AN INVESTIGATION OF THE ELLENSBURG FORMATION

by

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A thesis submitted for the degree of

MASTER OF SCIENCE

UNIVERSITY OF WASHINGTON

1948

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ILLUSTRATIONS

AN INVESTIGATION OF THE ELLENSBURG FORMATION

INTRODUCTION

The Ellensburg formation of central Washington provides an important link in the geological history of the region in which the structures of the Cascade Mountains meet that of the Columbia Plateau. Despite its importance, the Ellensburg has not been exactly delimited nor defined, even within areas which have been mapped geologically.

Of a unique petrographical nature, the volcanic-derived fluviatile Ellensburg is strikingly different from the earlier and later Cenozoic sedimentary formations of the region. The investigation of the Ellensburg as a problem involving sedimentary petrography, was suggested by Professor Howard A. Coombs of the Department of Geology of the University of Washington. Professor Coombs had previously worked on this aspect of the problem and had found petrographical methods to be very practical in distinguishing the Ellensburg. The writer is indebted to Dr. Coombs for suggesting a thoroughly interesting problem and for his aid during the preparation of this thesis.

Field work was performed during 1947. Channel samples were collected from 150 localities within areas mapped as Ellensburg and from other localities having a bearing on the problem. The laboratory work was conducted at the University of Washington Department of Geology.

GEOGRAPHY

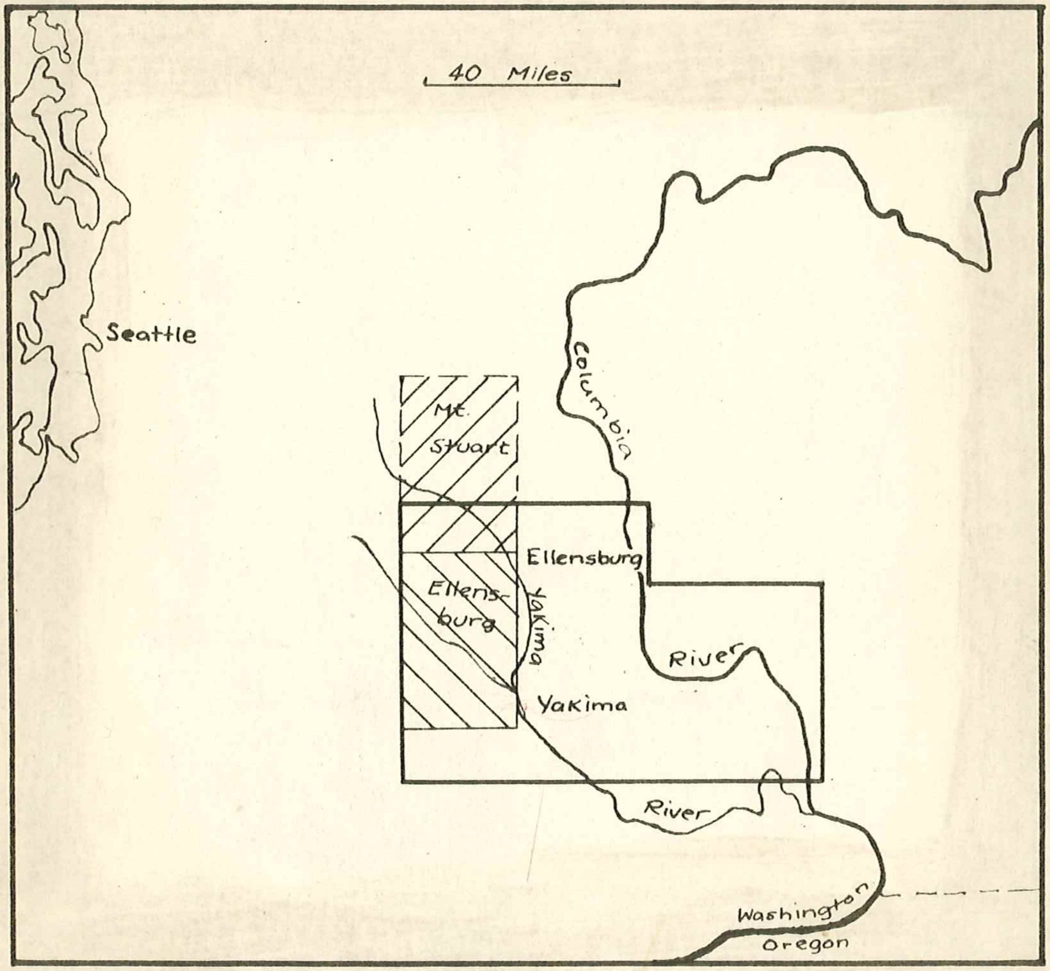
Field work was done within an area of about 4,000 square miles in Central Washington. As indicated on the locality map (Plate III) sampling was concentrated within the geologically mapped Ellensburg and Mt. Stuart quadrangles and within immediately adjoining areas to the east. The western part of the area is in the Middle-Cascade Mountains as distinguished by Fenneman (1931, pp.430-431). The eastern and greater part of this area is within Fenneman's (1931, pp. 264-266) Yakima District of the Columbia Plateau and extends eastward to the plateau proper.

The topography is controlled by the structures which extend from the Cascade Range into the Yakima district as a series of northwest-southeast trending anticlines and synclines with prominent topographic expression. Between Ellensburg and Union Gap just south of Yakima, the Yakima River cuts through four anticlinal ridges in gorges 1,000 to 3,000 feet deep. Smith (1903) has interpreted the Yakima River as being antecedent in this district. The Naches River, the principal tributary to the Yakima River, is also considered to be antecedent in its lower course.

Both the Yakima and Naches Rivers are essentially at grade in this district. The Naches River has an average gradient of about 70 feet per mile within the Ellensburg quadrangle and the Yakima River averages about 16 feet per mile throughout its course in the Mt. Stuart and Ellensburg quadrangles.

PLATE I

INDEX MAP SHOWING AREA FROM WHICH SAMPLES WERE COLLECTED.
ELLENSBURG AND MT. STUART QUADRANGLES INDICATED BY PATTERN.



Intensive agricultural operations are pursued within the larger synclinal valleys which have thick alluvial fillings. Irrigation is necessary, as the annual precipitation is from 10 to 12 inches, except in the westernmost part of the area. The fertile irrigated valleys stand in sharp contrast to the dry hills with their sparse covering of sagebrush and bunchgrass.

An excellent system of main highways and secondary roads affords ready access to most of the valley areas and greatly facilitates geological work.

GENERAL GEOLOGY AND PREVIOUS WORK

The Ellensburg and Mt. Stuart quadrangles have been mapped by the U. S. Geological Survey and the geology described by Smith (1902-1903) in Folios 106 and 86, respectively. Within the parts of those quadrangles concerned in the present work, eight geological units were recognized by Smith; 1) The Eocene Manastash formation, 2) the middle Miocene Yakima basalt, 3) the Wenas basalt, 4) the upper Miocene Ellensburg formation, 6) the Pleistocene Tieton andesite, 7) the Cowiche gravels and 8) alluvium. The pre-Pleistocene formations are all involved in northwest-southeast folding.

The Manastash formation outcrops over small areas in the southern part of the Mt. Stuart quadrangle. The Manastash formation shown on the eastern part of the Mt. Stuart quadrangle included on the geologic map (Appendix A) was considered somewhat doubtful by Smith, but to the West are definite areas from which Eocene floral fossils have been collected. The Manastash consists of arkosic sandstones and shaly beds. It was folded and eroded prior to the middle Miocene northwest-southeast folding.

The middle Miocene Yakima basalt occupies the greater part of the area. Its unconformable relation to folded Eocene and pre-Eocene rocks is visible at several localities in the Mt. Stuart quadrangle and in the Mt. Aix quadrangle as shown by Warren (1936). Smith (1902-1903) estimated the Yakima basalt to have a maximum thickness of about 2,000 feet in the Mt. Stuart and Ellensburg quadrangles. The basalt is black, aphantic and rarely contains very small phenocrysts of feldspar and augite. Columnar structure is well developed in many flows.

Overlying the Yakima basalt are the fluviatile sandstones, conglomerates and siltstones of the Ellensburg formation. The Ellensburg formation was first described, but not named, by Russel (1893). He regarded as typical, the exposures in the bluffs along the north side of the lower Naches River and those in the Wenas Creek valley. Russel considered the beds to be of Miocene age on floral evidence, and correlative with the John Day beds of Oregon. The beds at the White Bluffs of the Columbia River were considered a contemporaneous lacustrine phase of the same John Day System, as Russel termed it. Smith (1902) named the Ellensburg during the mapping of the Ellensburg quadrangle, but designated no type locality. He thought the exposures along the lower Naches River to be the best, but also stated that typical Ellensburg occurs near the Normal School in the town of Ellensburg. In the Mt. Stuart Folio, Smith mentions the exposures in the Yakima River bluffs east of Thorpe, north of Ellensburg as also being representative. He states the Ellensburg to be of upper Miocene age on the basis of Russel's floral evidence and additional collections of his own.

The uniform petrographical nature of the Ellensburg is described by Smith (1902, 1903). The beds consist almost exclusively of clastic materials derived from light gray and pink hornblende andesite and white pumice. Much of the gray and pink andesite is rather pumiceous.

The source of the clastics is indicated as somewhere to the west, in the area of the present Cascade Mountains, by the prevalent fluvial cross-bedding and the large andesite boulders present in the strata at Nile Creek and vicinity (locality 6, Plate III). Basalt pebbles are almost wholly lacking in the Ellensburg, despite the fact that the sediments conformably overly the basalt and that, in the Naches and Wenas valleys and at Taneum Creek (locality 11), the basal part is intercalated with the upper one or two basalt flows which Smith (1902) termed the Wenas basalt. Both the Wenas basalt and the lower Ellensburg beds are 20 to 100 feet thick at most of their occurrences.

X Nearly 1,600 feet of strata in the Naches River bluffs were measured and described by Calkins (1903). Smith ascribed the deposition of the Ellensburg to have taken place in a basin formed by subsidence in the center of the area covered by the Yakima basalt during and after the outpouring of the basalt. The andesitic fragments and pumice were easily carried away by streams operating within the vicinity of the volcanic activity and were deposited as alluvial fans by the overloaded streams issuing into the basin. The presence of coarse clastics throughout the Ellensburg was thought to indicate the continuance of subsidence during the period of Ellensburg deposition. X

The Ellensburg at many localities may be observed to have been folded with the basalt into a series of northwest-southeast trending anticlines and synclines. The structural relations are well known where the Wenas basalt is interbedded with the lower Ellensburg. According to Weaver (1937), the deposition of the middle Miocene Astoria

PLATE II

ELLENSBURG OUTCROPPINGS IN THE BLUFFS ON THE NORTH SIDE OF THE LOWER NACHES RIVER formation, which is intercalated with the basalt in Western Washington and Oregon, was followed by folding and the cessation of sedimentation and basaltic outpourings. Early Pliocene marine sediments are unconformable upon the folded Astoria and basalt. It is possible, therefore, as suggested by Warren (1941), that the deposition of the Ellensburg went on concurrently with the folding rather than as a simple downward warping with later folding superimposed.

The Tieton andesite unconformably overlies the Yakima basalt and presumably, the Ellensburg. It occupies a former valley of the lower Naches River. The andesite is a gray to black, aphanitic, porphyritic hypersthene andesite. It is quite distinct from the andesites in the Ellensburg clastics and from the Yakima basalt.

The Cowiche gravels were deposited as the result of the damming of the Tieton River and of the Cowiche Creeks by the Tieton andesite.

Alluvial fill is extensive in the valleys. Three sets of terraces were recognized by Smith (1903) along the Yakima River north of Ellensburg. The highest represents the maximum stage of aggradation during the glacial epoch, according to Smith.

Many contributions have been made to the geology of the Ellensburg since the work of Smith. Merriam and Buwalda (1918) have shown the beds at the White Bluffs of the Columbia River to be Pleistocene or possibly uppermost Pliocene in age and quite distinct from the Ellensburg formation. They named the White Bluffs strata the Ringold formation. Jenkins (1924) has reported the Ringold formation to unconformably overlie the Ellensburg in the bluffs of the Columbia

River east of the former town of White Bluffs. Culver (1937) has suggested that the Ringold formation is more extensive than formerly recognized. He believes that much of the sediments classified as Ellensburg in the vicinity of the town of Selah, north of Yakima, may more properly be assigned to the Ringold. On stratigraphical, structural and lithological grounds, Buwalda and Moore (1930) have correlated the Ellensburg formation with the Hood River conglomerate of south-central Washington and north-central Oregon and with the Dalles formation of north-central Oregon. They suggest an upper Miocene to lower Pliocene age for these formations on the basis of vertebrate fossils found within the Dalles formation. Warren (Feb., 1941) has traced the Hood River conglomerate in south-central Washington and has found it to be inter-bedded with the Ellensburg beneath a basalt flow at several localities to the east and south of Yakima. The abundant purple and brown quartzite pebbles in the Hood River conglomerate indicate the source of materials to have been the northern Rocky Mountain region of Idaho or British Columbia. Warren considers the Hood River conglomerate to have been transported by the ancestral Columbia River which flowed marginal to the accumulating Ellensburg sediments derived from the west. Coombs (1941) has shown the petrographic character of the Ellensburg sands to be remarkably uniform. He studied samples from the Naches-Wenas valley occurrences, from the coarse clastics at Mile Creek and from the bluffs of the Yakima River north of Ellensburg. Petrographic methods showed the heavy mineral content to consist almost exclusively of hornblende and magnetite.

The lighter materials are limited to volcanic glass and plagioclase. The crystals were found to be remarkably euhedral, although transported for as much as 50 miles from their probable source.

THE ELLENSBURG PROBLEM

Despite the many contributions to the geology of the Ellensburg, it has not been well defined as a formation. No type locality has been designated. The areal extent is largely unknown and the structural relations and geological age are imperfectly known. Although the Ellensburg has a uniformity in the Naches-Wenas occurrences, a heterogeneity may be demonstrated in other areas. Landslides, later sedimentation and younger beds intercalated within the lower Yakima basalt obscure the geological history of the Ellensburg and complicate its relations to other formations within its outcrop area. The present investigation was undertaken with the hope of uncovering petrographical evidence which might aid in determining the Ellensburg within the Mt. Stuart and Ellensburg quadrangles. Future workers may extend the definitely known Ellensburg to areas beyond these quadrangles.

The beds in the lower Naches and Wenas valleys, where the most complete section of the Ellensburg known has been described, were found to exhibit a uniform petrographical and structural nature. As Russel and Smith agreed upon the representative nature of this locality, it is suggested that it may well serve as the type locality of the Ellensburg formation. In this paper, other occurrences will be compared with this one.

WORKING METHODS

Channel samples averaging about one quart in bulk were collected at the places shown on the locality map (Plate II). The localities indicated are representative of the beds within a particular area of occurrence. Samples were collected from a much larger number of localities, but the compilation of further information would be of little value due to the uniformity over large areas. The Ellensburg, as noted by Smith (1903), is inconspicuous over much of its occurrence. Exposures are limited to localities oversteepened by stream cutting or by human activities. For this reason, as well as the problem of dealing with the large area involved, most of the samples were taken from road cuts.

The samples were split and disaggregated. Most of the sandstones are quite friable and may be easily crumbled by rubbing between the fingers. Some of the sampled beds are indurated and cemented by calcium carbonate or silica. Samples from these localities were crushed between boards or with a mortar and pestle. The progress of the disaggregation was checked by passing the materials through a 14 mesh screen and observing the products with a hand lens.

All of the samples were examined under a binocular microscope and the constituents estimated as to volume percentage. About 70 samples were selected for size grading and screened through a series of U. S. system sieves. Histograms were constructed from the results. The -100 to +200 grade sizes were examined with the binocular microscope, the constituents noted and 50 samples were selected for further analysis. These were cleaned in dilute hydrochloric acid and separated into heavy and light constituents by means of bromoform (G. 2.8). The heavy fractions were mounted on glass slides with "Permount" (n.= 1.53) and examined with the petrographic microscope. The light fractions and some of the heavies were petrographically examined with the aid of index of refraction oils. The percentage composition of the heavies was computed by counting approximately 100 grains from each sample.

FIELD AND PETROGRAPHICAL OBSERVATIONS BY LOCALITIES

Typical Occurrences of the Ellensburg

Naches and Wenas Valleys -- Localities 1-5 are within the Naches and Wenas Valleys, embodying the exposures considered typical of the Ellensburg by Russel and Smith. Coombs (1941) also selected this area for his petrographical studies.

Localities 1, 2, and 3 are within the area containing the thickest Ellensburg sequence known. It was here that Calkins (1902) measured and described nearly 1600 feet of strata. At locality 1 the basal beds are exposed. About five feet of Ellensburg overlies Yakima basalt and in turn is overlain by about twenty feet of Wenas basalt. Above the Wenas is the main body of the Ellensburg dipping in a general northeast direction about five degrees. It is noteworthy, that at this locality the Yakima basalt for two or three feet below the contact with the basal Ellensburg is composed of yellowish-green palagonitic glass with colloform structure microscopically. The basal foot of Wenas basalt has small pillow structures. These conditions suggest that basaltic outpourings and fluvial deposition took place in such rapid succession that locally, the still hot upper surface of the Yakima was flooded and that the Wenas advanced onto wet sediments.

At locality 2, on the road between the town of Naches and the Wenas valley over 200 feet of beds are exposed on the south side of the ridge. Forty-two samples were taken from this unusually well exposed section. The beds here represent the middle part of the Ellensburg. At locality 3, west of the town of Selah, the beds are representative of the upper

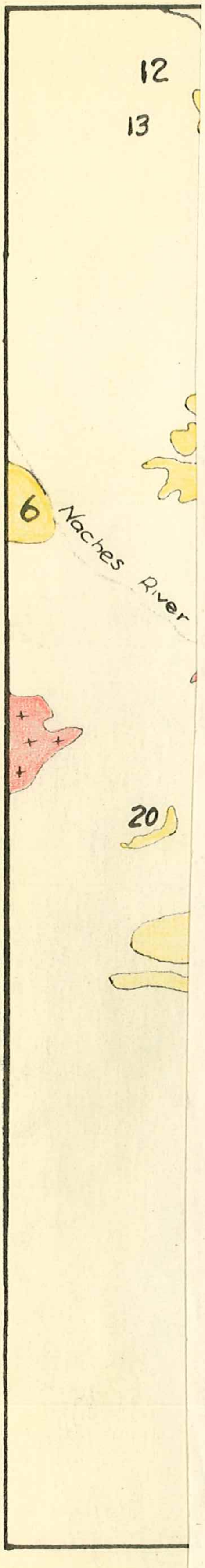

12
13
6
Naches River
20

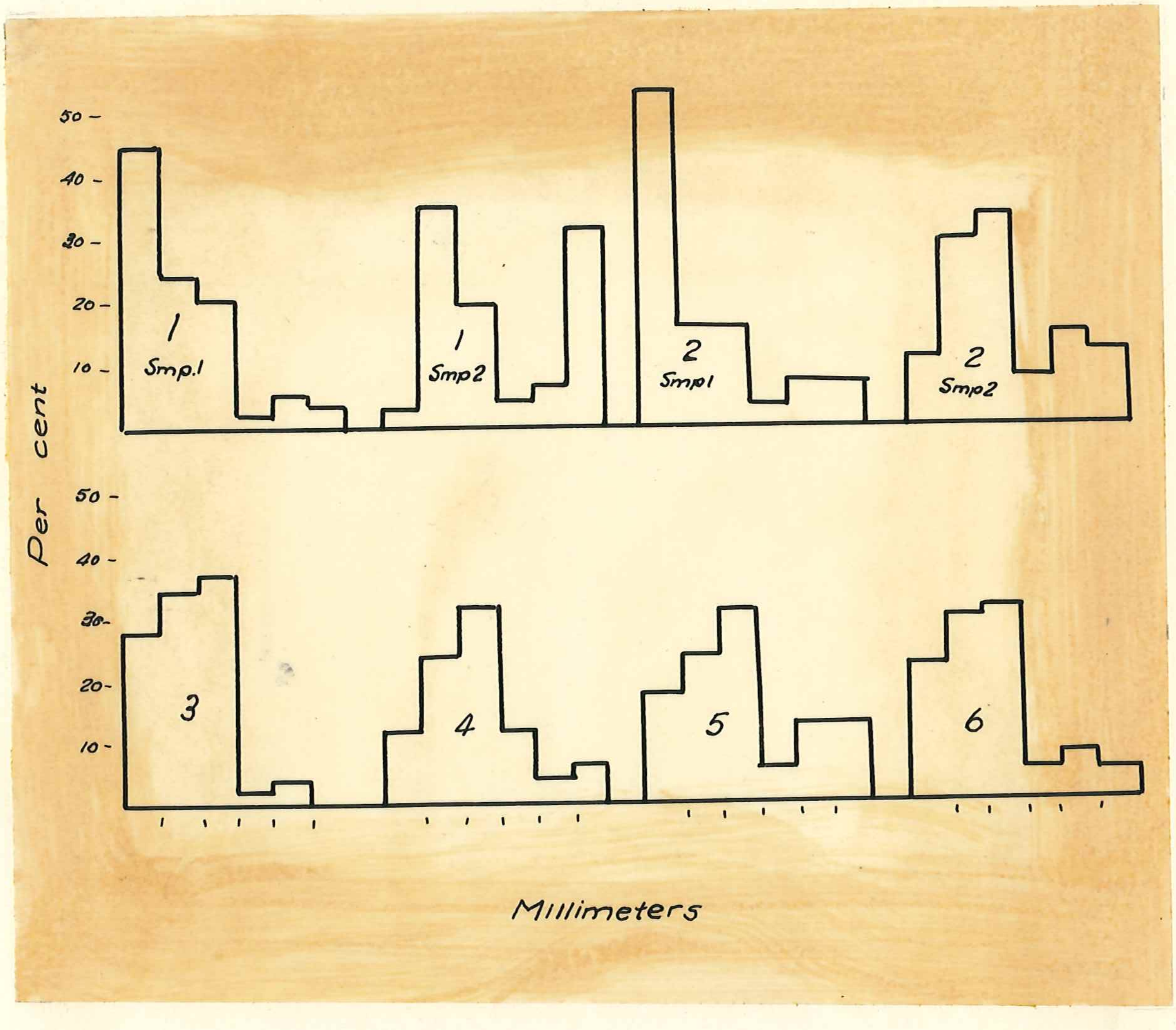
PLATE IV

ELLENSBURG EXPOSED IN AN IRRIGATION DITCH

CUT NEAR LOCALITY 1

PLATE V

HISTOGRAMS, LOCALITIES 1 - 6



part of the Ellensburg. Localities 4 and 5 are representative of the thinner deposits in the Wenas valley.

All the beds at the five localities indicated and at other localities examined in the Naches and Wenas district have common characteristics. The clastics consist of predominantly sand size fragments as indicated by the histograms (Plate IV). The larger sand grains may be megascopically identified as hornblende, feldspar and volcanic glass. The coarser clastics consist of gray and pink hornblende andesite and white pumice pebbles and cobbles. Pumice lapilli and occasional small ropy bombs are present. Large blocks and boulders of pumice are in the outcrops at locality 5, indicating nearness to the source of the clastics. A few basalt pebbles are present in some of the beds. Much of gray and pink andesite is pumiceous and all of it contains fifty percent or more of glass. Hornblende and feldspar are easily identified in the andesite and pumice. Some of the crystals are nearly one-

Heavy minerals, localities 1 - 5

Locality		Hornblende	Magnetite	Hypersthene	Zircon	Biotite
1	sample 1	70	25	4	tr.	1
	sample 2	74	21	4		1
2	sample 1	84	16			
	sample 2	54	43		tr.	3
3		75	25			
4		74	23	3	tr.	
5		90	10			tr.

half inch in length.

Cross bedding and torrential bedding are typical of nearly all the beds. Lensing, channeling, extreme lack of sorting and sudden changes in manner of deposition are characteristic.

The tabulation on the previous page illustrates the uniformity in heavy mineral content of the Ellensburg. Hornblende and magnetite comprise almost 100 percent of the heavies. Hypersthene, biotite and zircon are rare to absent. Some turbid materials present in a few of the samples may be alteration products of hornblende and hypersthene.

The hornblende crystals are shiny black to translucent green by reflected light and from clear green to opaque by transmitted light. Some of the crystals have opaque rims of magnetite or hematite and others are nearly colorless. About one third are almost perfectly euhedral and have well defined prism and clinodrome faces. The rest range from subhedral to subangular. Almost no rounding of the crystals is visible. Some have rather delicately frayed ends and may have been protected during transportation by a covering of glass which coats many of the crystals. Inclusions of magnetite, plagioclase and less commonly, apatite are present. Coombs (1941) has given the optical properties of the hornblende as follows:

Ng = 1.66	Z-green	2V about 62°
	Y-green	
Np = 1.64	X-brown	

Magnetite occurs as black, shiny octahedra and dodecahedra. Imperfectly formed crystals are common. Some of the magnetite has hematitic oxidation. Glass coatings bind some of the crystals together.

Hypersthene usually occurs as stubby, green crystals, not easily

PLATE VI

PHOTOMICROGRAPH OF HEAVY MINERALS FROM LOCALITY 2.

PLANE LIGHT X59

Hb = HORNBLENDE

M = MAGNETITE

Hy = HYPERSTHENE

PLATE VII

PHOTOMICROGRAPH OF LIGHT MINERALS FROM LOCALITY 7

PLANE LIGHT X 50

P= PLAGIOCLASE

G= GLASS

Q= BIPYRAMIDAL QUARTZ

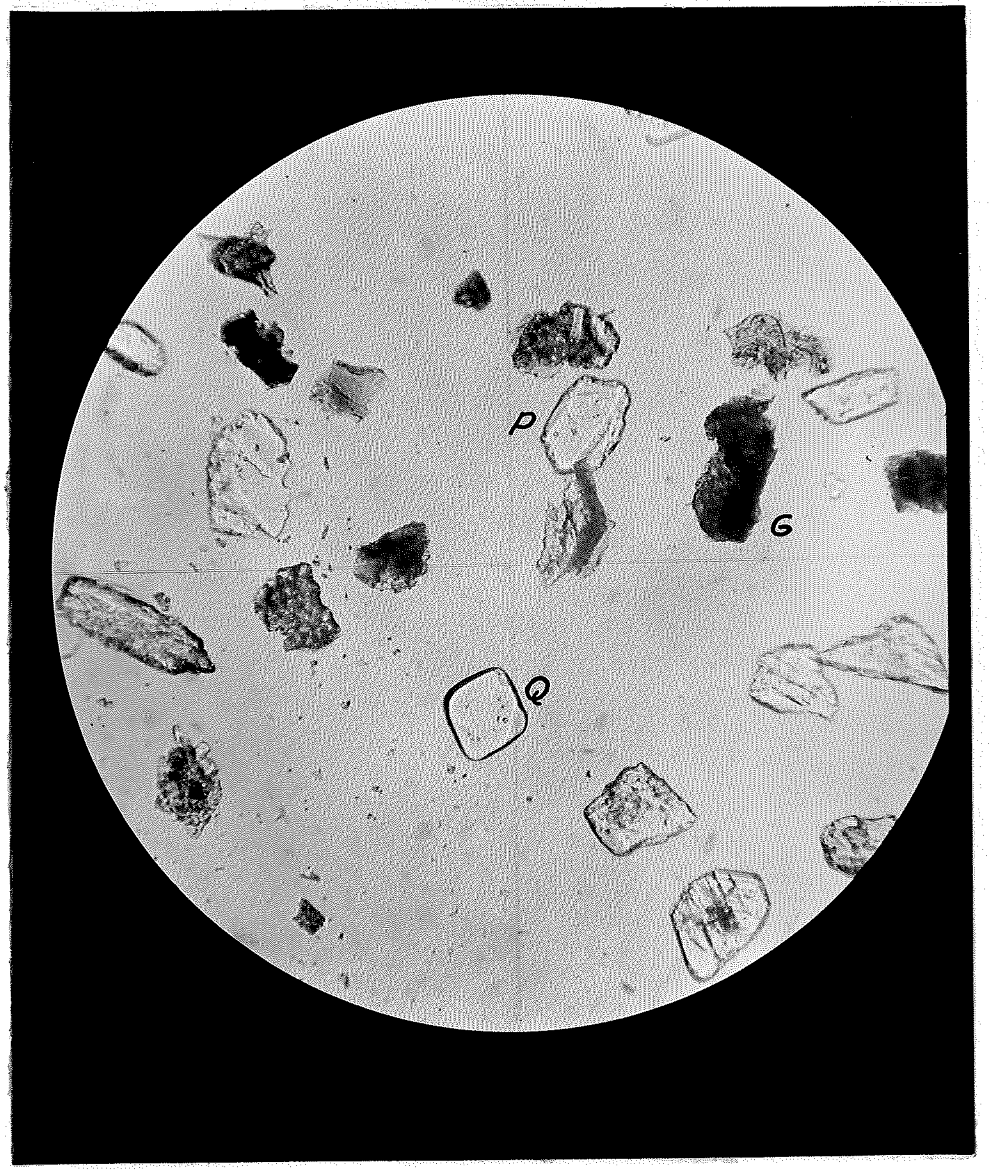


PLATE VIII

CONGLOMERATIC CROSS BEDDED ELLENSBURG AT LOCALITY 2.

NOTE THE EXTREME LACK OF SORTING.

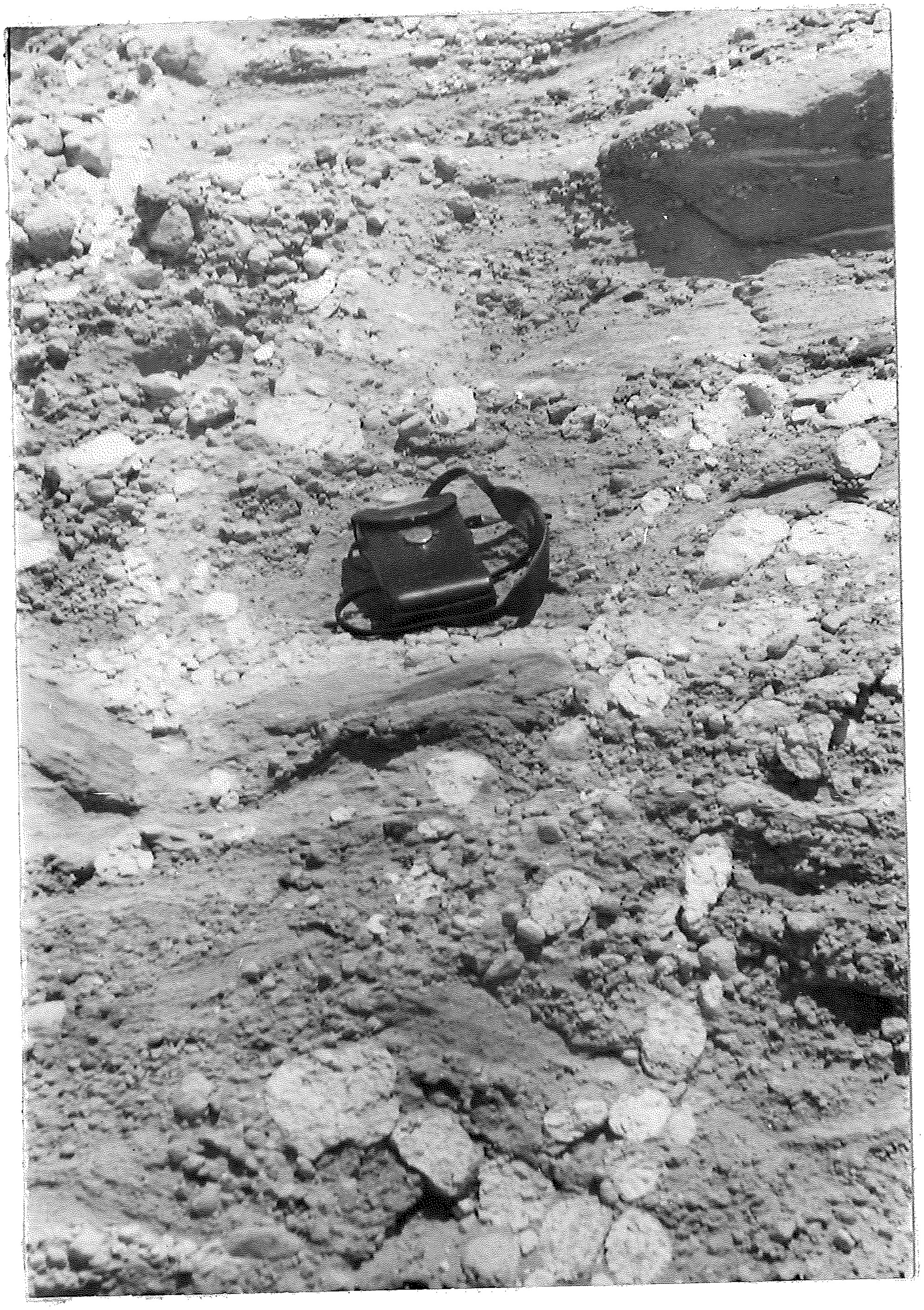


PLATE IX

CROSS BEDDED SANDSTONE OVERLYING MASSIVE SANDSTONE

AT LOCALITY 2

identified except by use of the petrographic microscope. It has a 2V of 70 to 90° and is pleochroic from yellow to reddish brown. Inclusions of plagioclase and magnetite are present.

Biotite occurs as brown to yellow-green flakes. A few perfectly euhedral crystals were noted.

Zircon is present in oval to euhedral crystals. Occasional crystals have a pinkish tint, but most are colorless.

Volcanic glass is the most abundant constituent of the light fractions. It is pale brown with colorless edges and somewhat devitrified. Pumiceous grains comprise most of the glass fragments, but denser, angular shards are also present. The index of refraction varies from 1.52 for the clear parts to 1.53 for the darker brown and generally more devitrified portions. Small crystals of magnetite and hornblende as well as magnetite dust and some hematite are included within the glass and cause some of it to sink in bromoform.

Plagioclase of Ab 66 to Ab 78 composition as determined by Coombs is next in abundance to the glass. Many of the crystals are euhedral and Carlsbad twins may be observed with the binocular microscope. Zoning and albite twinning are present and the cores of some crystals are rather turbid. Inclusions consist of glass and small, dark, rounded crystals.

<u>Nile Creek</u> -- Locality 6 is representative of the beds sampled in the Nile Creek area. Coombs (1941) also took samples from this locality. Here, the Ellensburg is largely composed of cobble and boulder conglomerates with interbedded pebble conglomerates and sandstones.

Boulders of andesite and boulders and blocks of pumice several feet in diameter are not unusual. Nearness to the site of andesitic eruptions is strongly indicated. The beds dip in a general direction slightly south of east and somewhat steeper than the gradients of the Naches River and lower Nile Creek. Between Nile Creek and Rattlesnake Creek, the conglomeratic beds are cemented by silica and calcium carbonate and form prominent bluffs. Although the actual contact with the Yakima basalt was not seen, the basalt appears to parallel the Ellensburg along the Naches River.

Heavy minerals, locality 6

Hornblende	Magnetite	Hypersthene	Zircon
68	30	2	tr.

The heavies tend to have somewhat better shapes than those from localities to the east, but are otherwise similar. Glass and plagioclase are the light constituents. A crystal of bipyramidal quartz was noted in one sample.

<u>Localities in the vicinity of Ellensburg</u> -- Along the Yakima River and in the valleys of Taneum Creek and Dry Creek are beds with the characteristics of those at localities 1 to 5. The large area of Ellensburg a few miles due north of the town of Ellensburg was not sampled as no outcrops were visible in the portions visited. The small northermost area on Lookout Mt. is apparently typical, but the readily accessible beds are within a large landslide area.

X

PLATE X

CROSS BEDDED AND TORRENTIALLY BEDDED SANDSTONE NEAR LOCALITY 3. NOTE THE PUMICE PEBBLES.

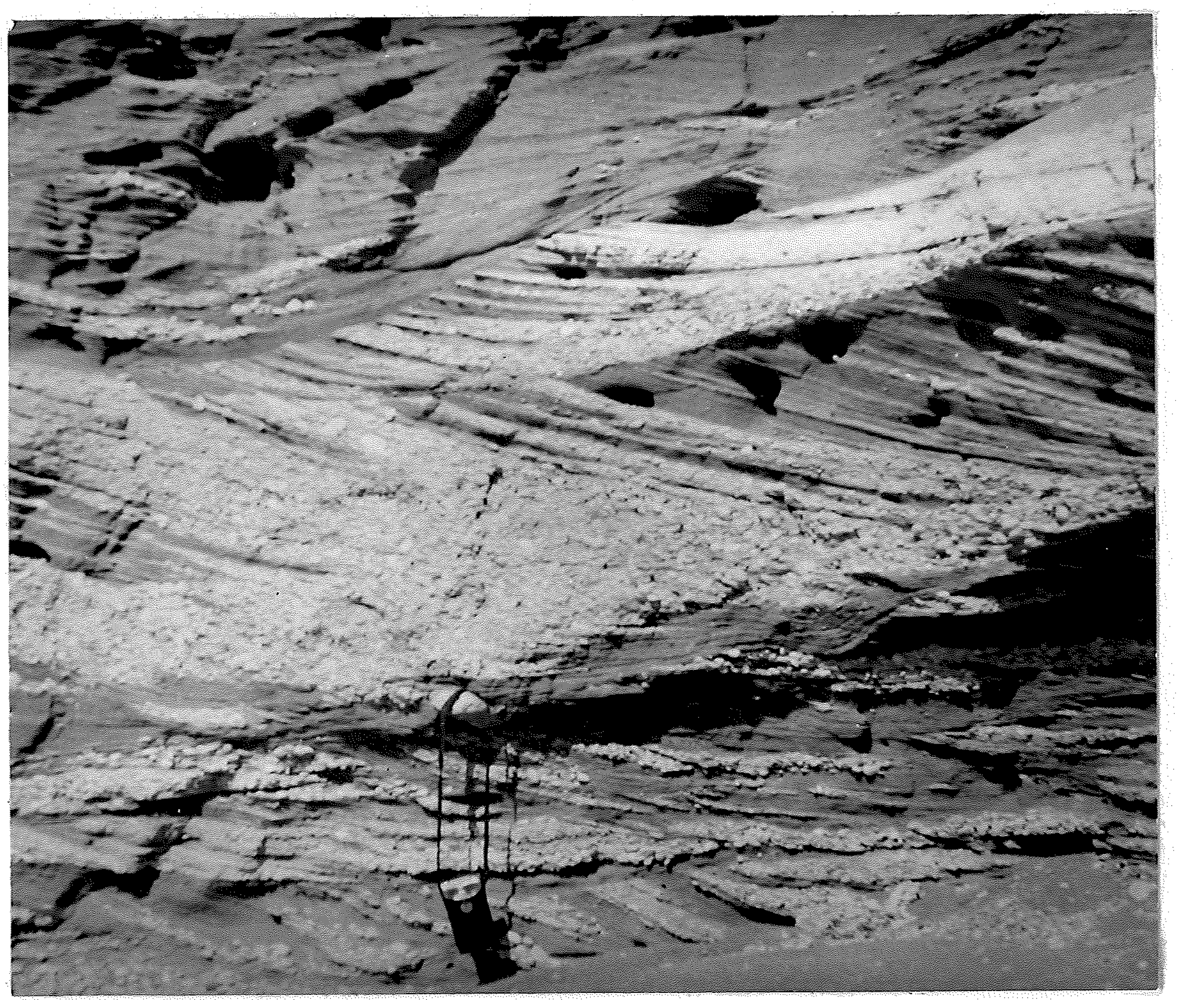
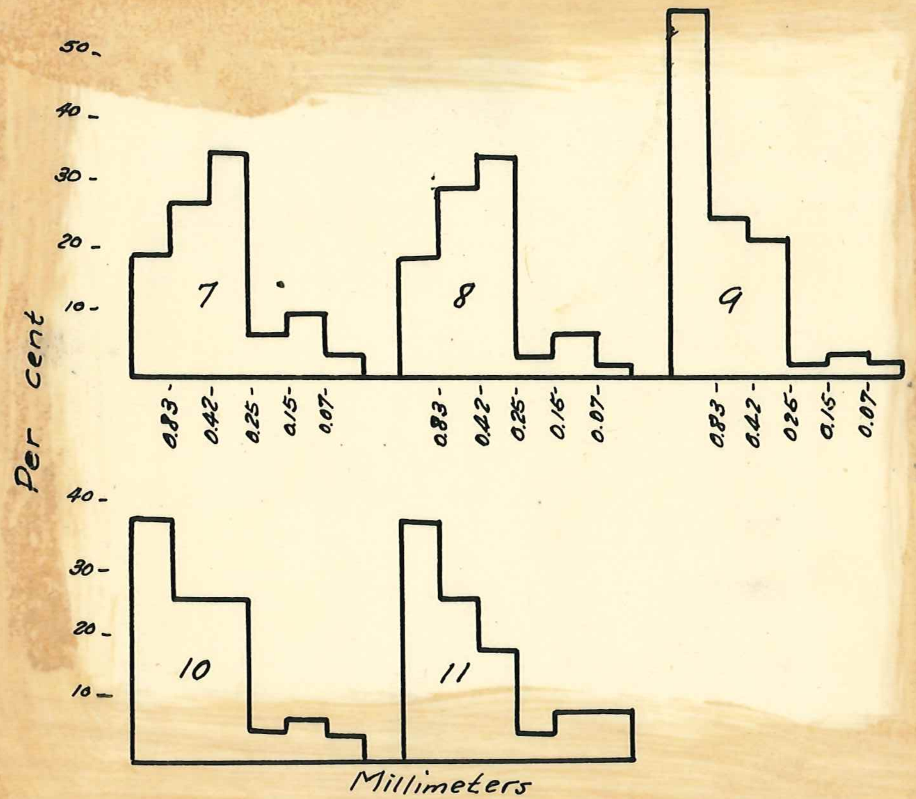


PLATE XI

BLUFF FORMING ELLENSBURG CONGLOMERATES NEAR
NILE CREEK

PLATE XII

HISTOGRAMS, LOCALITIES 7 - 11



Heavy minerals, localities 7 to 11

Locality	Hornblende	Magnetite	Hypersthene	Zircon	Biotite	Turbid
7	65	35				
8	90	10				
9	78	20		tr.	1	1
10	69	31	tr.			
11	52	33	8	3		4

At locality 7, at the bluffs along the Yakima River east of Thorpe is the best exposure of the Ellensburg in this vicinity. It was considered as typical by Smith and was one of Coomb's localities. About 100 feet of beds outcrop in the highway cut. They are of massive and cross bedded sandstone and contain much pumiceous material. Lack of sorting is pronounced. Cobbles and pebbles of andesite are mixed with sand size grains as though carried by a mud flow in one of the beds. The strata dips southeast about 8°, the inclination being noticeably steeper than the Yakima River gradient. The beds do not contact the basalt here, but not far to the north, in the canyon between Dudley and Teanaway Junction, the basalt dips to the southeast, apparently in conformity with the Ellensburg at locality 7.

Although the heavy minerals at this locality are in accordance with those at the preceding localities, the lights from two samples near the upper part of the outcrop are notable for containing several crystals of bipyramidal quartz in addition to the usual constituents. The quartz comprised one percent of the -100 to +200 mesh material in one of the samples. The crystals exhibit euhedral to subhedral shapes, although a few are corroded. Only domal faces are present and the crystals are very clear. A few pebbles of gray andesite containing this type of quartz were found in these samples. The andesite is about 90 percent crystalline, in contrast to all other andesite pebbles examined. Cream colored rather soft glass comprises about ten percent of the rock; hornblende, ten percent; magnetite, five percent; quartz, two percent and feldspar the remainder.

X At locality 8, a small mesa in the Yakima valley, a few miles south of Ellensburg and at locality 9 on the north slope of Manastash Ridge are sandstone beds which dip about 15° to the north. Similar beds with dips up to 45° to the north are exposed in the irrigation ditch cuts on the north side of Manastash Ridge, both east and west of the Yakima River. Bipyramidal quartz is a constituent of the lights in some of these beds and apparently provides a correlation with those at locality 7. X

At locality 10 on the Dry Creek road, the contact of the Ellensburg with the basalt is visible for about fifty feet along the road cut. The basalt is vesicular and has pillow structures and the contact is apparently conformable. North of the contact the beds dip about 5° to the north. Over the basalt, they are horizontal and south of the basalt they dip to the south from 5° to 10°. As only one component of the dip is visible, it is difficult to ascertain whether the change in dip is due to a small flexure or is a depositional feature.

Reference to the geological map (Appendix A) will show a small "window" of basalt in Dry Creek valley. The actual outcrop is not as large as indicated on the map, for a small outcrop of sandstone was found on the nose of the hill between the two forks of Dry Creek. On the north side of the hill, a short distance up the valley, massive conglomeratic sandstone beds dip about 10° south into the hill. The relations suggest a flow intercalated with the Ellensburg, especially as the basalt is columnar here, unlike that exposed in the road cut. However, as the attitude of the columns indicates a slight dip to the north, a flexure may be involved.

At locality 11 on Taneum Creek, about 150 feet of coarse, gray, massive sandstone is poorly exposed above approximately 100 feet of basalt and below two small knobs of basalt which Smith (1903) found to be the remenents of a small flow. Except for the relatively high percentage of hypersthene and zircon in the heavies, the sandstone appears to be typical Ellensburg. The relative abundance of these minerals may be due to contamination of this Ellensburg during deposition by materials derived from another volcanic source. The basalt capping this sandstone is evidently not the same as the Wenas basalt, as it appears to stratigraphically overlie most of the Ellensburg in this area.

Less Typical and Doubtful Occurrences of the Ellensburg.

Localities in the vicinity of Ellensburg -- At locality 11, beneath the lower basalt, is a twenty foot thickness of beds which outcrop along the Taneum Creek road for about one hundred yards. They are of indurated coarse sandstone and conglomeratic sandstone.

Heavy minerals, localities 11 - 13

Locality	Hornblende	Magnetite	Hypersthene	Biotite	Anthophyllite
11	70	18	12		
12	53	44	3		
13	80	8	5	5	2

These beds contain the highest percentage of hypersthene found in any of the beds sampled. It is believed that this may be of genetic significance. According to Beck (1948), fossil leaves similar to those in the middle Miocene Latah formation have been found at several localities along the Taneum Creek road and on the slopes above. Presumably, the leaves have been collected from beds corresponding to both the upper and lower sandstones at locality 11. This points to an earlier age for the beginning of Ellensburg deposition than previously recognized. The abundance of hypersthene may prove of value in tracing the lower beds farther to the west, as the eastward dip indicates that they should be found at higher elevations to the west. Recently, Waters (1948) has found beds of Ellensburg type beneath the Wenas basalt on Yakima Ridge northeast of Yakima. A correspondence with the lower beds on Taneum Creek is indicated, but is at present indeterminable.

Locality 12 is about 500 feet above Taneum Creek on the north side of the valley. A small outcropping of sandstone was found here. Basalt is exposed about fifty feet below, but the contact was not seen.

PLATE XLII

HISTOGRAMS, LOCALITIES 11 - 16

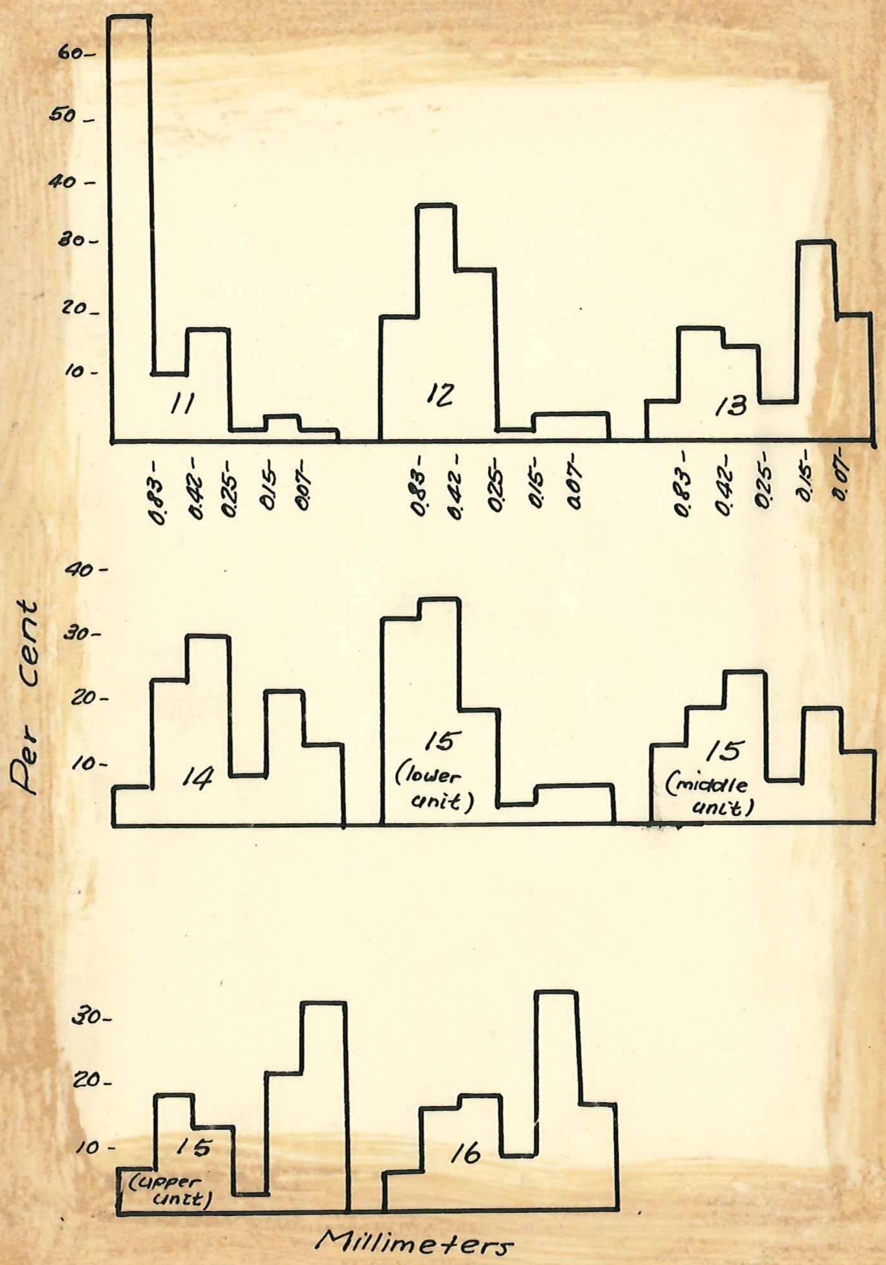


PLATE XIV

ELLENSBURG TYPE BEDS BENEATH THE LOWER BASALT ON TANEUM CREEK AT LOCALITY 11

Beck (1948) reports the finding of Latah type fossil leaves almost at the top of the ridge above this locality. Whether the upper or lower beds of locality 11 are represented here is not known, but a continuance of Ellensburg type beds beyond their previously known extent in this area is indicated.

Locality 13 is on the south bank of Taneum Creek, about one-fourth mile above the Guard Station at the western end of an area mapped as Manastash formation. An apparently horizontal bed of tuffaceous sandstone is exposed here. Basalt may be seen across the creek at a slightly higher elevation. The petrographical character of this sandstone is different than that of the Manastash sandstones as described by Smith (1903). The Manastash sandstone is described as arkosic and similar to that of the Eocene, Swauk and Roslyn formations, which contain very little glass, unlike the Ellensburg. It is possible that the sandstone at locality 13 represents an early phase of the volcanic activity which apparently culminated in Ellensburg time. Further evidence for this view is afforded by Beck who states that middle Miocene fossil leaves have been found in this vicinity, although not far below the Guard Station Eocene leaves have been collected from steeply dipping beds.

Locality 14 is near the south end of the mesa which extends for several miles along the east side of the Yakima River, north of Ellensburg. The Ellensburg beds at this locality should be a stratigraphically higher continuation of those at locality 7 as they vary in attitude from horizontal to a dip of about 5° to the southeast, as nearly as the channeling and lensing will allow measurement. The beds are very loosely consolidated here, having the character of sand and gravel. Basalt pebbles and granules comprise as much as fifty percent of the coarser sands and the gravels. Pebbles of quartz, quartzite and granitic rocks are abundant. The heavy minerals are magnetite and hornblende varying from ninety-nine percent hornblende to almost equal amounts of each. Many of the grains are rounded and limonitic oxidation is commonly present. The lights are glass and plagioclase which is somewhat rounded.

The petrographical character of these beds indicates that they are composed essentially of the same materials now being carried by the Yakima River and the structural conditions indicate that they are unconformable upon the Ellensburg of locality 7. These sands and gravels continue north for about two miles and may be seen on the east side of the southern end of the mesa. The probable relations of these beds to those at locality 7 are shown on structure section A-A of Appendix B.

Locality 15, east of the Central Washington College of Education at Ellensburg is one of the localities considered typical by Smith (1903). A low north-south trending ridge is the surface expression of the beds mapped as Ellensburg formation here. The beds are well exposed in the railroad cut about 200 yards south of the highway. Three stratigraphic units are visible. The lowest is a pebble conglomerate approximately 18 feet thick as measured in the exposure. It dips about 5° to the southeast, although the cross bedding and torrential bedding have steeper inclinations. A buff colored coarse sand comprises the matrix of this unit and forms lenses within it. About 75 % of the pebbles are basalt together with white quartz, some indeterminate green and black igneous rocks and a few of the Ellensburg type andesite. The middle unit is a cobble conglomerate also dipping about 5° to the southeast and filling channels in the lower conglomerate. The cobbles are almost entirely of basalt. In both of the conglomerates some of the pebbles and cobbles are flattened and have an imbricate structure with their flat sides inclined toward the northwest. The upper unit consists of silty and sandy beds with lenses containing pebbles of basalt, quartz, purple and green igneous rocks and a few of Ellensburg type. The dip is about 15° to the southeast at the western end of the exposure and gradually lessens to about 5° at the eastern end in a distance of approximately 200 feet. The contact with the middle unit is irregular.

Heavy minerals, locality 15

	Hornblende	Magnetite	Hypersthene	Biotite	Zircon	Zoisite	Turbid
Upper unit	81	10	5	3	tr.	tr.	1
Middle unit	53	31	6	1	2	5	3
Lower unit	54	28	2	1	1	5	9

Petrographically as well as structurally, the beds at this locality differ markedly from those of the Naches-Wenas occurrences. The lights as well as the heavies contain more kinds of minerals and almost all the grains exhibit evidence of wear and alteration. Many of the hornblende and magnetite grains are completely oxidized. In addition to the usual plagioclase and glass, quartz, orthoclase and some plagioclase of Ab 46 composition is present.

Locality 16 is on the north side of Kittitas Valley about eight miles east of Ellensburg and two miles south of the highway between Ellensburg and Vantage. A light gray tuffaceous sandstone underlain by a siltstone which contacts vesicular basalt may be seen at several places within the vicinity. The contact with the basalt appears to be somewhat irregular and is inclined to the north from a few degrees to 45°. The heavy mineral assemblage differs from that of the Ellensburg and the lights consist of plagioclase and only 5% glass unlike the Ellensburg. The beds are at variance structurally and petrographically with the alluvial fill in Kittitas Valley, which has an abundance of basalt pebbles. They may be intercalated with the Yakima basalt, but no upper cover was seen.

Heavy minerals, locality 16

Hornblende	Biotite	Zircon	Zoisite	Turbid (Clinozoisite?)
40	3	5	12	40

<u>Localities in the Yakima area</u> -- Locality 17 is about 100 feet above the Yakima River on the north side of Yakima Ridge. Beds dipping about 5° to the south are exposed in a large irrigation ditch cut here. To the south the river cuts through Yakima Ridge at Selah Gap exposing the anticlinal structure of the ridge. The beds on the north side of the anticline dip about 15° to 20° to the north and the Wenas basalt

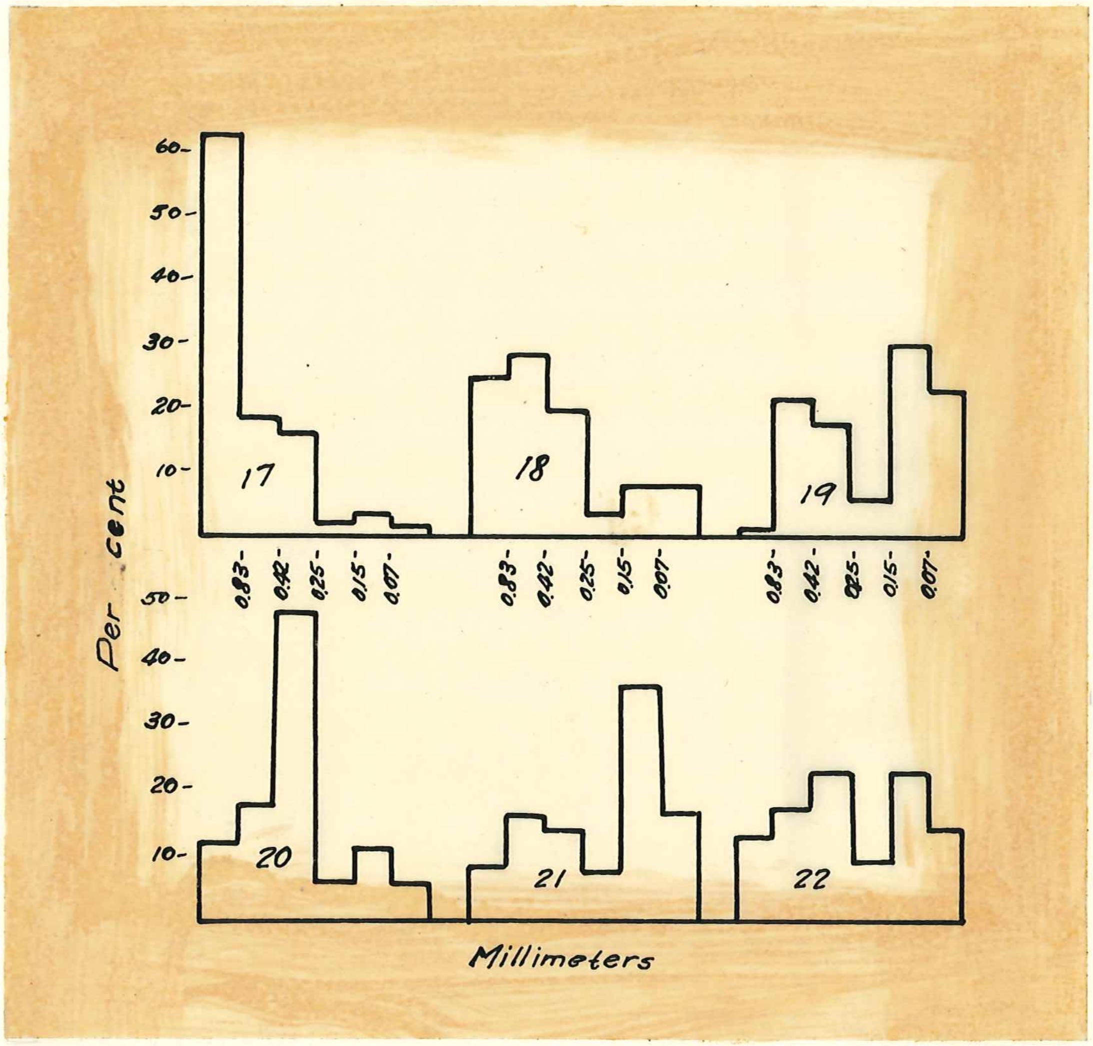
and the lower Ellensburg outcrop about 500 feet above the river level. There is an apparent structural disunity here which may be due to a fault, a very sharp flexure or an unconformity. As the beds have the megascopic properties of typical Ellensburg and the heavies consist of 75% hornblende and 25% magnetite it is probable that they parallel the basalt which may be seen to have a low south dip several miles to the north.

At several localities to the west and south of Yakima the Ellensburg seems to have features not in harmony with those of the Naches-Wenas beds. Much of the area between Cowiche Mountain and Ahtanum Ridge has a low relief and good outcrops are very difficult to find. Field work, therefore, produced no conclusive results, but certain observations, both field and petrographic, indicate that much of this Ellensburg is not typical.

In the area of locality 18, just east of Yakima, beds with the petrographic characteristics of the Ellensburg are overlain by conglomerates and sandstones containing reworked Ellensburg materials and pebbles of basalt and a dark porphyritic rock, which is evidently the Tieton andesite. A representative sample from the apparently true Ellensburg beds contains as heavy minerals; 73% hornblende, 24% magnetite and 3% biotite and as light minerals, the usual glass and plagioclase. These beds are essentially horizontal and show no evidence of cross bedding, but the conglomeratic beds have torrential and cross bedding which dips to the south as though they may have been deposited by the Yakima River.

PLATE XV

HISTOGRAMS, LOCALITIES 17 - 22



At locality 19 on Cowiche Mountain are sandstone beds which dip about 10° to the southeast. The attitude seems to parallel the flank of the Cowiche Mountain anticline, as might be expected of the Ellensburg, but the minerals indicate a derivation in part from a source foreign to that of the Ellensburg. The large proportion of biotite in the heavies and the presence of three or four percent of muscovite in the lights suggest an area of granitic rocks as a secondary source.

Heavy minerals, locality 19

Hornblende	Magnetite	Biotite	Zircon	Turbid
60	20	20	tr.	tr.

At locality 20, in the Cowiche Basin, similar sandstone was found overlying vesicular basalt. It was not certain that this locality was within the area mapped as Ellensburg in the basin, but the sandstone was the only sedimentary rock seen in the vicinity except for some slope wash containing a few andesite pebbles.

At locality 21, on the south slope of Ahtanum Ridge about three miles west of the Yakima River, no beds of Ellensburg type were found, although a large area of Ellensburg is indicated in the Ellensburg Folio. At a few places, friable gray and brown silty sandstones were seen. A sample taken from an outcrop at about 300 feet above the river level is representative. There were very few heavy mineral grains and these were of biotite and a trace of hornblende. The lights consisted of about 10% glass, 5% muscovite and 85% feldspar. At lower elevations, the basalt has a gentle dip and the sandstones appear to parallel the basalt, but at this locality neither the attitude nor the contact with the basalt was seen.

At locality 22 in Wide Hollow at the town of Harwood, a road cut exposes conglomerate channeled into sandstone. The attitude of both beds is nearly horizontal. Although the heavy minerals are the same for both beds and the lights are predominantly of glass together with plagioclase, the conglomerate contains almost as many basalt pebbles as andesite and the sand matrix has the limonitic staining characteristic of post-Ellensburg alluvium.

At other localities in the area between Cowiche Mountain and Ahtanum Ridge, the same sequence is present. The relative scarcity of magnetite is characteristic and may be of significance, but lack of satisfactory outcrops prevented the obtaining of any conclusive evidence.

Comparison of the Ellensburg with Other Formations

Petrographic studies were made of samples collected from several localities at which there are exposures of sedimentary rocks which are similar to the Ellensburg either in respect to age or appearance. Due to the general absence of paleontological evidence, such a comparison may be of value in defining the Ellensburg.

At locality 23, about 15 miles E of Ellensburg on the highway to Vantage, an interbasalt silty sandstone is exposed. The histogram for this locality is not accurate as the sample was very difficult to disaggregate properly. The heavies comprised only a small fraction

Heavy minerals, localities 23-27

Locality	Hornblende	Magnetite	Hypersthene	Biotite	Zircon	Clino-zoisite	Turbid
23	25	5		45	tr.		25
24	53	6	5	2	tr.	5	29
25	95	5	tr.		tr.		
26	93	5	2				
27	60	10		30	tr.	tr.	

of the sample. The high percentage of biotite differentiates this sample from those taken from the Ellensburg. Glass constitutes most of the light fraction. It is more devitrified and has a slightly higher index of refraction than that in the Ellensburg. Angular fragments of plagioclase comprise about 1% of the lights.

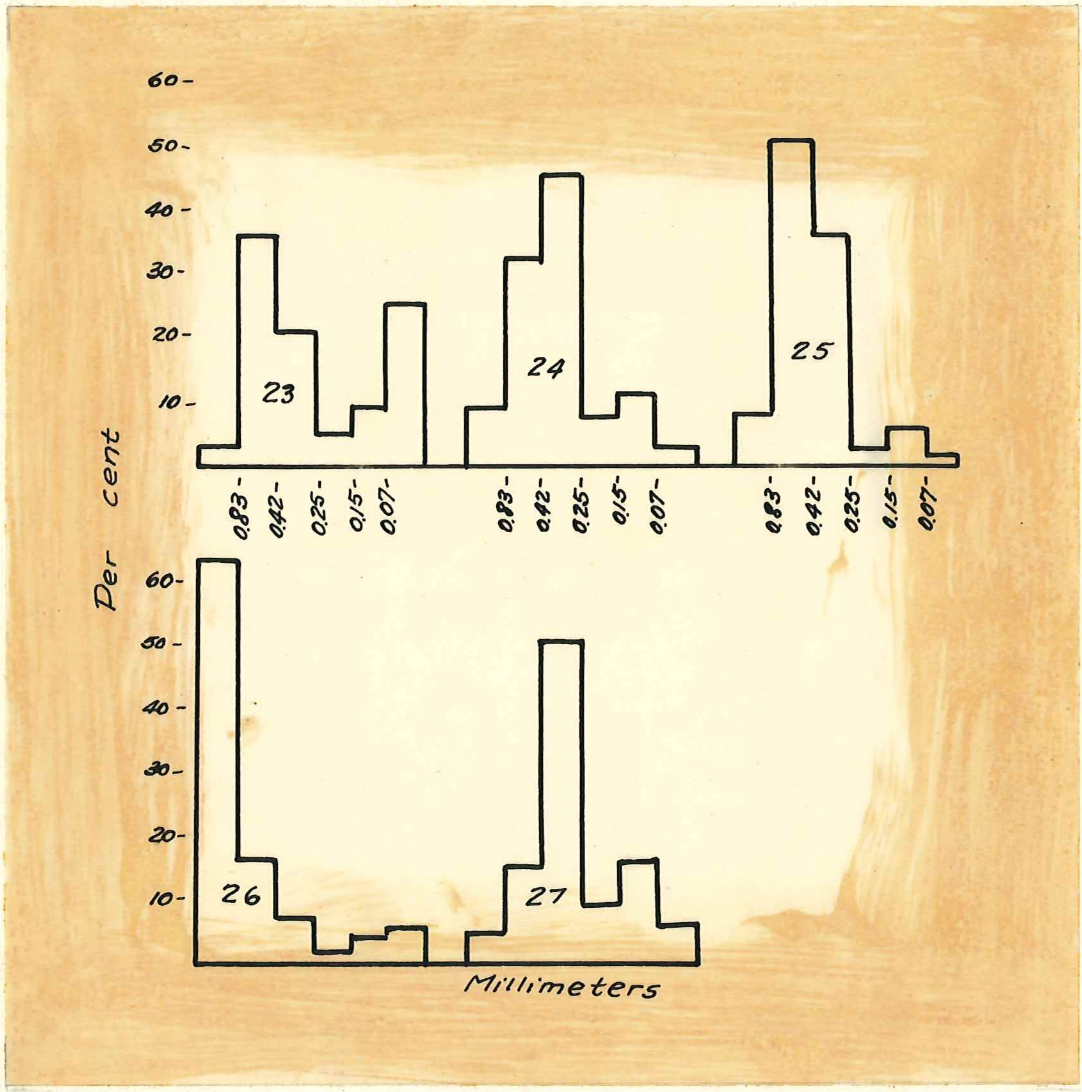
Samples were collected from interbasalt beds near Vantage on the Columbia River and from a locality near Grand Coulee Dam. Biotite forms a large part of the heavies in these samples and quartz and muscovite are conspicuous in the lights.

Samples were collected from three localities at which there are occurrences of the Hood River conglomerate.

Locality 24 is at Saddle Mountain on the east side of the Columbia River. This occurrence was mentioned by Warren (Feb., 1941) and the stratigraphic sequence was measured and described by Carithers (1946). Approximately 200 feet of sandstones and conglomerates are exposed between basalt flows. The conglomerates contain the abundant basalt

PLATE XVI

HISTOGRAMS, LOCALITIES 23-27



and quartzite pebbles, which together with the structural relations, serve to identify the Hood River conglomerate. The heavy and light mineral content is like that of the Ellensburg except for the clinozoisite and the abundance of turbid grains. Few of the crystals are as well shaped as those in the Ellensburg. Near the top of the sequence are beds of pumicite as described by Carithers. These consist of 95% or more of fluted, clear, flakes of glass. The refractive index is 1.52 like that of the Ellensburg glass, but no glass of similar appearance was found in the Ellensburg. A source of andesitic material distinct from that of the Ellensburg is indicated.

Locality 25 is about two miles east of the Yakima River on the north slope of the Rattlesnake Hills, the eastern continuation of Ahtanum Ridge. Beds of the Hood River conglomerate dipping about 70° to the north are interbedded with Ellensburg type sandstone. Somewhat better sorting is apparent in these beds than in those at typical Ellensburg occurrences, but they are mineralogically similar to the Ellensburg. The proportions of hornblende are similar to those in the samples from the area between Cowiche Mountain and Ahtanum Ridge, west of the Yakima River.

Locality 26 is on the northwestern end of Snipes Mountain near the town of Granger. Beds of Hood River conglomerate type interbedded with Ellensburg type sandstone dip about 20° to the north parallel to the surface. The beds are mineralogically similar to those at locality 25, the degree of sorting is similar and pumice fragments are much less abundant than in most of the Ellensburg beds.

Locality 27 is near Ringold on the east side of the Columbia River. Several samples were collected from the Ringold formation, which is exposed here in bluffs about 150 feet high. The beds are mostly of silty sandstones with interbedded coarser sandstones. Those that are cemented with calcium carbonate form small scarps. The biotite in the heavies and the muscovite and quartz in the lights differentiate this formation petrographically from the Ellensburg. The grains are much more worn and altered than those in the Ellensburg.

The alluvium in the valleys of the Yakima River and its tributaries within the outcrop area of the Ellensburg differs from the Ellensburg in that pebbles of basalt are abundant and there are other igneous and metamorphic rocks foreign to the Ellensburg. Although the sand grains in most of the alluvium contain the Ellensburg mineral assemblage, the grains are worn and oxidized in contrast to the very fresh crystals in the Ellensburg.

THE STRUCTURE OF THE ELLENSBURG

Fig. 1. Structural map of the Ellensburg quadrangle showing anticlines (red) and synclines (blue).

THE STRUCTURE OF THE ELLENSBURG

In the occurrences regarded as typical, it is quite certain that the lower beds are conformable to the basalt and are folded with the basalt. This relation is especially clear in Wenas Valley where the lower Ellensburg is intercalated between the Yakima basalt and the Wenas basalt. The thick deposits between the lower Naches and Wenas valleys owe their preservation to rather special structural conditions. The Cleman Mountain anticline turns northeast to join the Umptanum Ridge anticline. The Cowiche Mountain anticline trends northeast and joins the eastward trending Yakima Ridge. Between these two major anticlines and the minor ones between Umptanum Ridge and lower Wenas Creek is a structural basin with its low point about four miles west of the Yakima River. It is probable that the upper beds in this basin were deposited as the folding progressed. Weaver (1937) has concluded that the folding of the Miocene basalt and the intercalated marine Astoria formation in western Washington took place late in the middle Miocene. If the accepted upper Miocene to lower Pliocene age of the Ellensburg is correct, the upper beds must have been deposited in structural troughs as the structures in western and central Washington can be traced through the Cascade Mountains.

In the Ellensburg area, the beds described as typical are apparently in conformity with the basalt, but structural and petrographical evidence indicate that the beds at Ellensburg and on the south end of the mesa northwest of Ellensburg are unconformable to the basalt and the typical Ellensburg.

CONCLUSIONS

As a result of field and petrographic studies, it is possible to classify the beds mapped as Ellensburg formation in the Mt. Stuart and Ellensburg quadrangles into at least five separate stratigraphic units.

At Ellensburg are three units; 1) the upper beds which may have been deposited by Wilson Creek as an alluvial fan, 2) the cobble conglomerate and 3) the pebble conglomerate. The latter two units were evidently deposited by the Yakima River. All three units are stratigraphically younger than the typical Ellensburg exposed to the north and south.

In the Naches-Wenas occurrences are two units which are regarded as the most typical Ellensburg. These are; 1) the beds above the Wenas basalt and 2) the beds below the Wenas basalt. Other occurrences in the Mt. Stuart and Ellensburg quadrangles have been found to correspond to these units.

In addition there are other units which cannot be definitely classified at present. These are; 1) the beds on the south end of the mesa north of Ellensburg, which may correspond to one of the units at Ellensburg, 2) and 3) the two interbasalt units on Taneum Creek, neither of which seem to correspond to the beds below the Wenas basalt, 4) the beds in the Cowiche Mountain - Ahtanum Ridge area which are petrographically dissimilar to the typical Ellensburg.

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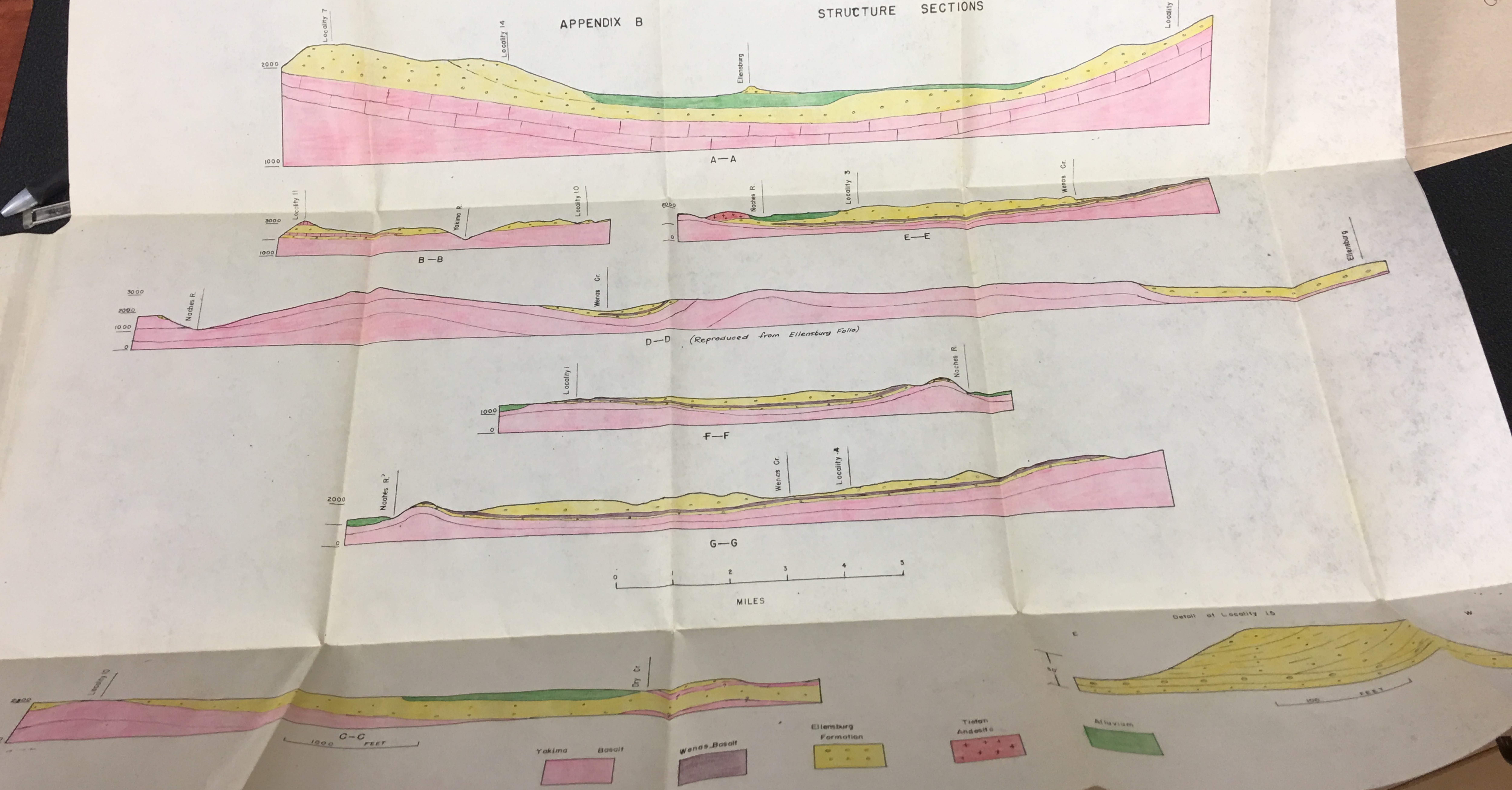
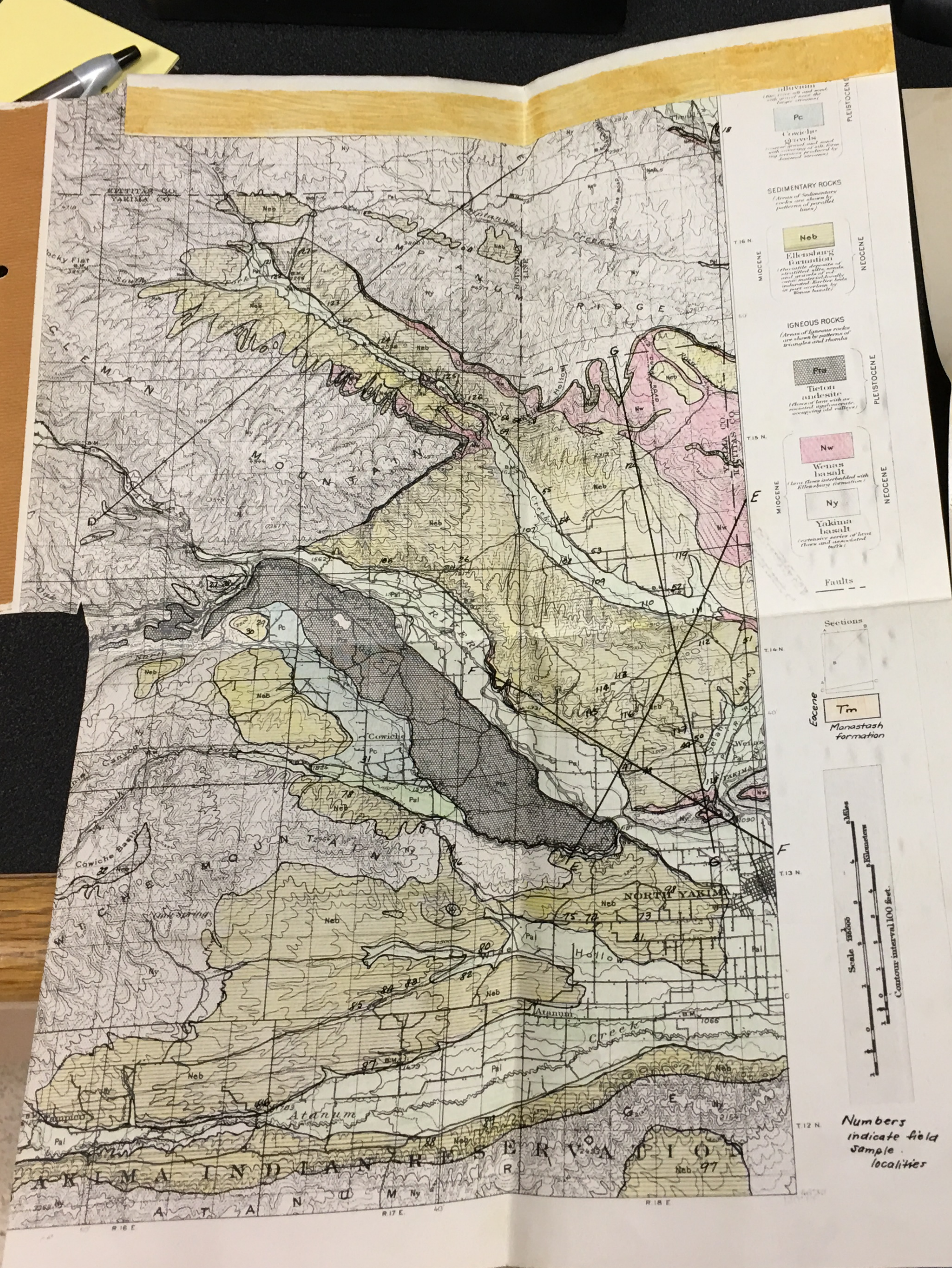
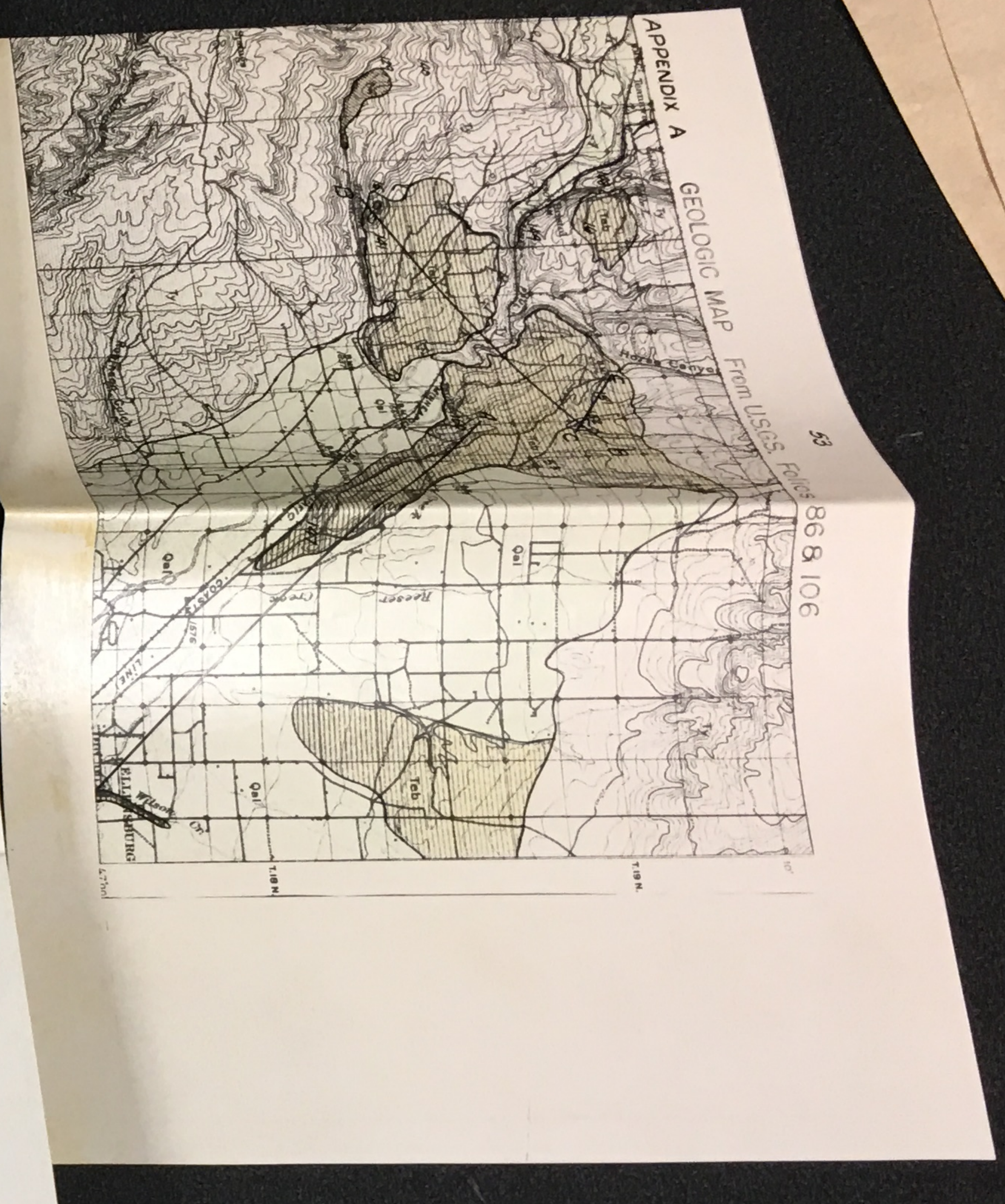
APPENDIX B

STRUCTURE SECTIONS




UMPTANUM RIDGE
COLEMAN
MOUNTAIN
KITTITAS CO.
YAKIMA CO.
Cowiche
Cowiche Basin
NORTH YAKIMA
Atanum
Atanum Creek
Hollow
Selah
Wenas
YAKIMA INDIAN RESERVATION
ATANUM RIDGE
Neb
Ny
Nw
Pc
Pal
Pta
D
E
F
G
T.16 N.
T.15 N.
T.14 N.
T.13 N.
T.12 N.
R.16 E.
R.17 E.
R.18 E.
alluvium
Pc
Cowiche gravels
PLEISTOCENE
SEDIMENTARY ROCKS
(Areas of Sedimentary rocks are shown by patterns of parallel lines)
Neb
Ellensburg formation
(fluviatile deposits of stratified silts, sands and gravels of volcanic material, locally indurated. Earlier beds in part overlain by Wenas basalt)
MIOCENE
NEOCENE
IGNEOUS ROCKS
(Areas of Igneous rocks are shown by patterns of triangles and rhombs)
Pta
Tieton andesite
(Flows of lava with associated agglomerate, occupying old valleys)
PLEISTOCENE
Nw
Wenas basalt
(lava flows interbedded with Ellensburg formation)
Ny
Yakima basalt
(extensive series of lava flows and associated tuffs)
MIOCENE
NEOCENE
Faults
Sections
Eocene
Tm
Manastash formation
Scale
Miles
Kilometers
Contour interval 100 feet.
Numbers indicate field sample localities


APPENDIX A GEOLOGIC MAP From USGS Folios 86 & 106
53
Qal
Tsb
T.18 N.
T.19 N.