BEDROCK GEOLOGIC MAP OF THE ALBION 7 ½ MINUTE QUADRANGLE, WHITMAN COUNTY, WASHINGTON.

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INTRODUCTION

The bedrock geologic map and cross-sections of the Albion quadrangle were constructed primarily from examination of major outcrops and water well drill logs (Table 1). The principal rock units include the basalts of the Columbia River Basalt Group (CRBG) and older metasedimentary rocks. Regional maps by Swanson and others (1980) and Gulick (1994) were also used in the compilation. Examination of outcrops and well logs on all adjoining quadrangles assisted with determination of stratigraphic units and structural trends.

Distribution of loess of the Palouse Formation is not illustrated on the map in keeping with the emphasis on bedrock geology. For the same reason colluvium next to topographic highs of pre-CRBG units is generally not shown. However, alluvium and colluvium associated with the major streams are illustrated, because their map patterns help interpret bedrock contacts and structural relationships in basalt terrains (Bush and others, 1998). Continuous outcrops are rare and contacts between basalt and the older units are covered with loess and colluvium. Therefore, the contact lines are interpretive.

The lack of exposures and deep drill data make structural interpretations difficult on the Albion quadrangle. The most significant structural features of the CRBG in the eastern margin of the Columbia Plateau are broad folds with shallow plunges. Such folds are difficult to detect without detailed mapping on a regional scale. Geologic work in recent years has shown that the basalts are much more structurally complex in the Moscow-Pullman area than previously thought (Bush and others, 2001; Teasdale and others, 2001; Teasdale 2002; Bush and Garwood, 2003). Attitudes of basalt units and fold axial traces are illustrated wherever possible. The structure and

stratigraphic nature of the basalt of the northern half of the quadrangle was particularly hard to interpret because of the lack of basalt chemical data from wells.

DESCRIPTION OF MAP UNITS

QUATERNARY DEPOSITS

Qac Alluvium and Colluvium (Holocene) – Stream, slope-wash, and debris-flow deposits in drainage areas. Composition consists of loess, basalt, and pre-CRBG materials. The South Fork of the Palouse River and Fourmile Creek commonly contain mixtures of granule and sand-sized basalt and quartz fragments. In the intermittent drainages, reworked loess is more common. Close to pre-CRBG topographic highs, fragments of loess and poorly rounded quartz and quartzite fragments occur in poorly sorted mixtures.

Qls Landslide Deposits (Holocene-Pleistocene?) – Talus and slump blocks of quartzite dominate the wooded north side of Kamiak Butte (Gulick, 1994).

Ql Palouse Formation (Pleistocene) – Silty and clayey loess of the Palouse hills. Shown in cross-section only.

COLUMBIA RIVER BASALT GROUP (CRBG)

The stratigraphic nomenclature of the Columbia River Basalt Group is based on that presented by Swanson and others (1979). The sequence is divided into four formations: from base upward, these are the Imnaha Basalt, Grande Ronde Basalt, Wanapum Basalt, and Saddle Mountains Basalt. On the Albion quadrangle no units of the Imnaha and Saddle Mountains formations have been identified. At the surface only outcrops of the Priest Rapids and Roza Members of the Wanapum Formation were noted.

WANAPUM FORMATION

Tpr Priest Rapids Member (Miocene) – Medium- to coarse-grained basalt with phenocrysts of plagioclase and olivine in a groundmass of intergranular pyroxene, illmenite blades, and minor devitrified glass. Other workers have previously identified and described these flows which have reverse magnetic polarity (Wright and others, 1973; Swanson and others, 1979). This basalt is exposed in quarries and small road cuts throughout the quadrangle.

No outcrops were sampled and analyzed for verification. Samples from the Palouse quadrangle to the northeast (Duncan, 1998) show that the Priest Rapids Basalt is the Lolo chemical type of Wright and others (1973). Hooper and Webster (1982) note that in the Pullman area to the south, the Lolo chemical type underlies much of the area and that the Rosalia chemical type occurs locally.

Tr Roza Member (Miocene) – Consists of basalt with abundant plagioclase phenocrysts. The phenocrysts average about 10 mm across and occur with phenocrysts of olivine and augite in an intergranular groundmass. Small outcrops of these flows occur in the western edge of the quadrangle along the South Fork of the Palouse River and Fourmile Creek. The unit, which is approximately 100 feet thick near the western edge, is interpreted to pinch out to the east by at least the mid portion of the quadrangle. Typically the lower and upper portion of this unit is underlain and overlain by Latah sediments.

GRANDE RONDE FORMATION

Tgr_{N2}, Tgr_{R2} (Miocene) – Consists of flows of fine-grained to very fine-grained aphyric basalt. Shown in cross-section only. Though not exposed, the Grande Ronde is interpreted to occur beneath the Wanapum throughout much of the quadrangle. Regional maps and well chip chemistry shows the presence of the upper most flows (N2-normal polarity) on nearby quadrangles (Swanson and others, 1980; Hooper and Webster, 1982; Gulick,

1994; and Bush and others, 2001). The Grande Ronde has been subdivided based on chemistry in several wells in the Pullman area (Bush and others, 2001). That stratigraphic work was extrapolated northward and used to construct the cross-sections for the southern part of the Albion quadrangle, but without deep well data the thicknesses and stratigraphic relations illustrated must be considered estimates. An isopach map showing potential thickness using geophysical methods by Klein and others, (1987) was also used. If their work is correct, the thicknesses illustrated in the cross-sections would be a maximum.

LATAH FORMATION

Tl (Miocene) – Consists of clay, silt, sand, and minor gravel deposits that range from a few feet to over 75 feet in thickness. The sand is angular to surrounded, poorly sorted, and consists primarily of quartz with muscovite common in places. The term "Latah Formation" is typically used for any sequence of sediments interlayered with or associated with Miocene basalt flows of the CRBG. On the Albion quadrangle two exposures were noted about one mile south of Albion along the Pullman-Albion highway. That interbed occurs between the Roza and Priest Rapids members. Well data show that the Vantage Member of the Latah Formation can be correlated north from the Pullman area into the southeastern part of the quadrangle. In that area, the nature and thickness of the Vantage varies. In some wells no interbed was noted. Typically the interbed is less than 20 feet thick. The term "Vantage" is used herein to denote the interbed between the lowermost Wanapum and uppermost Grande Ronde (Siems and others, 1974). In the northern half of the quadrangle, most of the shallow wells (<300 feet) encountered thin interbeds, but accurate correlation of the Vantage was not possible because of the lack of basalt chemical data.

PRE-CRBG UNITS

The pre-CRBG units on the Albion quadrangle consist primarily of quartzite, which makes up the resistant ridges of Kamiak Butte and Smoot Hill. A less resistant argillite-phyllite unit occurs

north of Kamiak Butte. Both of these units lack the ability to transmit large quantities of ground water and understanding their contact relations with the basalt units is important. All existing topographic, well, float, and outcrop data available were used in constructing the geologic map and associated cross-sections. However, it must be understood that the contact lines represent a working basis for future workers and are only approximations.

Cqk Quartzite of Kamiak Butte (Cambrian?) – Consists primarily of massive-bedded quartzite with minor schist and phyllite (Gulick, 1994). The quartzite is white to creamy white, light gray to bluish purplish gray, pink, and reddish brown. It consists primarily of recrystallized quartz with small amounts of feldspar, muscovite, and biotite locally. The quartz grains, where visible, range from well sorted to poorly sorted and would typically be described as "clean" due to the very high percentage of quartz. Though recrystallized, inconspicuous relict bedding planes, laminations, and cross-beds are present in places. The best exposures of this unit are on top of and along the north slopes of Kamiak Butte. Exposures on Smoot Hill are rare, but where exposed, the quartzites exhibit a higher grade of metamorphism.

There has not been an accepted stratigraphic age for this quartzite sequence (Savage, 1973; Hooper and Webster, 1982; and Bush and Provant, 1998). Hooper and Webster (1982) believed that the rocks could be Cambrian in age based on their similarity to Cambrian quartzite in northeastern Washington and suggest the name "quartzite of Kamiak Butte". This report follows that suggestion. The quartzite lacks the feldspar of Belt Supergroup quartzite and field relations suggest it overlies the Belt rocks, although no outcrop proving that relationship has been noted. However, detrital zircon signatures of Kamiak Butte rocks suggest they are consistent with easterly derived units of the Belt Supergroup (Ellis and others, 2004).

BELT SUPERGROUP

Pasp Undivided argillite, siltite, and phyllite (Precambrian) – Consists of greenish-gray argillite and light gray siltite with minor micaceous phyllite in places. Relict bedding

consists of alternating light gray siltite and dark gray argillite laminations and microlaminations. Gulick (1994) noted two occurrences of the unit to the north on the adjoining Elberton quadrangle and describes the unit primarily as phyllite. From those occurrences the unit was extended onto the northern edge of the Albion quadrangle by mapping small exposures, float, and interpreting shallow well data. The laminations and microlaminations of this unit are typical of the Belt Supergroup throughout nearby northern Idaho.

GENERAL GEOLOGIC DISCUSSION

Regionally, the basalt units on the Albion quadrangle are part of the Palouse Slope located on the eastern edge of the Columbia Plateau (Reidel and others, 2002). However, the presence of pre-CRBG rocks disrupts the westward regional dips common to that slope. The northwestern part of the quadrangle is dominated by Smoot Hill and Kamiak Butte. West of these ridges of pre-CRBG rocks the basalt units dip primarily to the west, but on the east and southeast of the Albion quadrangle the basalt dips, in most places, to the east and southeast. The attitude of the basalt is difficult to determine along the eastern edge of Smoot Hill, but the basalt units clearly dip southward and southeastward on the southern side of Kamiak Butte.

On the west side of both buttes the Roza Member thins and pinches out beneath the Priest Rapids near the quartzite. Two exceptions are where Fourmile Creek and the South Fork of the Palouse River exit westward through eroded gaps in the Pre-CRBG rocks. At those locations the Roza extends eastward for at least one mile before pinching out, which is significant because it denotes a westerly dip for the upper Grande Ronde surface along the western edges of Smoot Hill and Kamiak Butte. The Roza is approximately 200 feet thick in Colfax southwest of Albion, but thins eastward and the top of the Grande Ronde rises 200 feet over the same distance. Therefore, the quartzite units mark a change in geologic structure and may create a potential boundary condition for ground water flow. Whether ground water flow occurs in any significant amount across the gaps depends primarily on the thickness of basalt in those two areas. Data from Holom (2006) shows that the basalt extends downward to at least 2065 feet in the center of the Fourmile gap.

The southern part of the quadrangle is dominated by its location on a large northwest-trending anticlinal high that extends into the southwest corner of the area from the Pullman quadrangle. This feature is part of a subsurface topographic high on top of the Grande Ronde that Bush and Garwood (2003) have documented. However, the nature of the feature is not clearly defined on the Albion quadrangle due to a lack of subsurface basalt chemical data and the irregular nature of the sediments between the Wanapum and Grande Ronde Formations. In the southeastern corner of the quadrangle the Vantage interbed is known to change in thickness from absent to over 75 feet thick and it is not uncommon for the interbeds to change in composition between wells. Clays are most common, but sand and silt are also present. Some wells have more than one interbed and, therefore, the top of the Grande Ronde cannot be determined without basalt chemistry.

Part of the inconsistency in subsurface relations is due, in part, to the thinning and pinching of the Roza from the west against the high. Such pinching from approximately 100 feet thick on the western edge of the quadrangle to absent on the eastern side caused rapid lateral changes in sedimentation, and contact relations. The two cross-sections (AB and CD) illustrate potential relations near Albion on the western end of the quadrangle. These types of relations should also exist in the gap between Smoot Hill and Kamiak Butte in the northwestern area.

The thickness of the Grande Ronde on the Albion quadrangle could be important in controlling the nature of the water resources for the area. Although there are no deep wells, some geophysical data is available. Klein and others (1987) report the existence of a pre-CRBG rock shelf that extends east from Smoot Hill 1½-2 miles east where the entire basalt and sedimentary sequence is less than 1000 feet. The same report shows the potential for a thick sequence of Grande Ronde extending north-northeast from Pullman towards Palouse. This extra thickness, if present, would lie under the southeast portion of the Albion quadrangle along the eastern edge of the pre-CRBG shelf. A computer model of the pre-CRBG surface by Opatz (2003) shows a deep valley also extending between Palouse and Pullman, which roughly corresponds to the location of the potential thick sequence of basalt. The interpretation is that the pre-CRBG drainage was from Palouse to Pullman. The earliest CRBG flows plugged this valley and began to force

drainages northward as the canyon areas to the south of Pullman were filled. In summary, it is interpreted that the total basalt thickness is around 1000 feet over much of the quadrangle with the potential of rapid thickening to the east over the pre-CRBG stream channel on the very eastern edges of the quadrangle.

GENERAL HYDROLOGICAL DISCUSSION

The pre-CRBG rocks provide little to the overall ground water supply. Most domestic wells on the Albion quadrangle are from basalt aquifers, but the supply is inconsistent and unpredictable. This unpredictable nature of the aquifer differs from the Palouse and eastern Moscow area where the Wanapum provides consistent and dependable water supplies for domestic use. It is not uncommon for wells in the Wanapum to be dry or have very low production in parts of the Albion quadrangle. It is also not uncommon to have wells of different depths and production within one mile of each other. Several domestic wells are deep enough (300-400 ft.) that they penetrate into the Grande Ronde. These wells have considerable variability in water production and water levels. It places, a separation between higher water levels of Wanapum wells and lower levels for Grande Ronde wells is apparent. In other places the separation is not so clear. All of these variations may be explained by the variability in the nature of the Wanapum-Grande Ronde contact developed on the subsurface topographic high, complicated further by the thinning of the Roza and rapid changes in sediment composition and thickness.

The lack of deep wells in the Grande Ronde prohibits a good understanding of that system. From indirect evidence (geophysics and computer modeling), it is suggested that the Grande Ronde is less than 1000 feet over much of the quadrangle.

The combination of basalt and quartzite dip slopes indicate that ground water movement in the Wanapum and upper Grande Ronde should be eastward from Smoot Hill and south-southeastward from Kamiak Butte. If there is not considerable flow westward at Fourmile Creek and along the South Fork of the Palouse, these dip slopes could be major sources of recharge for both Wanapum and Grande Ronde aquifers to the east and southeast of the quadrangle boundary.

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Table 1 - Wells used in Construction of Bedrock Map of the Albion 7 ½ Minute Quadrangle, Whitman County, Washington.

Well No.	Original Owners Name	Total Depth (ft)	Overburden Thickness (ft)	Geologic & Other Comments	Sources *
W-1	Steve Clark	305	13	No indication of Wanapum/Grande Ronde	Visual
W-2	G.D. Thompson	105	5	Base of Wanapum at 90 ft.	Visual
W-3	McGregor Company	220	Not Determined	Top of Grande Ronde? at 100 ft.	Heinemann (1994)
W-4	James Kinzen	161	11	Base of Wanapum at 134 ft.	Visual
W-5	Jeff West	53	4	Good shallow source of water	Visual
W-6	Alex Migregor	353	45	Top of Grande Ronde at 197 ft.	Visual
W-7	Bill Criste	320	65	No indication of Wanapum/Grande Ronde Contact	Visual
W-8	Western Farms	400	9	Not clear, possible top of Grande Ronde at 180 ft	Verbal
W-9	Walt Zakarison	342	Not Determined	No strong indication of Wanapum/Grande Ronde contact. Possibly red flow top 327 ft.	Visual
W-10	Eric Thompson	340	41	Top of Grande Ronde interpreted to be at 149 ft.	Visual
W-11	George Burrows	183	53	Base of Wanapum at 183 ft.	Visual
W-12	Cocahran Partnership	305	0	Probable top of Grande Ronde at 134 ft.	Visual
W-13	Dumas Corporation	255	33	Probable top of Grande Ronde at 131 ft.	Visual
W-14	Edgar Russell	242	132	Base of Wanapum at 240 ft.	Visual
W-15	Ross Howell	305	21	Possible top of Grande Ronde at 195 ft.	Visual
W-16	J. McInotosh	Not Determined	Not Determined	Use to pick top of Wanapum at elevation 2450 ft.	Heinemann (1994)
W-17	G. Conklin	263	Not Determined	Top of Grande Ronde at 110 ft.	Heinemann (1994)
W-18	B. Collins	230	Not Determined	Top of Grande Ronde at 110 ft.	Heinemann (1994)
W-19	M. Harlow	160	Not Determined	Top of Grande Ronde at 155 ft.	Heinemann (1994)
W-20	J. Morrison	165	Not Determined	Top of Grande Ronde at 160 ft.	Heinemann (1994)

*Visual indicates location of buildings and well log location matched; verbal means some individual was contacted who verified location.