deposits of that kind of material exist. In the western hills some residual basaltic clay has formed that is similar to that sampled as No. 341 in Cowlitz County, but no large deposits are known.

Extensions of formations better exposed in Lewis County occur in the southwestern part of the county. These include Oligocene sediments south of the Chehalis River and coal-bearing Eocene sediments in the vicinity of Tenino and Bucoda. Outcrops are not abundant, as the beds are commonly concealed by surface soil and vegetation even in the driftless area, but the strata are exposed in some places, particularly along streams and in road and railway cuts.

Just north of Tenino extensive cuts along the Northern Pacific Railway expose the Tertiary sediments. Shale predominates here, and is well situated for cheap mining. In the NW cor. sec. 19, (16-1 W), a fresh cut, a quarter of a mile long and more than 60 feet deep, shows at the bottom, 11 feet of compact nearly black shale interbedded with three sandstone members, each being about 6 inches thick. The beds strike S. 30° W. and dip 15° SE. Above these beds is some 50 feet of sliding buff-colored clay that has resulted from the weathering of massive overlying shales. Mixed with the upper clay is some glacial gravel that has slumped from the overburden on still higher disintegrated shales, occurring farther west in this landslip area.

Sample No. 373 was taken of the unweathered shale and is very dark bluish gray in color. It is practically free from any but the finest grit and is fine-grained, very compact, and hard.

Plastic and dry properties Sample No. 373

Plasticity	Fair	Volume shrinkage	22.6% dry volume
Shrinkage water	11.6%	Linear shrinkage	8.2% dry length
Pore water	14.1%		
Water of plasticity	25.7%		

Fired properties Sample No. 373

Cone	Color	Condition	L.S.%d.l.	T.L.S.%d.l.	V.S.%d.v.	Abs.	A.Por.
010	Buff-brown	Good, hard	1.5	9.7	4.2	15.4	28.8
06	Lt. brown-red	Good, hard	2.3	10.5	7.6	13.8	27.0
04*	Brown-red	Good, slight scum, S.H.	3.2	11.4	9.4	9.2	19.5
2	Dk. red-brown	Vitreous, vesicular, S.H.	....	....	2.4	6.3	11.5
3-4	....	Fused	....	....	....	....	....

Remarks: Best firing range: 08-04. Cone fusion: 3. Develops best body and finally fuses at low temperatures.

Class of ware: Brown and red structural wares.

Weathered shales are exposed at several places in cuts along the county road near the above location. Considerable slumping of higher clay has rendered structural data uncertain. Glacial gravels form a heavy overburden in part, but the shale in some places could be easily removed in great quantities without excessive stripping.

Sample No. 374 was taken from a bank 40 feet high and 300 feet long about 100 yards northeast of the location of No. 373. It is an irregularly stained greenish-gray and brown material that is much jointed and spheroidally weathered. Some sand is present, but most of the sample is "fat" and free from grit.

Plastic and dry properties Sample No. 374

Plasticity	Fair	Volume shrinkage	36.0% dry volume
Shrinkage water	21.6%	Linear shrinkage	13.8% dry length
Pore water	23.8%		
Water of plasticity	45.4%		

Fired properties Sample No. 374

Cone	Color	Condition	L.S.%d.l.	T.L.S.%d.l.	V.S.%d.v.	Abs.	A.Por.
04*	Red-brown	Surface cracks, hard	3.0	16.8	8.6	14.4	26.7
2	Red-brown	Surface cracks, S.H.	9.1	22.9	24.9	6.3	13.4
6*	Brown-red	Vesicular, fused, S.H.	7.6	21.4	21.2	3.9	8.7

Remarks: Best firing range: 05-1. Cone fusion: 3-4. High dry shrinkage.

Class of ware: Need nonplastic material for red-brown structural ware.

The outer limit of the great Pleistocene ice sheets that covered the Puget Sound region was well south in this county. So, aside from the higher hills and the narrow strip south of Tenino, the whole county is covered with glacial sediments. The clays have their best exposures in the sea cliffs bordering the inlets of Puget Sound. At other places gravels are likely to be too abundant for economical clay operation. The clays occur in similar manner to those found elsewhere throughout the Sound region, and they are practically identical in physical properties with the rest. Reference may be made to descriptions of the glacial clays of King and adjacent counties for data on this type of clay.

WAHKIAKUM COUNTY

Wahkiakum County includes an area of 267 square miles fronting on the Columbia River in southwestern Washington. The region has considerable relief and is sparsely settled except in the river valleys. The formations here are continuations of those occurring in Pacific County, and consist of Eocene basalts and interbedded sediments, Oligocene sediments, Miocene basalt and sediments, and Willapa Pleistocene terrace deposits. The shales are of marine and brackish-water origin, and, as they are red firing and have a moderate fusion point, they probably have little economic value for anything but local markets. The terrace deposits are unusual in that they contain, at least in one locality, buff-firing clays. In general, however, the most abundant surface material is a colluvial clay that has been somewhat worked over by streams. This material is mostly derived from basalt and has a reddish-brown color from the high content of iron oxide. Such clay is slightly and irregularly sandy and generally has an earthy texture, but makes very satisfactory brick and drain tile.

Sample No. 305-A, representative of the last-mentioned clay type, is from sec. 7, (8-4 W), about 2 miles west of Cathlamet. It is a friable reddish-brown clay that is almost identical in appearance with sample No. 341 from Cowlitz County. The colloidal brown mineral of the beidellite group is particularly noticeable.

Plastic and dry properties Sample No. 305-A

Plasticity	Fair	Volume shrinkage	23.3% dry volume
Shrinkage water	14.3%	Linear shrinkage	8.5% dry length
Pore water	25.1%		
Water of plasticity	39.4%		

Fired properties Sample No. 305-A

Cone	Color	Condition	L.S.%d.l.	T.L.S.%d.l.	V.S.%d.v.	Abs.	A.Por.
010	Buff-brown	Weak, very soft	0.9	9.4	2.8	31.3	47.8
06	Light red-brown	Weak, very soft	1.2	9.7	3.6	20.7	47.0
01	Brown-red	Good, hard	5.3	13.8	15.1	20.7	38.2
10	Dark purple	Good, hard	8.1	16.6	22.4	16.6	31.8

Remarks: Best firing range: 01-8. Cone fusion: 15. Firing shrinkage high. Requires higher temperature than usual.

Class of ware: Red and brown structural wares.

A mile north of Skamokawa, near the center of the E½ sec. 8, (9-6 W), a landslide has exposed a great thickness of shale for 400 yards along the sides of a ravine. It is thick-bedded and dips 35° SW. Two kinds of material are most abundant, one rather smooth and the other sandy.

Sample No. 303 is a soft shaly rather carbonaceous sandstone. It is bluish to greenish gray in color, moderately fine textured, and uniform. Aluminum sulphate is present in sufficient quantities to form a frost of needle-like crystals on the surface of drying lumps.

Remarks: A fair degree of plasticity was developed. The sample should be further tested for low-temperature red-brown structural wares. The cone fusion temperature was cone 6 minus.

Sample No. 304 is a grayish-buff to brown shale. The texture is fine and uniform and rather smooth in spite of some sand. Dried lumps are very compact but brittle.

Plastic and dry properties Sample No. 304

Plasticity	Fair	Volume shrinkage	28.7% dry volume
Shrinkage water	17.9%	Linear shrinkage	10.7% dry length
Pore water	25.6%	Dry condition	Medium strength
Water of plasticity	43.5%		

Fired properties Sample No. 304

Cone	Color	Condition	L.S.%d.l.	T.L.S.%d.l.	V.S.%d.v.	Abs.	A.Por.
08	Buff-brown	Weak, soft	1.8	12.5	5.3	25.4	39.4
05	Buff-red	Good, hard	6.4	17.1	18.0	14.9	27.9
01	Bright brown-red	Good, S.H.	9.2	19.9	25.2	12.0	22.9
3-4*	Bright brown-red	Good, S.H.	10.4	21.1	28.0	10.1	20.3
6-7*	Bright brown-red	Good, S.H.	22.1	11.4	30.4	6.6	13.6

Remarks: Best firing range: 06-7. Cone fusion: 9-10.
Class of ware: Brown and red structural wares.

A very promising Willapa Pleistocene clay occurs in one of the terrace deposits and may exist in considerable quantity in this vicinity. Owing to some local conditions when the clay was deposited, there accumulated here a material of much greater purity than has so far been found in any bed of similar origin in western Washington. It is expected that future prospecting may prove an extent and depth that will make this clay commercial.

Sample No. 306 was taken from a small abandoned prospect pit on the Watkins farm, about three-quarters of a mile north of Cathlamet. The location is on the edge of a terrace that extends for some distance toward the hills and has an elevation of about 150 feet above the Columbia. Because of the condition of the pit, no idea could be had of the deposit other than is shown by the sample. A quartzite pebble, an inch in diameter, in the sample indicates what may prove to be a detrimental feature of the deposit. Two feet or so of soil forms the only overburden. The clay is a soft bluish-gray material that is tough and plastic. The texture is fairly fine and uniform, yet somewhat gritty.

Plastic and dry properties Sample No. 306

Plasticity	Weak	Volume shrinkage	24.5% dry volume
Shrinkage water	14.1%	Linear shrinkage	8.9% dry length
Pore water	13.2%	Linear shrinkage	7.8% wet length
Water of plasticity	27.3%	Dry condition	Fair dry strength

Fired properties Sample No. 306

Cone	Color	Condition	L.S.%d.l.	T.L.S.%d.l.	V.S.%d.v.	Abs.	A.Por.
03	Light buff	Good, hard	....	....	....	17.9	35.8
02	Light buff	Good, hard	1.2	10.1	3.5	16.5	30.1
01-1	Light buff	Good, hard	2.1	11.0	6.2	15.8	28.4
3-4*	Light buff	Good, S.H.	3.8	12.7	10.9	12.8	24.5
6-7*	Gray	Good, S.H.	4.7	13.6	13.5	10.2	19.0
12*	Brown	Good, S.H.	5.8	14.7	16.5	1.2	2.7

Remarks: Best firing range: 04-12. Cone fusion: 23. Plasticity may be increased by fine grinding in water.

Class of ware: Buff structural ware. Terra cotta when mixed with clays of better strength.

On the farm of T. M. Bowman, a quarter of a mile north of the Watkins pit, clay was encountered in sinking a well. The report is that "under 28 feet of overburden is a 22-foot bed of very tough clean gray clay. This is underlain by sand." It is said that the clay contained very few pebbles and that it corresponded with that found to the south on the Watkins farm.

A gravelly gray clay is exposed in a cut, three-quarters of a mile from Cathlamet, on a logging railroad grade. This is not far from the locations mentioned just previously, though considerably lower in elevation. The cut is 50 feet long and, at its maximum, 5 feet high. The pebbles are rounded and mostly small, but some are as much as 2 inches in diameter. All those other than quartzite are decomposed and softened. A large amount of clay is available, but the pebbles would prove an objectionable feature in working this deposit.

Sample No. 305, from this cut, is gray in color and dries to a rather light shade. The texture is very uneven, some of the clay being firm and very tough and plastic, while the rest is highly sandy and friable.

Plastic and dry properties Sample No. 305

Plasticity	Good	Volume shrinkage	22.2% dry volume
Shrinkage water	11.7%	Linear shrinkage	8.0% dry length
Pore water	13.5%	Dry condition	Strong bars
Water of plasticity	25.2%		

Fired properties Sample No. 305

Cone	Color	Condition	L.S.%d.l.	T.L.S.%d.l.	V.S.%d.v.	Abs.	A.Por.
07	Light buff	Weak, scft	-0.2	7.8	-0.6	17.3	30.2
04	Lt. red-buff	Good, hard	....	....	....	15.5	29.0
02	Lt. red-buff	Good, hard	2.7	10.7	7.8	15.7	29.8
01-1	Buff	Good, hard	....	....	....	13.0	24.3
3-4*	Buff-brown	Good, S.H.	12.3	4.3	12.3	10.8	21.4
6-7*	Brown	Good, S.H.	5.1	13.1	14.4	6.6	13.6
10	Gray-brown	Vesicular, S.H.	3.9	11.9	11.1	1.6	2.9
12*	Deep brown	Vesicular, S.H., near fusion	2.2	10.2	6.3	2.7	4.0

Remarks: Best firing range: 05-7. Cone fusion: 14.
Class of ware: Brown structural ware.

WALLA WALLA COUNTY

Walla Walla County is in the southeastern part of the State and includes an area of 1,265 square miles. The topography varies through level plains along the Columbia River and rolling hills in the middle country to high mountains of the southeastern part. Basalt forms the bedrock throughout the county, and only ordinary red-firing clays are known to occur. In a few places, as in the western part of the county, are loose gray silty sandstone and clays, a part of the Ringold formation which occurs so extensively in Franklin County. Other beds, similar to the Ellensburg formation, are doubtless present, and one body probably of this kind, intercalated between flows of basalt, is mentioned by Russell[1]:

"At a locality on the south side of Walla Walla Valley, about midway between Walla Walla and Wallula, the upper portion of a bed of fine clay beneath basalt is open to view for a short distance. The thickness of this bed that is exposed to view is only about 4 feet, but its total thickness is unknown."

The common surface material covering the basalt—in some places to great thickness—is a structureless to rudely stratified variable deposit. In the western part of the county it is rather loose and sandy; in the central section it shows an increase in fineness and contains much silty clay, the whole being light and fluffy; and in the eastern part a heavy reddish-yellow clay predominates that is similar in appearance and origin to the Palouse clay of the counties to the northeast.

Clays of the Ellensburg or Ringold formation are used for ordinary structural ware in Yakima County (see pp. 332/335),

[1] Russell, I. C., A reconnaissance in southeastern Washington: U. S. Geol. Survey Water Supply Paper 4, p. 51, 1897.

and it is possible that beds in western Walla Walla County, such as are exposed in some railway cuts, would be satisfactory for brick and tile. Recent alluvial clay occurs in the Walla Walla and Touchet valleys and is suitable for red-firing ware. It was used for a good grade of brick and tile by a plant that formerly operated at Walla Walla. Palouse clay is used in Spokane County (see pp. 276-278) and was formerly used in several Whitman County brick yards. So abundant clay is available for common red-firing ware to fill the needs of any local market.

WHATCOM COUNTY

Whatcom County, in northwestern Washington, has an area of 2,082 square miles. It is largely a rough, mountainous area, although broad valleys and lowlands separate the hills of the western part. The county extends from tidewater to the summit of the Cascades and includes many formations and varieties of rock. Granodiorite occurs over a large area in the eastern part of the county. Good clays could result from the decomposition of such rock, but erosion in this mountainous part is too active to allow deposits to accumulate. To the east and west of the granodiorite area are extensive areas of metamorphic rock—argillites, slates, quartzites, and schists. These are not materials from which usable clays commonly form. So the clay resources are confined to the Tertiary shales and glacial sediments of the western part of the county.

COMMON SHALES

The shales of the county are of two types, both belonging to the coal-bearing fresh-water Chuckanut formation of Eocene age. The most abundant is a dark-gray sandy shale that weathers buff, commonly exposed with sandstone in excavations and road cuts. This material is red firing and suitable for ordinary structural wares. The other type of shale is known to occur only in the vicinity of Sumas, where it has been mined for many years and has furnished a large tonnage for the use of the ceramic industry.

A sample taken at the Bellingham Coal Mine, in Bellingham, is representative of the better class of the more abundant shales. This shale forms the roof of the main coal bed and could be easily mined with the coal. The general relations are shown in the following section:

Section of strata at Bellingham Coal Mine

Surface of ground	
Pleistocene (glacial)	*Feet*
Gravelly soil; clay	12
Sand and gravel, water-bearing	22
Blue clay	100
Sand, gravel, some clay	130
Unconformity	
Eocene	
Sandstone	15
Very dark gray shale. (Sample No. 393)	12
Coal; clay partings	14
Shale	....

The structure is very regular, the beds striking S. 28° E. and dipping 10° SW. In mining, an incline of 18° is used to reach bedrock, after which the slope conforms to the bedding.

Sample No. 393 is a very dark gray, nearly black, massive shale. The texture is very fine and uniform, and the material is nearly devoid of sand. It is compact, and although hard, is brittle, breaking with a fine subconchoidal fracture.

Plastic and dry properties Sample No. 393

Plasticity	Good	Volume shrinkage	17.4% dry volume
Shrinkage water	7.2%	Linear shrinkage	6.2% dry length
Pore water	12.7%		
Water of plasticity	19.9%		

Fired properties Sample No. 393

Cone	Color	Condition	L.S.%d.l.	T.L.S.%d.l.	V.S.%d.v.	Abs.	A.Por.
08	Brown-buff	Good, hard	2.0	8.2	5.6	13.5	28.3
02	Brown	S.H.	6.4	12.6	18.1	5.8	13.4
2	Dark brown	Vitreous, good, S.H.	7.5	13.7	20.8	3.2	9.3

Remarks: Best firing range: 07-2+. Cone fusion: 15. Promising material.

Class of ware: Brown structural wares.

Formerly a brick and tile plant operated at Grandview Station on the Great Northern Railway 4 miles south of Bellingham. The shale that was used is part of the Chuckanut formation and occurs under steeply dipping beds of sandstone which form the sea cliffs at this place. The material mined was sandy and nonuniform and contained an abundance of large concretionary masses. The beds strike S. 42° E. and dip 55° SW., or toward the plant, which was at the foot of the bluff.

Sample No. 394 was taken of the rock last worked—a material more nearly sandstone than shale. It is laminated, dark gray to nearly black in color, and is composed of fine sand grains in a clayey cement. Pieces are moderately compact and break in slabs along the bedding planes.

Plastic and dry properties Sample No. 394

Plasticity	Good	Volume shrinkage	14.5% dry volume
Shrinkage water	8.5%	Linear shrinkage	5.1% dry length
Pore water	19.0%		
Water of plasticity	27.5%		

Fired properties Sample No. 394

Cone	Color	Condition	L.S.%d.l.	T.L.S.%d.l.	V.S.%d.v.	Abs.	A.Por.
05	Brown-red	Good, hard	4.0	9.1	11.5	17.1	31.6
02	Red-brown	Good, S.H.-	6.6	11.7	18.5	10.8	22.3
1	Dk. red-brown	Vitreous, good, S.H.	9.9	15.0	26.9	3.6	8.3

Remarks: Best firing range: 05-01. Cone fusion: 5.

Class of ware: Formerly used for red-brown brick and tile.

The shale quarry, now abandoned, extends 125 feet along the bluff and has a working face about 150 feet high. The deposit was worked by stripping 10 feet or more of massive sandstone from the face of the bluff and then quarrying the sandy shale and shaly sandstone which intervenes between the member removed and an underlying sandstone. Sufficient shale is available for several years' running, but the deposit is not large; to work laterally along the strike would entail expensive stripping; while long continued quarrying across the beds would mean the use of new, unproved shales, eventually the undermining of the highway, and finally the encountering of massive sandstone.

SUMAS SHALES

A series of interbedded shales, sandstones, and conglomerates, that has properties quite unlike the ordinary beds, forms the basal part of the Chuckanut formation near Sumas. The base of the formation is exposed in only a few places in the county; it appears on Lummi Island, on the south end of Lookout Mountain, on the east shore of Samish Lake, and at some other locations, but in all these exposures the lower shales are similar to those commonly found throughout the 12,000 to 16,000 feet of strata that comprise the formation. In other words, they are muddy-appearing red-firing, moderate-fusing materials having no outstanding properties of particular value. In the vicinity of Sumas, however, the basal section contains bright-red plastic shales, turquoise-blue flint clays, and clear-colored bluish-gray fire clays. Some 16 percent of the argillaceous members are buff firing and are refractory or semirefractory. The total area covered by the Sumas series is not known. The strata was deposited on a surface that had considerable relief, and lower beds may be interrupted by projecting masses of older rock. Most of the formation has been eroded, and detached remnants, commonly separated by metamorphic and igneous rock, are all that remain of a formerly extensive series of beds.

In the canyon of Saar Creek, 3 miles southeast of Sumas, in the SE¼ sec. 12, (40-4 E), the pre-Tertiary thin-bedded slaty argillites and quartzites, upon which the Sumas series was deposited, are well exposed. Above the well-marked unconformity, is a massive basal conglomerate; this, in turn, is overlain by shales and sandstones. The series is very well stratified; individual beds are uniform in texture and composition, and they are fairly uniform in structure. The average strike is N. 20° E. and dip, 35° NW. The creek cuts the series at approximately right angles to the strike, and a fairly accurate stratigraphic section may be measured along the bank and in the tunnels and prospect cuts of an old clay mine. Farther downstream, outcrops are concealed by soil and vegetation, and at the edge of Sumas Valley the dip of the strata takes the beds under the alluvial flats.

The series reappears across the valley 4½ miles to the north in British Columbia, on the south end of the Canadian Sumas Mountain. There, the name of Huntingdon formation has been given these beds by Daly[1], who suggests that they should be correlated with the Puget group (Eocene) and calls attention to the fact that they are apparently of the same nature and age as the coal-bearing rocks in the Hamilton and lower Nooksack Valley districts south of the international boundary. The beds north of Sumas Valley, where not slumped, strike N. 50° W. and dip, 14° SW., indicating that the series is involved in a broad westward-plunging syncline, the axis of which underlies the alluvium-filled Sumas Valley.

The Sumas series differs somewhat in origin from the rest of the Chuckanut formation, of which it is a part, as is shown by the unusual physical properties of the shales. It is composed of lacustrine sediments that accumulated mostly in moderately deep water. At least part of this material was supplied by streams, possibly an ancient Fraser River, that drained an area in which such rocks as the Sumas granite and the Chilliwack granodiorite predominated. When the high-alumina clays accumulated there could have been little if any connection between this lake and the water bodies in which were being deposited the mixed, impure detritus that makes up the usual Chuckanut

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[1] Daly, R. A., Geology of the North American Cordillera at the forty-ninth parallel: Canada Dept. of Mines Geol. Survey Mem. no. 38, pt. 1, pp. 519-520, 1912.

strata. Thus, the Sumas shales are of relatively local occurrence; they are lower in impurities than the heterogeneous mixtures comprising the rest of the formation; and they have the refractory property that would be expected from clays derived from feldspathic rocks.

Stratigraphic section of Sumas series

D-R[1] *No.*	Top of section concealed	*Feet*
1.	Shale, coarse, concretionary (red-firing)	50+
	Conglomerate	15
2.	Shale, sandy (low-grade dark buff-firing fire clay)	12
	Conglomerate	20
3.	Shale, sandy (red-firing medium-plastic)	10
	Shale, reddish-colored sandy	20
4-A.	Shale (plastic, similar to 6-A)	3-6
	Shale	10
4.	Shale, sandy greenish-blue (low-grade fire clay)	10
	Shale, sandy	15
5.	Shale[2], blue, fine-grained (main bed worked for fire clay; medium-plastic)	4-12
	Shale, mottled red and yellowish (low-grade fire clay)	20
6.	Shale, yellowish (low-grade plastic fire clay)	6
	Shale, yellowish (semiplastic)	12
6-A.	Shale[3], yellowish-blue (plastic fire clay)	4
	Conglomeratic sandstone	40
16.	Shale[4], fine-grained, light-blue (fire clay). "Tiger"	0-7
16.	Shale, spotted light-blue (low-grade plastic fire clay)	12
16-AA.	Shale (fire clay similar to 17-A)	1½-2
	Sandstone	3
17.	Shale, blue, red-mottled (plastic)	20
17-AA.	Shale[5], blue sandy (plastic fire clay)	2-3
	Sandstone	5
17-A.	Shale, blue sandy (fire clay)	1-2
	Sandstone	4
17-B.	Shale, similar to 18	4
	Sandstone; carbonaceous partings	4
18.	Shale[6], fine-grained (plastic)	11
	Sandstone; carbonaceous partings	4-5
19.	Shale, iron-stained (very plastic)	12
20.	Shale, light-blue ("flint fire clay")	3
21.	Shale, fine, even-grained, red	30
	Sandstone and fine conglomerate[7] ("ganister")	40

[1] D-R numbers are those by which the Denny-Renton Clay & Coal Co. designated the beds.
[2] Tested as sample No. 207.
[3] Tested as sample No. 203.
[4] Tested as sample No. 204.
[5] Tested as sample No. 208.
[6] Tested as sample No. S-18.
[7] Tested as sample No. 206.

Stratigraphic section of Sumas series—Continued

D-R[1] *No.*	Top of section concealed	*Feet*
22.	Shale[8], light blue sandy	3-4
23.	Shale, red-stained	10
24.	Shale, sandy red	5
	Conglomerate	3
	Shale	1+
	Conglomerate: pebbles average 1-2 inches in diameter and are as much as 18 inches at base of bed	80
	Approximately	525
	Unconformity	
	Argillite and quartzite, thin bedded, slaty.	

Beds of the Sumas series crop out or have been exposed by prospect pits or tunnels at several places in T. 40 N., R. 5 E.; in the SE¼NW¼, the S½NE¼, and near the S. line SW¼ sec. 7; in the SW¼ sec. 5; in the N½ sec. 8; in the SW¼ and SW¼-NE¼ sec. 17; and in the NW¼NW¼ and SW¼ sec. 18. The largest, most persistent exposures are in the canyon of Saar Creek in the SE¼ sec. 12, (40-4 E), where, for many years, the old Denny-Renton Clay & Coal Co. operated a clay mine. In all, the series is known to occur throughout 2 or 3 square miles in this vicinity. It is possible that the beds may continue in the direction of their strike into the region to the south and west. This adds an area of some 4 square miles in the vicinity of South Pass and to the northwest of it and Breckenridge Creek, that is favorable prospecting ground. It includes a region of moderate relief immediately north of Sumas Mountain—an area that is in marked contrast to the surrounding country but in keeping with the relief to be expected from a formation that is 60 percent shale.

The workings, now abandoned, of the Denny-Renton Clay & Coal Co.— in the SE¼ sec. 12 (40-4 E)—are on the southwest side of Saar Creek near the Chicago, Milwaukee, St. Paul & Pacific Railway trestle. Two main drifts were used, the longest running some 500 feet on their No. 5 shale. (See "D-R numbers" on the preceding stratigraphic section.) Two auxiliary tunnels also were used, and an incline from one of these connected with the standard-gauge track below. Coal-mining methods were employed, and shipments, ranging from a car a day to considerably more than that amount, were made to the Renton and Van Asselt plants of the company. The red-firing shales, though some were of excellent quality, were not mined, but the buff-

[1] D-R numbers are those by which the Denny-Renton Clay & Coal Co. designated the beds.
[8] Tested as sample No. 205.

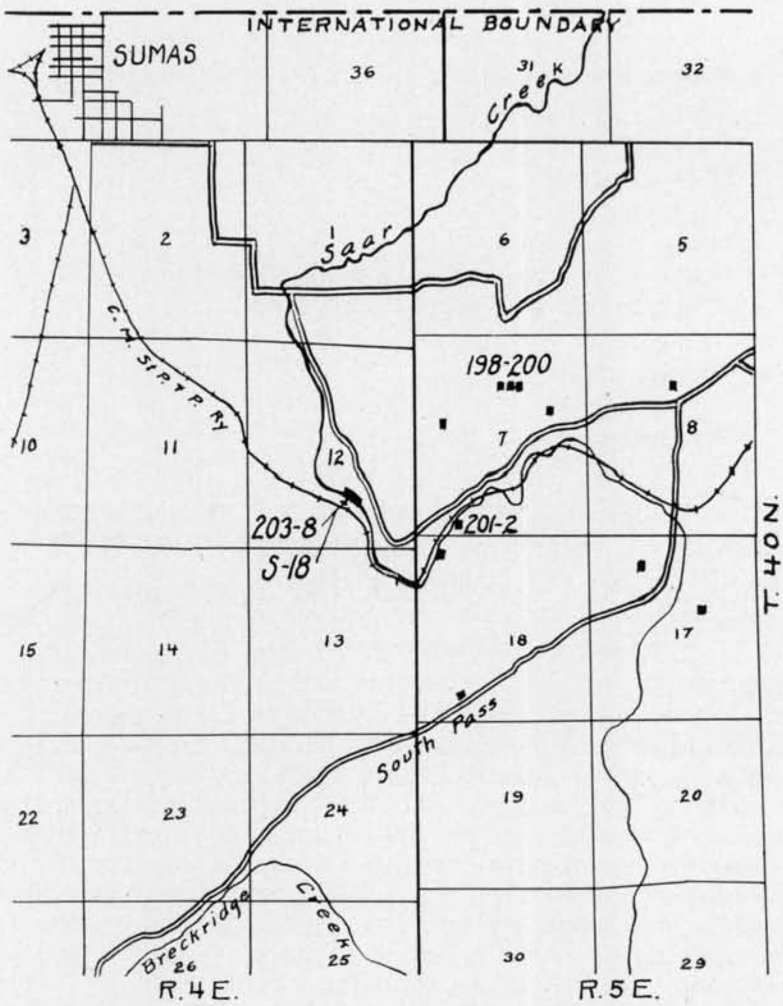

FIGURE 5.—Map showing location of clays sampled near Sumas, Whatcom County. Occurrences of clays of the Sumas series are shown by black squares; adjacent numerals indicate sample numbers.

firing and refractory types were used in terra cotta, fire clay, and other bodies.

Sample No. 207 (Denny Renton's No. 5) is from one of the upper beds of the Saar Creek exposure. This member ranges from 4 to 12 feet thick and is the one that was most extensively mined. The sample is indicative of the near surface part of the bed, but farther underground a No. 1 refractory was obtained from this same bed. The material is a massive shale, dark grayish blue in color, very fine grained, and free from sand. It is hard and breaks with a subconchoidal fracture.

Fired properties Sample No. 207

Cone	Color	Condition	L.S.%d.l.	T.L.S.%d.l.	V.S.%d.v.	Abs.	A.Por.
06	Light buff	Crumbly, very soft	....	....	....	15.7	29.6
01	Light buff	Crumbly, very soft	....	....	....	15.0	29.0
3-4*	Lt. brown-buff	Crumbly, soft	....	....	....	14.2	27.4
6	Brown-buff	Crumbly, soft	1.5	6.0	4.4	13.5	26.9
10	Buff-brown	Good, hard	2.2	6.7	6.4	12.5	24.4
12*	Deep brown	Good, hard	2.2	6.7	6.6	11.3	21.7

Remarks: Best firing range: 10-15. Cone fusion: 23-26, bloated.

Sample No. 203 (Denny-Renton's No. 6-A), from Saar Creek, is a varicolored medium-hard shale, 4 feet in thickness, that overlies a 40-foot conglomeratic sandstone member. The shale is predominantly yellowish green but has stains of purple, brown, and yellow on the joints. The texture is fine and uniform, and the material contains very little sand.

Remarks: When tempered with water, a fair plastic strength is developed. Hard bodies are produced when fired between cones 02 and 10. As cone 28-29 is the fusion point, a No. 2 refractory brick can be made from this sample. The fired colors are buffs and browns.

Sample No. 204 (Denny-Renton's "Tiger 16") from Saar Creek, is of a light bluish-gray shale that is absent in some places and as much as 7 feet thick in others. It underlies the conglomerate mentioned above. This shale member is nonuniform in texture and is moderately hard. It is partly very smooth, but contains layers and lenses of a friable material that is virtually fine-grained clayey sandstone.

Plastic and dry properties Sample No. 204

Plasticity	Good	Volume shrinkage	17.7% dry volume
Shrinkage water	9.1%	Linear shrinkage	6.3% dry length
Pore water	12.1%	Linear shrinkage	4.9% wet length
Water of plasticity	21.2%	Dry condition	Good dry strength

Fired properties Sample No. 204

Cone	Color	Condition	L.S.%d.l.	T.L.S.%d.l.	V.S.%d.v.	Abs.	A.Por.
012	Lt. purple-gray	Soft, weak	....	....	....	16.8	30.8
01	Cream	Soft, weak	0.2	6.5	0.7	16.8	31.3
3-4*	Lt. buff	Soft, weak	....	....	....	15.4	32.3
6-7*	Buff	Soft, weak	1.2	7.5	3.7	15.0	28.2
10	Spotted buff	Good, hard	1.3	7.6	4.0	13.9	26.1
12*	Buff-brown	Good, hard	1.7	8.0	5.0	12.5	22.1

Remarks: Best firing range: 10-15. Cone fusion: 28.

Class of ware: No. 2 refractory. Finer grinding may reduce required firing temperature for buff structural ware.

Sample No. 208 (Denny-Renton's No. 17-AA), from Saar Creek, is from a 2- to 3-foot bed of very sandy shale. It is a bluish-gray material with abundant red grains; these latter are altered from femic minerals in an originally arkosic sandstone. Dry lumps are moderately hard.

Plastic and dry properties Sample No. 208

Plasticity	Weak	Volume shrinkage	8.1% dry volume
Shrinkage water	3.9%	Linear shrinkage	2.8% dry length
Pore water	9.4%	Dry condition	Weak dry strength
Water of plasticity	13.3%		

Fired properties Sample No. 208

Cone	Color	Condition	L.S.%d.l.	T.L.S.%d.l.	V.S.%d.v.	Abs.	A.Por.
010	Lt. purple-gray	Weak, very soft	-0.2	2.6	-0.6	15.5	29.7
02	Lt. gray	Weak, soft	-0.3	2.5	-0.9	16.6	31.4

Remarks: Best firing range: 6-12. Cone fusion: 23. Poor plastic and dry strength which may be bettered by finer grinding, with water.

Class of ware: Gray and brown structural ware.

Sample No. S-18 (Denny-Renton's No. 18), from Saar Creek, is from an 11-foot shale member. It is a fine-grained uniform material of bluish-gray color.

Plastic and dry properties Sample No. S-18

Plasticity	Good	Linear shrinkage	4.7% wet length
Water of plasticity	26.3%		

Fired properties Sample No. S-18

Cone	Color	Condition	L.S.%d.l.	T.L.S.%d.l.	V.S.%d.v.	Abs.	A.Por.
012	Gray-buff	Very soft	....	....	....	16.4	30.9
01	Light buff	Good, hard	....	....	....	14.9	28.9
3-4*	Light buff	Good, hard	....	....	....	13.7	....
6-7*	Light buff	Good, hard	3.4	....	8.5	13.5	26.3
12*	Brown-buff	Good, S.H.	4.1	....	11.7	7.6	16.3
15	Spotted brown	S.H.	....	....	....	....	....

Remarks: Best firing range: 4-15. Cone fusion: 26.

Class of ware: Buff-colored structural ware.

Sample No. 206, from Saar Creek, is from a 40-foot bed of argillaceous sandstone and fine conglomerate. In the latter the pebbles are predominantly quartz or white quartzite and are mostly less than one-half inch in diameter. The material is rather friable.

Plastic and dry properties Sample No. 206

Plasticity	Weak	Volume shrinkage	2.2% dry volume
Shrinkage water	1.2%	Linear shrinkage	0.7% dry length
Pore water	17.3%	Dry condition	Weak
Water of plasticity	18.5%		

Fired properties Sample No. 206

Cone	Color	Condition	L.S.%d.l.	T.L.S.%d.l.	V.S.%d.v.	Abs.	A.Por.
03	Light gray	Crumbly, very soft	....	....	....	16.2	30.4
1	Light gray	Crumbly, very soft	0.5	1.2	1.4	15.5	28.3
3-4*	Light buff	Crumbly, soft	1.0	1.7	3.0	15.9	32.7
6-7*	Light buff	Crumbly, soft	1.6	2.3	4.8	15.0	28.2

Remarks: Cone fusion: 26-27. Very poor strength.

Class of ware: Could be used as a siliceous nonplastic material with a clay having excessive plasticity.

Sample No. 205 (Denny-Renton's No. 22), from Saar Creek, is from a 3- to 4-foot bed underlying No. 206. It is a bluish-gray moderately hard shale that is almost free from grit. The texture is very fine and uniform.

Plastic and dry properties Sample No. 205

Plasticity	Good	Volume shrinkage	18.1% dry volume
Shrinkage water	9.4%	Linear shrinkage	6.4% dry length
Pore water	13.9%	Linear shrinkage	4.6% wet length
Water of plasticity	23.3%	Dry condition	Good

Fired properties Sample No. 205

Cone	Color	Condition	L.S.%d.l.	T.L.S.%d.l.	V.S.%d.v.	Abs.	A.Por.
04	Cream	Soft	....	....	....	14.4	29.0
3-4*	Light buff	Soft	....	....	....	12.0	....
6-7*	Light buff	Good, hard	3.2	9.6	9.2	11.2	22.6
10	Light buff	Good, hard	3.9	10.3	11.2	9.9	21.0
12*	Brown-buff	Good, hard	4.4	10.8	12.7	9.2	18.6

Remarks: Best firing range: 6-15. Cone fusion: 31.

Class of ware: No. 1 refractory and buff structural ware.

Prospect pits have been dug on some shale and sandstone strata that occur in the west side of a hill on the old Smith place. This is northeast of the Saar Creek workings and is near the center of the N½ sec. 7, (40-5 E). The shales appear to be in very thick beds, but further prospecting is needed to definitely determine their extent and structure. They are advantageously situated for mining and are one-third mile up the hill from the Chicago, Milwaukee, St. Paul & Pacific Railway.

Sample No. 198, from the lowest of three hillside pits, is from a thick stratum of dark reddish-brown shale. It is a highly ferruginous material, almost devoid of ordinary sand but containing fine grains of magnetite. It is hard but very brittle and easily shatters into small angular pieces with sharp conchoidal fracture.

Remarks: When dry-ground and tempered in the usual manner with water, only a feeble plastic strength could be developed. In this condition it may be possible to mold ware by the dry-press process. Grinding in water may develop better strength. When fired between cones 3 and 10, red-brown colors are produced suitable for dark structural wares. The sample deformed at cone 18-19.

Sample No. 199 is from a prospect (known as "S. P. No. 1") some distance above the preceding one, where spheroidally weathered shale is exposed. It is greenish buff colored and stained to dark brown on joints. The texture is very fine and uniform. It resembles sample No. 198 in being free from sand, hard, very brittle, and breaking with a sharp conchoidal fracture.

Remarks: Further tests should be made to develop a No. 1 refractory body of this clay. Cone deformation point is cone 32. Plastic strength must be obtained by addition of a plastic bond or by grinding in water in a ball mill, or use must be made of the dry-press process.

Sample No. 200 is from a prospect (known as "N. W. No. 1") still farther up the hill. This shale is almost identical with sample No. 199 except that it has a bluish-gray color.

Plastic and dry properties Sample No. 200

Plasticity	Weak	Linear shrinkage	10.2% wet length
		Dry condition	Weak (gum added)

Fired properties Sample No. 200

Cone	Color	Condition	L.S.%d.l.	T.L.S.%d.l.	V.S.%d.v.	Abs.	A.Por.
06	Brown-buff	Good, S.H.-	5.5	....	15.5	14.7	28.5
05	Lt. buff-brown	Cracked, S.H.-	....	....	....	13.2	25.9
04	Lt. buff-brown	Cracked, S.H.-	6.9	....	19.2	12.8	25.4
3-4*	Deep buff	Cracked, S.H.	10.3	....	27.9	6.8	14.7
6	Deep buff	Cracked, S.H.	11.6	....	31.0	5.8	14.0
12*	Deep brown	Cracked, S.H.	....	....	....	1.4	2.1

Remarks: Best firing range: 02-12. Cone fusion: 31. Shrinkage is high.

Class of ware: No. 1 refractory. Needs bond clay or the development of plasticity by grinding in water. May be usable for dry-pressing.

Sedimentary beds crop out in the bed of Saar Creek near the south line of the SW¼ sec. 7 (40-5 E). This is practically within the right-of-way of the railroad. The strata are similar to those exposed on the old Smith place and are probably continuations along the strike. Massive sandstone, containing some conglomerate, is overlain by at least 6 feet of shale and probably much more.

Sample No. 201 is identical in appearance with sample No. 198 from the Smith place.

Remarks: The plasticity developed by this clay, when ground and tempered in the usual manner, is too poor for the handling of commercial wares. It is possible that better plastic strength can be produced by wet-grinding. May be usable by the dry-press process. The fired color is dark red-brown; the firing range is approximately between cones 3 and 10; and the cone fusion point is cone 16-17.

Sample No. 202 is from a thin bed lying between No. 201 and the sandstone. It is a hard, very brittle shale that breaks with a sharp, hackly fracture and is blue in color with yellow and reddish-purple mottlings.

Plastic and dry properties Sample No. 202

Plasticity	Weak	Volume shrinkage	10.4% dry volume
Shrinkage water	5.1%	Linear shrinkage	3.6% dry length
Pore water	10.0%	Linear shrinkage	2.1% wet length
Water of plasticity	15.1%	Dry condition	Weak

Fired properties Sample No. 202

Cone	Color	Condition	L.S.%d.l.	T.L.S.%d.l.	V.S.%d.v.	Abs.	A.Por.
06	Lt. red-brown	Weak, soft	....	....	....	16.7	32.7
01	Buff-brown	Weak, soft	5.8	9.4	16.3	11.9	25.2
3-4*	Buff-brown	Weak, soft	6.1	9.7	17.3	11.3	22.4
6-7*	Buff-brown	Weak, soft	....	....	....	11.5	23.3
12*	Dark brown	Hard	5.9	9.5	16.8	11.8	31.9
15	Brown and black	Hard	6.6	10.2	18.5	11.6	25.5

Remarks: Best firing range: 8-14. Structure, granular. Cone fusion: 23-26. Needs fine grinding with water or dry-pressing, and high temperatures for fired strength.

Class of ware: Brown structural wares.

Considerable prospecting has been done in sec. 17, (40-5 E). The first work was for coal, which is commonly associated with the shales and sandstones of the Sumas series, though, so far, not found in minable quantity; later, efforts were made to block out sufficient tonnage of the high-quality, refractory shales to justify mining operations. This doubtless could be done by drifts along the beds, instead of crosscuts to intersect some stratum far below its outcrop. The difficulty here is that the exposures are on a steep mountain side where erosion has left only basal remnants of the series, and these have not only been so folded that dips range from 70° to 90°, but have also been involved in land slips.

Sumas clay mine.—At present, work on the series is confined to that being carried on by Gladding, McBean & Co. at the Sumas clay mine. This property is on the highway in secs. 7 and 8, (45-5 E) where the company has 101 acres of clay land. The strata in this vicinity are practically horizontal and are very easily mined. The haulage way is in the SW. cor. SE¼NE¼ sec. 7; it has been driven N. 8° W. into the south slope of a hill for 200 feet on a hard gray sandy mudstone. Some of this bed has been taken out and shipped; it is a buff-firing material, not very uniform in physical properties, that contains reddish phases similar to sample No. 198 from the Smith place, and abundant coaly streaks and lenses. The fusion temperature is approximately cone 15. The principal work, however, has been on two buff-firing beds lying over the haulage-way mudstone and reached by raises. No. 1, the first of these beds, is a hard, dark-gray mudstone, 5 feet thick, that has a cone fusion of about 20. It is overlain by a variable thickness (up to 3 feet) of carbonaceous shale and bone, and above this is bed No. 8, from 5 to 10 feet thick, of nearly black, carbonaceous claystone that has a cone fusion of 31. Mining is by rooms and pillars. The rock is loaded into dump-cars, trammed 550 feet to a bunker and tipple on a siding of the Chicago, Milwaukee, St. Paul & Pacific Railway, and shipped to Renton for use in refractory and other bodies.

Across the international boundary the British Columbia extension of the series is being worked steadily at Kilgard. A large well-equipped plant has operated there for many years, making refractories, sewer pipe, face brick, and other high-quality structural wares.

On the west side of Sumas Mountain is a peculiar deposit of brown, ferruginous shale or mudstone that is called "hematite" in this vicinity. Field relations have yet to be worked out; the material may be a residual blanket deposit underlying the Chuckanut formation but appears to be a thick, massive sediment and so to be correlated with some bed, possibly that sampled as No. 198, of the Sumas series. The deposit is reported to cover as much as 2 square miles of this broken, precipitous part of the mountain. It is well exposed at an elevation of about 800 feet in a ravine which crosses the NW¼ sec. 2, (39-4 E). A few included thin conglomerate layers show the strike to be N. 10° E. and the dip, 35°-40° NW. No exposure of the bottom of the bed could be found, so the total thickness, though probably great, is in doubt. Overlying the ferruginous shale is a massive conglomerate bed that contains large pebbles and boulders and at least one bed of interstratified black shale.

Sample No. 209 was taken of the ferruginous shale. It is very hard, weathers spheroidally, and breaks with a conchoidal fracture. The texture is fine and uniform. Except that the sample is darker colored, it corresponds closely in appearance with the red shales of the Smith place (see sample No. 198).

Remarks: The plasticity that developed when the shale was ground and tempered in the usual manner was too poor for the molding of commercial ware. It is possible that a better plastic strength can be produced by grinding in water. A dry-press process may be applicable. The firing range is very short; the cone fusion is cone 9; and the fired color is dark red-brown.

Sample No. 210 was taken from another "hematite" deposit farther up the mountain. It is chocolate brown to purple brown in color and contains an abundance of disseminated rounded grains of quartz and crystals of magnetite.

Remarks: Very similar in properties to No. 209, except that the fusion point is cone 5.

PUGET SOUND GLACIAL CLAYS

Puget Sound glacial clays are abundant in the county and are well situated for economical mining close to the centers of population. Excellent exposures occur in the sea cliffs and in the ravines that postglacial erosion has cut into the Pleistocene sediments. Characteristic examples are on the south side of Nooksack Valley above Cedarville, in the sides of Squalicum Valley, and on tidewater near Point White Horn. Brick yards have formerly operated in Bellingham on such materials. The clays are similar in their physical properties to the glacial clays described elsewhere (see King County) so need no particular description.

WHITMAN COUNTY

Whitman County lies north of the Snake River along the Idaho boundary and on the eastern border of the Columbia basalt plains. Much of the area is between 2,000 and 2,500 feet above sea level. It is extremely hilly, but there is a marked concordance in most summit levels. This feature, indicating an original level surface, is very apparent from heights such as the top of Bald or Steptoe buttes. Now, however, old water courses, usually dry, and the present drainage channels dissect the former plain into a close network of branching, irregular valleys. These may be as much as 300 feet deep, and the innumerable intervening rounded hills, carved from the thick cover of Palouse clay, characterize the region. This whole area of unusual topography is also one of exceptional fertility that has come to be known as the "Palouse country".

Basalt is the common bedrock of the county, though the flows failed to cover elevations above 2,500 feet; so in many places high points of the pre-basalt surface of granite and quartzite which were never inundated by the lava rise as prominent hills above the general level. Bald Butte, Smoot Hill, Kamiak Mountain, Ladow Butte, Steptoe Butte, and Naff Ridge are all "island" masses of this kind. Elsewhere the basalt is chiefly exposed along the sides of the deeper valleys, where erosion has cut through the soft surficial cover.

LIGHT-FIRING CLAYS

As discussed in greater detail under the heading of Spokane County, the pre-basalt rocks have been a source of excellent clays and kaolins. The various buttes, or monadnocks, of the county are too limited in extent to have played an important role in forming available clays, but beyond the State line, in Idaho, are great areas of old granites and associated rocks of which the Whitman County buttes are mere outliers. These feldspathic rocks have long been subject to decomposition and erosion and have given rise to the extensive beds of valuable kaolins and various buff-firing clays in Idaho. Fortunately for Washington the drainage has been westerly, so continuations of the deposits occur in this State.

With the coming of the basalt, in Miocene time, the drainage was interrupted and gradients decreased. This resulted in the accumulation of lacustrine and fluviatile clays in front of and on the basalt flows. Some of these sediments were covered by later flows; others were never reached by basalt and have only an overburden of detritus from the granite and quartzite hills and the ever-present Palouse clay. Thus a Miocene age, contemporaneous with the Latah formation of Spokane County and elsewhere, is indicated for the interbasalt sediments and related clays, including most of the kaolins and buff-firing varieties, of Whitman County.

The sediments intercalated with basalt flows are exposed in canyons and road cuts and are commonly reported from drilled wells. One such bed at Pullman is mentioned by Russell[1] as having a thickness of 30 feet. Examples may be seen on the Lewiston grade, where the Snake River has cut down through flow after flow of basalt to a depth of nearly 2,000 feet, and highway cuts have newly exposed interbedded clays. One bed, near the top of the valley wall, was formerly well exposed for 5 feet below a flow contact. The sediment has a shaly structure and is very compact and brittle. For a foot or so from the basalt it is baked to a bright red; this part lacks the harsh feel common to recently fired clays, for alteration since the baking in Miocene time has made the shale smooth and unctuous though without restoring plasticity. Below the contact zone the material is nearly black from the effect of heat under reducing conditions. The bed is uniformly fine-grained, smooth, free from grit, and has the sheen of wax on freshly cut surfaces.

Sample No. 25-B, of the black shale, did not slake in water, failed to develop any plastic strength by the usual methods of testing, and fired to red and brown colors.

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[1] Russell, I. C., A reconnaissance in southeastern Washington: U. S. Geol. Survey Water Supply Paper 4, p. 51, 1897.

DISTRICTS

For convenience in considering the deposits and possible occurrences of light-firing clays, the county is divided into the Palouse, Bald Butte-Fallon, and Garfield-Tekoa districts.

Palouse district.—The best-quality clays opened so far in Whitman County are those occurring a mile south of the town of Palouse. Several square miles in this vicinity may be underlain by similar material, as indicated by well records, but in general the beds are covered by a thick overburden of the yellowish-brown "Palouse clay". This not only effectually conceals valuable deposits but would render mining operations expensive on most of those that are known. These clays are of alluvial origin and have been derived from the old feldspathic rocks to the east in Idaho. Former streams carried the clay material into this section, where it was deposited as well-stratified beds in some places and as poorly assorted masses in others. The older rock in this immediate vicinity is quartzite, so much silica sand and quartzitic fragments occur with the clays. As the area is about on the border between the basalt and the older rock, some deposits have been exposed by erosion of thin flows and others have never been covered.

Cox pit.—Many years ago a pit was opened on the Cox place, in the NW¼NW¼ sec. 7, (16-46 E), and considerable clay was mined. A small pottery (Pioneer Pottery Co.), making common stoneware, formerly operated on this deposit, and clay was shipped, also, to potteries located at Portland (Pacific Stoneware Co.) and other places. Although several kinds of clay were mined here, it is said that only one-third of the clay body was taken from this place when the old pottery was working the deposit; the rest used was a more plastic clay taken from deposits in the southeast part of the same section and in sec. 13, (16-45 E). When last operated, the pit measured about 100 feet in length and exposed a 15-foot face of clay. As the workings are located in the side of one of the small rounded hills common to the country, the face will become greater as work progresses. The top mantle, a foot or two of soil and Palouse clay, varies from place to place but is mostly thin. Beneath this is sandy, fragmental material containing rounded quartzite pebbles; so the total overburden might average about 3 feet in thickness. The upper sedimentary clay member is very irregular both in appearance and occurrence. At the west end of the pit it has a thickness of at least 5 feet, probably more, of very firm even-grained plastic material that is free from grit. However, in color it varies from nearly pure white to portions that are gray, blue, lavender, yellow, pink, and red. This was the last clay to be worked.

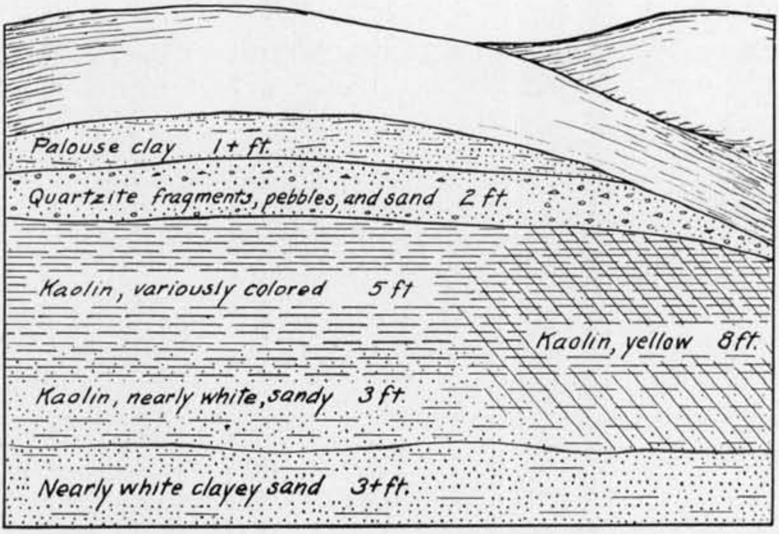

FIGURE 6.—Section of beds at the Cox pit, near Palouse, Whitman County.

Sample No. 36, taken here, is compact and brittle when dry and is nearly white in color. It has a smooth, soapy feel, and only the finest grit can be detected when a fragment is taken between the teeth.

Remarks: Strong plastic strength is developed with 45.1 percent water of plasticity. When fired between cones 06 and 15, buff-brown colors are produced. The body becomes steel hard about cone 04 and practically non-absorbent at cone 3. As it deforms at cone 32, the clay when mixed with grog could be used for a No. 1 refractory and as a bond clay for a refractory clay of less strength. The high shrinkage and cracking do not permit its use alone.

The light-colored clay grades on the east into a slightly coarser, more compact, material that has a horizontal bedding so distinct as to give it the appearance of a shale. This clay, locally known as "Palouse yellow", is heavily stained to a clear yellow from iron brought in by percolating solutions. Dendritic manganese oxide forms black coatings on joint planes. The variable concentrations of iron and manganese have given portions of the adjacent less pervious white clay its mottled appearance. The bed has a thickness of about 8 feet.

Sample No. 31, of the yellow clay, has not quite the soapy feel of the white clay. It is compact and brittle but contains very fine sand and some white mica.

Plastic and dry properties Sample No. 31

Plasticity	Good	Volume shrinkage	36.4% dry volume
Shrinkage water	20.8%	Linear shrinkage	14.0% dry length
Pore water	24.5%	Linear shrinkage	6.9% wet length
Water of plasticity	45.3%	Dry condition	Good

Fired properties Sample No. 31

Cone	Color	Condition	L.S.%d.l.	T.L.S.%d.l.	V.S.%d.v.	Abs.	A.Por.
06	Brown-red	Weak, soft	3.8	17.8	11.0	25.7	41.6
03	Bright brown-red	Good, hard	....	....	....	18.0	....
3-4*	Bright brown-red	Good, S.H.-	....	....	....	15.8	....
6	Brown-red	Good, S.H.	13.2	27.2	34.7	9.4	20.6

Remarks: Best firing range: 03-10. Cone fusion: 18. Too much plastic material, giving high shrinkage.

Sample No. 32 was taken at the east end of the pit from an indefinite bed, about 3 feet thick, that may be a leached surface phase of the underlying yellow clay. It is a very smooth, greasy-feeling, fine-grained (slightly gritty) grayish-white clay. The fired properties are very similar to the yellow clay (sample No. 31), probably owing to thin concentrations of limonite on joints and bedding planes. Underlying the white and yellow strata is a light-gray sandy clay which grades downward into a loose clayey sand. The thickness of the lower clay is unknown, as the pit bottom is still in that material, but it is probably well over 7 feet.

Sample No. 35, from near the pit bottom, is a light-gray sandy clay, so soft that lumps when dry are easily crushed between the fingers. A peculiarity of this material is the presence of minute hairlike pores or holes. These vary from microscopic size to nearly a millimeter in diameter and 10 or 20 are present to the square inch. They are curved and irregular as to direction and are commonly branching. In every instance the hole is lined with a brown waxlike coating of aluminous material apparently something between beidellite and nontronite in mineral character. The presence of such holes, probably caused by root fibers and worm borings, in only one stratum of a sedimentary deposit is unexplained but is suggestive of an eolian origin for this one member. The clay appears to have a fine even grain, but the microscope shows quartz sand and white mica in a matrix of much finer quartz and kaolin.

Plastic and dry properties Sample No. 35

Plasticity	Good	Volume shrinkage	25.3% dry volume
Shrinkage water	15.3%	Linear shrinkage	9.2% dry length
Pore water	19.4%	Linear shrinkage	7.0% wet length
Water of plasticity	34.7%	Dry condition	Medium hard

Fired properties Sample No. 35

Cone	Color	Condition	L.S.%d.l.	T.L.S.%d.l.	V.S.%d.v.	Abs.	A.Por.
05	Light buff	Good, soft	....	11.2	....	21.7	36.2
3	Light buff	Good, S.H.	....	13.5	....	16.6	30.3

Remarks: Best firing range: 04-15. Cone fusion: 30.

Class of ware: Refractories if used with grog. When mixed with proper clays could form part of a body for stoneware, terra cotta, etc.

Sample No. 34, of the underlying loose clayey sand, is only different from the above in being sandier and containing none of the irregular holes. It, also, is micaceous and contains kaolin and much very finely divided quartz. This member has been known as "Palouse fire clay".

Plastic and dry properties Sample No. 34

Plasticity	Good	Volume shrinkage	28.8% dry volume
Shrinkage water	16.3%	Linear shrinkage	10.7% dry length
Pore water	15.1%	Linear shrinkage	7.0% wet length
Water of plasticity	31.4%	Dry condition	Good

Fired properties Sample No. 34

Cone	Color	Condition	L.S.%d.l.	T.L.S.%d.l.	V.S.%d.v.	Abs.	A.Por.
04*	Spotted buff	Good, hard	1.5	12.2	4.4	17.3	31.5
02	Spotted buff	Good, hard	3.1	13.8	8.8	16.4	29.5
6	Spotted buff	Good, S H.-	4.2	14.9	12.0	12.1	22.4
10	Spotted buff-brown	Good, S.H.	....	....	....	8.4	16.8
12*	Spotted buff-brown	Good, S.H.	6.1	16.8	17.1	7.5	15.0

Remarks: Best firing range: 04-15. Blisters at cone 16. Cone fusion: 31*.

Class of ware: Refractories if used with grog. When mixed with proper clays could form part of a body for stoneware, terra cotta, etc.

On another visit to this property a sample was taken of the face at the west end of the pit. This was intended to be "run-of-pit" and so include the clays formerly sampled as Nos. 34 and 35 but eliminate those sampled as Nos. 31 and 32. Some additional work had been done in the pit and a new face of clay was exposed that varied somewhat from the material sampled previously.

Sample No. 713 is of this material.

Plastic and dry properties Sample No. 713

Plasticity	Good	Volume shrinkage	42.0% dry volume
Shrinkage water	24.7%	Linear shrinkage	16.7% dry length
Pore water	19.4%	Linear shrinkage	6.7% wet length
Water of plasticity	44.1%	Dry condition	Lamination cracks from auger machine

Fired properties Sample No. 713

Cone	Color	Condition	L.S.%d.l.	T.L.S.%d.l.	V.S.%d.v.	Abs.	A.Por.
08	Lt. red-brown	Weak, soft	3.9	20.6	10.8	24.3	40.4
06	Lt. brown-buff	Rough surface, hard	4.3	21.0	12.0	22.0	34.8
6	Dark buff	Rough surface, S.H.	12.8	29.5	33.6	1.6	3.6
10	Buff-brown	Cracks, S.H.	....	....	....	2.8	6.7
12*	Lt. brown	Good, rough, S.H.	14.3	31.0	37.0	2.8	6.2

Remarks: Best firing range: 06-15. Cone fusion: 33+. Add non-plastics to reduce shrinkage.

Class of ware: No. 1 refractory. Buff-colored structural ware and pottery, if properly treated.

A quarter of a mile east of the old pottery site is a small opening in the side of one of the rounded hills. It is reported that this clay was mined for fire brick and that the kilns of the pottery were constructed of the product. It is a part of the same clay series that is exposed at the pottery and is similar to the lower member (see sample No. 34) of that deposit.

Sample No. 34-A, taken from here, is a gray color, stained in part to buff. It is very coarse textured, has large quartz grains disseminated unevenly throughout, and is very micaceous. Sufficient clay is present to bind the grains together so that when dry it is fairly compact.

Plastic and dry properties Sample No. 34-A

Plasticity	Good	Volume shrinkage	36.3% dry volume
Shrinkage water	19.9%	Linear shrinkage	11.5% dry length
Pore water	13.7%	Linear shrinkage	8.0% wet length
Water of plasticity	33.6%	Dry condition	Good

Fired properties Sample No. 34-A

Cone	Color	Condition	L.S.%d.l.	T.L.S.%d.l.	V.S.%d.v.	Abs.	A.Por.
08	Light buff	Good, hard	1.5	13.0	4.5	21.6	36.8
04*	Bright buff	Good, S.H.–	5.9	17.4	16.6	11.5	22.0
3	Bright buff	....	....	....	....	9.0	17.4
6	Bright buff	Good, S.H.	7.0	18.5	19.6	7.1	15.4

Remarks: Best firing range: 06-15. Cone fusion: 30.

Class of ware: Refractories if used with grog. When mixed with proper clays could form part of a body for stoneware, terra cotta, etc.

In the SE¼ sec. 13, (16-45 E), near the Great Northern Railway, a shaft was sunk through the Palouse clay to the underlying white beds. As the old workings were full of water, nothing could be seen at the time of the writer's visit, but it is reported that smooth, plastic clay was obtained here.

For several years after about 1900 the Palouse Pottery Co. operated in the town of Palouse. Clay was chiefly from Onaway (near Potlatch), Idaho, but part of the body was from the Cox pits and part, also, was from a pit that was dug in the barnyard of the Tweedmyer place near town. This last opening, about 100 feet in diameter, was carried 10 feet into a plastic white clay that underlay some 6 feet of brown Palouse clay. The pit was only operated for two seasons and was allowed to cave and fill with wash when mining stopped.

Sample No. 29, of the Onaway clay, was taken to show the kind of material that would be easily available for use with the high-grade clays that are available near Palouse. It is a very light-gray fine-grained clay that is similar in appearance to sample No. 36.

Plastic and dry properties Sample No. 29

Plasticity	Strong	Volume shrinkage	14.9% dry volume
Shrinkage water	22.5%	Linear shrinkage	5.2% dry length
Pore water	16.8%	Linear shrinkage	9.3% wet length
Water of plasticity	39.3%	Dry condition	Good

Fired properties Sample No. 29

Cone	Color	Condition	L.S.%d.l.	T.L.S.%d.l.	V.S.%d.v.	Abs.	A.Por.
02	Light buff	Good, S.H.	9.7	14.9	26.3	12.4	25.1
3	Light buff	Good, S.H.	....	....	....	9.1	18.9
4-5	Light buff	Good, S.H.	....	....	....	8.2	21.3

Remarks: Best firing range: 02-20. Cone fusion: 32*.

Class of ware: Refractories with grog, light buff-colored pottery, or terra cotta.

Bald Butte-Fallon district.—Thick beds of kaolin have accumulated in the vicinity of Moscow, Idaho. Extensions of the deposits may occur at no great depth below the Palouse clays in the vicinity of Bald Butte and between Pullman and Moscow. The hills surrounding the station of Ayer, on the Great Northern Railway northeast of Pullman, are granitic; good clays no doubt occur near the borders of that rock, though concealed by the deposits of Palouse clay. It is reported that a well on the Ayer farm struck a thick bed of white clay under 10 feet of Palouse clay. Another well in this vicinity is said to have gone through 40 feet of Palouse clay, then 10 feet of white clay and about 10 feet of dark-brown clay and sand. A sample of this last "white clay" was really a slight brownish gray when fresh and damp, but a weathered sample, after drying, was nearly pure white. It was free from any noticeable sand. Similar clays would be expected to occur east of Fallon and Whelan in the general vicinity of the east line of T. 40 N., R. 45 E.

Garfield-Tekoa district.—Russell[1] mentions a well put down 3 miles northeast of Garfield, probably near Walters, a station on a branch line of the Oregon-Washington Railway and Navigation Co. Drilling reached 113 feet in depth, and basalt was passed through for 65 feet from the surface. This was underlain by 14 or 15 feet of clay beneath which was water-bearing sand. The region is near the edge of the basalt flows and close to high hills of quartzite. In the same report Russell says, also, that a deposit of sandy clay and white kaolin was opened a mile west of Garfield, but the writer has been unable to find this occurrence.

Quartzite predominates in the hills north and south of Pine Creek Valley in the vicinity of Farmington, though little rock is exposed, owing to the mantle of Palouse clay. That a tongue of basalt reached up this valley is shown by rock found in the vicinity of the town, but the flow was thin and probably has been mostly decomposed or eroded away. It is reported that the whole valley is underlain by blue and white fine even-grained clay "with a very soapy feel". One occurrence was beneath 15 feet of overburden in a well put down on the site of an old planing mill. No samples are available. White clays occur in the Coeur d'Alene Indian Reservation near Tekoa, and continuations of these deposits, or material washed from them, no doubt underlie the surface mantle between Tekoa and Seltice.

DARK-FIRING CLAYS

Palouse clay, of probable Pleistocene age, forms the surficial material of practically the whole county as well as parts of adjacent counties. Although sometimes spoken of as "basaltic clay" this thick mantle is rarely derived in place from the underlying basalt. There are many places, as for instance, in a railway cut in the west center sec. 18, (23-46 E), where a complete gradation can be found from reddish-brown clay, through entirely decomposed rock still showing its original texture, to disintegrated fragments and hard unweathered basalt; in general, however, the clay is lighter in color than a true basalt residuum, contains mineral grains foreign to basalt, and is sharply separated from underlying little-weathered rock.

Road cuts commonly expose sections as much as 30 feet thick; wells show that 40 and even 60 feet of the clay is usual; and 2 wells, drilled a few miles southwest of Pullman, showed 173 feet of clay at the one place and 187 feet at the other. Characteristic exposures, as along the Colfax-Rosalia highway, may have from 1 to 6 feet of structureless silty-clay loam at the top. This bed conforms to the contour of the rounded hills through

[1] Russell, I. C., op. cit., p. 52.

which most of the cuts are made and is definitely of eolian origin. It contains much organic matter and is dark gray-buff to almost black. Underlying this upper deposit is the brownish-yellow to buff-colored silty clay that makes up the bulk of practically all exposures. There is little difference in the mineral composition or texture of exposures from top to bottom, but the lower phase commonly has a rude, indistinct stratification that separates the mass into horizontal beds from 1 to 4 feet or so in thickness. The bedding planes—mostly very obscure—are, in a few places, delineated by concentrations of calcium carbonate, forming irregular but more or less horizontal layers as much as an inch or so thick of sandy nearly white caliche. In all instances the bedding, when it can be seen at all, is truncated by the hill slopes, showing that the rounded hills were eroded from a thick nearly structureless blanket of country-wide extent. The origin of the dominant material is obscure. Bryan[1] summarized the hypotheses of earlier investigators and presents the results of his detailed study but concludes that the sedimentation process is still to be explained.

The dry clay is harsh-feeling and so compact that even small lumps cannot be crushed between the fingers. It is composed of a variable amount of actual clay and considerable fine sand and silt that include quartz, feldspar, white mica, and other minerals in less amount. The dry strength of lumps is increased by the presence of a brown waxlike, subtranslucent clay mineral that coats sand grains and lines the innumerable joints and minute irregular ramifying root-fiber holes that are present throughout. This brown mineral has been identified[2] as beidellite ($Al_2O_3 . 3SiO_2 . nH_2O$), though in some samples the mineral appears to be intermediate in composition between beidellite and nontronite $(Fe,Al)_2O_3 . 2SiO_2 . 2H_2O$. It is present in greater quantities in some places than others and may even occur as nearly pure, gritless irregular layers, a fraction of an inch in thickness, in the otherwise sandy deposits. This mineral may represent the decomposition product of basalt grains and volcanic ash, originally present in the bed, and so indicate an alteration, in place, since the deposit accumulated. It doubtless accounts in large part for the sticky plasticity that is a feature of the Palouse clay when wet.

Palouse clay may contain too much plastic clay substance for safety in drying the ware made from it. However, it is possible to establish a plant in most localities and manufacture nearly any of the ordinary red-firing structural materials. Work done at

[1] Bryan, Kirk, The "Palouse Soil" problem: U. S. Geol. Survey Bull. 790-B, 1927.
[2] Idem, p. 31.

one time in Pullman illustrates this: a brick yard in a neighboring town received a contract for a large number of common, red brick; rather than pay freight on these to Pullman the machinery was moved to the site of the proposed building, and the brick were made there from clay dug on the spot. The unsightly pit was long a reminder of the adaptability of the Palouse clay.

Yards have operated at various times in Colfax, Garfield, Palouse, and Pullman to supply the local demand for common brick, but in 1940 the Geo. Herboth Brick Co., at Uniontown, is the only one remaining. At this yard, the clay is taken from a bank with a working face about 25 feet high. The excavation has covered an area some 200 feet square and has used nearly all the available clay above easy drainage on the property.

Sample No. 25, of this clay, is sandy, but the texture is fine and rather uniform. The vertical jointing, slight consolidation, general silty character, and tawny brown color, are typical of Palouse clay.

Plastic and dry properties Sample No. 25

Plasticity	Good	Volume shrinkage	18.9% dry volume
Shrinkage water	10.2%	Linear shrinkage	6.8% dry length
Pore water	14.0%	Linear shrinkage	6.7% wet length
Water of plasticity	24.2%	Dry condition	Good

Fired properties Sample No. 25

Cone	Color	Condition	L.S.%d.l.	T.L.S.%d.l.	V.S.%d.v.	Abs.	A.Por.
010	Lt. red-brown	Weak, soft	−3.1	3.7	−0.9	20.6	35.6
07	Red-brown	Weak, soft	−0.2	6.6	−0.6	19.9	34.1
04*	Dk. brown-red	Vitreous surface, good, S.H.	3.9	10.7	11.3	9.2	19.0
01	Dk. brown-red	Vitreous surface, good, S.H.	7.4	14.2	20.5	5.0	10.4
2	Dk. red-brown	Vitreous surface, good, S.H.	9.8	16.6	26.7	2.3	4.8
6–7*	....	Near fusion, S.H.	3.2	10.0	9.2	1.3	2.8

Remarks: Best firing range: 06-2. Cone fusion: 8-9.

Class of ware: Used for common brick and tile. Good working properties; good firing range.

Geo. Herboth Brick Co. (inoperative).—The clay is caved and brought by horse-drawn dump-car to a soft-mud press for common brick or to an auger machine with vertical pug mill for drain tile. The ware is dried on pallets in covered open-air racks. Brick are fired in a scove kiln, and drain tile, the principal product, in a 12-foot rectangular down-draft kiln. Recent output has been sporadic and small, though 100,000 tile of various sizes and considerable brick have been made in some years.

Sample No. 23, of Palouse clay southeast of Johnson, was taken from a road cut 100 feet long by 8 feet high in the

SE¼SE¼ sec. 12, (13-45 E). The surface deposits here are no different from those of many other places, but a newly graded road made clean exposures available. It is an unstratified deposit that is dark brown in color when fresh but weathers to a much lighter shade. The texture is fine and even, although the clay is quite sandy. When dry, lumps are very compact and resistant to pressure.

Plastic and dry properties Sample No. 23

Plasticity	Fair	Volume shrinkage	22.8% dry volume
Shrinkage water	11.5%	Linear shrinkage	8.3% dry length
Pore water	13.0%	Linear shrinkage	7.5% wet length
Water of plasticity	24.5%	Dry condition	Good

Fired properties Sample No. 23

Cone	Color	Condition	L.S.%d.l.	T.L.S.%d.l.	V.S.%d.v.	Abs.	A.Por.
06	Brown-red	Weak, soft	0.4	8.7	1.3	17.1	31.2
04-03	....	Good	....	....	....	11.4	....
02	Bright brown-red	Good, S.H.	6.2	14.5	17.5	6.6	14.6
3-4*	....	Vitreous, good	....	....	....	0.9	....

Remarks: Best firing range: 05-3. Cone fusion: 10.
Class of ware: Common red-brown structural wares.

Sample No. 17 is almost identical in appearance to sample No. 23 but was taken from a large road cut near Ayer, northeast of Pullman. It shows the remarkable similarity of the Palouse clay even over large areas.

Plastic and dry properties Sample No. 17

Plasticity	Good	Volume shrinkage	21.8% dry volume
Shrinkage water	11.7%	Linear shrinkage	8.9% dry length
Pore water	16.3%	Linear shrinkage	6.6% wet length
Water of plasticity	27.0%	Dry condition	Good

Fired properties Sample No. 17

Cone	Color	Condition	L.S.%d.l.	T.L.S.%d.l.	V.S.%d.v.	Abs.	A.Por.
07	Lt. brown-red	Soft	0.3	9.2	1.0	17.5	31.7
03	Lt. brown-red	Hard	....	....	....	14.7	....
02	Brown-red	Good, S.H.	3.1	12.0	9.0	12.3	24.6
3-4*	....	Vitreous, but good, S.H.	....	....	....	1.5	....

Remarks: Best firing range: 04-3. Cone fusion: 6-7. Few cracks.
Class of ware: Common red-brown structural wares.

Light-gray silty clays, containing occasional fresh-water shells, occur in a few places in the county. They are lacustrine deposits, and though similar to Palouse clay in physical properties are quite distinct from those or the older buff-firing clays. So far as known, all are overlain by the typical Palouse clay.

Sample No. 24 was taken from a cut north of Colton at a road fork near the Northern Pacific Railroad in the NW¼ sec. 26, (13-45 E). Massive clay is exposed to a height of about 6 feet above the road for a distance of 100 feet. Palouse clay forms a considerable overburden that decreases in thickness at the ends of the exposure. As the base is concealed, the quantity of clay available can only be estimated but is probably large. Although slightly sandy, the material has a fine, even texture and appears to be more silt than clay. It is greenish gray when damp but dries to a light gray; lumps are then very easily crushed between the fingers. Minute vesicles, apparently formed by gas bubbles when the clay was first laid down, are abundant.

Plastic and dry properties Sample No. 24

Plasticity	Good, strong	Volume shrinkage	27.5% dry volume
Shrinkage water	14.9%	Linear shrinkage	10.2% dry length
Pore water	15.8%	Linear shrinkage	7.0% wet length
Water of plasticity	30.7%	Dry condition	Hard, strong

Fired properties Sample No. 24

Cone	Color	Condition	L.S.%d.l.	T.L.S.%d.l.	V.S.%d.v.	Abs.	A.Por.
08	Buff-brown	Weak, soft	0.0	10.2	0.0	21.0	36.0
04	Bright red-brown	Good, hard	2.0	12.2	5.9	18.5	32.0
01-1	Bright red-brown	Good, S.H.	8.3	18.5	22.8	6.3	13.5
1*	Bright red-brown	Good, S.H.	9.6	19.8	26.1	4.3	9.6
3-4*	Dk. brown-red	Vitreous, good, S.H.	....	....	....	1.0	2.0
6	Red-brown, black	Swelled, fused, S.H.	6.5	16.7	18.1	1.5	3.1

Remarks: Best firing range: 04-3. Cone fusion: 6-7. Needs a sandy admixture to reduce shrinkage.

Class of ware: Common red-brown structural wares.

Another lacustrine bed, well laminated, has been exposed in a road cut about 4 miles south of Rosalia, in the NW¼ sec. 3, (19-43E). Large amounts of this clay probably are present in this region though mostly covered with a thick overburden of Palouse clay.

Sample No. 61, from the exposure, is greenish gray when damp, and dries to a light-gray color. It is sandy but fine-grained and contains enough clay substance to have fair plasticity and become compact when dried. The clay is moderately calcareous, an unusual feature for clays in this region.

Plastic and dry properties Sample No. 61

Plasticity	Fair	Volume shrinkage	28.0% dry volume
Shrinkage water	14.0%	Linear shrinkage	10.4% dry length
Pore water	11.2%	Linear shrinkage	6.8% wet length
Water of plasticity	25.2%	Dry condition	Good

Fired properties Sample No. 61

Cone	Color	Condition	L.S.%d.l.	T.L.S.%d.l.	V.S.%d.v.	Abs.	A.Por.
05–04	Red-brown	Good, hard	....	11.0	....	19.3	32.9
02–01	Red-brown	Good, hard	....	13.1	....	12.2	17.0
6	Red-brown, black	Vesicular, S.H.	5.1	15.5	14.5	1.3	3.1

Remarks: Best firing range: 04-2. Cone fusion: 9. Shrinkage a little high. Fired colors just fair. Needs a sand to reduce shrinkage.

Class of ware: Use for common brick.

YAKIMA COUNTY

Yakima County is in the south central part of the State and has an area of 4,059 square miles. The western part of the county is on the eastern slope of the Cascade Mountains and is rugged and mountainous, but the central and eastern part comprise rounded ridges, broad valleys, and rolling plains.

Basalt forms the principal bedrock, and great thicknesses are exposed in places where rivers have cut into the many separate flows. Eastward-flowing streams in late Miocene time carried abundant sediments and built up thick beds of clays, sands, and gravels on and between basalt flows at lower elevations. These deposits, now loosely consolidated, are known as the Ellensburg formation. In some places they form extensive surface exposures apparently never covered by basalt; in others they appear only through the erosion of overlying basalt, and so their outcrops form bands several hundred feet thick which may extend for several miles. Other widespread surficial sediments are probable extensions of the Ringold formation of Pleistocene age. They are similar in appearance and properties to the Ellensburg sediments; in fact, the two are difficultly distinguished. The Ringold formation is excellently exposed in the White Bluffs of the Columbia, in Franklin County, and the results of tests made on samples of the most promising-appearing clays obtainable there are given under that county heading. Similar results would be expected from the Ringold clays occurring in Yakima County.

Recent silty alluvial clays have been deposited in the Yakima Valley and in the lower parts of tributary valleys. They occur with sands and gravels and apparently do not form either thick or extensive beds. They are sticky, weakly plastic clays only suitable for common red brick. Formerly such clays were used in brick yards in Yakima and Toppenish.

The clays of the Ellensburg formation are irregular in extent and are mostly sandy and nonuniform in texture. Those that appear the purest and contain the most clay substance apparently contain a large amount of volcanic ash or are derived from the decomposition of ash; this is indicated by a high content of fluxes and a sticky yet weak plasticity. So far as known they are all red firing. The only place where clays of this kind are being mined is at the pits of the Granger Clay Products Co., at the south edge of Granger. The thick series of silty clays crop out at the west end of Snipes Mountain, a ridge extending from Granger to Sunnyside and rising as much as 600 feet above the valley floor. The ridge is in part an anticlinal fold of basalt and sedimentary beds, but the relations are somewhat obscure and it is possible that these clays may belong to the Ringold rather than the Ellensburg formation.

The workings are at about the center of the SW¼ sec. 22, (10-21 E), 100 feet or so above the valley floor, and extend as a series of quarry-pits for a thousand feet along the hillside. The opening farthest east is the deepest and has a 40-foot face. It exposes a stratified series of blue-gray, buff, brown, and greenish-gray clays and sands. The strike of the beds is somewhat variable but, in general, is N. 65° W., or roughly parallel to the hillside here, and the dip is 10° to as much as 35° NE.

Section of beds exposed in Granger pits

	Feet
Slumped surface material including rounded quartzite gravels and boulders	....
Blue-gray and reddish-brown cross-bedded coarse sand and gravel	10
Greenish-gray sandy clay and thin beds of smooth plastic clay	8
Dark-gray compact sandy clay	2
Bluish-gray coarse sand	1
Buff-gray sandy clay	2
Light buff-gray compact, brittle fine-grained clay. (Sample No. 6-F.)	3
Greenish-gray sandy plastic clay	3
Bluish-gray clayey pumicite	5
Dark gray-green smooth plastic clay (an impure bentonite)	2
Buff-colored coarse clayey sand, gravelly in part	10
Sandy, somewhat decomposed gravel	1
Buff-colored clayey sand	5
Laminated yellow and greenish-gray clay, in part smooth but mostly sandy	15
	67
Base concealed	

The material is mined practically "run-of-pit" and very little attempt is made to sort the very different materials. The resultant mixture is far more suitable for use than would be any of the component beds, as is apparent from tests made on individual members.

Sample No. 6-F is a light-gray clay, fine-grained and very brittle, from the "North Pit". This type of clay is common in the Yakima country, particularly in association with diatomite deposits.

Plastic and dry properties Sample No. 6-F

Plasticity ....Fair
Shrinkage water 16.8%
Pore water 38.3%
Water of plasticity....................55.1%
Volume shrinkage ....18.9% dry volume
Linear shrinkage .... 6.8% dry length
Dry condition ....Weak dry strength

Fired properties Sample No. 6-F

Cone	Color	Condition	L.S.%d.l.	T.L.S.%d.l.	V.S.%d.v.	Abs.	A.Por.
06	Lt. red-brown	Weak, very soft	7.1	13.9	19.7	35.5	47.6
04	Brown-red	Few cracks, soft	9.6	16.4	26.2	28.0	42.3
02	Bright brown-red	Scum, few cracks, S.H.-	14.6	21.4	37.8	17.5	27.9
6-7*	Red-brown and black	Fused, S.H.	21.6	28.4	52.5	0.2	0.6

Remarks: Best firing range: 02-3. Cone fusion: 5. High percentage dry pore space; very high fired shrinkage. Color good.

Class of ware: Use in mixture with other clays for brown and red structural wares.

Sample No. 6-C is buff-colored weak, silty material that is taken from the "East bank".

Plastic and dry properties Sample No. 6-C

Plasticity ....Weak, silty
Shrinkage water 4.0%
Pore water 17.6%
Water of plasticity....................21.6%
Volume shrinkage .... 6.8% dry volume
Linear shrinkage .... 2.3% dry length
Dry condition ....Soft

Fired properties Sample No. 6-C

Cone	Color	Condition	L.S.%d.l.	T.L.S.%d.l.	V.S.%d.v.	Abs.	A.Por.
07	Lt. red-brown	Weak, very soft	-0.6	1.7	-1.8	20.8	35.2
04	Lt. red-brown	Good, hard	1.0	3.3	3.0	18.7	32.0
02	Dk. red-brown	Scum, good, hard	2.2	4.5	6.5	16.5	30.8
6-7*	Brown-black	Fused, S.H.	....	....	....	0.3	0.8

Remarks: Best firing range: 03-2. Cone fusion: 5. Mix with more plastic clay to develop better plastic strength.

Class of ware: Red and brown structural wares.

Sample No. 6-E is a very plastic gray clay from the "West Pit".

Plastic and dry properties Sample No. 6-E

Plasticity ....Fair
Shrinkage water 23.1%
Pore water 12.2%
Water of plasticity....................35.3%
Volume shrinkage ....35.1% dry volume
Linear shrinkage ....13.4% dry length

Fired properties Sample No. 6-E

Cone	Color	Condition	L.S.%d.l.	T.L.S.%d.l.	V.S.%d.v.	Abs.	A.Por.
05	Brown-red	Weak, soft	3.4	16.8	9.9	23.0	37.0
04	Brown-red	Good, hard	5.4	18.8	15.4	18.7	32.1
02	Brown-red	Good, S.H.	8.7	22.1	24.0	15.5	20.5
6-7*	Red-brown and black	Vitreous, near fusion, S.H.	11.8	25.2	31.4	0.8	1.7

Remarks: Best firing range: 04-5. Cone fusion: 7-8. Good color. Drying shrinkage is high. Good firing range.

Class of ware: Red and brown structural wares.

Sample No. 754 is ground clay from the plant and represents one of their general mixtures. It is 25 percent sand and 75 percent clay sampled as No. 6-E.

Plastic and dry properties Sample No. 754

Plasticity ....Weak	Volume shrinkage ....24.4% dry volume
Shrinkage water 15.4%	Linear shrinkage .... 8.9% dry length
Pore water 25.1%	
Water of plasticity....40.5%	

Fired properties Sample No. 754

Cone	Color	Condition	L.S.%d.l.	T.L.S.%d.l.	V.S.%d.v.	Abs.	A.Por.
010	Buff-brown	Weak, soft	0.5	9.4	1.3	26.2	40.5
05	Deep brown-red	Weak, soft	3.3	12.2	9.5	23.1	39.1
02	Deep brown-red	Vitreous, good, S.H.	7.1	16.0	19.7	....	....
1	Dk. red-brown	Vitreous, good, S.H.	8.7	17.6	24.0	11.7	23.3

Remarks: Best firing range: 03-1. Cone fusion: 6. Shrinkage too high and plastic strength is poor.

Class of ware: Used for common brick and tile.

Granger Clay Products Co.—The clay is caved, then pulled by tractor-operated drag-line scraper to a trap, where trucks are loaded. The haul to the plant is about 400 yards. There it goes through disintegrator rolls to a combination pug mill and auger machine and an 18-brick automatic cutter. Transfer cars take the ware from the off-bearing belt to a 12-tunnel coal-fired drier, where it is made ready for firing in about 48 hours. The ware is fired in six 30-foot round down-draft periodic kilns, each kiln holding about 75,000 brick. Two days are allowed for water-smoking and the firing is completed in another 6 to 7 days. The product comprises common brick, rough-textured face brick, and various sizes of hollow block and drain tile. With good market conditions about 40 kilns are fired per year.

APPENDIX 1

LOCATIONS AND PROPERTIES OF WASHINGTON CLAYS AND SHALES

LOCATION (nearest town)	CLAY TYPE	Cone fusion			a Fired color	USABLE FOR	b Analysis no. (Appendix 2)	Sample number	See page
		−10	10–26	26+					
ADAMS									
General	Silt, Palouse	x			Dark	Brick and tile			59
ASOTIN									
General	Silt, Palouse	x			Dark	Brick and tile			59
BENTON									
White Bluffs	Alluvial, silt	x			Dark	Brick and tile		9	61
Prosser	Alluvial, silt	x			Dark	Brick and tile	4		60
CHELAN									
Wenatchee	Shale			x	Light	Refractories	8–10		62
Wenatchee	Alluvial	x			Dark	Brick and tile	7	156	63
Chelan	Silt	x			Dark	Brick and tile	5–6	155	64
CLALLAM									
Port Angeles	Shale	x			Dark	Structural ware		368	66
Port Angeles	Shale	x			Dark	Structural ware		367	67
Port Angeles	Shale	x			Dark	Doubtful value		366	67
Port Angeles	Glacial	x			Dark	Brick and tile		365	68
CLARK									
Vancouver	Willapa Pleistocene		x		Dark	Sewer pipe, structural ware		300	69
Vancouver	Willapa Pleistocene		x		Dark	Structural ware		301	70
Vancouver	Willapa Pleistocene		x		Dark	Structural ware		302	70
Vancouver	Willapa Pleistocene	x			Dark	Brick and tile		769	71
COLUMBIA									
Dayton	Palouse, alluvial	x			Dark	Brick and tile	12–14		73
COWLITZ									
Kelso	Shale	x			Light	Structural ware		309	75
Kelso	Shale	x			Light	Structural ware		308	75
Castle Rock	Shale	x			Dark	Structural ware		311	76
Castle Rock	Shale	x			Dark	Structural ware		312	77
Castle Rock	Shale residuum		x		Light	Structural ware		342	77
Castle Rock	Shale		x		Dark	Structural ware		312-A	78
Castle Rock	Alluvial (?)		x		Light	Structural ware		312-B	78
Castle Rock	Alluvial (?)		x		Light	Structural ware		312-C	79
Castle Rock	Shale		x		Dark	Structural ware		312-D	80
Castle Rock	Shale residuum		x		Light	Structural ware		313	80
Castle Rock	Shale	x			Dark	Structural ware		310	81
Castle Rock	Basalt residuum		x		Dark	Structural ware		341	84
DOUGLAS									
General	Silt	x			Dark	Brick and tile	15		85
Wenatchee	Shale			x	Light	Refractories	8–10		86
FERRY									
Republic	Residual	x			Dark	Structural ware		151	88
Rockcut	Silt	x			Dark	Slip	17	150	88
FRANKLIN									
Hanford	Silt	x			Dark	Doubtful value		11-D	91
Hanford	Silt	x			Dark	Structural ware		11-A	91
Hanford	Silt	x			Dark	Doubtful value		12-A	92
Hanford	Silt	x			Dark	Doubtful value		12-B	92
Hanford	Silt	x			Dark	Doubtful value		12-D	92
Hanford	Silt	x			Dark	Doubtful value		14-B	93
GARFIELD									
General	Palouse	x			Dark	Brick and tile			94
GRANT									
Corfu	Silt	x			Dark	Doubtful value		1	96
Corfu	Silt	x			Dark	Brick and tile		2	96

LOCATIONS AND PROPERTIES OF WASHINGTON CLAYS AND SHALES —Continued

LOCATION (nearest town)	CLAY TYPE	Cone fusion			*a* Fired color	USABLE FOR	*b* Analysis no. (Appendix 2)	Sample number	See page
		—10	10–26	26+					
GRAYS HARBOR									
Humptulips	Shale	x			Dark	Structural ware		356	99
Hoquiam	Shale		x		Dark	Structural ware		358	99
Pacific Beach	Willapa Pleistocene	x			Dark	Structural ware		357	103
Hoquiam	Willapa Pleistocene		x		Dark	Structural ware		355	104
Hoquiam	Willapa Pleistocene		x		Dark	Structural ware		359	105
Hoquiam	Willapa Pleistocene	x			Dark	Structural ware		360	105
Aberdeen	Shale		x		Dark	Structural ware		361	100
Aberdeen	Willapa Pleistocene	x			Dark	Structural ware		354	103
Montesano	Shale	x			Dark	Structural ware		362	101
ISLAND									
General	Glacial	x			Dark	Brick and tile			106
JEFFERSON									
Quilcene	Shale	x			Dark	Structural ware		369	107
Quilcene	Shale		x		Dark	Structural ware		364	107
KING									
Enumclaw	Cascade residual		x		Dark	Structural ware	78	182	109
Enumclaw	Cascade residual		x		Dark	Doubtful value	79	185	109
Enumclaw	Cascade residual		x		Dark	Structural ware	80	186	110
Enumclaw	Cascade residual		x		Dark	Structural ware	81	184	111
Enumclaw	Shale	x			Dark	Structural ware	82	183	111
Enumclaw	Shale	x			Dark	Doubtful value	83	181	112
Renton	Shale	x			Dark	Structural ware	76	392	114
Renton	Shale	x			Dark	Structural ware			119
Renton	Shale			x	Light	Refractories			120
Renton	Shale	x			Dark	Structural ware		381	121
Renton	Shale	x			Dark	Structural ware		382	121
Renton	Shale	x			Dark	Structural ware	77	395	117
Renton	Shale		x		Dark	Structural ware		396	118
Renton	Shale		x		Dark	Structural ware		397	118
Issaqua	Shale		x		Light	Refractories		...	120
Taylor	Residual			x	Light	Face brick	66	179	122
Taylor	Shale	x			Dark	Structural ware	71	176	124
Taylor	Shale		x		Dark	Sewer pipe	72	177	124
Taylor	Shale		x		Dark	Sewer pipe		384	125
Taylor	Shale		x		Light	Structural ware	73	383	126
Bayne	Shale	x			Dark	Structural ware	56	173	134
Durham	Shale	x			Dark	Structural ware	57	174	134
Palmer	Shale	x			Dark	Structural ware	58	175	135
Palmer	Shale	x			Dark	Structural ware		380	135
Palmer	Hammer Bluff		x		Light	Structural ware		379	150
Kummer	Shale			x	Light	Refractories	45	168	129
Kummer	Shale			x	Light	Refractories	49	171	130
Kummer	Shale			x	Light	Refractories	48	169	131
Kummer	Shale		x		Dark	Structural ware	55	172	131
Kummer	Shale		x		Dark	Structural ware	51	170	132
Kummer	Sandstone					Mixture	40	167	132
Auburn	Shale		x		Dark	Structural ware		165	133
Auburn	Hammer Bluff		x		Light	Face brick, terra cotta	22	164	138
Auburn	Hammer Bluff		x		Light	Terra cotta		702	140
Auburn	Hammer Bluff		x		Light	Terra cotta		703	140
Auburn	Hammer Bluff		x		Light	Terra cotta		704	141
Auburn	Hammer Bluff		x		Dark	Structural ware	34	157	141
Auburn	Hammer Bluff		x		Dark	Structural ware	32	161	142
Auburn	Hammer Bluff				Light	Mixture		378	143
Auburn	Hammer Bluff		x		Light	Structural ware	33	162	143
Auburn	Hammer Bluff		x		Dark	Structural ware		163	144
Auburn	Hammer Bluff			x	Light	No. 2 refractory	29	158	145
Auburn	Hammer Bluff			x	Light	Terra cotta	30	159	146
Auburn	Hammer Bluff			x	Light	Terra cotta	31	160	146
Auburn	Hammer Bluff			x	Light	Terra cotta	25	159-A	147
Auburn	Hammer Bluff			x	Light	Terra cotta	27	160-A	147
Auburn	Hammer Bluff		x		Light	Structural ware	36	166	148
Seattle	Glacial	x			Dark	Brick and tile		385	152
Seattle	Glacial	x			Dark	Brick and tile		386	153
Seattle	Glacial	x			Dark	Brick and tile		391	154

LOCATIONS AND PROPERTIES OF WASHINGTON CLAYS AND SHALES —Continued

LOCATION (nearest town)	CLAY TYPE	Cone fusion			a Fired color	USABLE FOR	b Analysis no. (Appendix 2)	Sample number	See page
		—10	10–26	26+					
KING—Cont.									
Seattle	Glacial	x			Dark	Brick and tile	84	390	156
North Bend	Glacial	x			Dark	Brick and tile if mixed		5	159
North Bend	Glacial	x			Dark	Brick and tile if mixed		6	159
Various	Mixture		x		Light	Terra cotta		D-R 2	116
Various	Mixture		x		Light	Terra cotta		D-R 5	116
Various	Mixture		x		Light	Terra cotta		D-R 6	116
KITSAP									
Port Orchard	Shale	x			Dark	Doubtful value		375	161
Harper	Glacial	x			Dark	Brick and tile		376	162
Harper	Glacial	x			Dark	Brick and tile		377	162
KITTITAS									
Wymer	Silt		x		Dark	Doubtful value		6-A	165
Roza	Silt		x		Dark	Doubtful value		7	166
KLICKITAT									
General	Silt, alluvial	x			Dark	Brick and tile			166
LEWIS									
Toledo	Residual			x	Dark	Doubtful value		314	169
Toledo	Residual		x		Dark	Doubtful value		315	169
Toledo	Residual		x		Light	Terra cotta		316-A	170
Toledo	Shale			x	Light	Terra cotta		316	171
Toledo	Shale			x	Light	Refractories		317	171
Toledo	Shale			x	Light	Structural ware		318	172
Toledo	Residual			x	Light	Refractories		319	172
Toledo	Residual			x	Light	Refractories		320	173
Winlock	Shale	x			Dark	Structural ware		322	174
Winlock	Shale	x			Dark	Structural ware		323	174
Winlock	Shale	x			Dark	Structural ware		340	175
Vader	Shale	x			Dark	Structural ware		321	175
Vader	Willapa Pleistocene		x		Dark	Structural ware	95	321-B	184
Vader	Willapa Pleistocene		x		Dark	Structural ware	94	321-A	184
Napavine	Willapa Pleistocene		x		Dark	Structural ware		324	181
Napavine	Willapa Pleistocene		x		Dark	Structural ware		338	181
Napavine	Willapa Pleistocene			x	Dark	Structural ware		339	182
Napavine	Willapa Pleistocene		x		Dark	Structural ware		325	182
Napavine	Willapa Pleistocene			x	Light	Refractories		339-A	183
Napavine	Alluvial	x			Dark	Structural ware		326	188
Salkum	Shale	x			Dark	Undetermined			178
Pe Ell	Shale	x			Dark	Structural ware		347	176
Chehalis	Willapa Pleistocene		x		Dark	Struct. ware (mixed)	90	343	187
Centralia	Willapa Pleistocene	x			Light	Bond			186
Centralia	Alluvial	x			Dark	Structural ware		327	189
Mendota	Shale	x			Dark	Structural ware		345	177
Mendota	Shale		x		Dark	Structural ware		344	177
Mendota	Willapa Pleistocene		x		Dark	Structural ware		346	185
Morton	Alluvial		x		Dark	Structural ware		337	189
Morton	Shale		x		Dark	Structural ware		336	179
Mineral	Shale			x	Light	Structural ware; refractories		336-B	179
Mineral	Shale		x		Light	Structural ware		336-BA	180
LINCOLN									
General	Palouse	x			Dark	Brick and tile	96		189
MASON									
Hoodsport	Shale	x			Dark	Doubtful value		363-A	190
Hoodsport	Shale	x			Dark	Doubtful value		363-B	190
Hoodsport	Shale	x			Dark	Structural ware		363	190
Olympia	Willapa Pleistocene		x		Light	Structural ware		371	191
Olympia	Willapa Pleistocene		x		Dark	Structural ware		372	192
OKANOGAN									
Oroville	Argillite	x			Dark	Doubtful value	105	152	193
Oroville	Silt	x			Dark	Brick and tile	104	153	193
Brewster	Silt	x			Dark	Brick and tile	103	154	194

LOCATIONS AND PROPERTIES OF WASHINGTON CLAYS AND SHALES —Continued

LOCATION (nearest town)	CLAY TYPE	Cone fusion			[a] Fired color	USABLE FOR	[b] Analysis no. (Appendix 2)	Sample number	See page
		—10	10–26	26+					
PACIFIC									
Frances	Shale		x		Dark	Structural ware		348	195
Lebam	Shale	x			Dark	Structural ware		349	196
Raymond	Shale	x			Dark	Structural ware		350	197
Raymond	Shale		x		Dark	Structural ware		351	197
Raymond	Shale	x			Dark	Structural ware		352	198
Bay Center	Willapa Pleistocene	x			Dark	Structural ware		353	199
PEND OREILLE									
Ione	Argillite	x			Dark	Doubtful value	137	146	200
Ione	Silt	x			Dark	Doubtful value	138	145	203
Ione	Silt	x			Dark	Doubtful value	118	147	203
Ione	Silt	x			Dark	Brick and tile	115	144	203
Ione	Silt	x			Dark	Doubtful value	115	141	204
Metaline	Silt	x			Dark	Doubtful value	140	142	201
Metaline	Silt	x			Dark	Doubtful value	140	143	202
PIERCE									
La Grande	Cascade residual			x	Light	Refractories	166	184-A	206
La Grande	Cascade residual			x	Light	Refractories	166	184-B	207
La Grande	Cascade residual			x	Light	Refractories	167	185-A	207
Clay City	Cascade residual		x		Light	Structural ware		187	209
Clay City	Cascade residual		x		Dark	Mixtures	169	187-A	209
Clay City	Cascade residual			x	Light	Refractories	168	186-A	210
Clay City	Cascade residual		x		Dark	Mixtures		188	211
Clay City	Cascade residual		x		Dark	Mixtures		187-D	211
Clay City	Cascade residual		x		Light	Brick and tile		187-B	212
Clay City	Cascade residual		x		Dark	Face brick		187-C	212
Kapowsin	Cascade residual			x	Light	Structural ware		335	214
Carbonado	Shale		x		Dark	Structural ware		180	215
SAN JUAN									
General	Glacial	x			Dark	Brick and tile	170		217
SKAGIT									
Sauk	Argillite	x			Dark	Structural ware	190	191	218
McMurray	Shale	x			Dark	Structural ware	198	189	219
Concrete	Glacial	x			Dark	Structural ware	186	192	220
Concrete	Glacial	x			Dark	Structural ware	187	192-A	220
Hoogdal	Glacial	x			Dark	Structural ware	196	196	221
Hoogdal	Glacial	x			Dark	Structural ware	195	197	221
Tiloh	Alluvial	x			Dark	Structural ware	199	190	222
Sedro Woolley	Alluvial	x			Dark	Structural ware	191	193	223
Sedro Woolley	Alluvial		x		Dark	Doubtful value	192	194	223
Prairie	Alluvial	x			Dark	Structural ware	193	195	224
SKAMANIA									
General	Alluvial	x			Dark	Brick and tile			225
SNOHOMISH									
Everett	Glacial	x			Dark	Brick and tile	201	388	226
Snohomish	Alluvial	x			Dark	Brick and tile		389	227
Meadowdale	Glacial	x			Dark	Flower pots		387	228
SPOKANE									
Tekoa	S.-C.[c] lacustrine		x		Dark	Structural ware		65	235
Tekoa	S.-C. lacustrine		x		Light	Pottery		66	235
Tekoa	Shale		x		Dark	Structural ware		63	236
Latah	S.-C. lacustrine		x		Dark	Structural ware		71-A	237
Fairfield	Shale		x		Dark	Structural ware		74	237
Saxby	S.-C. residual		x		Dark	Structural ware		90-A	238
Saxby	S.-C. residual			x	Light	Refractories, pottery		90	238
Manito	S.-C. lacustrine				Light	Pottery	216		239
Lockwood	S.-C. residual		x		Light	Structural ware		78-A	240
Freeman	S.-C. residual			x	Light	Refractories, white-ware	219	78	242
Freeman	S.-C. lacustrine		x		Light	Structural ware		79	243
Freeman	Palouse	x			Dark	Structural ware	224	79-A	277

c—"S.-C." stands for the clay group designated as Spokane-Clayton in the report.

LOCATIONS AND PROPERTIES OF WASHINGTON CLAYS AND SHALES —Continued

LOCATION (nearest town)	CLAY TYPE	Cone fusion			*a* Fired color	USABLE FOR	*b* Analysis no. (Appendix 2)	Sample number	See page
		−10	10–26	26+					
SPOKANE—Cont.									
Mica	S.-C.*c* residual			x	Light	Refractories, pottery	211	94	246
Mica	S.-C. residual			x	Light	Refractories, pottery	210	94-B	247
Mica	S.-C. lacustrine			x	Light	Mixtures	213	94-A	249
Mica	Mixture			x	Light	Refractories		726	249
Mica	Mixture		x		Dark	Sewer pipe		736	250
Mica	S.-C. lacustrine			x	Light	Refractories, pottery	214	94-C	251
Moran	S.-C. lacustrine		x		Light	Structural ware			253
Chester	S.-C. lacustrine			x	Light	Structural ware, pottery	233	100	254
Chester	S.-C. lacustrine			x	Dark	Struct. ware, pottery		101	254
Chester	S.-C. residual			x	Light	Refractories	235	104	255
Chester	Shale		x		Dark	Structural ware		105	271
Mead	S.-C. residual			x	Light	Refractories, pottery	241	117	257
Mead	S.-C. residual			x	Light	Refractories, pottery	242	117-A	258
Mead	S.-C. lacustrine						244	118-A	258
Mead	S.-C. lacustrine		x		Light	Struct. ware, pottery		118-AB	258
Mead	S.-C. lacustrine			x	Light	Struct. ware, pottery		118-B	259
Mead	S.-C. lacustrine		x		Light	Struct. ware, pottery		118-C	259
Mead	S.-C. lacustrine			x	Light	Refractories, pottery		118-D	260
Mead	S.-C. residual			x	Light	Refractories, pottery	243	127	260
Mead	Silt (glacial)	x			Dark	Brick and tile	237		279
Chattaroy	S.-C. lacustrine		x		Dark	Structural ware		128	261
Spokane	S.-C. lacustrine				Light	Struct. ware, pottery			262
Spokane	Shale		x		Dark	Structural ware	236	125-A	268
Spokane	Shale		x		Dark	Structural ware		125-B	268
Spokane	Shale	x			Dark	Brick and tile		714	270
Spokane	Shale	x			Dark	Structural ware		125	271
Various	Mixture		x		Dark	Flower pots		133-A	266
Milan	S.-C. residual			x	Light	Refractories		130-A	262
Milan	S.-C. lacustrine			x	Light	Refractories, pottery		130-B	263
Milan	Shale		x		Dark	Structural ware		131	274
Milan	Shale		x		Dark	Structural ware		130	275
Milan	Shale		x		Dark	Structural ware		128-A	276
Deer Park	S.-C. lacustrine			x	Light	Struct. ware, pottery	246	135	265
Dartford	Shale	x			Dark	Doubtful value		121	273
Dartford	S.-C. residual (?)		x		Dark	Structural ware		121-A	273
Buckeye	Shale		x		Dark	Structural ware		122	273
STEVENS									
Clayton	S.-C. lacustrine			x	Light	Refractories, pottery	257	136	284
Clayton	S.-C. lacustrine			x	Light	Terra cotta		701	287
Clayton	S.-C. lacustrine		x		Light	Struct. ware, pottery	261	132	288
Clayton	S.-C. lacustrine		x		Dark	Flower pots		133	288
Clayton	S.-C. lacustrine			x	Dark	Pigment		134	289
Clayton	S.-C. lacustrine			x	Light	Struct. ware, pottery	270	135-A	290
Clayton	S.-C. lacustrine			x	Light	Struct. ware, pottery	271	135-B	291
Valley	S.-C. lacustrine		x		Light	Struct. ware, pottery	277	138	293
Chewelah	Silt (glacial)	x			Dark	Brick and tile	279	138-A	294
Bissell	Silt (glacial)	x			Dark	Brick and tile		139	295
Kettle Falls	Silt (glacial)	x			Dark	Brick and tile, slip	288	140	296
Bossburg	Silt (glacial)	x			Dark	Slip	300		297
Marcus	Silt (glacial)	x			Dark	Brick and tile		148	298
Orient	Silt (glacial)	x			Dark	Slip		149	299
THURSTON									
Tenino	Shale	x			Dark	Structural ware		373	300
Tenino	Shale	x			Dark	Structural ware		374	301
Olympia	Glacial	x			Dark	Structural ware	310		301
WAHKIAKUM									
Cathlamet	Basalt residuum		x		Dark	Structural ware		305-A	302
Cathlamet	Willapa Pleistocene		x		Light	Structural ware		306	303
Cathlamet	Willapa Pleistocene		x		Light	Structural ware		305	304
Skamokawa	Shale	x			Dark	Structural ware		303	303
Skamokawa	Shale	x			Dark	Structural ware		304	303
WALLA WALLA									
General	Palouse	x			Dark	Brick and tile			305

c—"S.-C." stands for the clay group designated as Spokane-Clayton in the report.

LOCATIONS AND PROPERTIES OF WASHINGTON CLAYS AND SHALES —Concluded

LOCATION (nearest town)	CLAY TYPE	Cone fusion			*a* Fired color	USABLE FOR	*b* Analysis no. (Appendix 2)	Sample number	See page
		—10	10–26	26+					
WHATCOM									
Bellingham	Shale		x		Dark	Structural ware		393	307
Bellingham	Shale	x			Dark	Brick and tile		394	307
Bellingham	Glacial	x			Dark	Brick and tile	330		319
Sumas	Shale		x		Dark	Refractories	316	207	312
Sumas	Shale			x	Light	Refractories		203	313
Sumas	Shale			x	Light	Refractories	314	204	313
Sumas	Shale		x		Light	Structural ware		208	313
Sumas	Shale		x		Light	Structural ware		S-18	314
Sumas	Sandstone			x	Light	Mixtures		206	314
Sumas	Shale			x	Light	Refractories		205	315
Sumas	Shale		x		Dark	Structural ware		198	315
Sumas	Shale			x	Light	Refractories	321	199	316
Sumas	Shale			x	Light	Refractories	322	200	316
Sumas	Shale		x		Dark	Structural ware		201	316
Sumas	Shale		x		Dark	Structural ware		202	317
Nooksack	Shale (?)	x			Dark	Doubtful value		209	318
Nooksack	Shale (?)	x			Dark	Doubtful value		210	319
WHITMAN									
Clarkston	Shale				Dark	Doubtful value		25-B	320
Palouse	S.-C. *c* lacustrine			x	Light	Refractories, bond		36	322
Palouse	S.-C. lacustrine		x		Dark	Mixtures		31	322
Palouse	S.-C. lacustrine		x		Dark	Mixtures		32	323
Palouse	S.-C. lacustrine			x	Light	Terra cotta, stoneware	331	35	323
Palouse	S.-C. lacustrine			x	Light	Ter. cot., stoneware		34	324
Palouse	S.-C. lacustrine			x	Light	Refractories, pottery		713	324
Palouse	S.-C. lacustrine			x	Light	Ter. cot., stoneware		34-A	325
Palouse	S.-C. lacustrine			x	Light	Refractories, pottery		29	326
Johnson	Palouse		x		Dark	Brick and tile	336	23	329
Uniontown	Palouse	x			Dark	Structural ware		25	329
Ayer	Palouse	x			Dark	Structural ware		17	330
Colton	Palouse	x			Dark	Structural ware		24	331
Rosalia	Palouse	x			Dark	Structural ware		61	331
YAKIMA									
Granger	Silt-clay	x			Dark	Mixtures		6-F	334
Granger	Silt-clay	x			Dark	Mixtures		6-C	334
Granger	Silt-clay	x			Dark	Structural ware		6-E	334
Granger	Mixture	x				Brick and tile		754	335
Yakima	Alluvial						338		332

a—"Dark" colors are reds and browns; "Light" colors are grays and buffs.

b—Some analyses given in appendix 2 were made of parts of samples on which physical tests were made; others are of clays similar to those sampled or indicate general character.

c—"S.-C." stands for the clay group designated as Spokane-Clayton in the report.

APPENDIX 2

a—Letters under this heading indicate that the analysis is quoted from, or was made by, the following:

A—Bethune, G. A., Second annual report, State Geologist of Washington, pp. 65-66, 1892.

B—Roberts, Milnor, Denny Clay Co.: Washington Geol. Survey Ann. Rept. for 1901, pt. 3, p. 15, 1902.

C—Landes, Henry, Cement resources of Washington: U. S. Geol. Survey Bull. 285, pp. 377-383, 1906.

D—Shedd, Solon, The clays of the State of Washington: State College of Washington, 1910.

E—Shedd, Solon, Cement materials and industry in the State of Washington: Washington Geol. Survey Bull. 4, 1914.

F—Wilson, Hewitt, The clays and shales of Washington, their technology and uses: Univ. of Washington Eng. Exp. Sta. Bull. 18, 1923.

G—Private investigations, the records of which were made available to the writer.

H—Wilson, Hewitt, Kaolin and china clay in the Pacific Northwest: Univ. of Washington Eng. Exp. Sta. Bull. 76, 1934.

I—U. S. Geol. Survey Bull. 591, p. 270, 1915.

J—U. S. Geol. Survey Bull. 878, p. 71, 1937.

CHEMICAL

LOCATION	MATERIAL	REMARKS	Reference or Analyst *a*	Sample number *b*	Analysis number
ASOTIN COUNTY					
Lime Hill, W. side	Shale, light-gray	Prospect	E	......	1
Lime Hill, near bluff on N.	Shale, red and green	Undeveloped	E	......	2
Asotin, 4 mi. up river from	Clay, compact yellow-gray	Undeveloped	E	......	3
BENTON COUNTY					
Prosser	Clay, light-gray	Old brick-yard pit	D	......	4
CHELAN COUNTY					
Chelan, S. end of lake	Clay, gray silty	Old brick-yard pit	D	*155	5
Chelan, S. end of lake	Clay, gray silty	Old brick-yard pit	G	155	6
Wenatchee	Clay, buff sandy	Wenatchee B. & T. Co. pit	G	156	7
Squillchuck Canyon	Shale, refractory	N.W.L.Brown prosp.	P	......	8
Squillchuck Canyon	Shale, refractory	N.W.L.Brown prosp.	P	......	9
Squillchuck Canyon	Shale, refractory	N.W.L.Brown prosp.	P	......	10
CLALLAM COUNTY					
Port Angeles	Clay, "pottery"	......	A	......	11
COLUMBIA COUNTY					
Dayton	Clay (surface)	Old brick-yard pit	D	......	12
Dayton	Clay (2-4 ft. below surf.)	Old brick-yard pit	D	......	13
Dayton	Clay (4-6 ft. below surf.)	Old brick-yard pit	D	......	14
COWLITZ COUNTY					
Castle Rock, 7 mi. NE. of	Calcined clay	Gladding, McB. mine	S	......	14-A
Castle Rock, 7 mi. NE. of	"C" deposit, burned "flint".	Gladding, McB. mine	S	......	14-B
DOUGLAS COUNTY					
Bridgeport	Clay	Undeveloped	D	......	15
FERRY COUNTY					
Republic	Clay	Undeveloped	C	......	16
Rockcut	Clay, silty gray	Railway cut	G	150	17
Laurier, terrace beds	Clay, slip	Undeveloped	D	......	18
KING COUNTY					
Green River, near Hammer Bluff	Clay, light-gray	Old Auburn Pottery pit.	D	*164	19
Green Riv., near Ham. Bluff	Clay, white	Old Auburn Pot. pit	D	*164	20
Green Riv., near Ham. Bluff	Sand	Old Auburn Pot. pit	D	*158	21
Green Riv., near Ham. Bluff	Clay, gray	Old Northern Clay Co. pit	G	164	22
Green River, near Hammer Bluff (lower bench)	Clay, gray	Old Northern Clay Co. pit	O	*164	23
Green River, near Hammer Bluff (upper bench)	Clay, gray	Old Northern Clay Co. pit	O	......	24
Green River, Hammer Bluff	Clay, sandy gray	"Upper prospect"	G	159-A	25
Green River, Hammer Bluff	Sand, clayey gray	"Upper prospect"	G	*158	26
Green River, Hammer Bluff	Clay, sandy gray	"Upper prospect"	G	160-A	27
Green River, Hammer Bluff	Clay, sandy gray	"Hammer prospect"	O	*159	28

K—Analyst, William Stowell & Co., Spokane, Wash.
L—Analyst, C. M. Fassett, Spokane, Wash.
M—Analyst, Elton Fulmer, Chemistry Dept., State College of Washington.
N—Analyst, Richard Marsh, Spokane, Wash.
O—Denny-Renton Clay & Coal Co.
P—Analyst, G. S. Eldridge & Co., Vancouver, B. C.
Q—Falkenburg & Co., Seattle, Wash.
R—Bogardus Testing Laboratories, Seattle, Wash.
S—Gladding, McBean & Co.

b—The physical properties of these samples are given in the body of this report under the respective county heading and sample numbers.

*—An asterisk (*) before a number indicates that the clay having that number is similar to that analyzed, though not necessarily from the same part of the deposit or, in some instances, from the same vicinity.

ANALYSES

Analysis number	Silica (SiO_2)	Alumina (Al_2O_3)	Ferric oxide (Fe_2O_3)	Lime (CaO)	Magnesia (MgO)	Potash (K_2O)	Soda (Na_2O)	Titanium (TiO_2)	Moisture (H_2O)	Combined water. Ignition	Miscellaneous	Total
1	26.28	15.32	1.57	28.72	Tr.	......	......	......	......	27.17	......	99.06
2	72.56	12.04	1.38	3.16	2.10	......	......	......	......	6.15	......	97.39
3	54.52	12.14	6.20	Tr.	2.07	1.92	1.30	......	......	8.06	......	99.19
4	54.92	18.56	6.48	1.34	1.14	1.76	1.14	1.50	5.23	8.04	MnO 0.10	100.21
5	59.84	16.40	4.10	5.84	0.36	1.62	2.84	1.20	0.74	5.51	1.32	99.77
6	59.5	18.8	5.0	......	......	......	......	......	......	......	......	......
7	50.3	23.0	5.49	......	......	......	......	......	......	......	......	......
8	51.26	32.65	0.61	0.50	0.21	0.55		......	......	14.22	......	100.00
9	44.80	37.35	0.41	0.58	0.09	1.29		......	......	15.48	......	100.00
10	48.20	34.79	0.61	0.56	0.12	1.07		......	......	14.65	......	100.00
11	35.40	31.20	0.70	0.44	0.18	0.52	0.36	0.00	13.90	......	MnO 0.45 Sand 10.19	......
12	63.06	13.00	5.53	2.47	1.03	1.82	1.62	1.30	2.68	6.58	1.06	100.15
13	63.25	15.34	5.91	2.34	1.26	1.50	1.31	1.20	2.63	3.96	1.22	99.92
14	64.52	14.58	4.47	2.35	1.50	1.86	1.78	1.15	1.70	3.57	2.53	100.01
14-A	43.48	53.68	0.26	1.12	0.25	......	......	1.00	......	0.21	......	......
14-B	45.25	43.12	0.52	1.08	Tr.	......	......	2.50	3.56	7.53	......	......
15	62.50	16.85	5.09	5.20	2.55	3.26		......	0.38	3.68	......	99.51
16	60.13	29.10		*c*8.98	*d*1.36	0.29		......	......	......	S 1.75	......
17	50.31	20.78	8.62	......	......	......	......	......	......	......	......	......
18	50.96	22.36	6.52	1.78	3.62	7.10		......	2.24	5.70	......	100.28
19	62.80	23.04	1.14	0.40	0.51	3.84		......	1.65	6.58	......	99.76
20	66.69	21.01	1.14	0.33	0.32	4.20		......	0.62	5.87	......	100.18
21	81.40	10.65	1.90	0.50	0.18	3.00		......	0.20	2.42	......	100.24
22	81.3	14.7	0.72	......	......	......	......	......	......	......	......	......
23	73.67	17.07	1.39	0.83	0.51	......	......	......	......	6.47	......	......
24	70.74	18.48	1.62	0.55	0.67	......	......	......	......	8.11	......	......
25	78.0	17.0	1.16	......	......	......	......	......	......	......	......	......
26	81.2	12.5	1.16	......	......	......	......	......	......	......	......	......
27	64.9	22.9	4.32	......	......	......	......	......	......	......	......	......
28	69.50	18.92	3.27	0.56	0.37	......	......	......	......	7.55	......	100.17

c—Calcium carbonate ($CaCO_3$)
d—Magnesium carbonate ($MgCO_3$)

CHEMICAL

LOCATION	MATERIAL	REMARKS	Reference or Analyst a	Sample number b	Analysis number
KING COUNTY—Cont.					
Green River, Hammer Bluff	Clay, sandy white	Road cut	G	158	29
Green River, Hammer Bluff	Clay, sandy gray	Road cut	G	159	30
Green River, Hammer Bluff	Clay, sandy gray	Road cut	G	160	31
Green River, Brooks place	Clay, sandy gray	Old D-R pit	G	161	32
Green River, Brooks place	Sand, clayey white	Old D-R pit	G	162	33
Green River, Diamond Mineral Spgs	Clay, gray stained	Prospect	G	157	34
Green River, Diamond Mineral Spgs	Clay, gray glacial	Undeveloped	G	......	35
Green Riv., "Flam. Geyser"	Sand, clayey white	Shorey prospect	G	166	36
Green River	Clay, pottery	......	A	......	37
Black Diamond (Kummer?)	Clay, fire	Clay mine	A	......	38
MacIntosh Bed, Green River	Clay, fire	......	A	......	39
Kummer, W. of old entry	Sandstone, clayey gray	Glad., McB. clay mine	G	167	40
Kummer	Sand, "Fire"	Glad., McB. clay mine	B	......	41
Kummer, old main tunnel	Clay, flint fire	Glad., McB. clay mine	D	*168	42
Kummer, old main tunnel	Clay, flint fire	Glad., McB. clay mine	D	*168	43
Kummer, old main tunnel	Clay, flint fire	Glad., McB. clay mine	B	*168	44
Kummer, outcrop	Clay, flint fire	Glad., McB. clay mine	G	168	45
Kummer	Clay, flint fire	Glad., McB. clay mine	F	*168	46
Kummer, old main tunnel	Clay, flint fire (calcined)	Glad., McB. clay mine	G	......	47
Kummer, outcrop	Clay, impure flint fire	Glad., McB. clay mine	G	169	48
Kummer, old S. tunnel	Clay, flint fire	Glad., McB. clay mine	G	171	49
Kummer, old S. tunnel	Clay, flint fire	Glad., McB. clay mine	G	*171	50
Kummer, above old S. tunnel	Clay, blue plastic	Glad., McB. clay mine	G	170	51
Kummer, old main tunnel	Shale, sewer-pipe	Glad., McB. clay mine	D	*172	52
Kummer, old main tunnel	Shale, sewer-pipe	Glad., McB. clay mine	D	*172	53
Kummer, old main tunnel	Shale, sewer-pipe	Glad., McB. clay mine	O	*172	54
Kummer, outcrop	Shale, sewer-pipe	Glad., McB. clay mine	G	172	55
Bayne, old quarry	Shale, dark-gray	Formerly mined	G	173	56
Durham, rock tunnel	Shale, dark-gray	Near portal	G	174	57
Big Six Spur	Shale, dark-gray	Railway cut	G	175	58
Taylor	Clay, light-yellow	Gladding, McB. mine	D	......	59
Taylor	Clay, light-yellow	Gladding, McB. mine	B	......	60
Taylor	Clay, light-yellow	Gladding, McB. mine	B	......	61
Taylor, clay tunnel	Clay, "Hard purple" residual	Gladding, McB. mine	D	......	62
Taylor, clay tunnel	Clay, "Hard purple" residual	Gladding, McB. mine	O	......	63
Taylor, clay tunnel	Clay, "buff" residual	Gladding, McB. mine	D	......	64
Taylor, clay tunnel	Clay, "buff" residual	Gladding, McB. mine	O	......	65
Taylor, clay tunnel	Clay, "white" residual	Gladding, McB. mine	D	*179	66
Taylor, clay tunnel	Clay, "white" residual	Gladding, McB. mine	O	*179	67
Taylor	Shale, paving-brick	Gladding, McB. mine	D	......	68
Taylor, glory hole	Shale, sewer-pipe	Gladding, McB. mine	O	*176	69
Taylor, glory hole	Shale, sewer-pipe	Gladding, McB. mine	O	*176	70
Taylor, glory hole	Shale, sewer-pipe	Gladding, McB. mine	G	176	71
Taylor, glory hole	Shale, sewer-pipe	Gladding, McB. mine	G	177	72
Taylor	Clay, fire	Gladding, McB. mine	O	*383	73
Taylor, west quarry	Clay, fire	Gladding, McB. mine	G	*383	74
Renton, quarry	Shale, paving-brick	Gladding, McBean pit	D	392	75
Renton, quarry, 30-ft. bed	Shale, paving-brick	Gladding, McBean pit	O	*392	76
Black River Jct., ½ mile north	Shale, light-gray	Beac. Coal M. Co. ent.	R	395	77
Enumclaw, 8 miles E. of	Clay, residual gray	Prospect pit	G	182	78
Enumclaw, 8 miles E. of	Clay, residual gray	Prospect tunnel	G	185	79
Enumclaw, 8 miles E. of	Clay, residual blue	Prospect tunnel	G	186	80
East Twin Creek	Clay, residual gray	Prospect tunnel	G	184	81
SE ¼ sec. 1, (19-8 E)	Tuff, decomposed	Prospect	G	183	82
Greenwater, 5 miles E. of	Shale, yellow	Road quarry	O	*181	83
Seattle, S. part	Clay, yellow glacial	Seattle B. & T. Co.	D	*390	84
Seattle, S. part	Clay, blue glacial	Seattle B. & T. Co.	D	*390	85
KITTITAS COUNTY					
Roslyn	Shale	Undeveloped	D	......	86
Hausen Creek	Clay, basaltic residual	Undeveloped	I	......	87
LEWIS COUNTY					
Chehalis	Clay, dark-colored	Chehalis B. & T. Co.	D	......	88
Chehalis	Clay, yellow	Chehalis B. & T. Co.	D	......	89
Chehalis	Clay, blue-gray	Chehalis B. & T. Co.	G	343	90
Centralia	Clay, light-yellow	Old brick-yard pit	D	......	91
Centralia	Clay, dark-yellow	Old brick-yard pit	D	......	92
Centralia, 2 mi. N. of	Shale, gray-brown	Railway cut	G	......	93
Vader	Clay, light-gray	Old L.F.F.C.Co. pit	D	*321-A	94
Vader	Clay, dark-gray	Old L.F.F.C.Co. pit	D	*321-B	95

ANALYSES—Continued

Analysis number	Silica (SiO_2)	Alumina (Al_2O_3)	Ferric oxide (Fe_2O_3)	Lime (CaO)	Magnesia (MgO)	Potash (K_2O)	Soda (Na_2O)	Titanium (TiO_2)	Moisture (H_2O)	Combined water. Ignition	Miscellaneous	Total
29	70.4	21.8	2.88									
30	67.9	22.5	2.60									
31	65.3	23.6	3.80									
32	68.9	22.9	1.44									
33	68.2	20.2	2.30									
34	62.0	21.7	6.75									
35	61.6	19.3	5.49									
36	67.6	17.7	5.49									
37	39.72	27.17	1.54	1.12	0.00	1.21	0.00	0.00	11.18		Sand 16.03	
38	57.50	34.37	1.24	0.50	1.00	0.68			4.71			100.00
39	69.71	18.39	1.44	0.35	0.15	0.19	0.83			8.94		100.00
40	75.2	15.3	2.30									
41	78.60	13.08	0.11	1.22	0.65				3.30		FeO 2.29	
42	40.37	38.57	3.43	0.67	0.45	0.08	0.22		1.56	15.30		100.65
43	40.26	35.84	3.20	0.40	0.26	0.00	Tr.	2.38	1.75	15.21	CO_2 0.70	100.00
44	33.44	45.23		1.60	3.61	1.44				16.44	FeO 1.57	
45	37.00	44.00	2.60									
46	40.80	39.30	1.47	0.87	0.54		1.30	0.30	1.28	14.90		100.76
47	50.00	41.00	3.48									
48	20.20	39.00	12.12									
49	38.80	41.90	1.16									
50	39.60	41.00	2.88									
51	66.00	23.80	2.30									
52	63.90	19.42	5.75	0.88	1.80	1.81			0.76	6.40		100.72
53	61.58	17.46	6.69	0.40	1.37	2.80	0.78	0.65	1.16	7.00		99.89
54	61.69	26.57	1.38	1.90								
55	57.50	22.20	6.00									
56	61.80	22.10	3.70									
57	64.10	21.70	4.04									
58	61.10	23.20	5.75									
59	62.42	17.98	4.34	1.34	1.84	2.78	1.56	0.68	1.44	5.74		100.12
60	41.36	40.49	0.71	0.62	Tr.	1.47				15.29		
61	72.30	19.95	0.71	0.52	Tr.	3.09				3.50		
62	68.98	15.56	4.90	0.50	0.36	2.30	1.64	0.34	0.18	5.54		100.30
63	69.50	16.36	4.53	0.95	0.47	2.25				6.35		100.41
64	72.27	16.16	1.56	0.00	0.29	2.90	1.68	0.68	1.20	3.58		100.32
65	73.50	19.50	0.65	0.98	0.12	2.40				3.50		100.65
66	74.77	16.06	0.70	0.00	0.56	2.34	1.64	0.50	0.18	3.08		99.83
67	73.60	19.80	0.40	0.67	Tr.	2.63				3.10		100.20
68	56.60	20.46	6.42	1.30	1.03	1.48	0.66	0.47	1.50	9.90		99.82
69	54.50	34.70		1.10	1.33					5.37	CO_2 3.00	100.00
70	59.70	30.60		1.00	0.97					5.33	CO_2 2.20	99.80
71	57.1	22.2	6.35									
72	63.0	20.8	5.10									
73	52.40	19.80	9.07	1.80	Tr.	1.29				5.25		90.21
74	55.8	28.1	3.48									
75	62.11	17.59	4.77	1.53	2.26	2.30	1.65	0.51	1.63	5.60		99.95
76	60.21	24.12	1.33	1.61								
77	58.50	19.02	3.10	*c*7.80	*d*2.36	2.12			6.80			99.70
78	48.3	25.6	9.8									
79	74.9	19.4	1.86									
80	61.2	21.5	6.4									
81	68.1	26.1	0.13									
82	70.5	17.4	2.88									
83	70.44	15.33	3.59	2.52	1.29	0.86	2.90			2.19		
84	58.96	16.57	6.10	2.37	2.97	0.83	3.24	0.65	3.58	3.36	MnO 1.15	99.78
85	60.80	18.44	6.00	3.17	1.34	1.32	2.90	0.40	2.10	3.29	MnO 0.40	99.76
86	58.20	23.83	4.61	0.67	1.40	3.15		0.06	1.28	6.42		99.62
87	52.95	15.69	11.85	4.40	2.04	1.11	2.09	2.57	2.19	4.64	P_2O_5 0.19	99.72
88	58.75	18.27	3.86	0.86	1.68	2.18	1.53	0.85	2.12	8.66	MnO 1.20	99.96
89	72.50	13.05	4.53	0.60	0.70	1.84	0.89	0.42	2.00	4.24		100.77
90	65.80	19.20	4.64									
91	60.10	16.61	8.55	1.43	1.29	1.18	0.80	0.98	3.04	6.60		100.58
92	54.83	21.25	7.00	0.80	1.04	0.36	0.69	1.06	5.30	7.62		99.95
93	62.90	26.00	4.32									
94	55.82	19.43	2.38	1.13	0.46	0.80	0.95	1.15	7.72	7.82	MnO 2.04	100.00
95	59.86	19.43	5.15	1.40	1.70	0.38	0.32	1.15	2.78	6.48	MnO 0.61	99.26

c—Calcium carbonate ($CaCO_3$)
d—Magnesium carbonate ($MgCO_3$)

CHEMICAL

LOCATION	MATERIAL	REMARKS	Reference or Analyst *a*	Sample number *b*	Analysis number
LINCOLN COUNTY					
Mondovi	Clay, light-brown	Undeveloped	D	......	96
OKANOGAN COUNTY					
Wauconda, 1 mi. N. of	Clay, light-yellow	Undeveloped	D,E	......	97
Havilla, 1 mi. E. of	Clay, light-yellow	Undeveloped	E	......	98
Scotch Creek Basin	Clay, blue gritty	Undeveloped	E	......	99
Scotch Creek Basin, Hess farm, sec. 25, (35-25 E)	Clay, blue gritty	Undeveloped	E	......	100
Conconnully, Pendergass farm	Clay, gritty, earthy	Undeveloped	E	......	101
Okanogan	Clay	Undeveloped	D	*154	102
Brewster, 1 mi. NE. of	Clay, gritty silty	Coulee bank	G	154	103
Oroville, ½ mi. SE. of	Clay, gritty silty	River bank	G	153	104
Oroville, 2 mi. E. of	Argillite, graphitic	Ravine sides	G	152	105
PACIFIC COUNTY					
Knappton, near dock	Shale, gray concretionary	Ravine sides	Q	......	106
PEND OREILLE COUNTY					
Newport, SE. of	Clay, white sandy	Prospects	D	......	107
Newport, SE. of	Clay, yellow	Prospects	D	......	108
Wolfred, ¾ mi. N. of	Clay, dark-gray	Undeveloped	G	*141	109
Wolfred, 2 mi. N. of	Clay, dark-gray	Undeveloped	G	*141	110
Dalkena, 3 mi. S. of	Clay, dark-gray	Undeveloped	G	*141	111
Cusick (near)	Clay, dark-gray	Undeveloped	G	*141	112
Ruby (near)	Clay, dark-gray	Railway cut	G	*141	113
Blue Slide, ½ mi. N. of	Clay, dark-gray	Railway tunnel	G	*141	114
Cement (Portland)	Clay, gray	River flat	D	*144	115
Cement	Clay, earthy yellow	Railway cut	E	*144	116
Cement	Clay, yellowish-brown	Undeveloped	E	*144	117
Cement	Clay, blue	Prospect	E	*147	118
Cement	Clay, buff	Prospect	E	*145	119
Cement	Clay, buff	Prospect	E	*145	120
Cement	Clay, buff	Prospect	E	*145	121
Cement	Clay, buff	Prospect	E	*145	122
Cement	Clay, buff	Prospect	E	*145	123
Cement	Clay, blue	Prospect	E	*147	124
Cement	Clay, buff	Prospect	E	*145	125
Cement	Clay, buff	Prospect	E	*145	126
Cement	Clay, buff	Prospect	E	*145	127
Cement	Clay, blue	Prospect	E	*147	128
Cement	Clay, buff	Prospect	E	*145	129
Cement	Clay, buff	Prospect	E	*145	130
Cement	Clay, blue	Prospect	E	*147	131
Cement	Clay, blue	Prospect	E	*147	132
Cement	Clay, buff	Prospect	E	*145	133
Cement	Clay, buff	Prospect	E	*145	134
Cement	Clay, buff	Prospect	E	*145	135
Cement	Clay, buff	Prospect	E	*145	136
Cement	Shale, light-gray	Undeveloped	E	*146	137
Ione	Clay, dark gray-buff	Muddy Creek bank	G	145	138
Metaline, 3 mi. S. of	Shale, dark-gray	Road cut	E	......	139
Metaline, 2 mi. S. of	Clay, silty buff	Road cut	E	*142	140
Metaline Falls	Shale, gray	Sullivan Creek bank	E	......	141
Metaline Falls	Shale, nearly black	Sullivan Creek bank	E	......	142
Metaline Falls	Shale	Sullivan Creek bank	E	......	143
Metaline Falls	Shale	Sullivan Creek bank	E	......	144
Metaline Falls	Shale	Sullivan Creek bank	E	......	145
Metaline Falls	Shale	Sullivan Creek bank	E	......	146
Metaline Falls (Sand Creek)	Clay, blue	Inland P. C. Co. pit	E	*143	147
Metaline Falls (Sand Creek)	Clay, blue	Inland P. C. Co. pit	E	*143	148
Metaline Falls (Sand Creek)	Shale, grayish	Inland P. C. Co. pit	E	*142	149
Metaline Falls (Sand Creek)	Shale, "Diamond"	Inland P. C. Co. pit	E	......	150
Metaline Falls (Sand Creek)	Shale, "Diamond"	Inland P. C. Co. pit	E	......	151
Metaline Falls (Sand Creek)	Shale, "Diamond"	Inland P. C. Co. pit	E	......	152
Metaline Falls (Sand Creek)	Shale, "Diamond"	Inland P. C. Co. pit	E	......	153
Metaline Falls (Sand Creek)	Shale, "Diamond"	Inland P. C. Co. pit	E	......	154
Metaline Falls (Sand Creek)	Shale, "Diamond"	Inland P. C. Co. pit	E	......	155
Metaline Falls (Sand Creek)	Shale, "Diamond"	Inland P. C. Co. pit	E	......	156
Metaline Falls (Sand Creek)	Shale, "Diamond"	Inland P. C. Co. pit	E	......	157
Metaline Falls (Sand Creek)	Shale, "Diamond"	Inland P. C. Co. pit	E	......	158
Metaline Falls (Sand Creek)	Shale, "Diamond"	Inland P. C. Co. pit	E	......	159
Metaline Falls (Sand Creek)	Shale, "Diamond"	Inland P. C. Co. pit	E	......	160
Metaline Falls (Sand Creek)	Shale, "Diamond"	Inland P. C. Co. pit	E	......	161

ANALYSES—Continued

Analysis number	Silica (SiO_2)	Alumina (Al_2O_3)	Ferric oxide (Fe_2O_3)	Lime (CaO)	Magnesia (MgO)	Potash (K_2O)	Soda (Na_2O)	Titanium (TiO_2)	Moisture (H_2O)	Combined water. Ignition	Miscellaneous	Total
96	60.52	19.37	5.95	1.94	1.65	1.99		....	4.02	4.74	....	100.18
97	65.66	16.66	6.56	3.10	3.76	Tr.	0.71	....	....	3.40	....	99.85
98	57.68	15.74	8.14	5.77	3.75	1.32	1.41	....	....	6.17	....	99.98
99	58.48	17.92	6.76	5.26	2.95	1.10	1.98	....	....	4.26	....	98.71
100	59.48	18.24	6.92	2.95	3.62	1.95	2.21	....	....	5.26	....	100.63
101	58.76	19.42	8.82	6.48	1.34	1.01	0.66	....	....	3.10	....	99.59
102	62.62	19.14	3.26	5.15	2.79	3.07		....	0.48	3.46	....	99 97
103	63.0	18.2	4.04	....	....	....	....	....	....	....	....	....
104	59.4	17.7	5.63	....	....	....	....	....	....	....	....	....
105	47.1	19.3	4.99	....	....	....	....	....	....	....	....	....
106	60.01	12.37	8.99	2.13	4.20	....	....	....	....	11.68	....	....
107	74.23	19.03	1.07	Tr.	0.54	0.47		....	0.20	4.52	....	100.06
108	59.32	20.04	5.76	1.54	2.33	5.05		0.06	1.64	4.76	....	99.50
109	63.5	20.1	4.64	....	....	....	....	....	....	....	....	....
110	66.8	18.3	3.48	....	....	....	....	....	....	....	....	....
111	66.5	17.9	4.50	....	....	....	....	....	....	....	....	....
112	66.0	18.8	4.36	....	....	....	....	....	....	....	....	....
113	53.8	15.8	4.64	....	....	....	....	....	....	....	....	....
114	53.6	16.3	4.91	....	....	....	....	....	....	....	....	....
115	61.58	20.29	5.95	1.34	2.30	2.01		....	1.94	4.14	....	99.55
116	63.28	18.64	7.52	1.97	3.16	1.70	1.07	....	....	2.26	....	99.60
117	62.96	18.82	7.35	2.00	3.62	....	....	....	....	3.00	....	97.75
118	57.53	28.37		1.88	4.50	....	....	....	....	....	....	....
119	68.33	22.71		1.88	2.55	....	....	....	....	....	....	....
120	66.32	24.48		1.96	2.68	....	....	....	....	....	....	....
121	71.74	20.56		1.97	2.23	....	....	....	....	....	....	....
122	68.94	21.64		1.36	2.24	....	....	....	....	....	....	....
123	76.00	17.02		1.46	1.66	....	....	....	....	....	....	....
124	76.52	16.38		1.36	1.77	....	....	....	....	....	....	....
125	70.90	20.04		1.30	1.99	....	....	....	....	....	....	....
126	77.95	15.53		1.61	1.26	....	....	....	....	....	....	....
127	71.58	17.93		1.46	1.67	....	....	....	....	....	....	....
128	54.10	32.38		7.03	0.86	....	....	....	....	....	....	....
129	60.80	26.20		9.74	3.15	....	....	....	....	....	....	....
130	65.60	27.12		6.16	....	....	....	....	....	....	....	....
131	63.00	24.40		2.85	Tr.	....	....	....	....	....	....	....
132	61.10	24.60		1.99	....	....	....	....	....	....	....	....
133	62.30	29.25		1.79	0.00	....	....	....	....	....	....	....
134	60.80	26.50		1.37	Tr.	....	....	....	....	....	....	....
135	63.50	20.80		5.66	0.00	....	....	....	....	....	....	....
136	59.10	24.50		2.53	....	....	....	....	....	....	....	....
137	54.68	22.15	9.09	2.03	2.52	1.75	1.42	....	....	4.78	....	98 42
138	64.7	17.6	4.40	....	....	....	....	....	....	....	....	....
139	14.76	2.80		42.63	2.26	....	....	....	....	35.84	....	98.29
140	54.88	20.08	7.57	3.98	3.08	....	....	....	....	8.61	....	98.20
141	44.16	19.06	6.09	13.06	2.15	....	....	....	....	14.36	....	99.45
142	48.22	17.46	4.38	12.10	2.24	....	....	....	....	11.29	....	95.69
143	41.61	22.84		15.07	2.83	....	....	....	....	....	....	....
144	23.54	15.20		30.22	2.38	....	....	....	....	....	....	....
145	10.54	6.42		43.01	2.99	....	....	....	....	....	....	....
146	48.26	21.84		12.10	2.24	....	....	....	....	....	....	....
147	57.02	20.62		7.01	3.67	....	....	....	....	....	....	....
148	63.40	16.10	4.10	5.34	2.75	....	....	....	....	5.00	....	96.69
149	63.20	20.20	5.34	2.75	....	....	....	....	....	....	....	....
150	72.04	13.72		*c*4.07	*d*4.13	....	....	....	....	....	....	....
151	70.84	14.40		*c*5.00	*d*4.13	....	....	....	....	....	....	....
152	69.40	14.20		*c*6.26	*d*4.34	....	....	....	....	....	....	....
153	66.04	14.12		*c*6.57	*d*6.95	....	....	....	....	....	....	....
154	65.64	11.20		*c*9.70	*d*9.44	....	....	....	....	....	....	....
155	74.12	12.16		*c*5.00	*d*6.06	....	....	....	....	....	....	....
156	65.96	12.64		*c*9.92	*d*8.75	....	....	....	....	....	....	....
157	67.08	10.84		*c*9.55	*d*8.60	....	....	....	....	....	....	....
158	65.72	8.84		*c*12.99	*d*10.15	....	....	....	....	....	....	....
159	66.48	12.08		*c*11.42	*d*8.40	....	....	....	....	....	....	....
160	70.68	12.80		*c*6.10	*d*7.12	....	....	....	....	....	....	....
161	71.12	13.36		*c*5.32	*d*5.30	....	....	....	....	....	....	....

c—Calcium carbonate ($CaCO_3$)
d—Magnesium carbonate ($MgCO_3$)

CHEMICAL

LOCATION	MATERIAL	REMARKS	Reference or Analyst *a*	Sample number *b*	Analysis number
PEND OREILLE COUNTY—Cont.					
Metaline Falls (Sand Creek)	Shale, "Diamond"	Inland P. C. Co. pit	E	......	162
Metaline Falls (Sand Creek)	Shale, "Diamond"	Inland P. C. Co. pit	E	......	163
Metaline Falls (Sand Creek)	Shale, "Diamond"	Inland P. C. Co. pit	E	......	164
Metaline Falls (Sand Creek)	Shale, "Diamond"	Inland P. C. Co. pit	E	......	164-A
PIERCE COUNTY					
La Grande, 1 mi. N. of	Clay, terra cotta	Old D-R pit	D	*184-A	165
La Grande, 1 mi. N. of	Clay, residual gray	Old D-R pit	G	184-A	166
La Grande, 1 mi. N. of	Clay, residual mottled	Old D-R pit	G	185-A	167
Clay City	Clay, residual gray	Far West B. & T. Co. pit	G	186-A	168
Clay City	Clay, residual greenish	Far W. B. & T. Co. pit	G	187-A	169
Carbonado	Shale, nearly black	Carbon River bank	G	180	169-A
SAN JUAN COUNTY					
Roche Harbor	Clay, glacial	Bluff outcrop	C	......	170
Roche Harbor	Clay, glacial	Bluff outcrop	C	......	171
Orcas Island, NW. shore	Clay, glacial	Bluff outcrop	C	......	172
Orcas Island, NW. shore	Clay, glacial	Bluff outcrop	C	......	173
Orcas Island, NW. shore	Shale	Bluff outcrop	C	......	174
Orcas Island, NW. shore	Shale	Bluff outcrop	C	......	175
East Sound, sec. 21, (37-1 W)	Clay, glacial gray	Old brick-yard pit	E	......	176
Lopez, 3½ mi. N. of	Clay, glacial gray	Bluff outcrop	D	......	177
SKAGIT COUNTY					
Concrete	Clay, glacial blue-gray	Old Wash.P.C.Co. pit	C	*192	178
Concrete	Clay, glacial blue-gray	Old Wash.P.C.Co. pit	C	*192	179
Concrete	Clay, glacial blue-gray	Old Wash.P.C.Co. pit	D	*192	180
Concrete	Clay, glacial blue-gray	Old Wash.P.C.Co. pit	E	*192	181
Concrete	Clay, glacial blue-gray	Old Wash.P.C.Co. pit	E	*192	182
Concrete	Clay, glacial blue-gray	Old Wash.P.C.Co. pit	E	*192	183
Concrete	Clay, glacial blue-gray	Old Wash.P.C.Co. pit	E	*192	184
Concrete	Clay, glacial blue-gray	Old Wash.P.C.Co. pit	E	*192	185
Concrete	Clay, glacial blue-gray	Old Wash.P.C.Co. pit	G	192	186
Jackman Creek, 2 mi. up	Clay, glacial blue-gray	Undeveloped	D	*192-A	187
Jackman Creek, 2 mi. up	Clay, glacial blue-gray	Undeveloped	E	*192-A	188
Sauk, 1 mi. N. of	Clay, glacial blue-gray	Prospect pits	D	*192	189
Van Horn, 3 mi. E. of	Argillite, gray	Road cut	G	191	190
S ½ sec. 30, (35-6 E)	Clay, talcose gray	Undeveloped	G	193	191
S ½ sec. 30, (35-6 E)	Clay, talcose gray	Undeveloped	G	194	192
Prairie, ¼ mi. S. of	Clay, graphitic, black	Undeveloped	G	195	193
Prairie	Clay	Undeveloped	D	......	194
Hoogdal	Clay, glacial blue	Railway cut	G	197	195
Hoogdal	Clay, glacial yellow	Railway cut	G	196	196
Alger, in flat	Clay, blue-gray	Former brick yard	D	*190	197
McMurray	Shale, brown	Road cut	G	189	198
Tiloh	Clay, blue alluvial	Knapp B.&T. Co. pit	G	190	199
Cumberland (Conner mines)	Clay, fire	Coal prospect	A	......	200
SNOHOMISH COUNTY					
Granite Falls	Clay, glacial	Undeveloped	C	*388	201
Index, 2 mi. E. of	Clay, glacial	Railway cut	E	*388	202
SPOKANE COUNTY					
Spokane, 13th and Perry Sts	Clay (Latah)	40-foot bank	J	......	203
Mica, ½ mi. N. of	Clay (Spokane-Clayton)	Well	J	......	204
Schuele's ranch, S. of Five Mile Prairie.	Clay (Latah)	Bed 20 ft. thick or more	J	......	205
Spokane, W. of Latah Creek	Clay (Latah shale)	S.P.& S. Ry. cut	J	......	206
Mica	Clay, gray coarse	Gladding, McBean pit	D	*94	207
Mica	Clay, gray fine	Gladding, McBean pit	D	*94-B	208
Mica	Clay, gray fine	Gladding, McBean pit	D	*94-B	209
Mica	Clay, light-gray	Gladding, McBean pit	G	94-B	210
Mica, north pit	Clay, gray fire	Gladding, McBean pit	G	94	211
Mica, north pit	Clay, gray fire (washed)	Gladding, McBean pit	H	......	212
Mica, south pit	Kaolin, white	Gladding, McBean pit	G	94-A	213
Mica, W. side of valley	Clay, coarse gray	W.B.L.&S.P.Co. pit	G	94-C	214
Mica, W. side of valley	Clay, blue plastic	W.B.L.&S.P.Co. pit	K	......	215
Manito Station	Clay, brown	Undeveloped	G	......	216
Manito Station	Clay, dark-gray fine	Undeveloped	G	......	217
Manito Station	Clay, dark-gray fine	Undeveloped	G	......	218
Freeman, north pit	Kaolin, sandy residual	W.B.L.& S.P.Co. pit	D	*78	219

ANALYSES—Continued

Analysis number	Silica (SiO_2)	Alumina (Al_2O_3)	Ferric oxide (Fe_2O_3)	Lime (CaO)	Magnesia (MgO)	Potash (K_2O)	Soda (Na_2O)	Titanium (TiO_2)	Moisture (H_2O)	Combined water. Ignition	Miscellaneous	Total
162	71.40	14.04		*c*5.48	*d*6.81	...	...	...	...	...	...	...
163	68.40	12.04		*c*9.55	*d*6.39	...	...	...	...	...	...	...
164	74.40	13.00		*c*2.81	*d*4.78	...	...	...	...	...	...	...
164-A	64.60	14.88		*c*5.27	*d*7.64	...	...	...	...	...	...	...
165	67.24	19.23	2.50	0.34	0.49	0.88	...	0.25	2.12	6.66	...	99.79
166	67.4	24.6	1.44	...	...	...	...	...	...	...	...	...
167	65.4	24.4	1.86	...	...	...	...	...	...	...	...	...
168	61.5	28.4	1.29	...	...	...	...	...	...	...	...	...
169	62.5	23.9	6.54	...	...	...	...	...	...	...	...	...
169-A	58.7	25.3	4.25	...	...	...	...	...	...	...	...	...
170	55.81	26.28		*c*4.34	*d*3.39	3.98		...	...	6.11	S Tr.	...
171	56.35	24.62		*c*3.66	*d*2.58	3.94		...	...	7.52	S 0.31	...
172	57.3	21.4		*c*5.1	*d*3.1	2.1		...	...	...	S 0.5	...
173	53.2	23.9		*c*6.3	*d*4.1	2.9		...	...	...	S 0.8	...
174	62.8	19.2		*c*10.2	*d*0.9	...	...	...	...	...	...	...
175	39.80	21.62		*c*29.10	*d*2.91	2.15		...	...	...	S 0.41	...
176	59.92	21.08	4.56	3.88	2.90	1.16	0.97	...	...	4.74	...	99.21
177	59.40	19.58	6.44	4.26	4.13	0.75	0.41	...	...	4.38	...	99.35
178	58.75	25.94		*c*4.66	*d*4.47	1.48		...	...	4.60	...	...
179	55.90	25.50		*c*4.90	*d*2.83	3.91		...	...	6.45	S 0.51	...
180	57.06	16.16	8.30	5.96	3.20	2.22		...	...	6.22	...	99.12
181	57.24	24.76		5.44	4.86	...	...	...	...	...	...	...
182	57.42	24.68		5.66	4.58	...	...	...	...	...	...	...
183	56.78	25.56		5.12	4.30	...	...	...	...	...	...	...
184	57.36	25.06		5.36	4.56	...	...	...	...	...	...	...
185	56.64	25.80		5.26	4.26	...	...	...	...	...	...	...
186	55.2	21.3	6.75	...	...	...	...	...	...	...	...	...
187	54.18	18.05	9.91	4.17	4.51	1.17	1.04	...	...	6.98	...	100.01
188	60.21	16.21	5.10	2.90	4.15	2.10	1.51	...	...	7.10	...	99.26
189	56.18	17.37	8.89	4.60	4.14	1.43	1.76	...	...	5.03	...	99.40
190	54.1	20.9	8.65	...	...	...	...	...	...	...	...	...
191	43.2	20.0	8.96	...	...	...	...	...	...	...	...	...
192	43.4	15.2	8.65	...	...	...	...	...	...	...	...	...
193	49.0	25.2	9.38	...	...	...	...	...	...	...	...	...
194	56.04	22.56	8.70	0.45	3.87	3.18		0.11	0.30	4.96	...	100.17
195	52.6	22.3	8.65	...	...	...	...	...	...	...	...	...
196	55.3	20.0	7.80	...	...	...	...	...	...	...	...	...
197	49.65	19.94	9.27	2.58	6.32	3.28		...	2.15	5.85	...	99.04
198	50.01	24.8	9.88	...	...	...	...	...	...	...	...	...
199	56.4	20.9	7.60	...	...	...	...	...	...	...	...	...
200	49.73	32.57	1.99	0.95	1.28	0.00	1.10	...	12.38	...	...	100.00
201	61.6	25.4		*c*7.2	*d*2.3	2.9		...	...	...	S 1.6	...
202	53.56	25.26	8.86	2.66	2.05	0.43	0.27	...	...	6.02	...	99.11
203	64.00	20.00	...	...	...	...	...	...	...	...	...	...
204	57.00	15.00	...	...	...	...	...	...	...	...	...	...
205	70.00	19.00	...	...	...	...	...	...	...	...	...	...
206	56.00	23.00	...	...	...	...	...	...	...	...	...	...
207	75.04	19.18	0.76	...	...	0.45		0.15	0.36	4.54	...	100.48
208	54.80	31.10	1.68	...	Tr.	0.21		0.23	2.70	9.40	...	100.12
209	72.68	13.15	2.01	0.59	1.21	0.34	1.51	...	8.49		...	99.98
210	56.4	30.8	1.5	...	...	...	...	...	...	...	...	...
211	56.0	30.5	2.1	...	...	...	...	...	...	...	...	...
212	47.3	37.8	0.9	0.1	0.1	...	0.3	0.9	0.0	12.6	...	100.00
213	46.0	38.2	1.8	...	...	...	...	...	...	...	...	...
214	60.4	28.1	1.5	...	...	...	...	...	...	...	...	...
215	45.2	38.5	3.1	Tr.	0.4	...	...	...	...	12.7	...	99.9
216	37.0	40.4	13.9	...	...	...	...	...	...	...	...	...
217	38.0	36.5	15.5	...	...	...	...	...	...	...	...	...
218	37.2	41.2	14.0	...	...	...	...	...	...	...	...	...
219	61.72	18.53	2.01	3.82	1.47	2.19	2.01	...	8.31		...	100.06

c—Calcium carbonate ($CaCO_3$)
d—Magnesium carbonate ($MgCO_3$)

CHEMICAL

LOCATION	MATERIAL	REMARKS	Reference or Analyst *a*	Sample number *b*	Analysis number
SPOKANE COUNTY—Cont.					
Freeman, north pit	Kaolin, sandy residual	W.B.L.& S.P.Co. pit	D	*78	220
Freeman, north pit	Kaolin, sandy residual	W.B.L.& S.P.Co. pit	F	*78	221
Freeman, north pit	Kaolin, very sandy residual	W.B.L.& S.P.Co. pit	K	*80	222
Freeman, north pit	Kaolin, washed	W.B.L.& S.P.Co. pit	F		223
Freeman, south pit	Clay, brown Palouse	W.B.L.& S.P.Co. pit	D	*79-A	224
Freeman, south pit	Clay, brown Palouse	W.B.L.& S.P.Co. pit	D	*79-A	225
Latah	Clay	Undeveloped	D		226
Cheney	Clay, Palouse	Undeveloped	D	*79-A	227
Moran Prairie	Clay, gray-white	Formerly mined	G		228
Chester, 2 ½ mi. E. of	Clay, light-yellow	Sommer's pit	D		229
Chester, 2 ½ mi. E. of	Clay, white	Sommer's pit	D		230
Chester, 2 ½ mi. E. of	Clay, brick	Sommer's pit	D		231
Chester, 2 ½ mi. E. of	Clay, light-gray	Sommer's pit	D	*100	232
Chester, 2 ½ mi. E. of	Clay, light-gray	Sommer's pit	G	100	233
Chester, 2 ½ mi. E. of	Clay, light-gray	Sommer's pit	O		234
SW ¼ sec. 30, (25-45 E)	Clay, gray	Barkuloo prospect	L	*104	235
Spokane, W. of Latah Creek	Shale, softened	Old Dishman pit	D	*125-A	236
Mead	Clay, soft gray	Old Davie's pit	D		237
Spokane, 6 mi. N. of	Clay, light-cream	Undeveloped	D		238
Trent (Smead place)	Clay, nearly white	Undeveloped	D		239
Deer Park	Clay, gray	Undeveloped	D	*135	240
S. center sec. 11, (26-44 E)	Clay, gray residual	Well	G	117	241
SW ¼ sec. 23, (26-44 E)	Clay, gray residual	Well	G	117-A	242
Center sec. 21, (27-44 E)	Sand, clayey residual	Well	G	127	243
SW ¼ sec. 27, (27-44 E)	Clay, gray fine	Fuher prospect	G	118-A	244
SW ¼ sec. 27, (27-44 E)	Clay, gray fine	Fuher prospect	M	*118-A	245
NE ¼ sec. 4, (29-42 E)	Clay, white	Conner pit	G	135	246
NE ¼ sec. 4, (29-42 E)	Clay, light-gray	Conner pit (N. side)	G	*135	247
NE ¼ sec. 4, (29-42 E)	Clay, white	Conner pit (N. side)	G	*135	248
NE ¼ sec. 4, (29-42 E)	Clay, white	Conner pit (S. side)	G	*135	249
NE ¼ sec. 4, (29-42 E)	Clay, white sandy	Conner pit	G	*135	250
STEVENS COUNTY					
Clayton	Clay, light-yellow	W.B.L.& S.P.Co. pit	D		251
Clayton	Clay, dark-yellow	W.B.L.& S.P.Co. pit	D		252
Clayton	Clay, brick	W.B.L.& S.P.Co. pit	D		252-A
Clayton	Clay, light-gray	W.B.L.& S.P.Co. pit	D		253
Clayton	Clay, white sandy	W.B.L.& S.P.Co. pit	D		254
Clayton	Clay, white fine	W.B.L.& S.P.Co. pit	D		255
Clayton	Clay, "Clayton plastic"	W.B.L.& S.P.Co. pit	F		256
Clayton	Clay, gray-white	W.B.L.& S.P.Co. pit (E. side)	G	*136	257
Clayton	Clay, gray-white	W.B.L.& S.P.Co. pit (E. side)	G	*136	258
Clayton	Clay, dark-gray	W.B.L.& S.P.Co. pit (SE. corner)	G	*136	259
Clayton, 2 mi. N. of	Clay, gray-white	Undeveloped	G	*135	260
N. center sec. 32, (30-42 E)	Clay, gray-white	A. B. pit	G	132	261
N. center sec. 32, (30-42 E)	Clay, nearly white	A. B. pit	G	*132	262
N. center sec. 32, (30-42 E)	Clay, nearly white	A. B. pit	G	*132	263
N. center sec. 32, (30-42 E)	Clay, light-gray	A. B. pit	G	*132	264
N. center sec. 32, (30-42 E)	Clay, nearly white	A. B. pit	D	*132	265
N. center sec. 32, (30-42 E)	Clay, nearly white	A. B. pit	D	*132	266
N. center sec. 32, (30-42 E)	Clay, nearly white	A. B. pit	D	*132	267
N. center sec. 32, (30-42 E)	Clay, nearly white	A. B. pit	K	*132	268
A. B. pit, 2 mi. W. of	Clay, light-gray	Well	G		269
SW ¼ sec. 34, (30-42 E)	Clay, gray-white	Neafus tunnel	G	135-A	270
SW ¼ sec. 34, (30-42 E)	Clay, gray-white	Neafus N. pit	G	135-B	271
SW ¼ sec. 34, (30-42 E)	Clay, light-brown	Neafus pit	G	*135-B	272
SW ¼ sec. 34, (30-42 E)	Clay, white	Deer P. Nat. P. Co.	N	*135-B	273
SW ¼ sec. 34, (30-42 E)	Clay, "yellow ocher"	Deer P. Nat. P. Co.	N		274
SW ¼ sec. 34, (30-42 E)	Clay, "red sienna"	Deer P. Nat. P. Co.	N		275
NW ¼ sec. 20, (31-41 E)	Clay, nearly white	Iron prospect	D,E		276
NW ¼ sec. 30, (31-41 E)	Clay, fine gray	Kulzer tunnel	G	138	277
Valley, 4 mi. NE. of	Shale, white to purple	Undeveloped	E		278
Chewelah	Clay, gray soft	Old Chew. B. Co. pit	G	138-A	279
Colville, 1 mi. NE. of	Clay, gray soft	Formerly used	G	*138-A	280
Colville, just E. of	Clay, sandy	Formerly used	G	*138-A	281
Colville (near ball park)	Clay, sandy	Formerly used	G	*138-A	282
Colville, 3 mi. S. of	Shale, gray	Railway cut	G		283
Colville, 7 mi. NE. of	Shale, black hard	On Clugston Creek	E		284
Colville, 3 mi. S. of	Shale, light-gray	Road cut	E		285

ANALYSES—Continued

Analysis number	Silica (SiO_2)	Alumina (Al_2O_3)	Ferric oxide (Fe_2O_3)	Lime (CaO)	Magnesia (MgO)	Potash (K_2O)	Soda (Na_2O)	Titanium (TiO_2)	Moisture (H_2O)	Combined water. Ignition	Miscellaneous	Total
220	73.58	17.29	1.73	Tr.	0.32	0.40		0.04	0.86	5.44	…	99.66
221	77.00	13.80	1.70	0.93	0.54	0.28	1.42	0.50	…	4.40	…	100.57
222	89.5	7.0	Tr.	Tr.	0.3	…	…	…	…	2.8	…	99.6
223	47.50	36.05	1.60	0.92	0.55	0.04	1.78	0.25	…	12.30	…	100.99
224	59.92	16.65	8.25	2.22	3.71	2.14	2.02	…	5.19		…	100.10
225	65.96	18.28	4.80	1.51	0.72	3.52		0.11	1.70	3.44	…	100.04
226	73.83	15.54	2.00	0.64	0.44	1.74	0.76	0.30	0.90	4.48	…	100.63
227	64.98	15.57	5.34	1.64	0.94	1.40	1.60	1.15	2.75	4.33	…	99.70
228	52.8	28.5	4.8	…	…	…	…	…	…	…	…	…
229	59.04	25.74	5.08	0.22	0.06	0.12	Tr.	0.52	0.39	8.81	…	99.98
230	76.96	16.39	0.31	0.40	0.08	0.20	Tr.	0.44	0.29	5.48	…	100.55
231	52.32	30.68	1.70	0.80	0.46	1.50	Tr.	0.52	1.76	10.08	…	99.82
232	58.13	19.01	6.84	2.06	3.17	2.03	1.51	…	7.14		…	99.89
233	51.66	35.86	1.66	…	…	…	…	…	…	…	…	…
234	60.55	26.37	2.43	1.20	…	…	…	…	…	8.60	…	…
235	60.08	28.83	3.79	0.76	1.03	…	…	…	…	5.46	…	…
236	59.59	18.93	4.69	0.83	1.14	3.10	0.34	0.65	2.20	8.94	…	100.48
237	60.53	16.15	6.28	2.60	1.93	3.23	1.08	0.57	1.36	5.76	…	99.49
238	67.16	19.26	3.26	0.47	1.13	1.63		…	1.76	5.32	…	99.99
239	71.28	17.46	1.80	0.40	0.05	2.74	0.28	0.70	5.50		…	100.21
240	51.22	33.52	1.72	…	Tr.	0.62		…	1.38	11.16	…	99.62
241	54.88	32.41	2.78	…	…	…	…	…	…	…	…	…
242	58.52	29.13	2.60	…	…	…	…	…	…	…	…	…
243	70.48	20.79	1.13	…	…	…	…	…	…	…	…	…
244	54.44	32.22	2.28	…	…	…	…	…	…	…	…	…
245	69.75	20.91	1.34	0.43	0.76	0.21		…	…	6.60	…	…
246	71.7	20.7	1.6	…	…	…	…	…	…	…	…	…
247	65.0	24.9	1.74	…	…	…	…	…	…	…	…	…
248	59.2	28.6	1.74	…	…	…	…	…	…	…	…	…
249	57.4	29.4	1.44	…	…	…	…	…	…	…	…	…
250	71.4	21.5	0.87	…	…	…	…	…	…	…	…	…
251	62.56	23.96	4.70	…	Tr.	1.12		…	0.92	6.84	…	100.10
252	65.80	18.78	5.42	…	2.46	3.39		…	1.38	3.14	…	100.37
252-A	65.90	16.26	3.95	1.36	1.98	3.04	1.92	0.85	1.08	3.28	MnO 0.10	99.62
253	49.67	32.38	1.50	0.25	0.58	1.35		0.51	2.30	10.92	…	99.46
254	53.64	31.96	1.82	…	Tr.	1.17		…	1.66	10.06	…	100.31
255	51.36	33.09	2.39	…	0.78	0.08		…	2.12	10.54	…	100.36
256	53.20	30.72	2.40	0.83	0.52	3.00		…	…	9.00	…	99.67
257	…	30.1	2.5	…	…	…	…	…	…	…	…	…
258	51.4	33.9	2.3	…	…	…	…	…	…	…	…	…
259	…	33.2	2.8	…	…	…	…	…	…	…	…	…
260	…	28.3	1.3	…	…	…	…	…	…	…	…	…
261	67.8	22.7	1.4	…	…	…	…	…	…	…	…	…
262	…	27.1	1.4	…	…	…	…	…	…	…	…	…
263	…	21.7	1.7	…	…	…	…	…	…	…	…	…
264	59.9	29.5	1.16	…	…	…	…	…	…	…	…	…
265	65.66	21.98	1.92	…	0.90	0.80		…	1.68	6.66	…	99.60
266	58.06	29.04	1.82	…	1.02	1.75		…	1.18	7.56	…	100.43
267	61.64	24.20	2.10	0.30	0.78	2.38	0.16	0.50	0.52	7.56	…	100.14
268	69.2	18.7	1.5	0.5	0.9	…	…	…	…	7.4	…	…
269	68.3	17.8	3.34	…	…	…	…	…	…	…	…	…
270	59.2	25.3	2.5	…	…	…	…	…	…	…	…	…
271	60.4	24.6	2.8	…	…	…	…	…	…	…	…	…
272	51.3	24.2	11.62	…	…	…	…	…	…	…	…	…
273	61.18	24.96	8.04	2.06	0.10	…	…	…	…	…	…	…
274	35.30	28.09	20.11	2.06	0.76	…	…	…	…	…	…	…
275	27.02	20.29	48.51	2.55	1.08	…	…	…	…	…	…	…
276	69.12	23.40	0.96	Tr.	0.92	0.17	0.15	…	…	4.92	…	99.64
277	57.2	25.4	1.76	…	…	…	…	…	…	…	…	…
278	28.36	2.29	5.39	18.56	6.01	…	…	…	…	32.41	…	98.41
279	52.2	21.1	6.06	…	…	…	…	…	…	…	…	…
280	52.7	18.9	4.76	…	…	…	…	…	…	…	…	…
281	52.4	20.5	7.80	…	…	…	…	…	…	…	…	…
282	54.2	18.9	5.78	…	…	…	…	…	…	…	…	…
283	42.4	10.9	3.17	…	…	…	…	…	…	…	…	…
284	72.64	12.70	3.00	1.64	1.97	1.30	1.43	…	…	3.54	…	99.78
285	41.28	10.31	2.33	21.93	3.12	…	…	…	…	19.42	…	98.39

CHEMICAL

LOCATION	MATERIAL	REMARKS	Reference or Analyst *a*	Sample number *b*	Analysis number
STEVENS COUNTY—Cont.					
Kettle Falls	Clay, gray silty	Old brick-yard pit	D	*140	286
Kettle Falls (foot of Rickey Hill)	Clay	Undeveloped	I	......	287
Kettle Falls, ½ mi. S. of	Clay, gray silty	Formerly mined	G	140	288
Kettle Falls, 5 mi. S. of	Shale, brown	Road cut	E	......	289
Kettle Falls, 6 mi. S. of	Shale, brown	Road cut	E	......	290
Marcus, across river from	Clay, dark-gray	Railway cut	E	*140	291
Marcus, 3 mi. N. of	Clay, silty gray	Road cut	G	*140	292
Evans, ½ mi. N. of	Clay, light-gray	Road cut	E	*140	293
Evans, ½ m . N. of	Clay, light-gray	Road cut	E	*140	294
Bossburg (in town)	Clay, light-gray	Road cut	E	*140	295
Bossburg (near)	Clay, light-gray	Rasmussen place	E	*140	296
Bossburg (near)	Clay, light-gray (slip)	Formerly mined	D	*140	297
Bossburg (near)	Clay, light-gray (slip)	As used at Clayton	D	*140	298
Bossburg, 4 mi. N. of	Clay, dark-gray	Railway cut	G	*140	299
Bossburg	Clay, dark-gray	Fitzgerald pit	G	*140	300
Bossburg	Clay, light-gray	Fitzgerald pit	G	*140	301
Bossburg, 1 mi. E. of	Shale, blue-gray	Undeveloped	E	......	302
Bossburg, 4 mi. E. of	Shale, blue soft	Undeveloped	E	......	303
Northport, across river from	Clay, yellowish-gray	Railway cut	E	*140	304
Northport, 2½ mi. S. of	Clay, yellowish-gray	Old brick-yard pit	E	*140	305
Northport, 2½ mi. NE. of	Clay, gray compact	Railway cut	E	*140	306
Northport, 1 mi. SE. of	Shale, blue-gray	Railway cut	E	......	307
Addy, 8 mi. NE. of	Shale, brown soft	Railway cut	E	......	308
Addy, 7 mi. NE. of	Shale, light-gray	Railway cut	E	......	309
THURSTON COUNTY					
Olympia (near)	Clay, glacial	Undeveloped	D	......	310
WHATCOM COUNTY					
Sumas, 3 mi. SE. of	Shale	Old clay mine, D-R.Co.	D	......	311
Sumas, 3 mi. SE. of	Shale	Old clay mine, D-R.Co.	D	......	312
Sumas, 3 mi. SE. of	Shale	Old clay mine, D-R.Co.	D	......	313
Sumas, 3 mi. SE. of	Shale, blue ("Tiger")	Old clay mine, D-R.Co.	G	204	314
Sumas, 3 mi. SE. of	Shale, blue ("No. 6")	Old clay mine, D-R.Co.	G	......	315
Sumas, 3 mi. SE. of	Shale, bluish ("No. 5")	Old clay mine, D-R.Co.	G	207	316
Sumas, 3 mi. SE. of	Shale, bluish (top half)	Old clay mine, D-R.Co.	F	*207	317
Sumas, 3 mi. SE. of	Shale, brown sandy	Old clay mine, D-R.Co.	G	......	318
Sumas, 3 mi. SE. of	Shale, gray ("No. 18")	Old clay mine, D-R.Co.	G	......	319
Sumas, 3 mi. SE. of	Shale, gray ("No. 20")	Old clay mine, D-R.Co.	G	......	320
Sumas, SE. of (on Smith pl.)	Shale, yellow-gray	Brown prospect	G	199	321
Sumas, SE. of (on Smith pl.)	Shale, yellowish	Brown prospect	G	200	322
Kendall, 5 mi. NW. of	Clay, glacial	Railway cut	E	......	323
Sec. 34, (40-5 E)	Clay, glacial	Undeveloped	E	......	324
Kendall district	Clay, glacial	Railway cut	C	......	325
Kendall district	Clay, glacial	Railway cut	C	......	326
Kendall district	Argillite	Undeveloped	C	......	327
Kendall district	Argillite	Undeveloped	C	......	328
Bellingham Bay	Clay, pottery	......	A	......	329
Brennan	Clay, glacial	Olympic P.C.Co. pit	E	......	330
WHITMAN COUNTY					
Palouse, 1 mi. S. of	Clay, white	Cox pit	D	*35	331
Palouse, 1 mi. S. of	Clay, white	Cox pit	D	*35	332
Palouse	Clay, light-colored	......	D	*35	333
Colfax	Clay, Palouse	Undeveloped	G	......	334
Colfax	Clay, Palouse	Undeveloped	G	......	335
Colfax, 4 mi. N. of	Clay, Palouse	Undeveloped	G	*23	336
Colfax, 6 mi. N. of	Clay, Palouse	Undeveloped	G	*23	337
YAKIMA COUNTY					
Yakima	Clay	Undeveloped	D	......	338

ANALYSES—Concluded

Analysis number	Silica (SiO_2)	Alumina (Al_2O_3)	Ferric oxide (Fe_2O_3)	Lime (CaO)	Magnesia (MgO)	Potash (K_2O)	Soda (Na_2O)	Titanium (TiO_2)	Moisture (H_2O)	Combined water. Ignition	Miscellaneous	Total
286	56.98	17.74	7.22	5.25	4.08	1.31	0.86			6.07		99.51
287	62.74	16.45	2.62	3.68	2.41	3.53	3.05		2.69		FeO 1.91 CO 0.65	99.73
288	57.8	20.1	5.49									
289	72.01	12.52	4.35	2.02	1.99	1.80	1.36			3.18		99.23
290	58.15	16.90	9.22	2.15	3.02	1.71	1.36			4.12		99.63
291	50.68	19.79	9.45	6.48	3.15	2.31				7.20		99.06
292	55.4	14.9	4.64									
293	56.48	20.52	7.16	4.18	3.49					5.10		98.93
294	57.68	22.60	8.26	5.95	2.08					1.69		98.26
295	60.14	20.00	5.68	4.07	2.85					4.50		97.24
296	55.90	20.69	7.55	3.63	2.32					6.40		96.49
297	51.12	21.26	9.12	3.48	4.26	3.29			1.34	5.40		99.57
298	52.94	22.12	6.72	2.99	3.91	4.62		0.06	1.56	4.98		99.90
299	56.9	20.9	6.66									
300	55.1	16.3	6.93									
301	51.0	20.4	8.08									
302	66.68	10.82	5.02	4.62	1.31					7.22		95.67
303	57.56	22.48	10.40	0.45	3.14					2.78		96.81
304	56.72	15.69	9.34	4.43	3.13	1.19	1.09			6.64		98.23
305	59.76	17.29	5.71	2.94	4.11	1.51	1.81			6.86		99.99
306	57.16	16.10	8.26	4.15	4.06	1.46	1.13			7.13		99.51
307	82.64	7.52	5.26	0.99	0.96					2.23		99.60
308	59.24	7.36	3.00	11.08	2.80					15.91		99.39
309	54.41	16.83	3.21	12.54	Tr.					12.83		99.82
310	57.36	18.79	6.68	3.89	2.42	1.06	0.10	0.50	3.56	3.58		96.91
311	48.7	32.1	4.9	0.9	0.3	Tr.			14.0			100.9
312	69.31	12.37	2.11	0.57	0.54	2.03			5.93	6.74		99.60
313	47.84	35.14		1.29	0.20				15.90			100.37
314	55.1	30.9	4.32									
315	66.4	25.2	1.74									
316	51.2	33.1	4.32									
317	46.57	32.73	4.10	1.74	0.61	0.96			2.37	11.07		100.15
318	44.1	39.8	3.48									
319	54.9	30.8	4.32									
320	47.0	40.6	1.44									
321	44.2	43.5	2.88									
322	46.6	37.5	3.80									
323	59.92	17.85	7.31	6.08	3.15					5.42		99.73
324	54.16	14.95	7.91	2.62	4.15					13.46		
325	61.27	25.30		*c*2.96	*d*4.68							
326	57.06	26.80		*c*10.62	*d*1.13	2.56						
327	66.01	17.65		*c*8.01	*d*3.15							
328	72.69	22.19		*c*2.16	*d*2.47							
329	43.30	35.21	1.07	0.08	0.14	0.52	1.30	1.11	15.90		Sand 1.20	
330	58.20	18.17	6.95	3.47	3.28					6.00		96.07
331	46.13	37.36	2.20	0.65	0.64	Tr.			1.34	12.20		100.52
332	58.77	30.28	1.60	0.34	Tr.	0.08			0.88	8.44		100.39
333	53.16	30.08	1.83	0.43	0.24	1.50	0.09	1.50	1.70	9.76		100.29
334		15.8	2.7									
335		15.8	2.7									
336		16.8	5.2									
337		17.1	5.3									
338	55.63	18.25	3.88	1.13	1.03	1.38	0.90	0.75	7.25	8.57	0.97	99.74

c—Calcium carbonate ($CaCO_3$)
d—Magnesium carbonate ($MgCO_3$)

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APPENDIX 3—TABLE 1
PRODUCTION OF CLAY PRODUCTS IN WASHINGTON, 1894-1939(1)

PRODUCT	1894	1895	1896	1897	1898	1899	1900	1901	1902	1903
Common Brick										
Quantity (thousands)	22,625	14,865	10,164	14,837	21,845	55,794	55,671	61,595	73,325	72,825
Value	$153,259	$84,305	$55,758	$86,607	$148,881	$405,678	$404,687	$477,960	$577,407	$557,147
Average price per M.	$6.77	$5.67	$5.48	$5.84	$6.82	$7.27	$7.27	$7.76	$7.87	$7.65
Vitrified Brick										
Quantity (thousands)	1,024	2,301	3,196	1,875	1,156	937	1,242	7,774	4,700	4,555
Value	$17,600	$32,965	$31,500	$20,250	$14,777	$14,260	$18,950	$139,162	$74,329	$67,314
Average price per M.	$17.19	$14.32	$9.85	$10.80	$12.78	$15.21	$15.26	$17.90	$15.81	$14.78
Face (front) Brick										
Quantity (thousands)	....	585	422	575	805	1,497	1,480	6,995	2,400	3,421
Value	$15,200	$19,100	$8,390	$10,063	$13,200	$31,790	$31,840	$147,881	$51,771	$65,755
Average price per M.	....	$32.64	$19.88	$17.50	$16.40	$21.23	$21.51	$21.14	$21.57	$19.22
Fire Brick										
Quantity (thousands)	....	....	....	....	....	....	....	....	....	....
Value	$24,400	$12,500	$8,300	$21,800	$23,250	$21,173	$22,988	$24,542	$18,662	$13,932
Average price per M.	....	....	....	....	....	....	....	....	....	....
Fireproofing; Hollow Building Block										
Quantity (short tons)	....	....	....	....	....	....	....	....	....	....
Value	$6,750	$2,500	$3,100	$3,000	(2)	(2)	(2)	(2)	(2)	(2)
Average price per ton	....	....	....	....	....	....	....	....	....	....
Drain Tile	$2,750	$3,175	$3,700	$2,500	$3,605	$5,346	(2)	$3,343	$7,649	$10,883
Sewer Pipe	$209,000	$85,700	$47,000	$46,500	$43,300	$76,694	$119,807	$118,584	$118,462	$171,133
Architectural Terra Cotta	$86,000	$24,000	$1,100	....	(2)	(2)	(2)	(2)	$35,225	(2)
Pottery	....	....	$1,180	$2,500	(2)	$13,350	$9,430	$17,500	$13,354	$16,100
Miscellaneous	$700	$1,200	$1,500	....	....	$10,484	800	....	$5,161	$651
Total Value	$515,659	$265,445	$161,528	$193,220	$250,988	$591,277	$625,459	$944,798	$905,231	$928,265
Number of Operators	59	52	52	42	27	41	48	53	66	67
Rank of State	25	31	35	34	33	29	29	24	25	25

(1)Statistics for the period 1894–1920, incl., from U. S. Geol. Survey, in cooperation with the Washington Div. of Geology; for the period 1921–1939, from the U. S. Bur. of the Census, modified, in part, by the U. S. Bur. Mines.
(2)Concealed.

APPENDIX 3—TABLE 1
PRODUCTION OF CLAY PRODUCTS IN WASHINGTON, 1894-1939—Continued

PRODUCT	1904	1905	1906	1907	1908	1909	1910	1911	1912	1913
Common Brick										
Quantity (thousands)	87,732	81,022	99,788	101,905	107,638	143,198	130,634	99,588	78,000	67,435
Value	$665,878	$566,385	$708,968	$846,971	$817,962	$1,081,579	$956,510	$695,100	$547,061	$475,874
Average price per M.	$7.59	$6.99	$7.10	$8.31	$7.60	$7.55	$7.32	$6.98	$7.01	$7.06
Vitrified Brick										
Quantity (thousands)	9,233	9,763	9,609	[3]	[3]	[3]	[3]	40,291	[3]	42,717
Value	$149,559	$143,702	$156,476	[3]	[3]	[3]	[3]	$743,352	[3]	$701,550
Average price per M.	$16.20	$14.72	$16.28	$18.22	$19.82	$18.72	$18.87	$18.45	$16.88	$16.42
Face (front) Brick										
Quantity (thousands)	3,999	3,304	4,439	4,539	4,011	7,802	5,570	5,224	6,881	6,122
Value	$81,142	$86,388	$122,770	$127,245	$112,749	$153,600	$124,952	$118,615	$146,265	$128,989
Average price per M.	$20.29	$26.15	$27.66	$28.03	$28.11	$19.94	$22.43	$22.71	$21.26	$21.07
Fire Brick										
Quantity (thousands)	711	759	1,670	1,506	1,407	2,853	672	2,250	1,170	2,191
Value	$22,445	$24,699	$46,525	$43,940	$42,045	$103,531	$25,017	$63,654	$34,293	$66,178
Average price per M.	$31.57	$32.54	$27.86	$29.18	$29.88	$36.29	$37.23	$28.29	$29.31	$30.20
Fireproofing; Hollow Building Block										
Quantity (short tons)										
Value	[2]	[3]	$14,792	[3]	$45,205	$71,067	$114,501	$153,180	$163,077	$157,069
Average price per ton										
Drain Tile	$8,812	$11,153	$13,057	$17,025	$28,551	$18,495	$34,128	$29,314	$24,676	$28,172
Sewer Pipe	$215,282	$242,245	$313,880	$482,870	$493,165	$737,847	$817,086	$738,473	$496,500	$501,102
Architectural Terra Cotta	[2]	[3]	[3]	$94,795	$171,845	$206,324	$198,358	$283,608	$365,109	$316,628
Pottery	$22,000	$41,100	$41,560	$30,695	$20,601	$16,211	[3]	[3]	[3]	[3]
Miscellaneous	$9,767	$59,360	$81,856	$278,393	$417,371	$671,832	$753,302	$15,076	$611,889	$14,664
Total Value	$1,200,919	$1,175,032	$1,499,884	$1,921,934	$2,104,289	$3,060,486	$3,023,854	$2,840,372	$2,388,870	$2,390,226
Number of Operators	26	72	61	63	67	65	65	55	50	45
Rank of State	24	25	24	17	13	12	11	11	15	15

[2] Concealed.

[3] Concealed to prevent disclosure of individual operations. Value included in "Miscellaneous".

APPENDIX 3—TABLE 1
PRODUCTION OF CLAY PRODUCTS IN WASHINGTON, 1894-1939—Continued

PRODUCT	1914	1915	1916	1917	1918	1919	1920	1921	1922	1923
Common Brick										
Quantity (thousands)	51,657	43,279	45,163	43,487	31,164	44,436	46,163	34,881	40,474	44,505
Value	$351,565	$285,423	$309,130	$367,906	$353,857	$627,015	$752,241	$474,808	$544,748	$602,693
Average price per M.	$6.81	$6.59	$6.84	$8.46	$11.35	$14.11	$16.30	$13.61	$13.46	....
Vitrified Brick										
Quantity (thousands)	(3)	14,861	20,218	(3)	(3)	(3)	(3)	(3)	....	....
Value	(3)	$265,691	$322,182	(3)	(3)	(3)	(3)	(3)	(3)	....
Average price per M.	$18.99	$17.88	$15.94	$20.40	$27.29	$34.23	$42.03	$53.31	....	....
Face (front) Brick										
Quantity (thousands)	5,319	4,246	4,425	3,565	2,476	3,528	3,895	3,375	6,795	11,755
Value	$109,197	$67,740	$70,509	$60,404	$60,884	$91,947	$151,059	$113,251	$162,046	$256,236
Average price per M.	$20.53	$15.95	$15.93	$16.94	$24.59	$26.06	$38.78	$33.56	$23.85	....
Fire Brick										
Quantity (thousands)	1,054	1,569	4,009	5,146	4,042	3,889	4,863	1,256	3,519	2,993
Value	$69,869	$45,414	$94,992	$143,696	$151,914	$153,170	$265,206	$53,254	$113,188	$107,432
Average price per M.	$28.34	$28.94	$23.69	$27.92	$37.58	$39.39	$54.54	$42.40	$32.16	....
Fireproofing; Hollow Building Block										
Quantity (short tons)	....	....	....	27,352	15,678	15,114	42,868	16,976	26,121	26,909
Value	$127,371	$192,263	$125,003	$183,812	$112,143	$136,609	$471,423	$139,228	$232,383	$251,013
Average price per ton	....	....	....	$6.72	$7.15	$9.04	$11.00	$8.20	....	....
Drain Tile	$48,750	$33,558	$37,138	$30,755	$60,132	$57,509	$58,585	$36,292	$27,613	$74,128
Sewer Pipe	$462,898	$318,397	$347,388	$340,621	$309,243	$430,198	$522,976	$285,992	$333,751	$256,660
Architectural Terra Cotta	$220,788	$234,377	$275,693	$190,468	$94,361	$118,274	$461,770	(3)	(3)	$493,499
Pottery	(3)	(3)	(3)	$996	(3)	$28,074	$60,657	$49,006	$43,039	$30,536
Miscellaneous	$419,053	$11,573	$5,357	$214,381	$132,174	$121,468	$179,770	$344,910	$525,991	$224,054
Total Value	$1,809,491	$1,454,436	(4) $1,589,574	$1,533,039	$1,274,708	$1,764,264	$2,923,687	$1,496,741	$1,982,759	$2,296,242
Number of Operators	51	43	40	33	32	31	34	31	28	32
Rank of State	18	21	22	26	26	26	25	26	25	....

(3) Concealed to prevent disclosure of individual operations. Value included in "Miscellaneous". (4) Total output may be $1,614,422.

APPENDIX 3—TABLE 1
PRODUCTION OF CLAY PRODUCTS IN WASHINGTON, 1894-1939—Continued

PRODUCT	1924	1925	1926	1927	1928	1929	1930	1931	1932	1933
Common Brick										
Quantity (thousands)	50,000	54,883	41,454	⑤	38,477	45,756	29,582	17,035	8,430	6,112
Value	$610,830	$639,790	$484,272	⑤	$452,914	$550,110	$339,760	$191,736	$91,889	$70,321
Average price per M.	......	......	......	......	......	......	......	......	......	......
Vitrified Brick										
Quantity (thousands)	......	......	......	......	......	......	......	......	......	......
Value	......	......	......	......	......	......	......	......	......	......
Average price per M.	......	......	......	......	......	......	......	......	......	......
Face (front) Brick										
Quantity (thousands)	14,197	20,242	25,018	⑤	23,030	17,031	17,970	17,475	7,358	3,597
Value	$345,950	$449,991	$489,662	⑤	$462,395	$373,952	$451,940	$339,543	$140,859	$75,836
Average price per M.	......	......	......	......	......	......	......	......	......	......
Fire Brick										
Quantity (thousands)	3,048	③	3,769	⑤	③	6,715	③	③	③	③
Value	$113,766	③	$100,213	⑤	③	$253,666	③	③	③	③
Average price per M.	......	......	......	......	......	......	......	......	......	......
Fireproofing; Hollow Building Block										
Quantity (short tons)	33,946	40,739	37,396	34,222	38,942	41,205	37,593	16,146	7,624	1,942
Value	$322,711	$282,707	$225,187	$252,196	$286,633	$303,751	$290,099	$151,330	$44,577	$19,749
Average price per ton	......	......	......	......	......	......	......	......	......	......
Drain Tile	$45,202	$31,811	$47,032	⑤	$43,458	$52,010	$38,057	$33,755	$24,403	$25,115
Sewer Pipe	③	③	③	⑤	③	$256,867	③	③	$102,227	③
Architectural Terra Cotta	$629,635	$545,609	$682,824	⑤	③	③	③	③	③	③
Pottery	$23,690	$22,043	$25,366	$52,527	$23,609	$46,055	$36,240	$20,223	③	$9,620
Miscellaneous	$515,613	$647,299	$528,777	$2,213,527	$699,917	$730,480	$1,244,686	$766,651	$318,628	$333,181
Total Value	$2,607,397	$2,619,250	$2,583,333	$2,518,250	$1,968,926	$2,566,891	$2,400,782	$1,503,238	$722,583	$533,822
Number of Operators	29	33	34	35	28	29	30	23	19	18
Rank of State	......	......	......	......	......	......	......	......	......	......

③Concealed to prevent disclosure of individual operations. Value included in "Miscellaneous". ⑤Details of production not available.

APPENDIX 3—TABLE 1
PRODUCTION OF CLAY PRODUCTS IN WASHINGTON, 1894-1939—Concluded

PRODUCT	1934	1935	1936	1937	1938	1939
Common Brick						
Quantity (thousands)	8,432	13,643	22,515	25,268	23,435	
Value	$128,210	$171,339	$292,954	$352,628	$293,340	
Average price per M.						
Vitrified Brick						
Quantity (thousands)						
Value						
Average price per M.						
Face (front) Brick						
Quantity (thousands)	4,511	4,226	8,095	7,860	7,096	
Value	$105,225	$76,402	$175,063	$191,764	$148,956	
Average price per M.						
Fire Brick						
Quantity (thousands)	[3]	[3]	[3]	[3]	[3]	
Value	[3]	[3]	[3]	[3]	[3]	
Average price per M.						
Fireproofing; Hollow Building Block						
Quantity (short tons)	3,205	[3]	8,845	9,933	10,782	
Value	$31,026	[3]	$74,668	$90,634	$126,883	
Average price per ton						
Drain Tile	$25,674	[3]	$38,110	$44,877	$36,966	
Sewer Pipe	[3]	[3]	[3]	[3]	[3]	
Architectural Terra Cotta	[3]	[3]	[3]	[3]	[3]	
Pottery	[3]	[3]	$25,438	$33,421	$29,797	
Miscellaneous	$461,229	$523,092	$656,292	$675,813	$456,873	
Total Value	$751,364	$770,833	$1,262,525	$1,389,137	$1,092,815	$1,030,025
Number of Operators	21	22	27	23	24	
Rank of State						

[3] Concealed to prevent disclosure of individual operations. Value included in "Miscellaneous".

APPENDIX 3—TABLE 2

CLAY PLANTS IN WASHINGTON, 1937

LOCATION OF PLANT		NAME OF FIRM	CLAY USED	PROCESS	DRIER	KILNS	PRODUCT
COUNTY	PLACE						
Chelan	Chelan, 2 mi. N. of.	St. Luise Bros. Brickyard	Surface loam	Soft-mud	Open air	1 Scove	Common brick.
	Wenatchee	Wenatchee Brick & Tile Co.	Recent alluvial	Stiff-mud	Open air	2 Scove	Common brick, rough-textured face brick, hollow brick.
Clark	Ridgefield, 3 mi. NE. of	R. B. Muffett Brick & Tile Co.	Willapa Pleistocene	Stiff-mud	Open-air shed	1 Scove	Rough-textured face brick.
	Vancouver	Hidden Brick Co.	Willapa Pleistocene	Soft- and stiff-mud	Open-air racks	1 Scove	Common brick, rough-textured face brick.
Cowlitz	Kalama	Dromore Pottery	Spokane-Clayton lacustrine	Casting and turning	Open air	2 Kerosine-fired up-draft	Art pottery.
King	Auburn	Auburn Pottery Co., Inc.	Puget Sound glacial	Pressing and jiggering	Hot room	1 Round down-draft	Flower pots.
	Auburn	Lange Pottery Co.	Spokane-Clayton lacustrine	Jiggering and turning	Hot room	1 Round down-draft	Art pottery, ovenware.
	Renton	Gladding, McBean & Co.	Various shales and clays	Stiff-mud, dry press, & special hand molding	Tunnels	1 Harrop tunnel; 4 round, 5 rectangular down-draft	Refractory brick and specialties, paving brick, acid brick, blow-pit brick, red face brick, roofing tile, glazed wall block, quarry tile.
	Seattle	Abrahamsen Brick Co.	Puget Sound glacial	Stiff-mud	Tunnels	1 Continuous	Common brick, rough-textured face brick.
	Seattle	Builders' Brick Co.	Puget Sound glacial	Stiff-mud	Tunnels	1 Continuous, 5 round down-draft	Common brick, rough and smooth-textured face brick, radial chimney brick, hollow block, drain tile.
	Seattle	Builders' Brick Co. (formerly Lohse Brick Co., inoperative)	Puget Sound glacial	Stiff-mud	Tunnels	1 Continuous	Common brick, rough-textured face brick.
	Seattle	Builders' Brick Co. (formerly Puget Sound Brick & Tile Co., inoperative)	Puget Sound glacial	Stiff-mud	Open air	1 Continuous	Common brick.
	Seattle	Northwest Pottery Co.	Puget Sound glacial	Pressing and jiggering	Hot room	1 Rectangular up-draft	Flower pots.
	Seattle	Potlatch Pottery, Inc.	Out-of-State	Casting, pressing, and hand modeling	Hot rooms	1 Down-draft	Art and tableware.
	Seattle	Seattle Brick & Tile Co.	Puget Sound glacial	Stiff-mud	Tunnels	2 Continuous, 2 round down-draft	Common brick, rough and smooth-textured face brick, hollow block, drain tile.
	Seattle	Seattle Pottery & Tile Co.	Puget Sound glacial	Pressing, jiggering, and stiff-mud	Rooms	2 Semimuffle rectangular, 1 round down-draft	Flower pots, mantel tile, quarry tile.
	Seattle	Washington Pottery Co.	Puget Sound glacial	Pressing and jiggering	Hot room	1 rectangular up-draft	Flower pots.
	Taylor	Gladding, McBean & Co.	Shale	Pressing	Floors, hot rooms	14 Round down-draft	Sewer pipe, flue lining, electric conduit, acid-resisting clay pipe.
	Woodinville	Bothell Brick & Tile Co. (inoperative)	Puget Sound glacial	Stiff-mud	Tunnels	2 Round down-draft, 2 scove	Common brick, drain tile.
Lewis	Chehalis	Chehalis Brick & Tile Co.	Shale & Willapa Pleistocene	Stiff-mud	Tunnels	1 Semicontinuous, 1 round down-draft	Common brick, rough-textured face brick, hollow brick, drain tile, hollow block.
Okanogan	Oroville	Oroville Brickyard	Recent alluvial and silt	Soft-mud	Open air	1 Scove	Common brick.
Pierce	Clay City	Far West Brick & Tile Co.	Cascade residual	Stiff-mud	Tunnels	8 Round down-draft	Rough and smooth-textured face brick, hollow block.
	McKenna, 2 mi. E. of	Paul Kirston Pottery	Recent alluvial	Hand modeling	Open air	1 Round down-draft	Novelty ware.
Skagit	Tiloh	Knapp Brick & Tile Co.	Recent alluvial	Stiff-mud	Tunnels	1 Round down-draft	Drain tile, hollow block.
Snohomish	Everett	Everett Brickyard	Puget Sound glacial	Stiff-mud	Tunnels	1 Continuous	Common brick, rough-textured face brick, hollow block, drain tile, roofing tile.
Spokane	Chester	H. Seidel Clay Co.	Spokane-Clayton lacustrine	Jiggering	Hot room	1 Round down-draft	Flower pots.
	Dishman	Washington Brick, Lime & Sewer Pipe Co.	Spokane-Clayton lacustrine and Palouse	Pressing	Floors	11 Round down-draft	Sewer pipe, hollow tile, flue lining.
	Mead	Building Supplies, Inc.	Silt	Soft-mud	Open-air racks	3 Clamp scove	Common brick.
	Mica	Gladding, McBean & Co.	Spokane-Clayton lacustrine and colluvial; Palouse	Stiff-mud, pressing	Tunnels, hot floors	9 Round down-draft	Common brick, face brick, fire brick and shapes, sewer pipe, hollow block, drain tile.
	Spokane	Pioneer Brick Co.	Weathered shale	Stiff-mud	Open-air sheds	1 Scove	Common brick, rough-textured brick.
Stevens	Clayton	Washington Brick, Lime & Sewer Pipe Co. (Brick plant)	Spokane-Clayton lacustrine and residual	Stiff-mud and repressing	Tunnels	2 Rectangular down-draft, 5 round down-draft	Common brick, face brick, fire brick.
	Clayton	Washington Brick, Lime & Sewer Pipe Co. (Terra cotta plant)	Spokane-Clayton lacustrine	Molding	Hot floors	2 Round down-draft	Terra cotta.
Whitman	Uniontown	Geo. Herboth Brick Co. (inoperative)	Palouse	Soft-mud	Open-air racks	1 Scove, 1 rectangular down-draft	Drain tile, common brick.
Yakima	Granger	Granger Clay Products Co.	Silt	Stiff-mud	Tunnels	6 Round down-draft	Common brick, rough-textured face brick, hollow block, drain tile.

APPENDIX 3—TABLE 3

PRODUCTION OF RAW CLAY IN WASHINGTON, 1907-1939 ①

Year	Producers	Fire clay		Stoneware clay		Miscellaneous clays and shales		Total	
		Short tons	Value	Short tons	Value	Short tons	Value	Short tons	Value
1907		②	②	②	②	950	$ 2,350	1,754	$ 4,623
1908		653	$ 5,921	②	②	200	500	3,883	15,511
1909		6,220	10,129			100	200	6,320	10,329
1910		3,451	5,932			400	1,200	3,851	7,132
1911		②	②			②	②	1,187	2,753
1912		②	②			②	②	1,570	5,000
1913		754	6,672			②	②	2,028	8,837
1914		342	3,139			②	②	691	3,829
1915		502	3,364			②	②	829	4,340
1916		630	3,934	②	②	②	②	1,840	6,251
1917		779	7,159	②	②	②	②	1,613	9,248
1918		1,795	9,853			②	②	3,435	17,637
1919		②	②	②	②	19,728	15,782	20,518	21,964
1920		763	8,854			②	②	1,319	10,377
1921	3	②	②			②	②	439	5,153
1922	7	5,681	12,779			455	1,966	6,136	14,745
1923	8	5,524	19,549	②	②	4,817	8,916	10,491	29,040
1924	7	4,317	16,142			15,456	19,557	19,773	35,699
1925	7	3,576	19,418			20,594	24,227	24,170	43,645
1926	8	1,500	15,381	756	2,268	10,691	13,866	12,947	31,515
1927	9	720	8,423	726	2,178	30,017	29,827	31,463	40,428
1928	7	5,906	18,925	③	③	29,135	20,707	35,041	39,632
1929	7	894	9,862	6,500	4,000	21,010	25,271	28,404	39,133
1930	6	1,421	4,785	③	③	27,363	19,862	28,784	24,647
1931	5	9,094	13,036	③	③	12,228	7,765	21,322	20,801
1932	5	674	2,307	③	③	9,697	8,988	10,371	11,295
1933	4	848	3,046	③	③	5,253	4,867	6,101	7,913
1934	9	772	1,452	2,556	1,656	14,373	11,252	17,701	14,360
1935	10	1,302	4,152	2,305	1,642	4,950	4,397	8,557	10,191
1936		13,637	49,270	3,500	2,300	26,831	52,920	43,968	104,490
1937		23,253	42,844	5,534	3,317	21,071	45,118	49,858	91,279
1938		23,781	46,202	3,301	5,267	11,911	10,805	38,993	62,274
1939		20,356	47,734	④	④	8,281	5,900	28,637	53,634

①—Statistics obtained by U. S. Geol. Survey to 1924 and by U. S. Bur. Mines from 1923 to 1939, in cooperation with Washington Division of Geology.
②—Production concealed.
③—Included in "Miscellaneous".
④—Included in "Fire Clay".

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