

SPOKANE QUADRANGLE . . . PANTOPS STA. ON INLAND EMPIRE ELECTRIC RR.

AUG 1 1922

ON HILLTOP 1/4 MI EAST OF RR. GNEISSIC GRANITE, SCHISTOSITY DIPPING  $35^{\circ}$  TO SE, STRIKE  $N40-45^{\circ}W$ . MAJOR JOINTS ARE NEARLY VERTICAL AND STRIKE  $N10-12^{\circ}W$ . PEGMATITE VEINS AND DIKES CUT THE GRANITE.

NORTH OF STATION ON WEST OF TRACK IS LARGE GRAVEL PIT EXCAVATED BY THE RR. GRAVEL IS FRESH, DARK GRAY IN COLOR, CURRENT-BEDDED WITH DIP TO SOUTHWARD. DEPTH EXPOSED IS ABOUT 30 FT. SCATTERED THRU THE STREAM GRAVEL ARE HUGE BLDRS CHIEFLY OF GRANITE, AVERAGING 2-3 FEET DIAMETER. BLDRS SUBANGULAR. GRANITE OF LOCAL KIND, PEGMATITE IN SCHISTOSE.

THIS GRAVEL ACCUMULATION LOOKS FROM ITS TOPOGRAPHY AND ITS SITUATION WITH REFERENCE TO BOUNDING ROCK HILLS ON EAST AND WEST AND THE OPEN VALLEY TO THE SOUTH, AS THO IT WERE DEPOSITED AS AN OUTWASH FAN AT THE EDGE OF THE ICE, THE ESCAPING WATER FLOWING SOUTHWARD. IT SLOPES OFF WITH A FAIRLY STEEP FRONT FOR AN ALLUVIAL FAN TO A NEARLY FLAT FLOOR JUST SOUTH OF PANTOPS STA. RANCHES ON THIS VALLEY FLOOR HAVE WELLS 120 FT TO WATER; DUG WELLS. THESE MUST BE IN THE SAME FLUVIOGLACIAL DEPOSIT BUT ON THE FLATTER SLOPES FARTHER FROM APEX OF THE FAN.

BASALT HILLS TO THE WEST. LOOKS LIKE COLUMBIA LAVA IN EVERY RESPECT. HAS THE MOUNDS ON IT

A PIT ABOUT A MILE NW OF PANTOPS ON NORTHWARD SLOPE OF THE BASALT MESA HERE, SHOWS THE SAME THING AS AT PANTOPS. ALTITUDE IS ABOUT 25 FT HIGHER THAN THE PANTOPS DEPOSIT. MUCH BASALT IN THE COBBLES HERE, LITTLE AT PANTOPS. BOTH HAVE SOUTHWARD DIP OF CURRENT BEDS BUT IN THIS SECOND LOCALITY THE BEDS APPEAR TO DIP RIGHT AGAINST THE FLANK OF THE BASALT HILL.

ON THE BASALT MESA, THREE GRANITE BLDRS AT 50 FT ABOVE PANTOPS ALTITUDE.

THE BIG ANGULAR OR SUBANGULAR BLDRS IN THE PANTOPS PIT SHOW CONSIDERABLE DECOMPOSITION ON THE LESS-RUBBED SURFACE. THE GRAVEL IN WHICH THEY ARE EMBEDDED IS FRESH. IT IS OBVIOUSLY THAT THESE BLDRS WERE DERIVED VERY LOCALLY; IN ALL PROBABILITY FROM THE GRANITE HILL ON WHICH THEY NOW LIE. DERIVED FROM THE RESIDUAL BLDRS OF DECOMPOSITION, OUTLINES DETERMINED BY JOINTS AND SCHISTOSITY, NOT FORN OFF BY THE GLACIAL ICE.

WHY DO THEY OCCUR WAY UP IN THE STRATIFIED GRAVEL? THEY MIGHT WELL OCCUR IN THE BASE OF THE DEPOSIT, HOWEVER. IF ICE CAME OVER ~~ON~~ HILLS OF GRANITE CONSIDERABLY HIGHER THAN THIS PANTOPS DEPOSIT, THIS WOULD BE EASILY EXPLICABLE. MAY IT NOT BE CONCEIVABLE THAT ICE HAD NOTHING TO DO WITH THEIR DETACHMENT AND TRANSPORTATION? MAY THEY NOT HAVE ROLLED AND SLID DOWN TO THE ACCUMULATING OUTWASH PLAIN? WHERE IN THE SPOKANE VICINITY ARE UNDOUBTED WISCONSIN TILL DEPOSITS?

SPOKANE QUADRANGLE GARDEN SPRINGS—S.P. & S. RR AND O-W RR CUTS, 2-3 MILES  
SOUTHWEST OF SPOKANE

FOUR CUTS HERE ON EACH RR IN 2 MILES DISTANCE. CHIEFLY IN SHALE ALONG SP AND S; THO BASALT AND SANDSTONE ALSO EXPOSED. CHIEFLY IN BASALT ALONG O-W RR N.P.R.R., ON EAST SIDE LATAH CREEK HERE, HAS ONLY GRAVEL EXPOSED.

SHALE IS HARD AND BLOCKY WHEN DRY, DOES NOT WEATHER INTO LAMINAE VERY STRIKINGLY. CHIEFLY BUFF IN COLOR. SS GRAY, STRATIFIED, ALSO POORLY DEFINED. BOTH ROCKS ARE COMPOSED CHIEFLY OR ENTIRELY OF VOLCANIC ASH.



SOIL HORIZONS AND ABUNDANCE OF EXCELLENTLY PRESERVED LEAVES. KNOWLTON HAS SUGGESTED MIOCENE AGE OF THE FLORA. HAS NOT YET WORKED IT OUT. HENRY FAIR SHIPT HIM 10 APPLE BOXES OF SPECIMENS RECENTLY.

SHALE AND SS INTUDED BY BASALT. BOTH DIKES AND SILLS AND MUCH THAT IS JUST BIG GOBS. NO FLOWS. COLUMNAR STRUCTURE POOR, PLATY PARTING VERY PRONOUNCED. IS THE COLUMNAR STRUCTURE CHARACTERISTIC OF THE COLUMBIA LAVA FLOWS AND THE PLATY STRUCTURE OF COLUMBIA LAVA INTRUSIONS? BUT LITTLE BAKING OF SHALE HAS OCCURRED. HOWEVER, MINUTE CLAY COLUMNAR JOINTING HAS BEEN BORMED SOME OF IT VERY CURIOUS. IN THE CLAY JOINT BLOCKS, 3-4 INCHES IN DIA, AND RATHER IRREGULAR ~~IRREGULAR~~ IN SHAPE, ARE 100S OF SMALLER JOINTS, AT RIGHT ANGLES APPROXIMATELY TO THE SURFACES OF THE LARGER AND RADIATING FROM A CENTRAL CORE LIKE THE PORTIONS OF A PINETREE CONE. RUSSELL HAS DESCRIBED THIS COLUMN-IN-COLUMN IN THE COLUMBIA BASALT ITSELF.

NO BASE TO THE SHALE AND SANDSTONE EXPOSED. BUT PROBABLY IT IS IN THE BASALT SERIES.

HENRY FAIR REPORTS A LOG BETWEEN FLOWS, FOUND IN SPOKANE, WHICH WAS SA<sup>W</sup>ED INTO BOARDS BLACK AS EBONY BUT NOT CRUSHED OR SILICIFIED. GRAIN (SEQUOIA=KNOWLTON) SHOWS PERFECTLY. CITY MUSEUM HAS A SA<sup>W</sup>N BLOCK OF THIS SAME LOG. MUSEUM ALSO HAS A COLLECTION OF LEAVES.

NP SECTION ON EAST SIDE LATAH CREEK EXPOSES ONLY GRAVEL. SOME BLDRS SEEN IN THE GRAVEL, AS AT PANTOPS. SECTION DOES NOT EXTEND VERY FAR SOUTH BUT PROFILE OF BLUFF TOP AND CHARACTER OF SLOPE TO THE SOUTH SUGGEST THAT THE GRAVEL CONSTITUTES THE ENTIRE BLUFF AT LEAST AS FAR AS JOCT OF LAKE CREEK. BRINK OF BLUFF 2300+. THIS IS 300 FT HIGHER THAN ANY OTHER PART YET FOUND OF THE WISCONSIN VALLEY TRAIN IMMEDIATELY NORTH OF SPOKANE IT PROBABLY IS A PLATEAU CONTROLLED BY BASALT, LIKE PLEASANT PRAIRIE AND FIVE-MILE PRAIRIE.

#### SPOKANE TO DARTFORD AUG. 1 1922

GREAT VALLEY TRAIN GRAVEL FILL EXPOSED IN NORTH PART OF CITY. MUST BE 100 FEET OF IT IN BLUFFS OF SPOKANE VALLEY. LIKE PANTOPS GRAVEL EXCEPT THAT IT HAS NO BLDRS. ASSUMED TO BE OF SAME AGE. SINCE FORESET BEDS INDICATE THAT WATERS FLOWED SOUTH, THIS SHOWS THAT THE PANTOPS BLDRS WERE LOCALLY DERIVED.

SAND DUNES ON V.T. GRAVELS DIRECTLY EAST OF FIVE-MILE PRAIRIE. ALSO SEEN EARLIER ALONG ~~SPRINT~~ IN VICINITY OF MEAD.. STEEP SLOPES ON NORTH, BEDDING IN GN CUTS DIPS NORTH.

#### SPOKANE TO VALLEYFORD TO MICA AUG. 2 1922

OUTWASH APPARENTLY WENT FROM PANTOPS SW ALONG BROAD VALLEY HERE OVER TO LATAH CREEK. NO GLACIAL MATERIAL SEEN ALONG INLAND EMPIRE ELECTRIC RR SOUTH OF MORAN STA. DEEPLY DECAYED GRANITE IN CUTS, MUCH PEGMATITIO DIKE MATERIAL IN IT.

FROM VALLEYFORD TO MICA, BASALT JUST BENEATH THE SOIL. SHALLOW WELLS IN IT. NO DEEP MANTLE OF SOIL ON THE BASALT. EITHER (1) BASALT DECAYS MUCH MORE SHOWLY THAN GRANITE OR (2) GRANITE HAS BEEN EXPOSED MUCH LONGER THAN BASALT. PERHAPS BASALT HAS BEEN SCRUBBED OFF HERE, THO THIS DOESNT SEEM LIBELY, EXCEPT IN POSSIBLE OUTLET CHANNELS.

LARGE'S LAKE OUTLET SEEMS PLAUSIBLE. NO DEFINITE CHANNEL IN WESTERN SPILLWAY, BUT A FEW SCATTERED FRESH GRANITE BLDRS AND QTZITE (PALE BLUE GREEN, FINE TEXTURED) BLDRS WERE FOUND. ONE QTZITE BLDR W'S ANGULAR AND PLANED AND STRIATED.



IF NOT A LAKE TO THE NORTH, AT LEAST THERE SEEMS TO BE EVIDENCE OF DISCHARGING ~~WATER~~ GLACIAL WATERS. THE FRESHNESS OF THE BLDRS INDICATES THAT THE DISCHARGE WAS ??

MICA TO BELL AUG 2 SOILS AND TOPOGRAPHY

AT MICA THE ENTIRE HILL WEST OF TOWN IS COMPOSED OF GRANITIC WASTE. THICKNESS MUST EXCEED 100 FT.. WASTE IS STRATIFIED, SOME STRATA ALMOST PURE KADLIN WHITE CLAY, SOME A FINE GRAVEL OF QTZ, FLDSPR AND MUSCOVITE, A COARSE ARKOSE. APPARENTLY THIS HILL HAS BEEN THE SITE OF A LOWLAND OF THE OLD GRANITE LAND, PERHAPS PRE-BASALT. FOSSIL LEAVES FOUND IN THE CLAY.

AT FREEMAN, THE SAME SITUATION IN A BIG PIT BDR CLAY, 50 FT DEEP. EXCEPT THAT STRATIFICATION ISNT VERY DEFINITE AND NO COARSE ARKOSE PRESENT.

IN SEVERAL CUTS BETWEEN FREEMAN AND BELL, PLENTY OF ANGULAR QTZITE WAS FOUND IN THE GRANITIC WASTE. ALL SIZES OF FRAGMENTS, NOT TRANSPORTED BUT PRODUCED BY WEATHERING ON THE PRESENT SLOPES. DEEPLY STAINED. NO OUTCROPS OF QTZITE FOUND BUT IT MUST BE PRESENT BENEATH.

PALOUSE LOESSIAL SOIL FOUND OVERLYING THE GRANITE WASTE AND, SOUTH OF BELL, OVERLYING BASALT APPARENTLY NOT RELATED CLOSELY TO UNDERLYING FORMATIONS. NO GRADATION BETWEEN BASALT AND SOIL SEEN BETWEEN BELL AND ROCKFORD. BASALT ISNT DEEPLY DECAYED. ON SLOPES AND IN VALLEY BOTTOMS, PLENTY OF BASALTIC RUBBLE AND EVEN LEDGES EXPOSED.

VALLEY OF MICA CREEK FROM VICINITY OF BELL SOUTH TO ROCKFORD IS CLEARLY ENTRENCHED BELOW THE SURROUNDING MATURE TOPOGRAPHY AND CLEARLY MUCH YOUNGER. THIS DOES NOT SHOW WELL ON THE MAP (100 FT INTERVAL) BUT IS PROMINENT TO THE OBSERVER IN THE FIELD. BELOW ROCKFORD, IT IS SHOWN WELL ON THE MAP.

ROCKFORD TO TEKOA AUG. 3

A DIVIDE RISING TO 2950+ RUNS NORTH FROM THE TEKOA MT MASS ALMOST TO ROCKFORD. AVERAGE SUMMIT OF BASALT HILLS 2500-2600. THESE HILLS PROBABLY NOT BASALT BUT NO ROCK SEEN IN TRAVERSE ACROSS. VERY MATURE TOPOGRAPHY OF DRAINAGE LINES SOUTH OF ROCKFORD, ABOUT FAIRFIELD AND ON ALL SIDES OF TEKOA MTN. QUITE IN CONTRAST WITH THE ROCK CREEK AND MICA CREEK VALLEYS AT ROCKFORD. ALSO NOTABLY IN CONTRAST WITH SLOPES OF TEKOA MTN.

TEKOA MTN. COMPOSED OF TILTED ARGILLITE AND QTZITE. NO SLATY STRUCTURE IN ARGILLITE. ORIGINAL SEDIMENTARY STRUCTURES, LIKE RIPPLE MARK LAMINATIONS, ETC., STILL VERY DEFINITE. MUCH JOINTED, HOWEVER. NO LEDGES OF ROCK ON THE MTN. BUT SLOPES AS STEEP AS THE LOOSE MATERIAL WILL MAINTAIN. MTN HAS ONLY A ~~SMALL~~ SMALL PIEDMONT WASTE SLOPE FLANKING IT, AND GENERAL EFFECT IS THAT OF AN ABRUPT RISE OUT OF THE BASALT COUNTRY. BASALT IN SITU FOUND WITHIN HALF A MILE OF THE BASE AT TEKOA. QUARRIES IN BASALT HERE AT BOTTOM OF LATAH CREEK VALLEY. NO TRACE OF BASALT EVER HAVING BEEN HIGHER ON FLANKS OF TEKOA THAN NOW. PROBABLY THE SMALL WASTE SLOPES OF THE MTN. SPREAD OUT ON THE BORDERING BASALT, THO THIS WASNT DEMONSTRATED. IF PRESENT, THIS RELATIONSHIP WOULD IMPLY THE FOLLOWING—— TEKOA AT TIME OF BASALT FLOWS WAS A PRECIPITOUS ROCK-WALLED MTN. VERY YOUTHFUL IN SLOPES. THESE HAVE SOFTENED AND THE SLOPES BECOME WASTE-COVERED WHILE THE BASALT HAS BONE THRU YOUTH TO MATURITY. THIS SEEMS PECULIAR, FOR HIGHER STEEPER SLOPES SHOULD BE ERODED MORE RAPIDLY THAN LOWER FLATTER SLOPES. LESS WATER RUNS OVER THESE HOWEVER.

DAVIS, IN ANALYSIS OF EROSION CYCLE, NOTES THAT MOST RAPID CONSUMPTION OF UPLANDS IS IN LATE MATURITY.



HELMEER SILT LOAM ON EAST SIDE TEKOA APPARENTLY A LOESS. BUFF COLOR INSTEAD OF BROWN AND BLACK, AS ARE THE PALOUSE SOILS. C.M. & STP RR CUTS 30-40 FT DEEP EAST OF TEKOA DO NOT EXPOSE BED ROCK. NONE IN STREAM BEDS EITHER. APPARENTLY A DEEPER SOIL THAN THE PALOUSE SOIL WEST OF TEKOA AT FAIRFIELD WHERE LEDGES OF BASALT AND BASALTIC RUBBLE ARE EXPOSED IN THE LOWER SLOPES OF THE MATURE VALLEY.

PALOUSE SOIL GOES UP ON SLOPES OF TEKOA BUT IS MINGLED WITH ANGULAR FRAGMENTS OF THE ARGILLITE AND QUARTZITE. WHY THE BUFF-COLORED HELMEER SOIL ON EAST OF TEKOA? DOES FORMER PRESENCE OF A FOREST HERE EXPLAIN THE DIFFERENCE? HYPOTHESIS—FOREST ON EAST AND PRAIRIE ON WEST DURING ACCUMULATION OF THE LOESSIAL DEPOSITS. PRAIRIE GRASSES YIELD DEEPER HUMUS SOIL THAN FOREST VEGETAL ACCUMULATIONS. HENCE THE BROWN (CARBONACEOUS) COLOR OF THE PALOUSE TYPE.

MOUNDS ON ARGILLITE AND QZITE DEBRIS IN SEVERAL PLACES ON TEKOA. BUFF, NOT BROWN SOIL. NOT CLOSELY SPACED BUT OTHERWISE TYPICAL. BARE OR FLOORED WITH ANGULAR ROCK FRAGMENTS BETWEEN. NO ROCK FRAGMENTS IN THE MOUNDS.

#### TEKOA TO PULLMAN AUG 4 1922

TEKOA TOWN IN FLOOR AND ON SLOPES OF SECOND CYCLE VALLEY (ENTRENCHED) AT BROADER PLACE WHERE TWO CREEKS JOIN. RR. CLIMBS (O-W) OUT TO THE SOUTH IN TWO OR THREE MILES AND THENCE TO A POINT BEYOND GARFIELD IS UP ON THE MATURE FIRST CYCLE TOPOGRAPHY WITH PLENTY OF HILLS OF DDBER ROCK TO THE EAST AND SOME TO THE WEST. THESE HILLS ARE SPURS AND DIVIDES OF THE IDAHO PRE-BASALT MTS. THEY ARE RIDGES AND GROUPS OF RIDGES LARGELY. SUCH PEAKS AS STEPTOE, GRANITE, ETC., ARE EXCEPTIONS.

THE RELATIONSHIP OF THE BASALT TO THESE FOOTHILLS, I.E. THE FLOODING BACK IN THE VALLEYS AND OVER THE LOWER SLOPES OF THE IDAHO MTS IS THE SOMETHING WHICH LINDGREN DESCRIBES FOR THE CONTACT TO THE SOUTHEAST IN IDAHO. IT MEANS THAT IF THE BASALT IS MIOCENE, THE PENEPLAIN OF IDAHO HAD BEEN UPLIFTED AND DISSECTED BEFORE MIOCENE TIME.

THE SPOKANE LEAF-BEDS, IN SP AND S CUT, ARE IN ALL PROBABILITY IN THE BASALT FORMATION. KNOWLTON SAYS MIOCENE, AFTER CURSORY EXAMINATION.

NOW, IF THE TRACE OF A PENEPLAIN WILL REMAIN ON THE SUMMITS OF A MOUNTAIN RANGE FROM EARLY MIOCENE TIME, AND THE STEPTOES WILL REMAIN ABOVE THE LAVA PLAIN AROUND THEM WHILE THAT PLAIN GOES TO MATURITY, THEN IT SEEMS IMPOSSIBLE THAT ANY PENEPLAIN UPLIFTED, WHATEVER ITS CLIMATE, COULD BE ERODED SINCE PLIOCENE TIME TO A RUGGED RANGE LIKE THE CASCADES. THIS IS A SEVERE CHECK ON THE CASCADES PLIOCENE PENEPLAIN.

HELMEER SILT LOAM IN EVERY SECTION OF SOIL FROM TEKOA TO GARFIELD. NONE OF THE BROWN TO BLACK SOIL EXCEPT FOR THE UPPER FOOT OR SO. BASALT FAIRLY CLOSE TO SURFACE, PLENTY OF EXPOSURE ON LOWER SLOPES, BUT NO LEDGES.

VALLEY AT FARMINGTON A MILE WIDE, YET ONLY A TRIBUTARY VALLEY IN THE FIRST CYCLE TOPOGRAPHY. NARROWS DOWNSTREAM, ACCORDING TO MAP, THO STILL IN FIRST CYCLE. EXPLANATION MUST LIE IN LOCAL CONDITIONS. SAME FOR REBEL FLAT AND SPRING FLAT SOUTH OF COLFAX. (SEE AUG 31 1923)

RR ENTERS SECOND CYCLE CANYON AFTER CROSSING DIVIDE SOUTH OF GARFIELD. LEDGES ON ALMOST ALL SLOPES, CLIFFS FOR HALF THE TOTAL CANYON DEPTH JUST ABOVE ELBERTON. IN FAVORABLE PLACES, HELMEER SILT LOAM ACCUMULATIONS 10-20 FT DEEP IN THE CANYON. THE PALOUSE RIVER CANYON HAS AN ENTRENCHED MEANDERING COURSE HERE. ITS MINOR TRIBS ARE ESSENTIALLY HANGING ABOVE PRESENT CANYON FLOOR.



CONSTRUCT PROFILES TO SHOW THE TWO CYCLE TOPOGRAPHY. GRADIENTS OF FIRST CYCLE VALLEYS  
MAX. DEPTHS OF SAME—GRADIENTS OF SECOND CYCLE CANYONS.— SUMMIT LEVELS OF DIVIDES IN THE  
BASALT PLAIN— COLORED CRAYON TO SHOW DISTRIBUTION OF FIRST CYCLE AND SECOND CYCLE STREAM  
COURSES.

O-W RR FROM COLFAX TO PULLMAN WHOLLY IN SECOND CYCLE CANYON. BUSINESS PART OF TOWN IN  
SAME. STATE COLLEGE ON THE BRINK. MANY HILLS OF FIRST CYCLE SEEM SMALLER AND MORE CLOSELY  
SET THAN ABOUT ROCKFORD, FAIRFIELD, TEKOA, FARMINGTON AND GARFIELD.

COLFAX TO ROSALIA AUG. 4 1922

PALOUSE RIVER VALLEY BELOW JCT OF SOUTH FORK AT COLFAX IS STRIKINGLY WALLED WITH BLACK  
BEETLING CLIFFS AND ESCARPMENTS. ONE THINKS OF THE JOHN DAY VALLEY BELOW CLARNO, EXCEPT FOR  
PROPORTIONS. MAP SHOWS CONTINUATION OF THIS CANYON BEYOND WESTERN LIMITS OF PULLMAN QUAD.

AT SUMMIT IN INLAND EMPIRE ELECTRIC RR WEST OF STEPTOE BUTTE, THERE ARE MANY SHORT HILLS  
ON THE LOWER SLOPES OF THE LONG CONCAVE PROFILES OF THE BASALT TOPOGRAPHY. RR. CUTS SHOW  
THESE SHORT HILLS TO BE HELMER SILT LOAM TO THE VERY BOTTOM. HERE APPARENTLY IS EVIDENCE OF  
A PREVIOUSLY MUCH DEEPER LOESSIAL MANTLE, NOW BEING REMOVED BY EROSION.

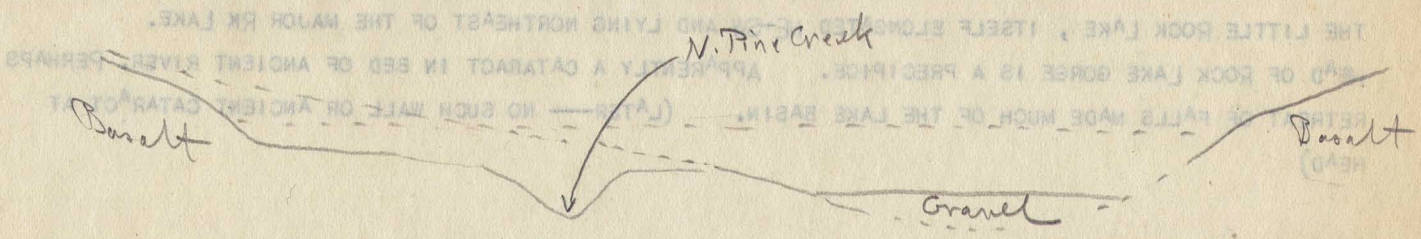
LOESSIAL MANTLE GOES UP ON FLANK OF STEPTOE BUT BECOMES MINGLED WITH QTZITIC DEBRIS. MUCH  
AS ON TEKOA MTN.

VALLEY OF PALOUSE RIVER AT COLFAX HAS CONVEX SLOPES, AS DO ALL THESE SECOND CYCLE VALLEYS.  
BUT A VIEW FROM THE TOP OF THE HILLS SHOWS THE SLOPES OF THE OLDER FIRST CYCLE VALLEY, SLOPES  
CONCAVE, DESCENDING TO THE BRINK OF THE CANYON. VERY STRIKING. REMNANTS OF FIRST CYCLE  
VALLEY FLOOR RECOGNIZED ALL THE WAY BETWEEN PULLMAN AND COLFAX.

ROSALIA TO MALDEN AUG. 5 SATURDAY.

SOIL SOMEWHAT MORE BROWN THAN HELMER TYPE AND MORE FRIABLE. NOT MORE THAN A VENEER ON  
THE WEST/ SLOPE OF PINE CREEK VALLEY AT ROSALIA. BASALT LEDGES PLAINLY SHOWING ON THE SLOPES.  
BASALT HILL LAND WEST OF ROSALIA HAS ABOUT 300 FT RELIEF, MORE THAN IN TEKOA REGION. NO STEPOES.

VALLEY OF NORTH PINE CREEK CONTAINS A CONSIDERABLE GRAVEL FILLING. THICKNESS AT LEAST  
30 FT. COMPOSED OF COARSE SUBANGULAR AND ROUNDED BASALT GRAVEL, BECOMING FINER ABOUT MALDEN.  
A FEW GRANITES AND QUARTZITES FOUND, ONE ROUNDED GRANITE IN THE GRAVEL DEPOSIT 2 1/2 MILES  
FEET MAXIMUM DIAMETER. A GREAT DEAL OF BOULDERY BASALT, ANGULAR TO SUBANGULAR, APPARENTLY  
FROM NEARBY CLIFFS AND TRANSPORTED BUT A SHORT DISTANCE DOWN THE VALLEY. POORLY SORTED, POORLY  
TERRACED. MUCH OF IT LOOKS LIKE HUGE BAR DEPOSITS IN A GREAT STREAM WHICH COVERED THE ENTIRE  
VALLEY BOTTOM TO A DEPTH OF SOME TENS OF FEET. A ROCKY SPUR AT JCT OF NORTH PINE CREEK AND  
PINE CREEK, 40 FEET ABOVE THE CREEK, HAS A STEEPWALLED CHANNEL CUT ACROSS IT, IN WHICH NORTH  
PINE CREEK NOW FLOWS, ALTHO THE VALLEY IS OPEN TO THE EAST.



THIS IS EXPLICABLE ONLY IF THE ENTIRE VALLEY BE FILLED BY A GREAT STREAM WHOSE MAIN CURRENT WOULD



CUT ACROSS THE SPUR AND NOTCH THE BASALT. THE GRAVEL IS FRESH.

HYPOTHESIS— LATAH CREEK VALLEY DAMMED AT SPOKANE BY GLACIAL ICE AND SPOKANE RIVER TURNED INTO A LAKE IN LATAH CREEK VALLEY, DISCHARGING OVER THE DIVIDE IN TWO PLACES (SEE MAP) INTO NORTH PINE CREEK. THUS ONLY A FEW ICE-FLOATED ERRATICS WOULD COME DOWN BUT MUCH BASALT FROM EROSION AT THE DIVIDE.

MOUNDS COMMON ON THE GRAVEL FILL AND ON THE BASALT MOUNDS NOWHERE HAVE BEEN FOUND ON THE LOESSIAL SOIL

MALDEN TO KWAN AUG 5

GRAVEL FILL EXTENDS DOWN PINE CREEK VALLEY, BECOMING FINER AND LOWER, TO THE ENTRANCE OF PINE CREEK INTO ROCK LAKE GORGE, TWO MILES BELOW KENOVA. KENOVA STANDS ON THE TERRACE SURFACE. MALDEN IS A LITTLE BELOW IT, PINE CITY A LITTLE BELOW. A HUGE GRAVEL PIT FOR CEMENT AND STEEL BALLS A MILE SOUTH OF KENOVA HAS BEEN EXCAVATED IN THE DEPOSIT.

TERRACE FORM ISN'T DEFINITE. THE DEPOSIT IS ONLY IN FRAGMENTS, AND THE REMNANTS HAVE BEEN GULLIED AND MODIFIED BY SLOPE WASH SO THAT TOPOGRAPHICALLY THEY ARE NOT GOOD TERRACES. SLOPE WASH FROM HIGHER LANDS HAS BUILT AN ALLUVIAL FAN PROFILE AT KENOVA.

CANYONS OF SECOND CYCLE APPARENTLY EXTEND UP AS FAR AS JOINT OF PINE CREEK AND NORTH PINE. THE GRAVEL LIES WITHIN THESE CANYONS. AT ENTRANCE OF PINE CREEK INTO ROCK LAKE GORGE, A VERY YOUTHFUL CANYON REACHES BACK INTO THE FLOOR OF THE SECOND CYCLE CANYON. APPARENTLY THE TOPS OF THE GLUFFS OF ROCK LAKE CONSTITUTE THE BASE OF THE CANYON CYCLE EROSION. IN THE DISTANCE TO THE NORTH AND NORTHEAST WERE SEEN ROUNDED HILLS WITH TYPICAL CONCAVE PROFILE WHERE SOIL MAP SHOWS PALOUSE SILT LOAM SOIL. THESE ARE REMNANTS OF THE OLDER CYCLE.

GRADIENT OF THE GRAVEL FILL FROM MALDEN TO KENOVA.

MALDEN 2070  
PINE CITY 2015  
KENOVA 1980

|  
| = 6 MILES  
|

ABOUT 100 FT BY RAILROAD BUT AT MALDEN THE TERRACE TOP IS ABOUT 30 FT ABOVE THE RR HENCE 130 TO THE 6 MILES OR 20 FT TO THE MILE

ROCK LAKE CLEARLY LIES IN A GREAT RIVER CHANNEL. SHEER BLUFFS OF BASALT RISE 200 FT OR MORE ABOVE IT ON BOTH SIDES FOR ITS ENTIRE LENGTH. DEPTH? SOIL MAP SHOWS ELONGATED BELT OF "ROUGH STONY LAND" REACHING BETWEEN CHAPMAN LAKE, A SMALLER BODY BUT ALSO ELONGATED NE-SW TO THE LITTLE ROCK LAKE, ITSELF ELONGATED NE-SW AND LYING NORTHEAST OF THE MAJOR RK LAKE. HEAD OF ROCK LAKE GORGE IS A PRECIPICE. APPARENTLY A CATARACT IN BED OF ANCIENT RIVER. PERHAPS RETREAT OF FALLS MADE MUCH OF THE LAKE BASIN. (LATER— NO SUCH WALL OR ANCIENT CATARACT AT HEAD)



LAKE BASIN APPARENTLY DUE TO GREATER DEPTH OF EROSION WHERE STREAM WAS CONCENTRATED BETWEEN THE UNBROKEN WALLS. AT LOWER END OF LAKE, THE VALLEY (CHANNEL) WIDENS AND THE BLUFFS BECOME LOWER. HERE THE ORIGINAL DEPTH MUST HAVE BEEN LESS. ADD TO THIS CONCEPTION, THAT OF RETREAT OF A CATARACT, AND CONSEQUENT PRODUCTION OF AN ELONGATED POTHOLE, AND THE LAKE BASIN IS EXPLAINED WITHOUT NEED OF A DAM AT OR NEAR EWAN (LATER—CATARACT RETREAT IDEA FEASIBLE, EVEN THO NO CLIFF NOW AT HEAD OF LAKE BASIN)

AT EWAN, THE CHANNEL IS INTERRUPTED BY MANY BUTTE-LIKE HILLS, FLAT-TOPPED HILLS, OF BASALT, WHICH WERE NOT REMOVED IN THE EROSION WHICH MADE THE CHANNEL. 3/4 TALUS. ESSENTIALLY A DALLAS RIVER BED TOPOGRAPHY, VERY LIKE THAT SHOWN ON CORFU MAP AT EAST END OF RENCHMAN HILLS

A DEPOSIT OF STRATIFIED RIVER GRAVEL NORTH OF EWAN IN HILLSIDE. C.M. AND STP RR HAS TAKEN OUT A GREAT QUANTITY IN TWO PITS, FOR BALLAST. ALMOST ALL BASALT, NOT MORE THAN HALF A DOZEN GRANITES SEEN. THESE ARE FRESH AND ROUNDED. SEVERAL SUCH GRANITES SEEN ALONG RR GRADE PARALLEL TO ROCK LAKE, IN BALLAST TAKEN FROM THIS PIT. THIS GRAVEL DEPOSIT 30-50 FT ABOVE BED OF ABANDONED CHANNEL. IN THE EXCAVATION IS A KNOB OF BASALT, SIMILAR TO THOSE ISLANDS OF BASALT ALREADY DESCRIBED, BUT SMALLER. THE CHANNEL THEREFORE PROBABLY ERODED BEFORE THE GRAVEL WAS DEPOSITED. POSITION OF DEPOSIT SHOWS THAT CHANNEL HAS BEEN EXCAVATED, OR RE-EXCAVATED, TO PRESENT FLOOR SINCE GRAVEL WAS DEPOSITED. UNLESS THE EXCAVATION OCCURRED LATER IN THE SAME EPISODE OF STREAM OCCUPATION. OR UNLESS THE BAR CONCEPTION BE USED. ALSO SHOWS ROCK LAKE BASIN HAS BEEN EXCAVATED, OR RE-EXCAVATED, SINCE THAT TIME, UNLESS ALTERNATIVE EXPLANATIONS CALLED INTO PLAY.

BETWEEN EWAN (CM AND STP RR) AND LAMONT (SP AND S RR)  
SUNDAY AUG 6 1922

HILL JUST NORTH OF EWAN IS SIMPLY AN ISLAND IN THE CHANNEL. ANOTHER CHANNEL TO THE NORTH, CARRYING ROCK CREEK, THE OUTLET OF ROCK LAKE. SIMILAR TO EWAN CHANNEL BUT SMALLER. GRANITES ON THE FLOOR.

NORTH OF THIS A BELT OF WHEAT LAND, LOESS-COVERED BASALT HILLS RISING ABOVE THE FLOOD OF GLACIAL WATERS. THEN ANOTHER VALLEY, PARALLEL TO THOSE DESCRIBED, NE-SW IN TREND, WITH A LITTLE SCABLAND AND SOME GRANITES, APPARENTLY ONE OF THE FIRST CYCLE VALLEYS, OCCUPIED FOR A BRIEF TIME AT THE HIGHEST FLOOD OF GLACIAL WATERS AND NOT NOTABLY MODIFIED. ALL THIS WITHIN THREE OR FOUR MILES BY ROAD FROM EWAN.

REMAINING DISTANCE TO LAMONT OVER FIRST CYCLE TOPOGRAPHY, WITHOUT A TRACE OF GLACIAL WATERS. RELIEF IS SOMEWHAT MORE THAN THE AVERAGE IN THE COUNTRY EAST AND SOUTHEAST OF ROCK LAKE, AND LOWER SLOPES OF THE VALLEYS NOT SO STRIKINGLY CONCAVE. MAJOR VALLEYS BROAD AND FLAT-FLOORED. PERHAPS THE GREATER RELIEF, PERHAPS THE LESSER RAINFALL, OF THIS AREA IS RESPONSIBLE FOR ITS LESS ADVANCED DEGREE OF EROSION.

MUCH COCOZ IN THE LOESS, IN TUBULES AND ROOT CAVITIES. BASALT UP IN THE HILLS AT LEAST HALF WAY TO SUMMITS, AS SHOWN BY LEDGES IN SMALL VALLEYS. SOME SLOPES LOOK SUSPICIOUSLY AS THO A VOLCANIC SEDIMENTARY LIKE THE ELLENSBURG WERE ABOVE THE BASALT BUT NO PROOF FOR THIS FOUND. THIS SUGGESTION OF AN ASH SEDIMENTARY IS MOST STRIKING A FEW MILES NORTH OF EWAN. IT LEADS TO THE HYPOTHESIS THAT PERHAPS THE MATURE TOPOGRAPHY WHICH CLEARLY HAS BEEN SWEEPED AWAY BY THE GLACIAL WATERS IN MAKING THE DRAINAGE CHANNELS, WAS DEVELOPED IN WEAKER SEDIMENTARIES, IN UPPER PARTS OF HILLS AT LEAST, AND THE HILLS WERE THEREFORE LOWER AT ONSET OF THE DERANGEMENT



BY GLACIATION SO THAT THE CHANNELS WERE LOCATED IN SUCH PLACES.

SUMMITS OF THESE HILLS RATHER BROAD AND FLATTISH NEAR LAMONT, AS THE REMNANTS OF AN ORIGINAL PLAIN.

LAMONT TO SPRAGUE SUNDAY AUG 6 1922

ENTIRE DISTANCE IS ONE MAZE OF SCABLAND BUTTES AND KNOBS AND RIDGES, WITH SEPARATING CHANNELS AND POCKETS. MORE BARE ROCK THAN SOIL-COVERED SURFACES. PATCHES OF STREAM GRAVEL HERE AND THERE. SOME GRANITE BLDRS, COBBLES AND FRAGMENTS.

FACE OF HILLS DESCENDING FROM WHEAT COUNTRY ON THE SOUTHEAST TO LAMONT IS NOTABLY STEEPER THAN THE SLOPES OF THE FIRST CYCLE TOPOGRAPHY, PROBABLY TWICE AS STEEP. AND ALL IN A RUDE ALIGNMENT. ASCRIBED TO THE HUGE GLACIAL STREAM WHICH UNDOUBTEDLY FLOWED SOUTHWESTWARD THRU HERE FROM THE SPOKANE REGION. GLACIAL STREAM ERODED PERHAPS 100 FT INTO BASALT IN PLACES. THE STREAM PROBABLY 6 MILES WIDE BETWEEN THESE TWO TOWNS.

FIRST CYCLE TOPOGRAPHY NORTH AND NORTHWEST OF SPRAGUE. SPRAGUE-LAMONT CHANNEL HIGHER THAN ROCK LAKE CHANNELS BY 100 FT., ROUGHLY. ALSO HAS BEVER GREAT ISLANDS IN IT.

NO SECOND CYCLE FEATURES BEEN SINCE ENTERING ROCK LAKE VALLEY.

A TEST OF THE AGE OF THE GLACIATION WHOSE WATERS MADE THESE GREAT SPILLWAYS MAY BE AFFORDED IN THIS WAY. THE "DALLES" TOPOGRAPHY HAS BEEN PRODUCED IN ALL THESE SPILLWAYS. IT HAS ALSO BEEN PRODUCED IN THE MOSES LAKE SPILLWAY TO CRAB CREEK (CORFU SHEET). THE MOSES LAKE DRAINAGE IS WISCONSIN IN AGE. COMPARE FRESHNESS OF CHANNELS, AMOUNT OF TALUS AT FOOT OF ESCARPMENTS, AMOUNT OF FILLING, ETC. IT SEEMS UNLIKELY THAT THE SHALLOW LAKES SO ABUNDANT IN THESE SPILLWAYS COULD ANTEDATE THE WISCONSIN GLACIATION.

SPRAGUE TO CHENEY MONDAY AUGUST 7 1922

AN EXTENSIVE GRAVEL PLAIN TO THE NORTHEAST OF SPRAGUE, NORTH OF NRRR. ALMOST ALL THE MATERIAL IS BASALT, BUT MORE FOREIGN MATTER THAN ELSEWHERE IN THESE CHANNELS SO FAR AS SEEN. PALE BLUISHGREEN QTZITE FAIRLY COMMON. GRANITES MOST COMMON. ONE BLDR 18 INCHES DIAMETER WITH FAINT GLACIAL MARKINGS ON ONE SIDE. NOTHING LIKE TILL SEEN. THE GRAVEL HAS COME IN TO THE SPRAGUE REGION BY SEVERAL SMALL SPILLWAYS THRU THE FIRST CYCLE HILLS TO THE NORTHEAST. THESE HILLS ARE THE FISHTRAP HILLS, DESCRIBED BY M.R. CAMPBELL IN THE NP GUIDEBOOK. THEY ARE LIKE THE FIRST CYCLE HILLS NORTH OF EWAN, NO BASALT MUCH ABOVE THE BASE, BUT NO REAL EXPOSURES. OF THE ASH SEDIMENTARY WHICH PRESUMABLY CONSTITUTES THEM. COVERED WITH THE PALOUSE LOESSIAL SOIL, IDENTICAL WITH THAT IN THE PALOUSE COUNTRY, BUT HERE (EWAN REGION AND FISHTRAP HILLS) THE SOIL IS ON A WHOLLY DIFFERENT ROCK.

TYLER ON SPOKANE CO SOIL MAP. MAP SHOWS SEVERAL PATCHES OF A FEW SQUARE MILES EACH OF PALOUSE SOIL, AND THESE WERE RECOGNIZED FROM THE TRAIN AS HILL TRACTS, THE HILLS OF THE FAMILIAR MATURE TOPOGRAPHY. SEPARATED BY BROAD FLAT TRACTS OF SCABLAND, INTERRUPTED BY LINEAR MEADOWS AND LAKES. THE SITUATION IS THE SAME AS ALREADY DESCRIBED. GLACIAL DRAINAGE HAS CROSSED THE FORMER MATURELY DISSECTED TOPOGRAPHY, SELECTING AREAS OF HILLS COMPOSED CHIEFLY OF THE ASH SEDIMENTARY, HAS WIDENED SUCH VALLEYS, SWEEPED THEM CLEAN, STEEPENED THEIR SIDES, AND ERODED CHANNELS IN THEM. FISH LAKE (FARRINGTON LAKE) NEAR CHENEY IS BUT ONE MORE OF MANY OF THESE.



AT CHENEY THE OLD TILL REPORTED BY CAMPBELL AND EXAMINED BY LEVERETT WAS SEEN. IT IS EXPOSED IN AN ABANDONED BRICKYARD NORTHWEST OF THE NORMAL SCHOOL, AT THE BASE OF THE HILL. A NUMBER OF ERRATICS WERE FOUND, LEFT IN THE CUT WHEN THE CLAY WAS EXCAVATED. ONE OF THESE WAS A PALE BLUISH FINE-GRAINED QZITE, OUTLINED BY JOINTS, SUBANGULAR AND BEAUTIFULLY STRIATED ON ONE SIDE. ALSO VERY GOOD CHATTER MARKS ON IT. OTHER STRIATED COBBLES AND PEBBLES FOUND. THE MATERIAL IS LARGELY QUARTZOSE AND MOST OF THE TILL IS CLAY. WHAT GRANITE WAS SEEN HERE AND AT A FEW OTHER PLACES ABOUT THE BASE OF THE HILL WAS PITTED, ETCHED AND COMMONLY CRUMBLING. IT DID NOT LOOK AT ALL LIKE THE FRESH BRIGHT SMOOTH HARD GRANITE BLDRS FOUND ON THE SURFACE ALONG THE GREAT SPILLWAYS. AT PRESENT WRITING, I AM CONVINCED THAT THE SPILLWAYS ARE WISCONSIN AND THE OLD TILL IS PROBABLY KANSAN, AS LEVERETT THOT.

THE ICE WHICH DEPOSITED THIS TILL MUST HAVE RIDDEN OVER THE GROUP OF PALOUSE HILLS IMMEDIATELY NORTH. THO THEIR OUTLINES ARE NOT QUITE TYPICAL, YET THEY SHOW NOTHING WHICH CAN BE ASCRIBED TO GLACIAL OVERRIDING. IT SEEMS PROBABLE THAT MUCH OF THE MATURELY DISSECTED TOPOGRAPHY OF THESE HILLS HAS BEEN FORMED SINCE THE GLACIATION RECORDED BY THE TILL.

MISS ELIZABETH MARTIN, A TEACHER IN THE CHENEY NORMAL SCHOOL, REPORTS THAT IN SEVERAL SHALLOW EXCAVATIONS IN THE VICINITY, ERRATIC COBBLES AND BLDRS HAVE BEEN FOUND. SHE ALSO HAS FOUND CALCAREOUS CONCRETIONS IN THIS TILL.

THE HILLS NORTH OF CHENEY HAVE THE GENTLE SLOPES OF THE FIRST CYCLE TOPOGRAPHY, EXCEPT ON SUCH MARGINS AS ARE BORDERED BY GLACIAL DRAINAGE CHANNELS. IN SUCH PLACES, THE SLOPES ARE STEEPENED IN THE MANNER ALREADY FAMILIAR.

GRANITE LAKE, A FEW MILES NORTH OF CHENEY, LIES IN WHAT I AM ASSURED BY MISS MARTIN IS A ROCK BASIN. SO FAR AS SEEN, GRANITE SURROUNDS THE LAKE. THE LAKE IS IN A GLACIAL DRAINAGE CHANNEL. ANOTHER SUCH CHANNEL LIES BETWEEN CHENEY AND FOUR LAKES. NEITHER OF THESE ARE CUT AS LOW AS THE FARRINGTON (FISH) LAKE CHANNEL, WHICH IS IN BASALT.

NORTH OF FARRINGTON LAKE IS A GROUP OF WILDLY RUGGED GRANITIC HILLS, OVER WHICH GLACIAL WATER CLEARLY SPILLED EARLY IN THE OCCUPANCY OF THE CHANNEL, AND CONSEQUENT EROSION BRINGING OUT THE PRESENT RUGGEDNESS. DID THEY SPILL TO THE BOTTOM OF FISH LAKE CHANNEL? WAS THAT CHANNEL THEN ERODED? WAS IT NOT ONLY STARTED?

NEAR THE GRANDVIEW SCHOOL, EAST OF CONNELLY, THE TYPICAL PALOUSE LOESS OVERLIES QZITE AND QZ SCHIST, CUT BY GRANITE DIKES. HERE IS ANOTHER CASE. TO ADD TO THE LIST, WHERE THE PALOUSE SOIL CANNOT BE EXPLAINED AS RESIDUAL IN ANY SENSE. EXCEPT IN ROAD CUTS, NO BRAGMENTS OF THE UNDERLYING ROCKS ARE TO BE FOUND.

VICINITY OF SPOKANE AUG 8 TUESDAY 1923

DEEP CREEK CANYON EXHIBITS SPLENDID BOMBS IN YELLOW ASH IN THE BASALT FLOWS. BOMBS AVERAGE 2 FT IN DIAMETER, HAVE A RADIAL COLUMNAR STRUCTURE AND A BLACK GLASS EXTERIOR. THE CANYON ALSO SHOWS A FINE SECTION OF CONTEMPORANEOUS SHALE AND SAND, DEPOSITED IN A POCKET OR DEPRESSION OF THE ROUGH, BOMB-COVERED COUNTRY. FOSSIL LEAVES REPORTED. ISNT THE EXTRAORDINARY AMOUNT OF INTERBEDDED SEDIMENTS OF THE SPOKANE REGION A RESULT OF NEARNESS TO THE SURROUNDING HIGHER LANDS? OR IS IT WHOLLY A MATTER OF EXPLOSIVE ACTION AND THE PRODUCTION OF ASH TO MAKE THE CLASTIC MATERIAL?



OUTWASH TERRACES— LIDGERWOOD TERRACE AT 2000+ EAST OF FIVE MILE PRAIRIE CANNOT BE TRACED AROUND THE NORTH END OF FIVE MILE. LITTLE SPOKANE HAS REMOVED IT. TRACED AROUND THE SOUTH END OF FIVE MILE, IT DESCENDS BY A SLOPE TOO STEEP FOR A TERRACE <sup>TOP</sup> SLOPE, YET HARDLY STEEP ENOUGH FOR A DELTA FRONT, TO THE LEVEL OF THE MAGNIFICENT GRAVEL TERRACE IN THE SPOKANE VALLEY BELOW THE CITY. THIS DESCENT MAY AMOUNT TO 100 OR 150 FEET. IS IT DUE TO ORIGINAL DEPOSITION OR TO SUBSEQUENT DISSECTION BY THE SPOKANE RIVER? WHAT BECOMES OF THIS SPOKANE V.T. DOWN-STREAM? IT SHOULD TERMINATED AS A DELTA IN THE NESPELEM SILT POND.

FIVE MILE PRAIRIE FLANKED ORIGINALLY BY OUTWASH. ON NORTH SLOPE, LITTLE SPOKANE HAS WHOLLY REMOVED THE V.T. GRAVEL SPILLED WESTWARD DOWN THE LITTLE SPOKANE VALLEY TO THE SPOKANE AT VICINITY OF NINE-MILE BRIDGE AND DAM. SURFACE UNBROKEN OVER 2-3 MILES ALONG HIGHWAY EAST FROM NINE-MILE, EVERYWHERE WITH UNIFORM WESTWARD SLOPE.

QUERY— DID GRAVEL OF LIDGERWOOD TERRACE MOVE NORTH OR SOUTH ALONG EAST SIDE OF FIVE MILE PRAIRIE? BEDDING IN PITS IN SPOKANE SHOWS CURRENTS FROM EAST, NOT FROM NORTH.. ALTITUDE OF SURFACE 2000+, AS IN PORTIONS OF THE BROAD GRAVEL FLAT EAST OF SPOKANE. DIDNT V.T. GRAVEL COME FROM EAST AND MOVE NORTH ALONG BOTH EAST AND WEST SIDES OF FIVE MILE PRAIRIE? LITTLE SPOKANE V.T. THEN MAY BE CONSIDERED AS TURNING WEST WITH THE STREAM AND PASSING FIVE MILE PRAIRIE ON THE NORTH, INSTEAD OF CONTINUING SOUTH TO THE CITY OF SPOKANE.

FIVE MILE PRAIRIE THE TOP OF THE BASALT. COINCIDES IN ALTITUDE WITH PLEASANT PRAIRIE, PARADISE PRAIRIE, THE MESA COUNTRY SOUTH OF SPOKANE, EAST OF MORAN, AND WEST OF LATAH CREEK AND SUNSET PRAIRIE. NORTHERN PART OF FIVE MILE PRAIRIE, ESPECIALLY ON THE BRINK ALONG THE HILL ROAD, IS STREWN WITH GLACIAL ERRATICS; QTZITES, GRANITES OF SEVERAL TYPES, ETC. MANY OF THESE STRIATED. THE GRANITES FRESH, ONLY HERE AND THERE REDDED ON THE EXTERIOR AND PERHAPS INTO THE FRACTURES. GRANITE ALL OVER THE TOP OF THE MESA BUT MOST ABUNDANT ON THE NORTHERN EDGE.

WHAT IS THE AGE OF THIS GLACIATION? IF IT IS WISCONSIN, THE DRIFT LIES WELL BEYOND WHAT HAS BEEN TRACED AS THE T.M. AND THE PANTOPS OUTWASH AT A SOMEWHAT SIMILAR LEVEL, 300-400 FEET ABOVE THE V.T., PROBABLY RECORDS THE EDGE OF THE ICE WHICH CROSSED FIVE MILE PRAIRIE. IF IT IS PRE-WISCONSIN, IT IS REMARKABLY LITTLE WEATHERED. THO IT MUST BE NOTED THAT BOTH HERE AND AT PANTOPS, THERE ARE NO PHYSIOGRAPHIC FORMS WHICH SUGGEST EITHER MORAINIC OR FLUVIOGLACIAL DEPOSITS. NOR IS THE FORM OF THE DRAINAGE CHANNEL DOWN FROM MICA TO CALIFORNIA CREEK A DEFINITE AFFAIR. NOR IS THE PINE CREEK GRAVEL FILL TYPICAL OF WISCONSIN TERRACES. ALL HAVE LOST ORIGINAL SHARPNESS AND A GOOD DEAL OF THEIR MATERIAL HAS BEEN ERODED AWAY.

IF WE VENTURE TO CALL THESE FEATURES PRE-WISCONSIN, DOES IT FOLLOW THAT THE ROCK CHANNELS TO THE WEST AND SOUTHWEST OF SPOKANE ARE ALSO PRE-WISCONSIN? SHOULD LAKES AND SWAMPS PERSIST IN SUCH ABUNDANCE FROM A PRE-WISCONSIN GLACIATION? AS ARGUED BY PARDEE AND LARGE, THE DRY CLIMATE MAY EXPLAIN THE FAILURE OF THESE BASINS TO FILL. BUT MIGHT IT NOT BE POSSIBLE THAT THE CHANNELS ARE PRE-WISCONSIN IN ORIGIN AND WERE RE-OCCUPIED DURING THE WISCONSIN GLACIATION? SUCH A HYPOTHESIS WOULD REQUIRE EITHER A WISCONSIN BLOCKING OF THE COLUMBIA SOMEWHERE IN THE VICINITY OF CRESTON OR DAVENPORT (NOT INDICATED BY THE MORaine TRACED BY BLACKWELDER AND GARREY) OR A DOUBLE DISCHARGEWAY FOR A TIME, THE GRAND COULEE EVENTUALLY TAKING PRECEDENCE BECAUSE OF MORE RAPID EROSION.

THE DEVELOPMENT OF SEVERAL PARALLEL LINES OF ESCAPING WATER, NOT FAR APART BUT AT DIFFERENT ALTITUDES SEEMS TO FORBID THE HYPOTHESIS THAT THE WATERS CAME FROM A LAKE. IT SEEMS TO DEMAND THAT EACH CHANNEL ORIGINATE AT THE EDGE OF THE ICE, AND, SEPARATED FROM THE OTHERS BY



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HIGHER LANDS, PURSUE ITS OWN COURSE ACROSS THE COUNTRY. SOME RETREAT OF THE EDGE OF THE ICE WOULD LATER PERMIT THE LOWER CHANNELS, SUCH AS ROCK LAKE, TO OBTAIN MORE WATER AND WITH THIS GLACIAL WATER, ITS DEBRIS FROM THE ICE PERHAPS ALREADY DEPOSITED IN LIMITED MARGINAL LAKES ~~AND THEN~~ DEVELOPING, TO ERODE AND CLEAN OUT MUCH OF THE GRAVEL FILLING PREVIOUSLY DEPOSITED.

NOW, IF THIS REASONING BE CORRECT, GLACIAL TILL MUST EXIST IN THE COUNTRY JUST NORTH OF THE CHANNEL HEADS. THE FIVE MILE AND THE PANTOPS DEPOSITS RECORD THE ICE IN THEIR DISTRICTS. CAN A RECORD BE FOUND ON SUNSET AND INDIAN PRAIRIES?

SPOKANE TO SOAP LAKE BY G.N.R.R. AUG. 9 1922

SUNSET PRAIRIE IS ON THE SURFACE OF HORIZONTAL BASALT FLOWS. THE PRAIRIE IS NOT LEVEL BUT HAS BROAD, NEARLY LEVEL SUMMIT TRACTS, AND IS INCISED BY BROAD, SHALLOW DRAINAGE LINES, TRIBUTARIES OF DEEP CREEK. IT LOOKS AS THO THE ORIGINAL EROSIONAL TOPOGRAPHY (FIRST CYCLE) HAD BEEN DEVELOPED HERE ON AN ASH SEDIMENTARY, LIKE THE FISHTRAP HILLS, AND THIS HAD BEEN CUT THRU INTO BASALT IN THE MAJOR VALLEYS. THEN, CONTINUING THE "LOOKS AS THO" HYPOTHESIS, GLACIATION OCCURRED AND THE ICE OR THE GLACIAL WATERS CLEANED OFF THE REMNANTS OF THE WEAKER SUPER-BASALT SEDIMENTARY DOWN TO THE BASALT FOUNDATION.

IN SUBSTANTIATION OF THIS HYPOTHESIS, IS THE PRESENCE OF WHAT, SEEN FROM THE TRAIN, IN THE RR CUTS, LOOKS VERY MUCH LIKE A STONY, SANDY BUT NOT CLAYEY TILL BOTH EAST AND WEST OF LYONS STA. LOW ROUNDED HILLS HERE AND POORLY DRAINED OR UNDRAINED HOLLOWES AMONG THEM. NO DRIFT SEEN FARTHER WEST EXCEPT IN THE GLACIAL DRAINAGE LINES.

WHY SHOULD THERE BE ANY HESITANCY IN CONSIDERING THAT HERE WE HAVE A CLEAR CASE OF GLACIAL ICE ADVANCING AS FAR SOUTH AS MEDICAL LAKE AND FOUR LAKES, THE HEAD OF THE CHANNELS ABOUT CHENEY? THE WHOLE THING IS COHERENT AND CONSISTENT. BUT CAN THESE FEATURES BE CONSIDERED OF WISCONSIN AGE?

THE WESTERNMOST OF THESE DRAINAGE CHANNELS WHICH WENT BY WAY OF SPRAGUE AND LAMONT COMES IN BETWEEN FISHTRAP AND SPRAGUE. BUT THERE ARE OTHERS, FARTHER WEST, WHICH SPILLED OVER INTO CRAB CREEK. THE EASTERNMOST OF THESE APPEARS TO BE THE CHANNEL WHICH IS CROSSED BY THE GNRR A LITTLE EAST OF WAUKON. NEXT ONE TO THE WEST IS CROSSED BY GNRR ABOUT A MILE EAST OF CANBY. IT IS ONE OF THREE DRAINAGE LINES WHICH UNITE HERE AT THE GNRR CROSSING. THE EASTERNMOST IS THE ONE ABOVE REFERRED TO. WHETHER OR NOT THE MIDDLE ONE CARRIED GLACIAL DRAINAGE WAS NOT DETERMINED. THE WESTERN ONE DID NOT. IT HAS THE SECOND CYCLE CANYON IN ITS FLOOR, BUT NO BUTTES, NO LINEAR SWAMPS OR LAKES, NO GRAVEL FILL, NO GRANITES AND ITS VALLEY IS RELATIVELY NARROW, COMPARED WITH THOSE VALLEYS OCCUPIED BY GLACIAL WATERS.

THE CANBY GLACIAL DRAINAGE LINE IS SEPARATED FROM THE WAUKON GLACIAL DRAINAGE LINE BY AN AREA OF FIRST CYCLE HILLS. THE CANBY CHANNEL IS ETCHED IN THE BASALT IN TYPICAL FASHION, MUCH SCABLAND, LOW IRREGULAR BASALT HILLS INTERRUPT THE CHANNEL, MUCH BASALTIC GRAVEL AND SOME GRANITE ON ITS FLOOR.

ABOUT BLUESTEM, THE FIRST CYCLE TOPOGRAPHY APPEARS MORE MATURE THAN IN THE PALOUSE COUNTRY. THERE IS MUCH MORE FLAT BOTTOM LAND, THE HILLS ARE FARTHER APART, LOWER AND HAVE GENTLER SLOPES. MUCH BARE ROCK ON FLOORS OF FIRST CYCLE VALLEYS AND LOESS, WHERE PRESENT, IS THIN. BUT A FEW MILES WEST OF BLUESTEM, ON THE DIVIDE BETWEEN CRAB AND COAL CREEKS, THE FIRST CYCLE TOPOGRAPHY IS TYPICAL. RR CUTS SHOW A DEEP YELLOW LOESS (25 FT EXPOSED) WITH CALCAREOUS ZONES AND CONCRETIONS.



LAMONA, ON COAL CREEK, IS NEAR THE HEAD OF THE SECOND CYCLE VALLEY. THE SECOND CYCLE VALLEY IS NOT A CANYON, HOWEVER. ITS FLOOR IS BROAD AND ITS SIDES NOT VERY HIGH, THO STEEP AND ROCKY. THIS SEEMS ODD BUT IS BELIEVED TO BE EASILY EXPLAINED WHEN CONSIDERED WITH THE VERY STRIKING CANYON PORTIONS OF THE CRAB CREEK VALLEY NEAR JUNCTION OF LAKE CREEK VALLEY ~~AND~~ BELOW ODESSA. BOTH HERE ARE DEEP AND NARROW AND WALLED IN WITH RUGGED PRECIPITOUS CLIFFS. THE EXPLANATION SEEMS TO BE THAT A PARTICULARLY RESISTANT BASALT FLOW, OR GROUP OF FLOWS, IS HERE INCISED BY THE STREAMS. THESE CAUSE THE UNUSUAL CANYONS AND ALSO ACT AS A TEMPORARY BASELEVEL ABOVE THE ENTRENCHED PORTIONS. THUS, THE VALLEY ABOVE IS OLDER, IN TERMS OF WORK DONE BY THE STREAM, THAN THE AVERAGE IN THIS PORTION, AND THAT IN THE MORE RESISTANT PART IS YOUNGER. NOTE ALSO THAT THE NARROW CANYON PORTION CONTAINS NO GRAVEL. EROSION TOO VIGOROUS FOR ~~to~~ IT TO LODGE.

GRANITE BLDRS, ROUNDED, FIRST SEEN IN COAL CREEK VALLEY A FEW MILES WEST OF LAMONA. THEY HAVE COME BACK (OR OVER) FROM CRAB CREEK WHICH COAL CREEK JOINS BETWEEN LAMONA AND ODESSA. A LARGE GRAVEL DEPOSIT IN CRAB CREEK VALLEY AT JCT OF COAL CREEK. 25-FOOT SECTIONS.

NO LOESSIAL MANTLE TO THE REGION SEEN FROM TRAIN IN VICINITY OF ODESSA. AT ODESSA, GRAVEL IN PITS 50 FT OR MORE ABOVE VALLEY FLOOR. IT SEEMS TO CONSTITUTE REMNANTS OF A ONCE CONTINUOUS FILLING. WHETHER LAKE CREEK VALLEY HAS SUCH A FILLING, I.E. CONTRIBUTES TO CRAB CREEK GRAVELS, CAN NOT BE SAID WITHOUT AN EXAMINATION OF THE VALLEY ABOVE THE CONSTRICTED PORTION.

A FEW GRAVEL PATCHES AND BARS (?) REACHING HALF WAY UP ON ROCK BLUFFS TOWARD MARLIN AT MARLIN, BROAD VALLEY FLOOR AGAIN, BUT WITH GREAT CLIFFS SHUTTING IT IN. MARLIN STATION STANDS ON A PROMINENT TERRACE OF ROCK, CARRYING GRAVEL AND BLDRS. SOME GRANITES. TOWN STANDS ON VALLEY FLOOR ABOUT 50 FT LOWER.

THE GRAVEL ABOUT MARLIN MAY BE FRAGMENTS OF A ONCE COMPLETE FILLING. IT ALSO MAY BE THAT ONLY BARS WERE DEPOSITED IN LEE OF ROCKY KNOBS AND ON INSIDE OF CURVES. IF REMNANTS OF A ONCE CONTINUOUS FILLING, IT HAS BEEN COMPLETELY REMOVED FOR MILES, EXCEPT FOR PATCHES, AND THIS POINTS TO A PRE-WISCONSIN AGE.

ONE TO THREE MILES EAST OF WISSON CREEK STATION ARE GREAT GRAVEL TERRACES ON THE NORTH SIDE OF THE VALLEY. THEY ARE CLEARLY REMNANTS OF A FILL COMPLETELY ACROSS THE VALLEY. DESPITE FRESHNESS OF THE GRAVEL, IT SEEMS THAT THIS FILL MUST BE CONSIDERED PRE-WISCONSIN. THE TERRACES HAVE ROUNDED EDGES AND ARE INCISED WITH FAIRLY WIDE AND GENTLY-SLOPED GULLIES—OLD GULLIES. THIS IS QUITE IN CONTRAST WITH THE WONDERFULLY SHARP OUTLINES OF THE SPOKANE V.T. ~~WHERE~~ WHERE DISSECTED.

WEST OF STRATFORD, THE VALLEY DISAPPEARS AND A GRAVEL PLAIN, SEVERAL MILES WIDE, APPEARS. SHALLOW CHANNELS ACROSS IT, APPARENTLY DATING BACK TO THE BUILDING OF THE PLAIN. BUT LITTLE POST-DEPOSITIONAL EROSION. ALTITUDE STRATFORD 1281 IS THIS PLAIN A RECORD OF THE LATE PLEISTOCENE COLUMBIA SUBMERGENCE? A DELTA IN THAT SUBMERGENCE, SUCH AS THE CHELAN GREAT TERRACE IS THAT TO BE? (LATER—NO. IT IS SPOKANE GRAVEL)

BIG GRAVEL PIT ALONG GNRR NEAR CROSSING OF GN AND NP (CENTRAL WASHINGTON BRANCH) EAST OF ADRIAN FINE FORESET DELTA BEDDING, 20 FT DEEP, SHOWS ABOVE STREAM BEDDING TO BOTTOM OF PIT, 10 FT MORE. STRATIFICATION DIPS WESTWARD.

WEST OF ADRIAN, THE GRAVEL PLAIN FROM STRATFORD TERMINATES ABRUPTLY WITH A LONG STRAIGHT FRONT. LOOKS SUSPICIOUSLY LIKE A DELTA FRONT.



MIDDLE OF OLD CHANNEL AT SOUTH END OF SOAP LAKE HAS A ROCKY KNOB, SEVERAL CITY BLOX IN EXTENT AND 40 FT ABOVE AVERAGE LAKE LEVEL. LOWER TRACTS ON EITHER SIDE LEAD OFF TO THE SOUTH THRU CHANNELS. THE CHANNEL ON THE EAST LEADS TO ROCKY FORD CREEK. BUT BOTTOM OF THIS CHANNEL, A MILE OR SO FROM THE LAKE, IS HIGHER EVEN THAN THE ROCKY KNOB AT THE LAKE SHORE. ADD TO THIS THE DEPTH OF THE LAKE, WHATEVER THAT IS, AND A GOOD IDEA OF THE IRREGULARITY OF THE BED OF A GREAT STREAM OVER COLUMBIA BASALT IS OBTAINED.

NO BERG-CARRIED BLDRS FOR A MILE SOUTH OF THE LAKE. THEN VERY ABUNDANT AS FAR SOUTH AS THE BIG SPRINGS AT THE HEAD OF ROCKY FORD CREEK. MOSTLY GRANITE, SOME BASALT. ONE CLOSE TO GNRRT TRACKS, ABUTTING AGAINST THE GRADE, IS 8 FT HIGH AND 12X12 ON THE GROUND. THESE GRANITE BLDRS ARE SURPRISINGLY WEATHERED ALONG JOINTS AND MUCH EXFOLUATED.

HIGH MESA OF GRAVEL EAST OF ROCKYFORD CREEK. CLIMBED AT THE SPRINGS. SPRINGS ALT. 1050± VERY COARSE GRAVEL, MUCH OF IT COBBLES. TOP IS 200 FT HIGHER THAN THE SPRINGS. MOUNDS WELL DEVELOPED, WITH OPEN-WORK COBBLES IN INTERMOUND SPACES, AND WITH MUCH FINE GRAVEL IN THE MOUNDS THIS MESA SLOES NORTHWARD AND EASTWARD GENTLY, AT THE PLACE WHERE CLIMBED. A MILE OR SO FARTHER SOUTH, ITS SLOPE BECOMES EASTWARD AND SOUTHWARD AND SO CONTINUES TO MOSES LAKE, A DISTANCE OF 8-10 MILES. MATERIAL ON SURFACE BECOMES NOTICEABLY FINER IN THAT DISTANCE. NO BERG-CARRIED BLDRS ON THE SUMMIT, THO VERY COMMON ON THE LOWER TERRACE WEST OF THE SOAP LAKE, ROCKY FORD CHANNEL ALTITUDE OF THIS LOWER TERRACE WEST OF THE BIG SPRINGS ABOUT 1100 ERRATICS ALSO PRESENT IN THE CHANNEL EAST OF THE GRAVEL MESA, THO EXTENT OF THEIR DISTRIBUTION ISNT KNOWN. FOLLOWED SOUTHWARD ON THE DOWNGRADE OF THE MESA, THE ERRATICS APPEAR AT ABOUT 1250 A.T. AND ARE VERY ABUNDANT THRU A VERTICAL RANGE OF A FEW 10S OF FEET. THEN NO MORE OF THEM FARTHER SOUTH. THE SIGNIFICANCE OF THIS CURIOUS DISTRIBUTION IS <sup>NOT</sup> CLEAR. THE ONLY HYPOTHESIS WHICH SEEMS SATISFACTORY IS THAT THIS IS THE STRAND LINE FOR THE SUBMERGENCE WHEN THE BERGS WERE DRIFTING, AND THAT THEY GROUNDED ALONG THE SHORES, HERE TO MELT AND LEAVE THEIR BURDEN OF GRANITE AND BASALT BLDRS. BUT ABSOLUTELY NO TRACE OF BEACH RIDGES OR WAVE-CUTTING HERE.

THE ORIGIN OF THE HIGH GRAVEL MESA IS A BIT PUZZLING. IF IT IS OF WISCONSIN AGE, IT WAS BUILT AND THEN DISSECTED SO THAT, BOTH EAST AND WEST, CHANNELS 150 FT OR SO IN DEPTH WERE FORMED, ALL BEFORE THE BERGS ARRIVED. MAY IT NOT BE A REMNANT OF A PRE-WISCONSIN OUTWASH PLAIN?

IF PRE-WISCONSIN IN AGE, THERE SHOULD BE MORE WEATHERING AND MORE EROSION IN IT THAN IN THE FLANKING LOWER TERRACES. NOTHING SEEN TO SUGGEST THIS EXCEPT PERHAPS ON THE EAST SIDE. ON THIS SIDE, THE SLOPE IS GENTLE DOWN TO THE LOWER TRACT (EXCEPT NEAR LATITUDE OF HEAD OF MOSES LAKE, WHERE A DEFINITE CHANNEL ON THE LOWER TRACT CUTS INTO THE EAST SIDE). IS THIS A CONSTRUCTIONAL SLOPE? IS IT EROSIONAL? IF THE LATTER, IT MEANS MATURITY OF SLOPES. WEST SIDE OF MESA IS STEEP ALL THE WAY, DUE TO THE CUTTING OF THE ROCKY FORD-SOAP LAKE CHANNEL.

IF THE SPOKANE SPILLWAYS ARE PRE-WISCONSIN, THEY LIE MANY MILES SOUTH OF THE MAPPED WISC. T.M. SHOULD NOT THE OKANOGAN LOBE SHOW THE SAME PHENOMENA, — GLACIAL DRIFT BEYOND LIMITS OF WISCONSIN T.M. AT COULEE CITY, AND TERRACES OF GRAVEL, OLDER AND HIGHER THAN THE WISC. GRAVEL? SUCH A CONCEPTION DEMANDS THAT THE GRAND COULEE FUNCTIONED AS A GLACIAL DISCHARGEWAY EARLIER THAN ITS WISCONSIN HISTORY. FURTHERMORE, THE GLACIAL DRAINAGE WHICH USED CRAB CREEK ABOVE STRATFORD HAS THE CHARACTERS OF, AND ALMOST CONTINUITY WITH, THE SPOKANE GLACIAL DRAINAGE PHENOMENA WHICH ARE POSSIBLY PRE-WISCONSIN. AND CRAB CREEK ENTERED THE GRAND COULEE LINE OF DRAINAGE JUST BELOW THE MOUTH OF THE COULEE. SURELY THERE MUST BE EVIDENCE IN THE FIELD TO SETTLE THIS.



LOOK FOR HIGH AND OLDER TERRACES ON FLANKS OF GRAND COULEE MOUTH AT SOAP LAKE. EXAMINE STRATFORD GRAVEL PLAIN.

FROM LATITUDE OF NORTH END OF MOSES LAKE SOUTHWARD TO NEPPEL, ON THE HIGHER MESA AND THE LOWER SURFACES TO THE EAST (VALLEY OF WILLOW CREEK) NO ERRATICS SEEN. A THIN SOIL ABOVE THE GRAVEL ON THE LOWER TERRACE. NO MOUNDS HERE, TO NEPPEL.

NEPPEL TO GOOSE LAKE TO WARDEN AUG 11 1922

BASALT OUTCROPS ON FLOOR OF VALLEY AT NEPPEL. TERRACE ON WHICH MOSES LAKE P.O. STANDS IS COMPOSED OF OUTWASH GRAVEL. DEPTH OF GRAVEL = HEIGHT OF TERRACE = ABOUT 100 FT. FROM A STUDY OF GRADIENTS OF TERRACES ON THE MOSES LAKE QUADRANGLE, AND A STUDY OF TOPOGRAPHY IN THE FIELD, IT IS CLEAR THAT THE TERRACE ON WHICH MOSES LAKE PO STANDS IS THE HIGHEST TERRACE EVER BLT IN THIS LATITUDE AND IS THE CONTINUATION OF THE HIGH GRAVEL MESA EAST OF ROCKY FORD CREEK. STREAM EROSION SUBSEQUENT TO ITS DEPOSITION HAS SEPARATED THE TRACT NORTH OF MOSES LAKE FROM THE PORTION EAST AND SOUTHEAST FROM THE LAKE (MOSES LAKE PO TERRACE) IN THE VALLEY ERODED IN THIS HIGHEST TERRACE LIE PELICAN HORN, PARKER HORN, LEWIS HORN AND WILLOW CREEK.

FROM MAP STUDY ALONE IT APPEARS THAT THE HIGH TERRACE ON WESTERN EDGE OF MOSES LAKE QUADRANGLE IS ALSO A PORTION OF THIS OLDEST AND HIGHEST GRAVEL FILL. INDEED, THIS TERRACE ON THE WESTERN EDGE OF MOSES LAKE QUADRANGLE AVERAGES 75 FEET HIGHER THAN AT M.L.P.O., 10 MI. STRAIGHT EAST.

NO GOOD SECTIONS IN THE TERRACE SEEN. CANNOT SAY FROM STRUCTURE WHETHER OR NOT IT IS A GREAT GRAVEL DELTA. THAT IT WAS A DELTA IS STRONGLY SUGGESTED BY THE ENTIRE ABSENCE OF GRAVEL TERRACES AGAINST THE NORTH FLANK OF FRENCHMAN HILLS. HAD IT BEEN A VALLEY FILL BY STREAMS ON A FLOODPLAIN, SURELY GRAVEL WOULD HAVE BEEN DEPOSITED HERE. AND SURELY SINCE THESE FLANKS ARE NOT IN OR NEAR THE CHANNEL WAYS THAT LATER WERE ERODED IN THE GRAVEL, ALL OF IT (ONCE DEPOSITED) COULDN'T BE REMOVED.

THE TERRACE IS NOT NOTCHED BY GULLIES TO ANY EXTENT AND ITS EDGE ALONG MOSES LAKE, ROCKY FORD CREEK AND WILLOW CREEK IS FAIRLY SHARP. THE SHARP EDGES HERE, HOWEVER, MEAN ONLY REGENCY OF INCISION, NOT REGENCY OF DEPOSITION. THE AMOUNT OF WEATHERING IS VERY SLIGHT, ONLY THE INCRUSTATIONS OF LIME INDICATING ANY CHANGES. GRAVEL IS FRESH AND BRIGHT JUST BELOW THE SURFACE.

THE BARCHAN DUNES A FEW MILES SOUTH OF MOSES LAKE PO COVER 8 TO 10 SQ. MILES WITH A TYPICAL SAHARA DUNE LANDSCAPE. FROM THE CENTRAL PART OF THE TRACT, ONE SEES NOTHING BUT THE MARCHING DESERT DUNES IN EVERY DIRECTION. DUNES ARE BLACK, COMPOSED OF BASALTIC SAND. VERY SOMBER EFFECT, RELIEVED ONLY BY PATCHES OF GREEN AND GRAY VEGETATION IN THE HOLLOW. SAGE DOES NOT GROW IN THE TRACT, THO A HEAVY GROWTH OF SAGE COVERS THE SURROUNDING TERRITORY. BARCHANS HAVE A HABIT OF EXTENDING IN LONG LINES, SEVERAL BARCHAN CRESTS ON EACH LINE. CONTOUR LINES CATCH MOST OF THE DUNES WELL UP ON THEIR SLOPES AND SHOW ONLY SEPARATED CRESCENTS, NOT THIS CONTINUOUS RIDGING. DUNES STAND ON THE MLPO TERRACE, 110 FT AT IN THE SOUTHERN PART OF THE TRACT, 1150 IN THE NORTHERN. THEIR SAND HAS BEEN BLOWN UP OVER THE WESTERN SCARP OF THE MLPO TERRACE FROM THE EXTENSIVE DUNE TRACT SOUTH AND SOUTHWEST OF MOSES LAKE, THE TRACT WHICH IS RESPONSIBLE FOR THE PONDING OF THE LAKE. RIPPLES ON THE SURFACE OF THE DUNES SHOWS THAT THE WIND IS DEFLECTED IN PART BY THE SUMMIT OF THE BARCHAN AND IS THROWN AROUND TO MAKE THE HORNS.

DUNE SAND ALONG THE COLUMBIA RIVER TODAY IS ALMOST AS LIGHT COLORED AS LAKE MICHIGAN DUNE SAND.



A MOST INTERESTING COUNTRY LIES AT THE EAST END OF THE FRENCHMAN HILLS ANTICLINE. FOR TEN MILES OR SO CRAB CREEK FLOWS SOUTHWARD THRU THIS COUNTRY. DRUMHELLER SPRINGS LIES JUST NORTH OF IT AND THE GRANT-ADAMS CO LINE BISECTS IT IN MID-LENGTH. THIS REGION IS CHARACTERIZED BY A MAZE OF STREAM-CUT, BASALT-WALLED CHANNELS, IN A MOST INTRICATE ANASTOMOSING PATTERN. THE CHANNELS ARE FROM A FEW TENS OF FEET TO 200 FEET OR MORE IN DEPTH. THERE ARE HUNDREDS OF THE SHALLOWER ONES AND TWO DOMINANT DEEP ONES, THE VALLEY OF CRAB CREEK AND THE CHANNEL NOW CONTAINING GOOSE LAKE. THE SHALLOWER ONES, OF COURSE, ARE AT HIGHER ALTITUDES. THESE CHANNELS, IN DISSECTING THE BASALT, HAVE LEFT ISOLATED BUTTES AND STACKS, EXCEEDINGLY PICTURESQUE, OVER THE WHOLE AREA. THE HIGHEST LEVEL OF ANY OF THESE ROCK ISLAND AREAS IS 1275. THIS IS IN SEC. 22, NW OF GOOSE LAKE. A CHANNEL WITH A "HOLE" IN IT, SEPARATES THIS SMALL HILL FROM THE UNDISSECTED COUNTRY TO THE WEST. CHANNEL HAS MAXIMUM DEPTH OF 150+ FT. HILL IS CAPPED BY 100± FEET OF A LIME CONGLOMERATE, LYING ON THE BASALT. MORE OF THIS SEDIMENTARY LIES WEST, ALONG THE SOUTH FACE OF THE FRENCHMAN HILLS, AND AN ISOLATED MESA LIES ABOUT 10 MILES EAST, NEAR THE C.M. AND STP ~~RR.~~ RR. THE REST OF IT HAS ALL BEEN SWEEPED AWAY.

TO SHOW GRAPHICALLY THE TOPOGRAPHY OF THIS AREA, COLOR THE MESAS, BUTTES AND STACKS WITH DIFFERENT SHADES OF A WASH COLOR. DARKEST FOR EVERYTHING ABOVE 1200, THEN SUCCESSIVELY LIGHTER FOR EACH 1000 FOOT INTERVAL LOWER. LEAVE CHANNELS WHITE.

ALTITUDE OF SURFACE OF GOOSE LAKE IS BETWEEN 850 AND 875. ALTITUDE OF FLOOR OF CRAB CREEK VALLEY LESS THAN HALF A MILE BELOW SEPARATION OF GOOSE LAKE AND CRAB CREEK CHANNELS IS 875. DEPTH OF GOOSE LAKE UNKNOWN. A ROCK BARRIER AT 850+ HOLDS IN THE WATER OF THE LAKE. IF THE OUTLET BARRIER AND THE HEAD OF GOOSE LAKE BE TAKEN FOR A STREAM GRADIENT, IT IS OBVIOUS THAT THE WATERS MOVED ON A DEAD LEVEL FOR THE LENGTH OF THE LAKE, ABOUT 3 MILES. BUT IN FLOWING FOR THREE MILES WITH NO FALL, THE ANCIENT STREAM CUT BELOW THE LEVEL SURFACE TO MAKE THE ELONGATED CAVITY WHICH HOLDS THE LAKE. COULD THE DEPTH OF THE LAKE BE OBTAINED, THE CASE WOULD MAKE A FINE EXAMPLE OF THIS FEATURE OF RIVER CHANNELS.

THE GOOSE LAKE CHANNEL IS NARROW, THE SURFACE OF THE LAKE IN SOME PLACES BEING LESS THAN 250 FEET WIDE, AND NOWHERE EXCEEDING 1000 FEET. THE CRAB CREEK CHANNEL IS BUT LITTLE WIDER, SO FAR AS SHOWN ON THE CORFU SHEET. BUT DIRECTLY EAST OF THE LOWER END OF GOOSE LAKE, THE CRAB CREEK CHANNEL IS A REAL VALLEY, HALF A MILE WIDE AND FLOORED WITH ALLUVIUM.

THE ENTIRE WIDTH OF THE CHANNELLED TRACT EXCEEDS 6 MILES ALONG THE GRANT-ADAMS CO LINE. AT THE HEAD, WHERE THE WATERS FIRST SPILLED OVER THE BASALT IN THE CREST OF THE ANTICLINE, THE TOTAL WIDTH IS THREE MILES. OF THE SEVERAL CHANNELS AT THE HEAD, THE TWO SMALLER JOIN AND LEAD OVER A RE-ENTRANT PRECIPICE MORE THAN 100 FT HIGH, THE RELIC OF A WATERFALL WHOSE RE-ENTRANT SHOWS RECESSION OF 1500 FEET.

THE LARGEST AND WESTERMOST CHANNEL HAS A MOST INSTRUCTIVE GRADIENT PROFILE. THE WATER IN THIS CHANNEL CUT SEVERAL BASINS IN THE BOTTOM BEDROCK, THE DEEPEST OF WHICH EXCEEDS 75 FEET.

THE EASTERN WALL ~~OF~~ AT THE HEAD OF THE EASTERN CHANNEL IS COMPOSED OF GRAVEL. IT IS THE SLOPE OF THE END OF THE HIGHEST AND LONGEST TERRACE OF THE MOSES LAKE REGION. NO TRACE OF GRAVEL WAS FOUND IN ANY OF THE CHANNELS, EXCEPT A LITTLE PATCH JUST ABOVE THE FLOOR OF CRAB CREEK CHANNEL IN ONE PLACE.

THIS MAGNIFICENT PLEXUS OF ANASTOMOSING ROCK-WALLED CHANNELS IS UNDOUBTEDLY THE WORK OF WATER DISCHARGING FROM THE GRAND COULEE. THE ROCK BARRIER OVER WHICH THEY FIRST FLOWED WAS FROM



1200 TO 1275 A.T. THREE OF THE ENTERING CHANNELS WERE ERODED BELOW 950 WHILE THE LARGEST FLOOD WAS AT ITS HEIGHT. CRAB CREEK SINCE THEN HAS NOT LOWERED THE CHANNEL IT NOW OCCUPIES (THE EASTERN ONE) ENOUGH TO SHOW ON THE MAP (25 FT INTERVAL) AS EROSION BY THE GREAT STREAM PROCEEDED, FAVORABLY SITUATED CHANNELS WERE CUT DEEPER AND PROBABLY WIDER, AND THE ORIGINALLY LARGE NUMBER OF SMALL SHALLOW CHANNELS WAS GREATLY DECREASED. THE FITTEST SURVIVED. THE HIGH SURFACE TERRACE WAS GRADED WHILE THE SURFACE OF THE WATERS ENTERING THE TRACT WAS AT ABOUT 1050. BUT THE THREE MAJOR CHANNELS MAY THEN HAVE BEEN AT PRESENT DEPTH AND THE WATER IN THEM MAY HAVE BEEN 125 FEET DEEP. (SEE DEPTH OF WATER IN PRESENT DALLES LONG CHUTE) THIS ISNT PROBABLE, HOWEVER, FOR SINCE POST-GLACIAL DISCHARGE HAS NOT LOWERED THE CHANNELS PERCEPTIBLY, THE MOSES LAKE-ROCKY FORD-WILLOW CREEK AND THE DISHAW (WINCHESTER QUAD) CHANNELS CAN NOT BE THE RESULT OF POST-GLACIAL EROSION. THEY MUST HAVE BEEN EXCAVATED INTO THE HIGH TERRACE WHILE THE CHANNELS WERE BEING ERODED IN THE BASALT.

A STRUCTURAL MOSES LAKE-WINCHESTER-QUINCY VALLEY MUST HAVE EXISTED BEFORE THE GRAND COULEE DISCHARGED THE GLACIAL COLUMBIA ACROSS THE BADGER MTS. WHETHER A DESSICATED BASIN OR WITH DISCHARGE IS NOT KNOWN. BUT WHEN THE GLACIAL FLOOD ARRIVED, SPILLAGE OCCURRED, APPARENTLY BY THREE ROUTES, ONE SURELY ACROSS THE EASTERN NOSE OF THE FRENCHMAN HILLS ANTICLINE, AND PROBABLY AND PROBABLY TWO FOR A SHORT TIME BY WAY OF THE POTHoles AND FRENCHMAN SPRINGS RE-ENTRANTS IN THE QUINCY QUAD. A GREAT GRAVEL FILL WAS BUILT SOUTHWARD ENTIRELY ACROSS THE LOCAL GLACIAL LAKE TO THE BARRIER, REACHING IT BY THE TIME THE WATER LEVEL IN THE SPILLWAYS ACROSS WAS DOWN TO 1050. PERHAPS SEVERAL MINOR TERRACINGS IN THE HIGH TERRACE RECORD LOWERING OF THE LAKE FROM 1275 TO 1050 WHILE THE FILL WAS EXTENDING ACROSS. FURTHER DOWNCUTTING ALLOWED THE THREE LOWER TRACTS (ML., WC., DISHAW) TO BE FORMED, THE GRAND COULEE DISCHARGE ABANDONING THE DISHAW FIRST AND THE WILLOW CREEK LAST. WHETHER THE GRAND COULEE CARRIED AS MUCH GRAVEL AS FORMERLY, OR ANY AT ALL, ISNT KNOWN.

IMMENSE QUANTITIES OF GRAVEL MUST HAVE GONE THRU THESE ROCK-WALLED RIVER CHANNELS. BUT NONE LODGED, SO FAR AS SEEN. THE CONSTRICTION AND THE GREAT VOLUME OF WATER CAUSED STRONG CURRENTS WHICH KEPT THEM CLEAN. (THO IT DOES SEEM AS THO AT FINAL ABANDONMENT, SUCH DEPRESSIONS AS GOOSE LAKE WOULD HAVE BEEN FILLED AT LEAST TO THE LEVEL OF THE ROCK BARRIER. PERHAPS THE STREAMS THEN DIDNT CARRY MUCH GRAVEL. PERHAPS ABANDONMENT WAS VERY SUDDEN, WITH OPENING OF DRAINAGE UNDER THE WANING OKANOGAN LOBE. IT CAN BE CONCEIVED THAT THIS HUGE FLOOD CEASED IN A DAY.

THE RELATIONS OF THE BERGS WHICH CARRIED ERRATICS TO THESE GRAVEL TERRACES AND THESE CHANNELS IS PUZZLING. DID BERGS FLOAT ON THE GLACIAL MOSES LAKE? WHY NOT, IF THE OKANOGAN LOBE THEN WAS AT ITS MAXIMUM? THEN ARE THERE ERRATICS IN THE GRAVEL? NO SECTIONS TO SHOW. ARE THERE ANY ON THE TERRACES? YES, UP TO THE UPPER LIMIT OF THE SUBMERGENCE ON THE HIGH TERRACE AND IN MANY PLACES ON THE LOWER TERRACES. ARE THERE ANY ERRATICS IN THESE CHANNELS AND ON THE BUTTES AND ROCKY ISLANDS. YES, AT ALTITUDES UP TO AT LEAST 1150+ A NEST OF THEM ALONG SECONDARY ROAD EAST FROM FOOT OF GOOSE LAKE ON THE LARGE ISLAND BETWEEN GOOSE LAKE AND CRAB CREEK CHANNELS, AT ABOUT 925. Err. THEY MUST HAVE BEEN DEPOSITED AFTER THE TERRACES WERE BUILT. AND IF STREAM WATERS WENT OVER THIS LARGE ISLAND IN THE EARLY STAGES OF DEVELOPMENT OF THE GREAT CHANNEL PLEXUS AND IF THE TOP OF THIS ISLAND WAS SCoured AND PERHAPS LOWERED BY EROSION, THIS NEST WOULD NEVER HAVE PERSISTED. THUS IT SEEMS CORRECT, AT PRESENT WRITING, TO PLACE THE COLUMBIA SUBMERGENCE AFTER THE TERRACE-AND-CHANNEL DEVELOPMENT.



ANOTHER PUZZLE IS TO GET THE BERGS OVER GRAND FALLS IN GRAND COULEE. PERHAPS THEY WOULD TAKE THE PLUNGE SAFELY. PERHAPS THE SUBMERGENCE BACKED THE WATERS UP OVER THE FALLS. ALT. OF LIP OF FALLS WILL SETTLE THIS. PERHAPS THE FALLS DEVELOPED AFTER THE SUBMERGENCE SUBSIDED. THE CHANNEL PLEXUS PROBABLY ANTIDATES THE SUBMERGENCE, BUT THE FALLS, HIGHER PROBABLY THAN ~~THE~~ ITS LEVEL, MAY HAVE DEVELOPED AFTER THE SUBMERGENCE (VERY BRIEF) HAD SUBSIDED BUT WHILE GLACIAL WATERS WERE STILL RUNNING. THIS IDEA DOES NOT HARMONIZE, HOWEVER, WITH THE SUGGESTION OF ABRUPT DIVERSION OF THE GLACIAL COLUMBIA TO PRESENT ROUTE.

AGE OF THE PLEXUS IS WISCONSIN. THIS FOLLOWS FROM (1) - WISCONSIN AGE OF OKANOGAN LOBE, (2) CONTEMPORANEOUS DEVELOPMENT OF THE TERRACES (WISCONSIN OUTWASH) AND CHANNELS. ~~BY~~ HOW DO THESE CHANNELS COMPARE IN FRESHNESS WITH THOSE OF THE ROCK LAKE GROUP AND THE SPRAGUE-LAMONT GROUP? SO FAR AS VISUAL IMPRESSIONS, TAKEN A WEEK APART, GO, THEY ARE OF THE SAME AGE. THE SAME AMOUNT OF TALUS, IN GENERAL, HAS ACCUMULATED AT THE BASE OF THE CLIFFS AND THE SAME AMOUNT OF DESTRUCTION OF CLIFF EDGES HAS OCCURRED.

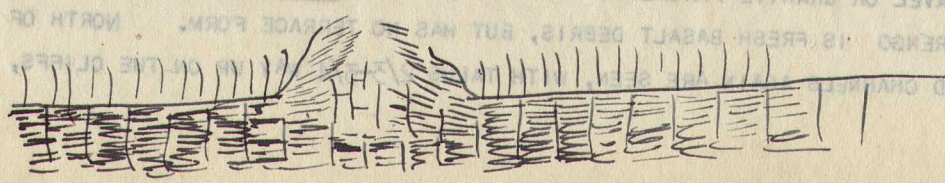
Ent.

AT WARDEN, TWO UNDOUBTED GRANITE ERRATIC BLDRS ON THE SURFACE OF THE BASALT PLAIN. ONE AT THE NORTHWEST CORNER OF THE TOWN ON THE CM AND STP RR RIGHT OF WAY, THREE FEET MAX. DIAMETER, LIME-ENCRUSTED, ALTITUDE CLOSE TO 1275. ANOTHER ALONG HIGHWAY HALF A MILE WEST OF NRRR AT ABOUT 1250 NO EASTWARD TILTING, AS MEINZER SUGGESTED, TO GET SPILLWAY SHIFTED FROM THE POTHOLES TO DRUMHELLER SPILLWAYS. ALTITUDE OF THESE BLDRS IS AT THE MAXIMUM FOR THEIR KIND.

THE GLACIAL DRAINAGE, EMERGING FROM THE DRUMHELLER PLEXUS, ALMOST ALL WENT WEST BY WAY OF NORTH FLANK OF SADDLE MTS, ALONG THE STRUCTURAL VALLEY THERE. BUT A SMALL SPILLWAY AT 925 WENT AROUND THE EAST END OF SADDLE MTN. THIS IS READ FROM THE CORFU MAP. NOT SEEN IN THE FIELD. ANSON SIDING AT THE COL. DID THIS SPILLWAY ENTER ESQUATZEL COULEE? (SEE 1923)

A LIMESTONE WITH PEBBLES EXPOSED IN NP AND CM AND STP CUTS WEST OF WARDEN. MOSTLY LIME. WHITE, FRIABLE, POORLY STRATIFIED, MANY CASTS OF ROOTS AND STEMS IN VERTICAL POSITIONS. STRATIFICATION MUCH DISTURBED IN A MINOR WAY. DRYING CRACK IN THE WHITE LIME, FILLED WITH BROWN SAND, ON ONE SURFACE. THIS IS BENT IN AN ARC OF 30-40°, A SHAPE IN WHICH IT NEVER WAS ORIGINALLY DEPOSITED. ALL TOLD, THIS CALCAREOUS LAYER, 6 FT. EXPOSED THICKNESS, APPEARS TO BE AN ALKALINE OR SALINE PLAYA; DESICCATED AND FILLED ALTERNATELY, PEBBLES WASHED IN, SAND WASHED IN, PLANTS GROWING AT TIMES. SUBSEQUENT TO ITS FORMATION, ITS MORE SOLUBLE CONSTITUENTS HAVE BEEN REMOVED BY LEACHING, THE ORIGINAL DEPOSIT HAS BECOME MUCH LESS IN VOLUME, AND MINOR DEFORMATIONS HAVE OCCURRED, NONE OF THEM DIASTROPHICALLY DETERMINED. THIS LIME PLAYA THEREFORE IS DATED BACK ONLY TO THE WEATHERING OF THE SURFACE OF THE COLUMBIA BASALT FORMATION.

A STRATIFORM MEMBER OF THE BASALT SERIES EXPOSED IN THE DRUMHELLER CHANNEL PLEXUS, HAS LARGE AND VERY UNIFORM COLUMNS FROM BOTTOM TO TOP. NO GRADATION <sup>upward</sup> FROM LARGE TO SMALL AND FROM SMALL TO THE CHECKED PHASE AND FINALLY TO THE SCORIAGEOUS UPPERMOST PART. THE STRAIGHT VERTICAL COLUMNS ARE STRIKINGLY HEXAGONAL AND HAVE INNUMERABLE HORIZONTAL PLATY PARTINGS. THE CHARACTERS OF THIS MEMBER OF THE COLUMBIA LAVA DIFFER SO STRIKINGLY FROM THE FLOWS ~~THAT~~ IT WAS SUSPECTED OF BEING A SILL. A LITTLE SEARCH SHOWED WHERE IT BROKE UP THRU THE OVERLYING BASALT FLOW, THE PLATY STRUCTURE CURVING AS SHOWN IN THE SKETCH. THE EROSION OF THE SECTION WAS SUCH THAT A





GOOD DIKE STRUCTURE DOES NOT SHOW, BUT THE SOIL CHARACTER IS CLEAR. TO WHAT EXTENT DO SILLS OCCUR IN THE COLUMBIA LAVA SERIES? THEY HAVE NEVER BEEN DESCRIBED IN THE LITERATURE.

WARDEN TO CHENEY AUG 12 1922

TOPOGRAPHY OF REGION BETWEEN WARDEN AND MARENGO ALONG C.M. AND STP RR IS MATURE. BUT THE SPACING OF STREAM WAYS IS MUCH WIDER THAN IN THE PALOUSE MATURE FIRST CYCLE TOPOGRAPHY. THIS GIVES, WITH APPROXIMATELY THE SAME RELIEF, LONGER AND GENTLER SLOPES FROM HILLTOPS TO VALLEY FLOORS. LOESS IN SOME PLACES IS AT LEAST 10-12 FT THICK. BUT ALMOST ALL SLOPES HAVE ROCK OUTCROPS SOMEWHERE. THE DIFFERENCE BETWEEN THIS AND THE PALOUSE FIRST CYCLE TOPOGRAPHY MAY BE DUE TO LESS RAINFALL HERE OR TO DIFFERENT MATERIAL IN WHICH THE EROSION OCCURRED. ALL BASALT FROM WARDEN TO MARENGO. AND SO FAR AS KNOWN, ALL BASALT IN PALOUSE COUNTRY. BUT FIRST CYCLE HILLS ABOUT MARENGO ARE CLEARLY OF AN ASH SEDIMENTARY ABOVE THE BASALT.

NO SECOND CYCLE CANYONS FROM WARDEN EAST IN LIND COULEE. WHAT LOOKS LIKE AN INNER CANYON IN PLACES APPARENTLY IS BUT THE PRESENCE OF AN UNUSUALLY RESISTANT BASALT FLOW.

NO MOUNDS FROM DRUMHELLER CHANNELS TO MARENGO. LOESS SOIL DOESN'T BEAR MOUNDS.

COW CREEK VALLEY BOTTOM HARDLY 100 FT BELOW DIVIDE NEAR RALSTON BETWEEN IT AND THE HEAD OF LIND COULEE. SO LOW THAT IT MIGHT BE EXPECTED THAT THE GLACIAL FLOOD WHICH CAME DOWN COW CREEK WOULD SPILL OVER DOWN LIND COULEE. BUT NO EVIDENCE OF THIS SEEN. TALUS IN COW CREEK VALLEY, AT FOOT OF MAIN WALLS, RESTING ON FLAT FLOOR, RISES 2/3-3/4 OR MORE OF THE TOTAL HEIGHT OF THE WALLS. AND PRETTY WELL BROKEN DOWN INTO FINE MATERIAL, AND TO SOME EXTENT, GRASSED. NOTHING LIKE THIS IN THE CRAB AND GOOSE CHANNELS, DRUMHELLER PLEXUS. PRACTICALLY NO TALUS ON THESE CHANNEL WALLS (LATER ????) CERTAINLY AND ASSUREDLY, THE DRUMHELLER CHANNELS ARE MUCH FRESHER THAN THE COW CREEK VALLEY. IS THERE ENOUGH DIFFERENCE IN RAINFALL IN THE TWO REGIONS TO ACCOUNT FOR THIS? IT IS VERY, VERY UNLIKELY. SEE RAINFALL MAP OF STATE.

FROM MARENGO TO CHENEY, THE C.M. AND STP RR TRAVERSES A GREAT GLACIAL SPILLWAY, THE SAME SPILLWAY (IN PART AT LEAST) WHICH HAS PREVIOUSLY BEEN CROSSED BETWEEN LAMONT AND SPRAGUE. AT MARENGO, NUMEROUS ISLAND-LIKE HILLS AND HILL TRACTS OF THE FIRST CYCLE TOPOGRAPHY STAND ISOLATED ON THE BASALT PLAIN, THEIR EDGES STEEPENED AND SHARPENED BY THE GLACIAL DRAINAGE WHILE THEIR OLD MATURE VALLEYS AND SLOPES LIE UNCHANGED ON THEIR UPPER SURFACES. THESE APPEAR TO BE COMPOSED WHOLLY OF AN ASH SEDIMENTARY. IT SEEMS CLEAR THAT THEIR COMPLETE REMOVAL OVER THE GLACIAL SPILLWAYS HAS BEEN DUE TO THAT VERY SPILLAGE. THE GLACIAL WATERS HAD MANY ROUTES, ANASTOMOSING IN A CURIOUS FASHION. THE BASALT SURFACE, SWEEPED BARE, HAS BEEN EXPOSED OVER A LARGER AREA THAN THE SURVIVING HILLS NOW COVER. THE BASALT FLOOR HAS BEEN ETCHED INTO BUTTES AND CHANNELS, AND THE TALUS ACCUMULATIONS HAVE SINCE CREPT NEARLY TO THE SUMMIT OF THE CLIFFS AND LIE WITH GENTLE SLOPES, SOME OF THEM GRASSED AS IN COW CREEK VALLEY. CLEARLY AND ASSUREDLY, THESE ARE OLDER FEATURES, PHYSIOGRAPHICALLY, THAN THE CANYONS OF THE DRUMHELLER COMPLEX. OPINION EXPRESSED IN NOTES ON THE DRUMHELLER TRACT IS DISTINCTLY IN ERROR. (LATER INTERPRETATIONS RETURN TO THE ORIGINAL. SEE 1923)

BETWEEN MARENGO AND CHENEY, THE GLACIAL SPILLWAY CHANGES CHARACTER SOMEWHAT FROM PLACE TO PLACE. ABOUT EMDEN THERE ARE NO CHANNEL FORMS BUT LEVEL SCABLAND EXTENDS TO THE HORIZON ON EITHER SIDE. NO GRAVEL OR GRANITE FRAGMENTS SEEN HERE, THO AT MARENGO BOTH ARE PRESENT. GRAVEL AT AND NEAR MARENGO IS FRESH BASALT DEBRIS, BUT HAS NO TERRACE FORM. NORTH OF EMDEN THE COULEE ROCK-WALLED CHANNELS AGAIN ARE SEEN, WITH TALUS 2/3-3/4 WAY UP ON THE CLIFFS, BUT NO



FIRST CYCLE HILLS IN SIGHT. STILL FARTHER NORTH, MORE FLAT SCABLAND FILLS THE LANDSCAPE. THEN, SHALLOW CANYONS AGAIN, ANASTOMOSING OR ABRUPTLY BEGINNING AND ENDING, WITH TALUS IN PLACES CLEAR TO THE TOP OF WALLS AND GRASSED.

CHENEY TO COULEE CITY BY WASHINGTON CENTRAL RR

SUNDAY AUGUST 13 1922

CHENEY TILL COVERED WITH SEVERAL FEET OF LOESS IN ONE OF THE PITS. MORE EVIDENCE THAT IT IS OLDER THAN THE LOESS AND THE MATURELY ERODED SLOPES. MORE OF THIS CHENEY TILL SEEN NEAR GRANITE LAKE ALONG ROADWAYS, BUT NOT AS GOOD EXPOSURES AND NO STRIATED MATERIAL. SUSPECT THAT IT EXISTS IN MANY PLACES IN THIS GROUP OF HILLS, FOR THEY MUST HAVE BEEN OVERRIDDEN BY THIS ANCIENT GLACIATION. (SEE 1923 NOTES)

GRANITE LAKE LIES IN A ROCK BASIN IN A GLACIAL DRAINAGE CHANNEL. IT HAS BASALT ABOUT THE SIDES AND THE ~~NORTH~~ SOUTH END, AND GRANITE ABOUT THE NORTH END. THE GRANITE IS INTERESTING BECAUSE IT CONTAINS SEVERAL DIKES OF BASALT, FEEDERS FOR THE ONCE OVERLYING COLUMBIA LAVA. BASALT PRESENT AT HIGHER LEVELS IN BLUFF TO THE WEST.

MEDICAL LAKE, SILVER LAKE, INDEED ALL LAKES IN THIS REGION, LIE ON GLACIAL DRAINAGE CHANNELS. THESE CHANNELS HEAD IN THE LATITUDE OF MEDICAL LAKE AND FOUR LAKES. TO THE NORTH, ABRUPTLY ENDING AGAINST THE HILLS FARTHER SOUTH, IS AN EXTENSIVE PLAIN WHICH, SEEN FROM WASHINGTON CENTRAL RR. IS COVERED WITH COARSE DARK SAND. NO COBBLES OR BLDRS TO SHOW VIGOR OF CURRENT. NO GRANITE FRAGMENTS. NORTH OF GNR RR TRAX, HOWEVER, THE PLAIN IS UNDULATING, THE RELIEF DUE TO THE BROAD SHALLOW VALLEYS OF DEEP CREEK TRIBUTARIES. IN THIS UNDULATING PORTION, BASALT COMES TO THE SURFACE. HILLS AND LAKES HANG TOGETHER. PLAIN A LITTLE LOWER THAN LAKE VALLEYS.

ABUNDANT GRANITE AND QTZITE (BLUE) BLDRS ABOUT HILLS AND LAKES. BOTH APPARENTLY DERIVED FROM THE HILLS WHICH ARE ROCK KNOBS OF THE PRE-BASALT TOPOGRAPHY. THESE BIG HILLS, THOT TO BE PRE-BASALT, EXTEND WEST OF MEDICAL LAKE FOR PERHAPS 10 MILES. THEY APPEAR TO BE LOESS-COVERED. THEY ARE MUCH MORE GENTLE IN SLOPES THAN STEPTOE, TEKOA, ETC. AND IN A STRIKING WAY, THEY ALL HAVE STEEPER SLOPES TO THE NORTH AND GENTLER TO THE SOUTH. THIS SUGGESTS OVERRIDING BY ICE AND ACCUMULATION OF A "TRAIL" OF TILL ON THE LEE SIDE. BUT NO ONE EVER DIGS A WELL OR GRADES A ROADWAY ON THESE HILLSLOPES AND THERE ARE NO EXPOSURES TO CLEAR UP THE MATTER.

DEEPLY DECAYED BASALT CLOSE TO SURFACE TWO MILES NORTH OF DEEP CREEK STATION. SCABLAND A MILE FARTHER. ABOUT HITE IS FIRST CYCLE TOPOGRAPHY WITH WIDE-SPACED VALLEYS AND GENTLE SLOPES. MORE PRONOUNCED, THO, THAN TOPOGRAPHY BETWEEN WARDEN AND MARENGO. ONE MILE EAST OF HITE ARE ABUNDANT GRANITES IN FIELDS AND ALONG RIGHT-OF-WAY OF RR, AND LOW KNOBS, PROBABLY OF GRANITE, IN THE FIELDS. THESE GRANITE BRAGMENTS ARE PROBABLY ALL LOCALLY DERIVED AND DO NOT IMPLY GLACIATION. PALOUSE SOIL HERE AND WESTWARD WHERE THERE IS ANY SOIL, COMPLETELY ACROSS TO HARTLINE. GRAVEL PIT ONE MILE WEST OF HITE, LIGHT-COLORED MATERIAL, MIGHT BE LOCALLY DERIVED FROM GRANITE. SEEN FROM TRAIN AND OF COURSE NO DEFINITE OPINION. LOESS TO BOTTOM OF CUTS, 12 FT. CALCAREOUS CONCRETIONS. NO BASALT SEEN FOR A FEW MILES ON EITHER SIDE OF HITE. ALMOST NO ROCK FRAGMENTS OF ANY SORT. ALL LOESS.

ABOUT REARDEN, MUCH SCAB BASALT. 2-3 MILES WEST OF REARDEN IT IS SCABBY ENOUGH FOR A GLACIAL DRAINAGE LINE. BUT NO CANYONS, LOW BUTTES, GRANITE FRAGMENTS OR GRAVEL. AND HILLS TO THE NORTH PROHIBIT GLACIAL DRAINAGE. (?) ALL LOESS ON MATURE SLOPES THENCE TO DAVENPORT AND MONDOVI.



WEST OF DAVENPORT, A LARGE PLANE TRACT, WITH SLIGHT UNDULATIONS, NO HILLS OR VALLEYS. SOIL THIN, BASALT CLOSE TO SURFACE, SAGE-COVERED, NO FARMING. NO GLACIAL DEBRIS OF ANY KIND SEEN. COMPARE WITH SIMILAR TRACT ABOUT EMDEN, NORTH OF MARENGO. DID GLACIAL DRAINAGE SCOUR OFF THE EMDEN TRACT? APPARENTLY IT DID NOT PRODUCE THIS AREA WHICH EXTENDS BEYOND ROCKLYN. (LATER— IT DID! 1923 NOTES)

TWO MILES WEST OF ROCKLYN, A FEW LOW FIRST CYCLE HILLS. THEN LEVEL SCABLAND NEARER TELFORD. TWO MILES WEST OF ROCKLYN, A GRANITE BLDR., 6 FT IN DIAMETER, CLOSE TO TRACK, SOUTH SIDE. LAKES AND SWAMPS IN THE SCABLAND. THESE FEATURES IMPLY GLACIATION OR GLACIAL DRAINAGE. BUT CHANNEL FORMS ARE INDEFINITE. SHALLOW ROCK BASINS ONLY. A FEW MILES FARTHER ON, A GOOD CHANNEL IN BASALT, 10-20 FT DEEP. TALUS NEARLY TO THE TOP OF MANY CLIFFS. GRANITE SCARCE BUT PRESENT. SOME BLDRS SEVERAL FEET IN DIAMETER.

THIS TRACT OF SCABLAND, APPARENTLY SCOURED OFF, EXTENDS FROM DAVENPORT TO CRESTON, WITH THE INTERRUPTION OF A FEW LOW FIRST CYCLE HILLS NEAR ROCKLYN. IT IS FROM 15 TO 20 MILES WIDE. FROM ROCKLYN TO TELFORD, THE CHANNEL FORMS ARE POOR, ETCHING NOT VERY DEEP. WEST OF TELFORD, THE COUNTRY IS ALL CUT UP INTO BUTTES, 20-30 FT HIGH, WITH SCOURED ANASTOMOSING CHANNELS AROUND THEM. TALUS WELL UP ON SLOPES, EVEN REACHING SUMMITS.

A FEW MILES EAST OF CRESTON ARE GRANITE OUTCROPS IN LOW RIDGES AND HILLS, NOT NOTABLY ABOVE LEVEL OF BASALT PLAIN. A BIG HILL, SOIL-COVERED, JUST SOUTH OF CRESTON, PROBABLY A PRE-BASALT TOPOGRAPHIC FEATURE. AS IN THE PLAOUSE COUNTRY, WE ~~ARE~~ ARE HERE CLOSE TO THE MARGIN OF THE GREAT PRE-BASALT BASIN AND FOOTHILLS OF THE OLDER MTS TO THE NORTH WERE NOT ALL COMPLETELY SUBMERGED. BY LOCAL AUTHORITY, THIS CRESTON HILL IS COMPOSED OF "HUNGRY QUARTZ".

LAKES SHOWN ON USGS WASHINGTON MAP SOUTH OF TELFORD UNDOUBTEDLY INDICATE SOUTHWARD EXTENSION OF THIS SCRUBBED TRACT. DRAINAGE INTO LAKE CREEK AND PERHAPS A FEW NEIGHBORING TRIBUTARIES OF CRAB CREEK.

ABOUT CRESTON, TO SOUTH AND WEST AND A FEW TO THE EAST, ARE FIRST CYCLE HILLS. A BROAD PLAIN, SOIL-COVERED, TO THE NORTH EXTENDS ALL THE WAY TO THE COLUMBIA. SHARP TRANSITION BETWEEN HILLS AND PLAIN TO NORTH, ALSO BETWEEN HILLS AND SCABLAND TO EAST. A FEW GRANITE ERRATIC FRAGMENTS ABOUT CRESTON, BUT SO MANY GRANITE KNOBS AND OUTCROPS THAT THIS MATERIAL LOSES ALL SIGNIFICANCE UNLESS ASSOCIATED WITH OTHER FEATURES.

LOESS SOIL FROM CRESTON WEST. A FEW GRANITE BLDRS SEEN ALONG TRACK AMONG FIRST CYCLE HILLS BETWEEN CRESTON AND WILBUR.

AT WILBUR, SCABLAND, GLACIAL DRAINAGE CHANNELS VERY DEFINITE, 40 FT DEEP, GRANITES AND MUCH BASALTIC GRAVEL. NO TERRACE FORMS. TALUS WELL UP ON CLIFFS. THIS IS ON WILSON CREEK.

HELLGATE ON USGS MAP AT HEAD OF WILSON CREEK SUGGESTS THAT A VERY DEFINITE DRAINAGE CHANNEL EXISTS HERE ACROSS THE DIVIDE. (LATER—; NOT SO) AT WILBUR, THERE IS NO WIDE SCRUBBED TRACT, THE FIRST CYCLE HILLS BEING NOT MORE THAN 3 OR 4 MILES APART ON THE TWO SIDES OF THE CHANNEL. A FEW MILES BELOW WILBUR, ALONG WILSON CREEK, THE FIRST CYCLE HILLS ARE VERY BROAD AND VERY GENTLY SLOPED. HEAD OF SECOND CYCLE VALLEY BEGINS HERE, JUST A FEW MILES BELOW WILBUR. BUT NOT A CANYON. IT IS BROAD, WITH STEEP BUT NOT HIGH CLIFFS.

AT GOVAN IS A BIG GRAVEL TERRACE, THE SUMMIT AT TOP OF SECOND CYCLE VALLEY AND FILLING IT DOWN TO THE BOTTOM. THE SECOND CYCLE VALLEY THEREFORE IS OLDER THAN THE GLACIAL SPILL.

AT ALMIRA, THE FIRST CYCLE HILLS ARE GENTLE IN SLOPE, BUT THE RELIEF IS A FEW 100S OF FT. PERHAPS THE HIGHER HILLS TO THE NORTH ARE FOLDED UP, NOT LEFT BY EROSION. DEFORMATION IS TO



BE RECKONED WITH, <sup>IN</sup> INTERPRETING TOPOGRAPHY IN THE COUNTRY WEST OF ALMIRA, AND THE DATING OF THAT DEFORMATION IN TERMS OF THE PHYSIOGRAPHIC HISTORY MUST BE DETERMINED. DEEP LOESS ON ALL SLOPES, NO ROCK OUTCROPS, NO ROCK FRAGMENTS. NO SECOND CYCLE, FIRST CYCLE VALLEY FLOORS BROAD AND FLAT AT HARTLINE AND WESTWARD TO THE EDGE OF THE SHARPER DESCENT TO COULEE CITY, THERE IS A BROAD APPARENTLY DEAD LEVEL VALLEY FLAT, MILES IN DIAMETER. SHALLOW VALLEYS IN IT SHOW THAT AT HARTLINE IT IS COMPOSED OF ALLUVIUM OR SILT OR LOESS. NEARER COULEE CITY AND HARD AGAINST THE HILLS TO THE NORTH, IT IS COMPOSED OF GRAVEL. THIS AGGRADED TRACT IS ANOMALOUS, IN TERMS OF THE FIRST CYCLE AND SECOND CYCLE HISTORY. LOOKS VERY MUCH AS THO A STRUCTURAL BASIN EXISTED HERE AND HAD BEEN FILLED.

COULEE CITY TO SOAP LAKE, VIA GRAND COULEE AUGUST 14 1922

AT COULEE CITY, BOTH WALLS OF GRAND COULEE ARE GENTLE. ON THE EAST, THE SLOPE DESCENDS FROM THE HARTLINE AGGRADATIONAL PLAIN BY A SERIES OF LOW STRUCTURAL TERRACES, AND ON THE WEST, A GREATER DESCENT IS MADE WITHOUT TERRACES THO THE SLOPE IS STEEPER. BOTH UP AND DOWN THE COULEE FROM THIS TOWN, PRECIPITOUS WALLS ENCLOSE THE CANYON. DOWNSTREAM, THE WESTERN WALL IS PROBABLY TWICE AS HIGH AS THE EASTERN.

THE GRAND FALLS IN THE FLOOR OF GRAND COULEE IS NOT A SIMPLE FEATURE. IT IS MADE UP OF A GREAT LEDGE OF BASALT, SOME 400 FEET ABOVE THE COULEE BOTTOM TO THE SOUTH, SEVERAL FLOWS BEING INVOLVED IN THE LEDGE. THIS LEDGE HAS A VERY IRREGULAR, CRENULATED MARGIN, CAUSED BY SEVERAL PROMINENT AND MANY MINOR CHANNELS CUT BACK INTO IT BY SEPARATE RECEDING FALLS OR PORTIONS OF THE GREAT FALL. THIS HAS GIVEN RISE TO HUGE BATTLEMENTED AND PALISADED SPURS AND BLADES PROJECTING DOWN THE COULEE AT VARYING DISTANCE. "DRY FALLS" IS AT THE HEAD OF THE LARGEST, MOST DEFINITE AND MOST DEEPLY NOTCHED RE-ENTRANT CUT IN THE GREAT LEDGE.

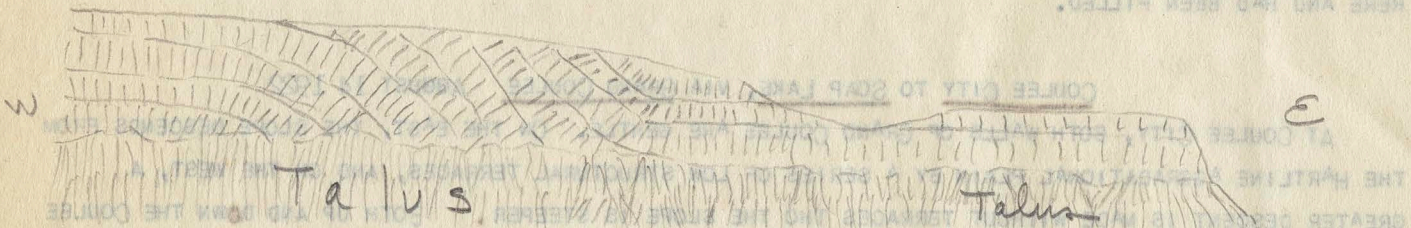
THE FACE OF THE GREAT LEDGE IS A SHEER DROP IN BUT FEW PLACES. IN MOST PLACES, IT IS BROKEN INTO LEDGES AND TERRACES, DETERMINED BY THE SEVERAL FLOWS INVOLVED. THE DIFFERENT CHANNELS AND THEIR FALLS ARE NOTCHED AT VARYING DEPTHS ON THE UPPER SURFACE OF THE LEDGE, ALSO. THE WHOLE ENSEMBLE WAS WELL ON THE WAY TO DISAPPEARANCE AS A UNIT WATERFALL AND TO TRANSFORMATION TO THE DALLES TYPE OF RIVER CHANNEL AT THE TIME IT WAS ABANDONED. THE CHARACTER OF THE ROCK LEDGE WAS NOT SUCH AS TO MAINTAIN THE NIAGARA TYPE OF FALL. PRISMATIC STRUCTURE ALLOWED EXCESSIVE PLUCKING IN FAVORED PLACES, RAPID ENTRENCHING OF SMALLER, DEEPER CHANNELS, AND RAPID RETREAT OF SMALLER FALLS IN SUCH PLACES, AND ABANDONMENT OF OTHER TRACTS TO BECOME ROCK ISLANDS OR ROCK SHALLOWS. THERE IS NO NOTABLY WEAKER ROCK IN THE LOWER PORTION OF THE GREAT LEDGE THAN IN THE UPPER, AND WERE IT NOT FOR THE PRISMATIC STRUCTURE, FALLS, IF ONCE INITIATED, WOULD NOT HAVE PERSISTED AT ALL OVER THE LEDGE.

IF THE ABOVE CONCLUSIONS ARE CORRECT, THE QUESTION ARISES "HOW COULD THESE FALLS HAVE RETREATED FOR THE 17 MILES WHICH MEINZER ASCRIBES, FROM SOAP LAKE AT MOUTH OF GRAND COULEE TO PRESENT LOCATION?" THE ANSWER IS "THEY HAVE NOT RETREATED FOR THAT DISTANCE" THE FALLS TOOK <sup>Freshwater</sup> ORIGIN AT THE HEAD OF BLUE LAKE AND THE EASTERN PART, IN WHICH HAS OCCURRED THE MAXIMUM RECESSION, DID NOT RETREAT EVEN 3 MILES. DRY FALLS IS AT THE HEAD OF THE LONGEST AND DEEPEST REENTRANT AND PERHAPS RETREATED AS FAR, BUT NOT TO EXCEED 3 MILES. THE EVIDENCE FOR THIS NOTABLY DIFFERENT INTERPRETATION IS FOUND IN THE STRUCTURE OF THE BASALT FROM THE HEAD OF <sup>Freshwater</sup> BLUE LAKE DOWN NEARLY OR QUITE TO SOAP LAKE. IT IS AS FOLLOWS.

*as part of the ...*



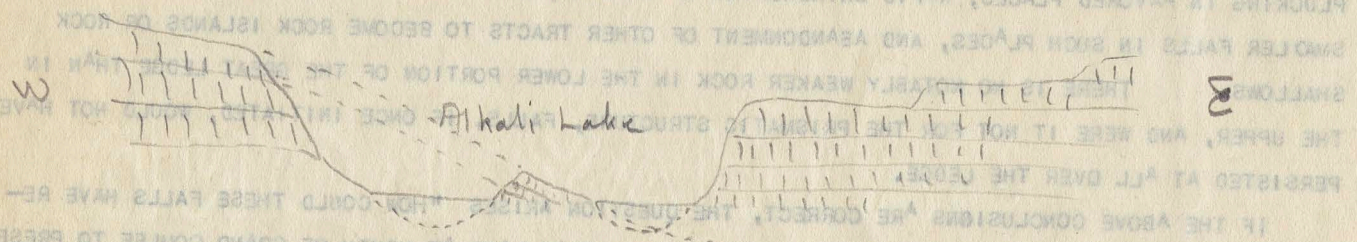
GRAND COULEE, BELOW HEAD OF ~~BLUE~~ <sup>FRESHWATER</sup> LAKE, IS ERODED IN TILTED BASALT, WITH SOME WIDENING ON THE EAST TO INVOLVE HORIZONTAL BEDS. THE COURSE OF THE COULEE IS THE STRIKE OF THE FLEXURE. THE DIP IS AS HIGH AS  $60^\circ$  AT THE HEAD OF ~~BLUE~~ <sup>FRESHWATER</sup> LAKE. THE STRUCTURE IS EITHER MONOCLINAL, WITH DIP DOWN TO THE EAST, OR SYNCLINAL WITH A STEEP WESTERN LIMB AND A VERY GENTLE EASTERN LIMB. NO STREAM FLOWING ON SUCH A STRUCTURE WOULD DEVELOP OR MAINTAIN FALLS. THE BEST SECTION TO SHOW THIS STRUCTURE IS AT THE NORTH END OF BLUE LAKE WHERE THE COURSE OF THE COULEE (FOLLOWED UPSTREAM) PASSES OUT OF THE TILTED ZONE WHERE IT TURNS EASTWARD. THE FOLLOWING IS A SKETCH OF THE NEARLY E-W CLIFF AT THE HEAD OF ~~BLUE~~ <sup>FRESHWATER</sup> LAKE



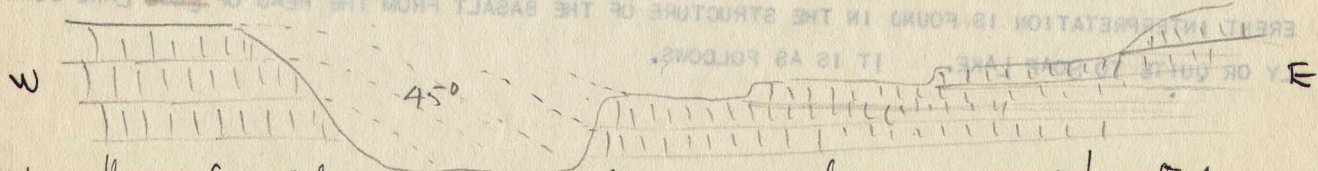
THE STEEPEST DIP SHOWN IN THE SECTION IS ABOUT  $60^\circ$  THE DOWNFOLD AMOUNTS ROUGHLY TO 1000 FEET. IT CARRIES THE HIGHEST BASALT EDGES IN THE WESTERN WALL (ABOUT 1000 FT HIGH) DOWN BELOW THE BOTTOM OF THE VALLEY EAST OF THE FOLD. THE STRATA ARE ESSENTIALLY HORIZONTAL EAST OF THE MONOCLINAL AXIS, AS SEEN IN THE GREAT CLIFFS IN THE EASTERN PART OF GRAND FALLS. THE STRATA THERE CONSTITUTING THE LEDGE OF THE FALLS ARE MISSING FROM THE SUMMIT OF THE WESTERN BLUFF. AT LEAST 500 FEET OF BASALT WAS ERODED FROM THE UPPER SIDE OF THE FOLD, BEFORE THE COULEE WAS FORMED.

THIS MONOCLINAL FOLD EXPLAINS THE HIGHER WESTERN AND LOWER EASTERN CLIFFS OF GRAND COULEE. THE COINCIDENCE OF ITS AXIS AND THE COURSE OF GRAND COULEE BELOW THE HEAD OF ~~BLUE~~ <sup>FRESHWATER</sup> LAKE EXPLAINS WHY THE FALLS DID NOT, COULD NOT, TAKE ORIGIN EXCEPT AT SUCH PLACE AS THE COULEE COURSE AND THE FOLD AXIS DIVERGE.

MORE EVIDENCE FOR THIS FOLD IS FOUND IN THE ISLANDS IN ~~BLUE~~ <sup>FRESHWATER</sup> LAKE AND ~~IN~~ ALKALI LAKE. MANY OF THESE ARE HOGBACK IN FORM AND STRUCTURE. FURTHER EVIDENCE TO BE SEEN IN THE BLUFFS. THE WESTERN GREAT CLIFFS IN MANY PLACES SHOW THE BENDING DOWN OF THE FLOWS AND SOME OF THE LOWER EASTERN BLUFFS SHOW AN UPTURNING OF THE FLOWS IN THE WALLS. THE GENERAL SITUATION IS AS SHOWN



THIS STRUCTURE IS CLEARLY A VERY UNSYMMETRICAL SYNCLINE NEAR MID-LENGTH OF ALKALI LAKE. THE MAXIMUM DIP OF THE WESTERN STEEPER LIMB ISN'T WELL SHOWN HERE BECAUSE OF REMOVAL BY EROSION, BUT IT AMOUNTS TO SOMETHING LIKE  $45^\circ$ . THE EASTERN LIMB RISES IN THE SLOPES EAST OF THE COULEE AT ABOUT A  $3^\circ$  SLOPE. AS FOLLOWS—



Apparently, a few miles east of the coulee, the upland is nearly or quite as high as on the west.



THE GRAND COULEE IS NOT A SIMPLE GREAT GORGE BELOW COULEE CITY. THE ORIGINAL SPILLWAY WAS MUCH WIDER ON THE EAST THAN NOW. AT ALTITUDES AVERAGING PERHAPS 500 FT ABOVE THE PRESENT FLOOR ARE TYPICAL SPILLWAY CHANNELS, ANASTOMOSING, WITH BASALT BUTTES AND ISLANDS AMONG THEM, DEPTH A FEW TENS OF FEET UP TO 100 FT., IDENTICAL IN CHARACTER WITH THE SPILLWAYS SEEN ON THE BASALT SW OF SPOKANE AND ACROSS LINCOLN, ADAMS AND GRANT COUNTIES. CONTINUED DOWNCUTTING RESTRICTED THE DEEPER PORTION TO THE <sup>TILTED</sup> ~~DEEPER~~ FLOWS.

TALUS ON COULEE WALLS AVERAGES HALF THE HEIGHT OF THE CLIFFS. ANGLE OF REPOSE OF FRESHLY FALLEN ANGULAR BASALT FRAGMENTS IS 35°. HOW MUCH LONGER HAS A CLIFF BEEN WEATHERING, WHOSE TALUS STANDS 3/4 OF THE WAY UP ON A CLIFF? ASSUME A VERTICAL CLIFF AND A HORIZONTAL BASE. ASSUME CLIFF COMPOSED OF COLUMNAR BASALT SO THAT AT ALL TIMES, THE UPPER PORTION, ABOVE THE TALUS REMAINS VERTICAL. ASSUME UNIFORM RATE OF FALL OF MATERIAL FROM SUCH A CLIFF. SOLVE GRAPHICALLY BY 1/4S, COMPUTING VOLUME (AREA IN SECTION) IN A TALUS 1/4, 1/2, 3/4 THE HEIGHT OF THE CLIFF, ALLOWING FOR RETREAT OF CLIFF TO YIELD EACH 1/4 AS TALUS CLIMBS.

BERG-CARRIED GRANITIC BLDRS VERY RARE IN THE COULEE. ONE SUCH BLDR, NOW FRAGMENTED, ON HIGHEST ROCK ISLAND IN GRAND FALLS, ONE MILE SOUTH OF COULEE CITY. ANOTHER, INTACT, 8x8, ABOUT 40 FT ABOVE LEVEL OF BLUE LAKE (ALKALI LAKE?) ONE MILE NORTH OF BULLOCK'S RANCH. A GROUP OF SMALLER BLDRS (OR BRAGMENTS OF A LARGER ONE) WELL UP ON EAST SIDE, ON MATURELY ERODED SLOPES ABOVE ALL SCoured SURFACES, EAST OF MID-LENGTH OF ALKALI LAKE. THE ONE ON THE BRINK OF GRAND FALLS IS TOO HIGH FOR THE SUBMERGENCE, SO FAR AS NOW KNOWN. PROBABLY LEFT BY A BERG WHICH STRANDED ON THIS ISLAND. THE ONE DOWN BY BLUE LAKE SHOWS THAT THE COULEE WAS ALREADY EXCAVATED WHEN IT WAS DEPOSITED. THE GROUP UP ON THE MATURE SLOPES SHOWS THAT THE SUBMERGENCE FLOODED BACK OUT OF THE COULEE ON PRE-COULEE SURFACES. ITS ALTITUDE WOULD BE SIGNIFICANT BUT COULD NOT BE DETERMINED AT TIME OF TRAVERSE.

FROM SURVEY OF THE COULEE FROM HIGHER LAND TO THE EAST, IT APPEARS THAT THE MATURE SLOPES (FIRST CYCLE) EXTEND DOWN AT LEAST 2/3 OF THE WAY TO THE BOTTOM OF THE ENTIRE CUT. THIS ISNT TRUE OF THE WESTERN SIDE, WHERE THE MATURE SLOPES DO NOT DESCEND MORE THAN 1/3 OF THE TOTAL DEPTH. <sup>Also gabled headlands along west wall, like those in Moses Coulee.</sup> THUS AN OLD VALLEY, AT LEAST IN LATITUDE OF ALKALI LAKE, IS CLEARLY INDICATED. THRU THIS THE GLACIAL SPILL OCCURRED. BUT THE LOWER ALTITUDE OF THE MATURE SLOPES OF THE EASTERN SIDE STRONGLY SUGGESTS THAT THE DEFORMATION, OR A CONSIDERABLE PORTION OF IT, OCCURRED AFTER THE MATURITY OF THE FIRST CYCLE, LIFTING THE OLD LAND TO THE WEST RELATIVE TO THAT OF THE EAST.

AN ALTICLINAL STRUCTURE CROSSES THE COULEE AT SOAP LAKE. STRUCTURE SHOWN IN BLUFFS OF THE LAKE AND IN THE ELONGATED HILL (E-W) EAST OF THE LAKE. A BROAD, WIDE VALLEY LIES NORTH OF THIS ANTICLINAL HILL BETWEEN IT AND THE MAIN UPLIFTED REGION TO THE NORTH. BUT NO SUCH LOW TRACT ON THE WEST SIDE, NORTH OF THE LAKE. APPARENTLY THIS IS A CROSS FOLD ON THE GRAND COULEE MONOCLINE. OR IT MAY BE CONSIDERED AS A CONTINUATION OF THE BADGER MTN UPFOLD (IF THIS MTN IS SIMILAR TO SADDLE AND FRENCHMAN AND OTHER FOLDS OF CENTRAL WASHINGTON) AND THE MONOCLINE MAY BE A CROSS FOLD, SUBSIDIARY TO THE MAIN STRUCTURE.

GRAVEL NOT COMMON IN GRAND COULEE. MOST CHANNELS CLEAN. BUT THERE ARE SOME LARGE GRAVEL BARS IN FAVORED SITUATIONS. SOME OF THESE LOOK LIKE TERRACES, AND MAY BE SUCH, BUT MOST OF THEM ARE ONLY BARS.

A TREE MOULD, CURIOUSLY PRESERVED, STANDS IN THE LAVA ALONG BLUE LAKE OPPOSITE BULLOCK'S RANCH. IT IS REACHED BY CRAWLING INTO A SMALL CAVE IN THE FACE OF THE BLUFF. JUST A FEW FEET BACK, ONE FINDS HIMSELF IN A VERTICAL CYLINDRICAL CHAMBER, 12 FT. HIGH, 3 1/2 FEET IN DIAMETER



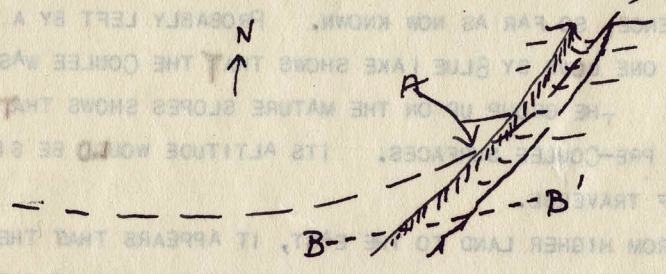
AT TOP, 4 1/2 AT THE BOTTOM. THE BOTTOM FLARE STILL CONTAINS FOSSIL WOOD. CHARCOAL CHECKS, RIBS AND RIDGES OF THE VERTICAL GRAIN, STILL PRESERVED IN THE LAVA. LAVA LAID UP AROUND IT IN GREAT ROPY ROLLS, IN MANY CASES NOT TIGHTLY PACKED TOGETHER.

SOAP LAKE TO ADRIAN AUG. 15 1922

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GRANITE, QZITE, DIORITE, GRANITE PORPHYRY AND OTHER FOREIGN MATERIAL NONE LARGER THAN 12 INCHES IN DIAMETER, LIES ON THE SOUTHERN SLOPE OF THE HILL EAST OF SOAP LAKE UP TO ALTITUDES OF 1400. FOUND CHIEFLY IN SHALLOW WASHES. NOT OF THE BERG-CARRIED CATEGORY. 100 FT OR SO ABOVE THE HIGHEST GRAVEL TERRACES OF THE REGION. MATERIAL NOT MUCH DECAYED BUT THIS MAY MEAN THAT IN THE SLOPE WASH, THE CRUMBLER EXTERIORS ARE WORN OFF AND ONLY NUCLEI REMAIN. WHAT THIS SCATTERED MATERIAL MEANS IS NOT CLEAR. IT PROBABLY IS A RECORD OF HIGHER TERRACES, OR THE RELICS OF AN ANCIENT TILL COVER. IF THE LATTER, IT SHOULD BE CORRELATED WITH THE CHENEY TILL FOR NO ICE OF THE IMMEDIATELY PRE-WISCONSIN GLACIATION EVER GOT THIS FAR. BERG-CARRIED ERRATICS ARE COMMON EAST OF SOAP LAKE UP TO ABOUT 1250. NONE ABOVE THAT APPROXIMATE ALTITUDE.

MORE IDEAS ON THE STRUCTURE OF THE REGION. THE SOUTHWARD FRONT OF THE BADGER MTN BY EPHRATA, WINCHESTER AND QUINCY SWINGS AROUND TO FACE SOUTHEAST TOWARD SOAP LAKE AND THIS CURVE OF THE FRONT IS COINCIDENT WITH THE COURSE OF LOWER GRAND COULEE



THIS FRONT OF BADGER MTN IS A MONOCLINAL FLEXURE, AS IS THE STRUCTURAL AXIS ALONG THE COULEE THIS SOLVES THE PROBLEM OF WHAT BECOMES OF THE MONOCLINE TO THE SOUTH. AT A THE BASALT FLOWS COME DOWN WITH A GENTLE DIP TO THE SOUTH. B--B' IS THE AXIS OF THE SMALL SOAP LAKE ANTICLINE. IT IS NOT A SPUR OR CROSS FOLD, SO MUCH AS IT IS A RUDELY PARALLEL SUBSIDIARY FOLD. THE HEIGHT OF THE COUNTRY NORTH OF THE MOSES LAKE PLAINS IS LESS TO THE EAST OF GRAND COULEE THAN TO THE WEST OF IT. YET THERE IS A RISE OF 200-300 FEET OR MORE. THIS UNDOUBTEDLY IS STRUCTURAL AND INDICATES FURTHER DETAILS OF STRUCTURE, YET TO BE WORKED OUT.

MORE IDEAS ON THE GLACIATION OF THE REGION. THE STRATFORD (CRAB CREEK) GRAVEL PLAIN, EXPOSED IN SECTION AT ADRIAN, IS PRE-WISCONSIN. THIS FOLLOWS FROM THE OLDER CHARACTER OF ITS ASSOCIATED CHANNELS AND THE AMOUNT OF EROSION IT HAS SUFFERED. IT WAS BUILT OUT INTO THE MOSES LAKE STRUCTURAL DEPRESSION. SINCE IT HAS BEEN LEFT TO THE MERCY OF ALL AGENTS OF SUBAERIAL EROSION FOLLOWING THIS PRE-WISCONSIN GLACIATION, AND SINCE THE VALLEY IN WHICH IT ENDED WAS STRUCTURALLY ENCLOSED, IT FOLLOWS THAT BY THE TIME WISCONSIN GLACIATION DEVELOPED, THIS PLAIN AND THE VALLEY CONTAINING IT SHOULD HAVE BEEN MODIFIED CONSIDERABLY BY EROSION. IF THIS BE TRUE, ANY ISOLATED PORTIONS APPROXIMATELY AT THE ALTITUDE OF THE STRATFORD PLAIN SHOULD BE PARTS OF THE ORIGINAL PRE-WISCONSIN PLAIN.

THE INTERPRETATION NOW FAVORED IS THAT THE STRATFORD PLAIN, THE CENTRAL HIGH GRAVEL MESA, THE MOSES LAKE P.O. TERRACE AND THE HIGH TERRACE WEST OF DISHAW CHANNEL ARE ALL PARTS OF THE



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SAME ORIGINAL FILLING. THE SOUTHWARD CONTINUATION OF THIS TERRACE REACHES THE DRUMHELLER PLEXUS.

THEN ARE THE VALLEYS IN WHICH LIE MOSES LAKE AND ITS HORNS AND TRIBUTARIES IN LARGE PART THE RESULT OF INTERGLACIAL EROSION? TO ACCEPT THIS IS TO ADMIT THAT A NOTCH, OR NOTCHES, WERE CUT AT THE DRUMHELLER PLEXUS BY ORDINARY RUN-OFF DURING INTERGLACIAL TIME. BUT ALL EVIDENCE INDICATES THAT AN ENORMOUS FLOOD CUT THESE NOTCHES. SIMILARLY, THE SAME FLOOD WATERS ERODED THE BROAD CHANNELS IN THE HIGH PRE-WISCONSIN GRAVEL PLAIN. WHAT GENTLE SLOPES THESE FRAGMENTS OF THE PRE-WISCONSIN PLAIN POSSESS WERE PRODUCED BY EROSION OF THE GRAND COULEE TORRENTS ACROSS THE BUT LITTLE MODIFIED PRE-WISCONSIN PLAIN. PROBABLY THERE WAS A CRAB CREEK ROUTE BY WAY OF WILLOW CREEK, COMPARABLE TO THE PRESENT CRAB CREEK COURSE AT ADRIAN AND ABOVE. PROBABLY THERE WAS A ROCKY FORD CREEK COURSE, AND PERHAPS A THIRD ENTRENCHMENT, FARTHER WEST; HAD BEEN FORMED BY DRAINAGE OFF THE BADGER MTS. ALL THESE WERE MODIFIED BY THE WISCONSIN FLOODS, RESULTING IN THE DISHAW, RKY FORD, AND WILLOW CREEK CHANNELS. ANOTHER CHANNEL THEN FORMED, APPARENTLY, IS THE WELL-MARKED AFFAIR NOW OCCUPIED BY CRAB CREEK DRAINAGE BETWEEN ADRIAN AND SOAP LAKE. ITS FLOOR IS MUCH HIGHER THAN SOAP LAKE, ABOUT THE ALTITUDE OF ADRIAN AND SOAP LAKE STATIONS.

HOW MUCH OF THE GRAVEL IN THE MOSES LAKE REGION WAS CARRIED OUT THERE DURING WISCONSIN OCCUPANCY OF GRAND COULEE? HOW MUCH OF IT IS SIMPLY RE-ARRANGED PRE-WISCONSIN GRAVEL? DID THE WISCONSIN WATERS ADD TO OR SUBTRACT FROM THE TOTAL VOLUME OF THE MOSES LAKE GRAVELS? DID THE WISCONSIN GRAVEL ALL GO ON THRU THE CRAB CREEK AND GOOSE LAKE COUNTRY; DRUMHELLER PLEXUS??

GRAVEL AT ADRIAN AND STRATFORD LIES IN THE SECOND CYCLE VALLEYS.

A PECULIAR FEATURE OF THE GRAVEL MESA AND THE TERRACE AT ADRIAN IS THE GENTLE DOWN-SLOPE TOWARD THE NORTH. THE ONLY EXPLANATION, IF THESE TERRACES ARE EROSIONAL REMNANTS, IS THAT SUCH LONG GENTLE SLOPES, IMPERCEPTIBLY GRADING INTO THE SUMMIT PLANES, ARE MATURELY GRADED. IF THESE TERRACES ARE WISCONSIN IN AGE, THESE SLOPES MUST BE CONSTRUCTIONAL AND THE ONLY ADEQUATE EXPLANATION NOW CONCEIVED IS THAT THEY ARE THE GRADED PROFILE OF THE BOTTOM OF THE HUGE STREAMS WHICH HERE SPREAD OUT FROM THE CONSTRICTED SOAP LAKE CHANNEL. IN SUCH A SITUATION, THE VELOCITY OF THE WATER WOULD RAPIDLY DECREASE AS IT SPREAD OUT AND DEPOSITION TO MAKE A GRADED FLOOR WOULD PRODUCE A SURFACE SLOPING AGAINST THE STREAM.

HOW MUCH OF THE MATERIAL IN THE MOSES LAKE TERRACES CAN BE CONSIDERED GLACIAL OUTWASH, AND HOW MUCH OF THE DEBRIS<sup>IS</sup> FROM THE EROSION FROM GRAND COULEE? PROBABLY BY FAR THE LARGER PART IS FROM THE CUTTING OF THE COULEE.

NO BERG-DROFTED ERRATICS ON THE TERRACE NORTH AND NORTHWEST OF ADRIAN. SURFACE OF THE TERRACE SLOPES NORTHWESTWARD. IT AVERAGES 50 FT OR MORE ABOVE ADRIAN (1237A.T.)

FORESET BEDDING ONE MILE EAST OF ADRIAN, EARLIER NOTED, RECORDS ONLY A SHALLOW FLOODPLAIN POOL. BEDS DIP SOUTHWARD TOWARD THE ROCKWALL. STREAM BEDDING BENEATH.

ADRIAN TO COULEE AND VICINITY OF COULEE AUG. 16 1922

RR NORTH FROM ADRIAN FOLLOWS "DRY COULEE" VIRTUALLY ALL THE WAY TO C.C. THIS "DRY COULEE" IS A VERY PICTURESQUE AND INTERESTING GROUP OF GLACIAL DRAINAGE CHANNELS CUT IN BASALT. ALL THE FAMILIAR PHENOMENA ARE HERE, AND THE GROUP DIFFERS FROM THE CHANNELS BETWEEN GRAND COULEE AND SPOKANE ONLY IN BEING MORE DEEPLY INCISED, MORE OF THE GRAND COULEE TYPE.



AND IN LARGE PART DRY COULEE IS BUT A PORTION OF GRAND COULEE. AT LEAST THREE DEFINITE ROCK-CUT CHANNELS LEAD OUT OF GRAND COULEE ON THE EAST AND CONVERGE INTO DRY COULEE. THERE APPEARS TO BE ONE MORE ROCK CHANNEL WITH BORDERING SCABLAND, DRAINING FROM THE HARTLINE PLAIN TO DRY COULEE GROUP. AND IF THE HARTLINE PLAIN SHOULD PROVE TO BE GLACIAL OUTWASH OR GRAND COULEE WASH, THE ENTIRE DRY COULEE SYSTEM WOULD HAVE TO BE CONSIDERED A PART OF THE GRAND COULEE SPILLWAY. IT IS CLEAR THAT AT AN EARLY STAGE IN DEVELOPMENT OF THE GRAND COULEE SOUTH OF COULEE CITY, THE FLOOD OF WATERS WAS Poured OVER A WIDTH OF SEVEN MILES OF COUNTRY. THERE COULD HAVE BEEN NO PRE-EXISTING VALLEY OF NOTEWORTHY PROPORTIONS TO GUIDE AND CONCENTRATE IT. SCABLAND WITH SHALLOW CHANNELS ALL OVER THE COUNTRY BETWEEN THEM AND GRAND COULEE, SOUTH OF C.C., ATTEST THIS. BUT FAVORED ROUTES WERE TRENCHED MORE DEEPLY AND THE WIDESPREAD FLOOD WAS RESTRICTED TO A FEW CHANNELS. EVENTUALLY, THE ROUTE ALONG THE MONOCLINAL FLEXURE DESCRIBED IN PRECEDING NOTES, TOOK PRECEDENCE AND WATERS WERE DRAWN DOWN FROM ALL THE OTHER CHANNELS.

PROBLEM— IF THE GRAND COULEE CARRIED PRE-WISCONSIN WATERS, SHOULD NOT THESE HIGHER CHANNELS BE OF THAT AGE, AND ONLY THE DEEPER ONES BE THE PRODUCT OF THE WISCONSIN WATERS? HERE OUGHT TO BE A BETTER OPPORTUNITY TO SETTLE THIS QUESTION OF PRE-WISCONSIN AND WISCONSIN DRAINAGE THRU THE COULEE THAN THAT OFFERED BY THE GRAVEL TERRACES IN THE MOSES LAKE REGION AND THE TALUS PILES WILL ANSWER IT!!

MORE ABOUT THE STRUCTURE OF THE GRAND COULEE REGION. THE MONOCLINAL FLEXURE AT COULEE CITY IS TRULY A VERY UNSYMMETRICAL SYNCLINE, AS IT IS AT ALKALI LAKE; EXCEPT THAT THE BEDS DO NOT RISE AS HIGH TO THE EAST OF THIS TOWN AS THEY DO EAST OF ALKALI LAKE. THE STEEPER WESTERN LIMB (THE MONOCLINAL FLEXURE PROPER) WEST OF COULEE CITY IS DOUBLY FLEXED, A STRUCTURAL TERRACE LYING PART WAY UP ON THE LONG SLOPE TO THE HILL SUMMIT—1000 FEET ABOVE THE TOWN.

THE TREND OF THE FLEXURE CHANGES, NW OF COULEE CITY, TO NORTHEASTWARD AND EASTWARD, AND CROSSES GRAND COULEE AT THE BEGINNING OF THE GREAT WALLED PORTION WHICH EXTENDS FROM A POINT 3 MILES NORTH OF THE TOWN TO THE COLUMBIA RIVER. THE FLEXURE SHOWS WELL IN SECTION ON THE EAST SIDE, THE FLOWS DIPPING  $30^{\circ}$  SOUTHWARD AND THE SURFACE OF THE REGION DESCENDING WITH THE STRUCTURE. COULEE CITY IS BUILT ON THE FLOOR OF THE STRUCTURAL VALLEY IN AN UNDISSECTED PORTION. IT WAS THIS STRUCTURAL VALLEY WHICH SPREAD OUT THE SOUTHWARD-FLOWING WATERS TO FORM THE LARGE NUMBER OF HIGHER SHALLOW CHANNELS, SOME TO DRY COULEE, SOME TO THE GRAND COULEE ROUTE. NONE OF THESE LAY WEST OF THE PRESENT GRAND COULEE, FOR THE STEEPLY RISING BASALT THERE CARRIED THE SURFACE WELL ABOVE THE LEVEL OF THE FLOOD.

THE ARGUMENT FOR A RECEDING WATERFALL IN THE GRAND COULEE SPILLWAY CAN BE APPLIED BETTER IN THE <sup>UPPER</sup> GRAND COULEE SPILLWAY THAN TO THE LOWER, FOR HERE THE STRATA WERE HORIZONTAL ACROSS THE GREAT GORGE. BUT IF ONE EVER DEVELOPED IN THIS FAVORABLE PLACE, IT HAS ENTIRELY DISAPPEARED.

PILOT KNOB, THE SPECTACULARLY LARGE AND SPECTACULARLY PLACED BASALT BLDR, IS 1000 FT ABOVE ABOVE COULEE CITY ON THE UPFOLD. THE GREAT BOULDER STANDS AT LEAST 40 FEET ABOVE ITS BASE. THE SURROUNDING TOPOGRAPHY IS MORAINIC IN DETAIL, WITH KNOBS AND KNOLLS OF DRIFT AND TYPICAL TILL IN SECTIONS. BUT THIS DETAIL IS SUPERPOSED ON THE FIRST CYCLE TOPOGRAPHY, ERODED IN THE COLUMBIA BASALT. ONE WELL WITHIN A MILE OF THE KNOB PENETRATES 70 FEET OF HARDPAN WITHOUT REACHING BASALT BEDROCK. IN OTHER PLACES, THE BEDROCK COMES CLOSE TO THE SURFACE.

"DRY FALLS" LIES ALMOST DIRECTLY WEST OF COULEE CITY, ABOUT 2 MILES DISTANT, 4 MILES OR SO BY ROAD. IT IS THE LARGEST, CLEANEST, BEST-SHAPED AND MOST TYPICAL WATERFALL OF ALL THOSE ACROSS THE GREAT LEDGE. BUT IT IS NOTHING MORE. IT DID NOT RETREAT FARTHER FROM BATTLESHIP



ROCK (THE SOUTHERNMOST PROMONTORY AMONG THE DIFFERENT FALLS) THAN DID THE FALL AT WHOSE FOOT LIES DEEP LAKE. IT IS HIGHER SIMPLY BECAUSE THE CHANNEL AND RAPIDS ABOVE THE BRINK ARE NOT CUT AS DEEPLY IN THE HIGHEST FLOW OF THE LEDGE. THE LAKE AT THE FOOT (THE POTHOLE LAKE) IS MORE IRREGULAR AND NOT ELONGATED AS IS DEEP LAKE. DEEP LAKE IS A MORE TYPICAL FEATURE RESULTING FROM RETREAT OF A FALL AND CONSEQUENT ELONGATION OF ITS POTHOLE AT THE FOOT. FURTHERMORE, THERE ARE ROCK LEDGES IN THE IRREGULAR MARGIN OF THE LAKE AND SOUTHWARD TO THE CONFLUENCE OF ALL CHANNELS AT BATTLESHIP ROCK WHICH SHOW THAT NO DEEP GRAVEL-FILLED ELONGATED CHANNEL EXISTS HERE.

DRY FALLS IS BROAD, THE BROADEST OF ALL FALLS IN THE GROUP. PERHAPS 3/4 OF A MILE ACROSS. THIS IS BECAUSE TWO FALLS DEVELOPED SIDE BY SIDE AND RETREATED AT THE SAME RATE, SEPARATED BY A NARROW SPUR, AND THIS SPUR FINALLY WAS SO UNDERCUT THAT IT WAS ISOLATED AS AN ISLAND. A REMNANT OF THE ORIGINAL SPUR STILL SEPARATES THE TWO PORTIONS OF THE FALLS.



COULEE CITY IS BUILT ON THE SURFACE OF THE COLUMBIA LAVA FORMATION, SO FAR AS THAT SURFACE IS EXPOSED IN THIS REGION. IT IS WARPED DOWN 1000 FEET FROM THE HILLS.

THE HARTLINE "GRAVEL FLAT" AS TERMED BY THE NATIVES, BEGINS AT THE EASTERN EDGE OF THE VALLEY AT COULEE CITY. INDEED, THE EASTERN WALL OF THE VALLEY HERE IS ALL GRAVEL, 200 FT ABOVE THE TOWN. THE MAIN SCARP AT THE TOP IS 100 FT HIGH, WEST OF IT IS A CHANNEL 30 FEET DEEP AND ABOUT 1000 FEET WIDE, THEN A LOWER TERRACE 80-90 FEET ABOVE TOWN, AND THENCE A GENTLE SLOPE TO THE TOWN. THE GRAVEL IN EACH TERRACE IS LARGELY BASALTIC AND FRESH AND BRIGHT IN APPEARANCE. THE UPPER TERRACE (THE HARTLINE FLAT) HOWEVER, HOWEVER, IS PRE-WISCONSIN IN AGE, THE LOWER IS WISCONSIN. THIS WILL BE CLEAR FROM WHAT FOLLOWS.

THE HARTLINE FLAT IS A GREAT GRAVEL AND SILT DEPOSIT, EXTENDING NORTHEASTWARD BETWEEN TWO BROAD UPWINDS OF THE BASALT WHICH STRIKE IN THE SAME GENERAL DIRECTION. IT WAS DEPOSITED IN THE COULEE CITY STRUCTURAL BASIN, AND ORIGINALLY MUST HAVE EXTENDED WESTWARD FROM THE PRESENT SCARP ABOVE DESCRIBED, TO THE WEST SIDE OF THE BROADENED PORTION OF GRAND COULEE VALLEY.

THE DRAINAGE OF THIS TRACT IS BOTH SURFICIAL AND SUBTERRANEAN. THE SURFACE WATERS FLOW SOUTHWARD INTO DEADMAN GULCH, 6-7 MILES EAST OF COULEE CITY. THE GROUND WATERS, IN PART, TAKE THE SAME COURSE AND IN PART EMERGE AT THE FOOT OF THE WESTERN SCARP AS SPRINGS. THE SPRINGS WHICH SUPPLY COULEE CITY COME FROM THIS SOURCE.

THE SURFICIAL DRAINAGE ENTERS DEADMAN'S GULCH THRU BROAD SHALLOW VALLEYS ERODED IN THE GRAVEL. THERE ARE NO SHARP TERRACE FORMS HERE, AND GRAVEL SLOPES DO NOT AVERAGE STEEPER THAN 5°. THE GULCH IS A MORE MARKED MEMBER OF A LARGE NUMBER OF GLACIAL SPILLWAY CHANNELS IN BASALT, TYPICAL IN THEIR ANASTOMOSING CHARACTER, THEIR "HOLES" IN THE BOTTOMS, FALLS AND CASCADES AND BUTTE-LIKE ISLANDS. THE BASALT IS SCRUBBED OFF FROM THE HEAD OF THIS DRAINAGE WAY CLEAR ACROSS WESTWARD TO THE GREAT FALLS, JUST SOUTH OF COULEE CITY.



BUT THESE SPILLWAY FEATURES ARE MUCH OLDER THAN THOSE OF GRAND COULEE. TALUS STANDS ON THE AVERAGE  $\frac{3}{4}$  TO  $\frac{4}{5}$  THE TOTAL HEIGHT OF THE ORIGINAL CLIFFS. MANY ORIGINAL BLUFFS ARE TALUS-COVERED TO THE VERY SUMMIT. SOIL ON MOST TALUS SLOPES SUFFICIENT FOR GRASS AND SAGE. ANGLE OF REPOSE FOR MOST TALUS IS BETWEEN  $20^{\circ}$  AND  $25^{\circ}$ . SOME IS STEEPER. NO CLEAN ROCK KNOBS ON CHANNEL FLOORS, ALL BROKEN DOWN TO ROUNDED HILLOCKS OF ROCK, HEAVILY MANTLED ON SLOPES WITH BASALTIC RUBBLE.

THIS DRAINAGE LINE IS CLEARLY PRE-WISCONSIN AND NEVER WAS OCCUPIED BY WISCONSIN DRAINAGE. THE HARTLINE PLAIN THEREFORE IS PRE-WISCONSIN.

TALUS PILES HAVE A CURIOUS PREVAILING CONVEXITY OF PROFILE. UPPER SLOPES MAY BE  $5^{\circ}$  TO  $10^{\circ}$  GENTLER THAN LOWER. THIS DIFFERENCE DOES NOT APPEAR TO BE DUE TO DIFFERENCE IN SIZE OR SHAPES OF FRAGMENTS AND ITS CAUSE IS NOT CLEAR.

LARGE, SHATTERED GRANITE BLDR AT HEAD OF DEADMAN GULCH..

VICINITY OF STRATFORD AND SPRING COULEE AUG 18 1922

THE GRAVEL PLAIN NORTH OF ADRIAN AND 100 FT  $\pm$  ABOVE THAT TOWN WAS BUILT BY WATERS WHICH ~~SPILLED OUT OF DRY COULEE FROM THE NORTH AND NOT BY WATERS WHICH CAME DOWN CRAB CREEK FROM THE NORTH AND NOT BY WATERS WHICH CAME DOWN CRAB CREEK FROM THE EAST.~~ AT ADRIAN AND FOR THREE OR FOUR MILES EASTWARD, CRAB CREEK FLOWS IN A NARROW VALLEY, WITH BASALT WALLS ON THE SOUTH AND THE BIG GRAVEL TERRACE SCARP ON THE NORTH. BUT ABOUT STRATFORD, THE VALLEY FLOOR IS A MILE WIDE AND THERE ARE ONLY LIMITED GRAVEL TERRACES BACK IN RE-ENTRANT ANGLES AND MOUTHS OF TRIBS.

THE EXPLANATION IS CLEARLY THAT THE ADRIAN TERRACE IS WISCONSIN IN AGE AND THE GRAVELS ABOUT STRATFORD AND FARTHER EAST ARE PRE-WISCONSIN. WISCONSIN SPILLAGE THEN BUILT THE HIGHEST TERRACES IN THE DEBOUCHURE OF CRAB CREEK INTO THE MOSES LAKE STRUCTURAL VALLEY. THEREFORE, THE SMALLER VALLEYS, CONTAINING RKY FORD CREEK, MOSES LAKE AND ITS HORNS, ETC, ARE DUE TO TRENCHING OF THE WISCONSIN GRAVEL FILL BY WISCONSIN WATERS WHILE THE DRUMHELLER SPILLWAYS WERE BEING DEEPEINED. THERE IS NO PRE-WISCONSIN GRAVEL IN PRE-WISCONSIN TERRACES IN THE ENTIRE STRUCTURAL DEPRESSION!!  
((( LATER ???????))

A SPILLWAY, ERODED TO CONSIDERABLE DEPTH, LEAVES CRAB CREEK VALLEY ABOUT ONE MILE WEST OF STRATFORD, ON THE SOUTH SIDE, AND LEADS PROBABLY TO WILLOW CREEK VALLEY. ITS SLOPES INDICATE WISCONSIN OCCUPANCY.

SPRING COULEE, THE ONE WHICH CONTAINS BROOK LAKE AT ITS MOUTH AND LONG LAKE IN MID-LENGTH, RECEIVES DEADMAN'S GULCH DRAINAGE A MILE ABOVE THE HEAD OF LONG LAKE. THE DRAINAGE OF THE GULCH SPILLS OVER THE WALL OF THE COULEE, WITH HARDLY A NOTCH TO BE SEEN FROM THE BOTTOM OF THE COULEE. ABOVE THE ENTRANCE OF THE DRAINAGE OF THE GULCH, THE COULEE FLOOR IS AGGRADED 20-40 FEET DEEP WITH TALUS MATERIAL, WELL-LEVELLED OFF. AT AND BELOW ENTRANCE OF GULCH DRAINAGE, THIS FILLING HAS BEEN ERODED INTO RUDE TERRACES AS FAR DOWN AS IT EXTENDS, TO THE GREEN FLAT AT THE HEAD OF THE LAKE. FROM THIS FLAT DOWN TO STRATFORD, THERE IS NO FILLING OF COARSE DEBRIS IN THE COULEE. BOTH LONG LAKE AND BROOK LAKE ARE SHALLOW. LONG LAKE IS SET DOWN IN A STRIKING ROCK-WALLED WALLEY BUT TALUS CLIMBS HALFWAY OR NEARLY SO UP ON THE WALLS. HENCE NO NOTABLE DEPTH. REPORTED THAT HORSES HAVE WADED ACROSS THE LAKE, AND THAT BROOK LAKE HAS GONE DRY IN THE SUMMER.

THE PROFILES OF SPRING COULEE ARE PUZZLING. THERE IS NO QUESTION ABOUT THE PRE-WISCONSIN AGE OF THE UPPER CLIFFS AND THEIR TALUS ACCUMULATIONS. BUT THE LOWER CLIFFS ARE CLEAN IN PLACES AND ALMOST NOWHERE HAVE TALUS MORE THAN HALFWAY UP THE FACE. IT LOOKED AT TIME OF TRAVERSE AS



THO SOME WISCONSIN DRAINAGE HAD SPILLED OVER FROM DRY COULEE OR GRAND COULEE AND HAD CLEANED OUT THE LOWER PART OF THE COULEE. BUT WHEN THE HEAD WAS REACHED, NEAR BACON STATION, IT WAS SEEN THAT THE UPPER PART OF THE COULEE HAD NOT BEEN OCCUPIED BY WISCONSIN WATERS AND THAT THE DIVIDE HAD NOT BEEN CROSSED BY SUCH DRAINAGE. FURTHERMORE, DEADMAN GULCH NEVER BROT IN THE WISCONSIN WATERS. STILL FURTHER, THERE IS NO GRAVEL DEPOSIT AT THE MOUTH OF SPRING COULEE AT STRATFORD INSTEAD, CRAB CREEK VALLEY IS WIDE OPEN HERE AND THE FILLED PORTION BEGINS FARTHER WEST AT THE MOUTH OF DRY COULEE. THE CONCLUSION MOST SATISFACTORY IS THAT THE VIGOROUS SPRING DRAINAGE OFF HARTLINE FLAT MUST BE THE CAUSE OF THE CLEANING OUT OF THE LOWER PART OF SPRING COULEE. BUT WHY HASNT THIS DRAINAGE FILLED THE LAKES WITH DEBRIS? NO ANSWER. BUT HYPOTHESIS OF OCCUPANCY BY WISCONSIN WATERS IS LAID ON THE SHELF, FOR THE TIME BEING.

TWO LARGE GRANITE BLDRS SEEN IN THE FILLING IN UPPER PART OF SPRING COULEE. COULD ONLY HAVE BEEN RAFTED DOWN TO WHERE THEY LIE.

SOME STRUCTURE SHOWING IN SPRING COULEE WALLS. FOLDS ARE GENTLE AND DIFFICULT TO RESOLVE INTO A SYSTEMATIC ARRANGEMENT, IN THE ABSENCE OF A TOPOGRAPHIC MAP. BUT IT APPEARS THAT A LOW ANTICLINE, AXIS E-W OF NE-SW, IS CROSSED BY THE COULEE NEAR THE FOOT OF LONG LAKE, AND THAT THE COULEE ABOVE THE LAKE, HERE ORIENTED NOT FAR FROM E-W, LIES IN A SHALLOW SYNCLINE. ANOTHER LOW ANTICLINE TO THE NORTH OF BACON STATION.

VICINITY OF BACON FRIDAY AUG 18 1922

THERE ARE TWO GREAT SPILLWAYS OVER INTO DRY COULEE FROM GRAND COULEE, NEAR BACON. EACH IS WITHIN A MILE OR SO OF THE STATION. EACH CUTS ACROSS THE LOW ANTICLINE WHICH IS ALREADY NOTED NORTH OF BACON. THIS UPWARP APPEARS TO BE THE SAME ONE WHICH SHUTS IN THE C.C. - HARTLINE STRUCTURAL VALLEY ON THE SOUTH. EACH SPILLWAY IS A GORGE OF SPECTACULAR PROPORTIONS AND EACH FLATTENS OUT TO A DRAINAGE WAY OF INSIGNIFICANT ACCENTUATION IN THE SYNCLINE ALREADY NOTED. STILL FARTHER NORTH (PERHAPS 4 MILES NORTH OF BACON) ANOTHER NOTCH OF THE SAME CHARACTER AND HAVING THE SAME RELATIONS TO DRY COULEE. INDEED, DRY COULEE IS BUT THE LOWER PART OF THE SPILLWAY MADE BY THESE TRANSECTIONS OF THE ANTICLINAL BARRIER. IN ITS LOWER PORTIONS, DRY COULEE IS DEEPLY FILLED WITH WISCONSIN GRAVEL, AND NOT A CONSPICUOUS FEATURE.

COULEE CITY TO THE COLUMBIA SAT. AUG. 19 1922

GRAND COULEE NORTH OF COULEE CITY IS A SIMPLE WIDE CANYON, AVERAGING 2-2 1/2 MILES WIDE TO 1000 AND 800 FEET DEEP. ITS WALLS ARE VERTICAL, ABOVE THE TALUS WHICH STANDS HALF WAY UP ON THE CLIFFS. AT STEAMBOAT ROCK, 20 MILES FROM COULEE CITY AND 10 MILES FROM THE COLUMBIA, THE COULEE IS ABOUT 5 MILES WIDE. THIS IS DUE TO THE PRESENCE OF THE ROCK IN MID-CHANNEL, (TOP OF STEAMBOAT HAS AN AREA OF ABOUT ONE SQ. MILE.) AND PERHAPS IN PART TO THE PRESENCE OF A GRANITE RIDGE, ORIGINALLY BURIED BY THE BASALT, NOW EXPOSED AND BRODED INTO A LINEAR (E-W) GROUP OF ROCK HILLS AND KNOBS. STEAMBOAT ROCK REPORTED TO HAVE A GRANITE BLDR ON TOP "AS BIG AS A HOUSE" THE ROCK IS OF BASALT TO THE BOTTOM, EXCEPT PERHAPS AT THE NORTH FOOT WHERE THERE MAY BE GRANITE IN THE LOWER PART OF THE WALL.

THE ROW OF GRANITE HILLS HAS A TOPOGRAPHY IN STRIKING CONTRAST WITH THAT OF THE BASALT CLIFFS. THE GRANITE IS SHEETED AT A HIGH ANGLE TO THE HORIZON AND THIS HAS PRODUCED PINNACLED AND BLADED FORMS, NOT THE MOST STRIKING OF THEIR KIND, BUT VERY CONSPICUOUS AS INTERRUPTIONS IN THE BROAD VALLEY SHUT IN WITH VERTICAL BASALT CLIFFS.



THESE GRANITE KNOBS AND HILLS ARE STEEP AND JAGGED ON THE SOUTH SIDE BUT NOTABLY ROUNDED AND SMOOTHED ON THE NORTH SIDE. THEY HAVE, WITHOUT QUESTION, BEEN OVERRIDDEN BY GLACIAL ICE. STRIAE AND GROOVINGS ARE DIFFICULT TO FIND NOW, FOR THE GRANITE HAS WEATHERED AND CRUMBED CONSIDERABLY. SOME WERE FOUND, HOWEVER, WITH ORIENTATION S 18° E.

IF THESE HILLS HAVE BEEN GLACIATED TO THEIR BASE, THE BOTTOM OF THE GRAND COULEE, A NUMBER OF NEW ITEMS IN THE PLEISTOCENE HISTORY MUST BE INTRODUCED.

(1) THE UPPER GRAND COULEE EXISTED ESSENTIALLY TO ITS PRESENT DEPTH BEFORE THE WISCONSIN GLACIATION OCCURRED.

(2) THE ICE OF THAT GLACIATION CROWDED ACROSS THE UPPER END OF THE GRAND COULEE, AS FAR SOUTH AS STEAMBOAT ROCK (SEE GRANITE BLDG ON TOP) AND THE WISCONSIN MORAINE MUST EXIST EAST OF THE HEAD OF THE COULEE, UP ON THE SUMMIT OF THE BASALT PLATEAU.

(3) AT THE TIME OF SUCH INVASION AND BURIAL OF THE NORTH END OF THE COULEE BY GLACIAL ICE, THE PONDED COLUMBIA MUST HAVE HAD SOME OTHER SPILLWAY. PERHAPS THIS WAS BY WAY OF ROCK LAKE CHANNEL, SW OF SPOKANE, PERHAPS BY WAY OF HELLGATE TO WILSON CREEK. THE LATTER HARDLY SEEMS POSSIBLE, HOWEVER, FOR CRAB CREEK VALLEY (ABOVE STRATFORD) CONTAINS NO WISCONSIN GRAVEL FILL.

(4) THE GRAVEL CARRIED THRU GRAND COULEE DURING WISCONSIN OPERATION WAS NOT OF GREAT DEPTH AT THE GRANITE RIDGE, ELSE THE GLACIATED SURFACES WOULD HAVE BEEN ETCHED ALONG THE STRUCTURALLY WEAKER ZONES AND PLANES. IS IT NOT PROBABLE THAT THE GREAT VOLUME OF GRAVEL IN THE MOSES LAKE TERRACES IS PRE-WISCONSIN IN AGE, AND THAT WISCONSIN WATERS REHANDLED IT ONLY ENOUGH TO GIVE TOPOGRAPHIC EXPRESSION? IS IT NOT POSSIBLE THAT MOST OF THE MATERIAL IN THESE GRAVELS CAME FROM THE EROSION OF GRAND COULEE AND ITS SUBSIDIARIES, AND THEREFORE TOOK ORIGIN ALONG THE LENGTH OF THE COULEE, LITTLE GRAVEL ENTERING, MUCH GRAVEL LEAVING? THE LATTER OF THESE POSSIBILITIES ALLOWS THE GRANITE RIDGE TO ESCAPE WITH MINIMUM ATTRITION, SINCE IT IS SO NEAR THE HEAD OF THE COULEE.

A DEPOSIT OF EXCEEDINGLY FINE ~~MATER~~ GREY TO WHITE LAMINATED CLAY OR ROCK FLOUR OCCURS IN TERRACES, SOMEWHAT DISSECTED BY GULLEYS, FROM THE COLUMBIA TO A POINT MIDWAY BETWEEN  $\infty$  AND THE RIVER— ALTITUDE OF THE TERRACES NOTED BY MEINZER, EARLIER. THEY ARE SEASONALLY BANDED!! THEY LIE ON THE GRAVELS AND COBBLES OF THE OLD STREAM. EXCEPT THE ALKALI FLATS AND LAKE BEDS, THEY ARE THE YOUNGEST DEPOSITS IN THE GRAND COULEE. THEY BEAR NO GRAVEL AND NO BERG-DRIFTED BLDRS. ARE THEY NOT A DEPOSIT OF GLACIAL SILT-LADEN WATERS?

NORTH END OF GRAND COULEE SUNDAY AUG 20 1922

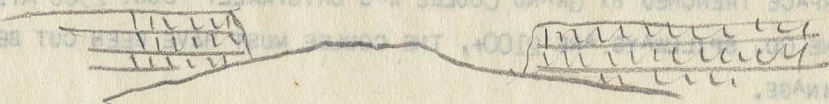
THE SILT TERRACE AT THE NORTH END OF GRAND COULEE EXTENDS OUT INTO THE COLUMBIA VALLEY EAST OF THE HEAD OF THE COULEE AT AN ALTITUDE OF ABOUT 1665. NO SECTIONS IN IT BUT IT IS CLEARLY COMPOSED OF THE SAME WHITE OR NEARLY WHITE VERY FINE MATERIAL. FINE TERRACES AT THE SAME ALTITUDE ARE TO BE SEEN FARTHER UP THE COLUMBIA ON THE SOUTH SIDE AND ON BOTH SIDES DOWN THE VALLEY. THEIR SURFACES ARE NOT LEVEL BUT SLOPE GENTLY DOWN TOWARD THE CENTER OF THE VALLEY.

AN EXTENSIVE TERRACE OF THE SAME CHARACTER IS SPREAD OUT IN MID-COULEE ABOUT THE GRANITE KNOBS A MILE TO A MILE AND A HALF SOUTH OF OSCAR OSBORN'S RANCH BLDGS. THESE KNOBS CONSTITUTE A SECOND ROW PARTIALLY ACROSS THE COULEE, A MILE NORTH OF THE MAIN ROW, ALREADY NOTED. THIS TERRACE IS CONSIDERABLY DISSECTED, MOST OF THE ORIGINAL SUMMIT FLAT IS GONE. THE TOP IS 125 FT ABOVE THE OSBORN RANCH HOUSE AND THE THICKNESS IN ALL PROBABILITY IS AT LEAST THAT AMT. THE RANCH HOUSE IS AT THE BOTTOM OF THE DRAINAGE LINE IN THE COULEE. NO MATERIAL OF ANY



KIND, EXCEPT THE WHITE SILT, SEEN ACROSS THIS TRACT.

THE GRANITE HILLS CLEARLY WERE HILLS MUCH AS NOW IN THE PRE-BASALT TOPOGRAPHY. THEY HAVE HAD CHANNELS CUT OUT AMONG THEM BY THE GRAND COULEE RIVER AND HAVE BEEN GLACIATED, AT LEAST SOME OF THEM HAVE. OTHERWISE, THEY ARE ESSENTIALLY THE PRE-BASALT HILLS. THIS IS WELL SHOWN UP NORTH UP ~~GLA~~ CANYON EAST OF STEAMBOAT ROCK. EXCAVATION BY THE TRIBUTARY STREAM HERE HAS BARED SEVERAL GRANITE HILLS BENEATH THE BASALT, THE STREAM FINDING THE GRANITE AND USUALLY MIGRATING LATERALLY ALONG THE SLOPE OF THE GRANITE SURFACE WITH FURTHER DOWNCUTTING. IN SOME PLACES, THE GRANITE HILL NOW STANDS CENTRALLY PLACED AND THERE ARE GULLIES AND CANYONS ON EITHER SIDE.



NOT ALL OF THE GRANITE HILLS OUT ON THE COULEE FLOOR SHOW GLACIAL ~~MARKINGS~~ SMOOTHING ON THE NORTHERN SLOPES. THOSE AT THE EASTERN END OF THE CHIEF ROW OR RANGE, IMMEDIATELY NORTH OF STEAMBOAT ROCK, DO NOT SHOW IT. IT APPEARS THAT THE MARGIN OF THE OKANOGAN LOBE IN THE COULEE, WEST OF STEAMBOAT ROCK, EXTENDED DIAGONALLY ACROSS, NOT REACHING AS FAR SOUTHWARD ON THE EAST SIDE AS ON THE WEST. THIS IS TO BE EXPECTED IF THE ICE DEPLOYED FROM THE MOUTH OF OKANOGAN VALLEY IN THE FORM OF A LOBE.

DID THE ICE CLIMB THE EASTERN WALL OF THE COULEE? DID IT BLOCK THE COLUMBIA DRAINAGE DOWN THIS COULEE? NO DEFINITE ANSWER CAN YET BE GIVEN. THE EASTERN BLUFF WAS CLIMBED ALONG THE ALMIRA ROAD AND GLACIAL ERRATICS (DIORITE, SLATE, ARGILLITE, SCHIST, QTZITE) WERE FOUND TO THE SUMMIT, 2400 A.T. AND 900 FT ABOVE THE COULEE FLOOR. BUT THERE ARE PREWISCONSIN SPILLWAYS ACROSS THIS TRACT EAST OF THE BRINK OF THE EAST WALL AND THESE ERRATICS MAY ANTEDATE THE WISCONSIN GLACIATION. NO MORaine WAS FOUND. IF EVER DEPOSITED, IT WAS SWEEP AWAY BY THE <sup>Wisconsin</sup> WATERS ESCAPING ALONG THE MARGIN OF THE ICE. PROBABLY NEVER WAS FORMED FOR THIS REASON. THE ONLY WAY BY WHICH THIS QUESTION OF CLOSURE OF THE GRAND COULEE AT MAXIMUM OF WISCONSIN GLACIATION CAN BE ANSWERED IS BY EXAMINATION OF THE LOWEST SPILLWAYS OF THE SPOKANE GROUP, FROM MARSHALL SOUTH TO ROCK LAKE. IF WISCONSIN CHANNELS CAN BE FOUND THERE, THE CASE WILL BE ESTABLISHED.

FOR A WIDTH OF 3 MILES EAST OF THE HEAD OF GRAND COULEE, THE SUMMIT OF THE BASALT IS MUCH SCoured BY GLACIAL WATERS. TYPICAL CHANNELS, "HOLES", BASALT KNOBS AND BUTTES ALL OVER IT. MAXIMUM DEPTH OF CHANNEL CUTTING HERE IS ABOUT 75 FT. ALTITUDE OF SURFACE OVER WHICH THE GLACIAL WATERS ORIGINALLY SPILLED IS ABOUT 2500 FT A.T., 1000 FT ABOVE THE COULEE FLOOR. THE SPILLWAYS ARE CLEARLY PRE-WISCONSIN. TALUS NOWHERE IS STEEPER THAN 20° AND EVERYWHERE CLIMBS 3/4 TO 4/5 OF THE FACE OF THE CLIFFS. SCATTERED ERRATICS ARE HERE ALSO.

THE INTERPRETATION OF THE HISTORY OF GRAND COULEE SEEMS CLEARLY TO INVOLVE A PRE-WISCONSIN SPILL ACROSS A 2500-FOOT SURFACE WHERE NO VALLEY EXISTED, THE FLOOD SPREADING OUT ABOUT 5 OR 6 MILES WIDE (3 MILES FOR THIS OLD SCoured SURFACE AND 2 1/2-3 MILES FOR THE WIDTH OF THE COULEE. SEARCHING OVER THE BASALT, THE FLOOD FINALLY SELECTED THE WESTERN PART OF THE TRACT FOR DEEPER TRENCHING AND THIS EASTERN PART WAS ABANDONED, NEVER AGAIN TO BE TOUCHED BY GLACIAL ICE OR GLACIAL WATERS. WITNESS THE UNDISTURBED TALUS ACCUMULATIONS. WISCONSIN ICE, IF IT REACHED THE SUMMIT OF THE EASTERN BLUFFS OF THE COULEE, (2400+) DID NOT ENCRoACH ON THIS SURFACE TO ANY EXTENT. *Non-did its waters!*



THE PRE-WISCONSIN SPILL ERODED THE COULEE NEARLY OR QUITE TO PRESENT DEPTH. PERHAPS BY RECESSION OF FALLS AND CASCADES, INITIATED AT THE MONOCLINAL TRANSECTION NORTH OF COULEE CITY, PERHAPS BY DOWN-CUTTING ALONG THE 30-MILE ~~TRACT~~ EXTENT FROM THE HEAD TO THE COULEE CITY STRUCTURAL VALLEY. CERTAINLY THE VALLEY WAS AT PRESENT DEPTH WHEN THE WISCONSIN ICE OVERBODE THE GRANITE HILLS IN THE COULEE. SOME OF THE EXCAVATION MIGHT HAVE OCCURRED FROM THE FIRST WISC. DIVERSION OF COLUMBIA RIVER TO GRAND COULEE TO THE TIME OF MAXIMUM EXTENT OF WISCONSIN ICE. CERTAINLY THE COULEE WAS CUT LOWER THAN THE ~~P/C~~ SPOKANE SPILLWAYS OR THE LINCOLN CO SPILLWAYS, ELSE THEY AND NOT GRAND COULEE WOULD HAVE BEEN OCCUPIED WHEN THE WISCONSIN DAMMING OCCURRED. AND SINCE THE BASALT SURFACE TRENCHED BY GRAND COULEE WAS ORIGINALLY ABOUT 2500 AT.T, AND THE LOWEST LINCOLN OR SPOKANE CO. SPILLWAYS ARE 2100+, THE COULEE MUST HAVE BEEN CUT BELOW THAT FIGURE TO HAVE SECURED THE DRAINAGE.

THE REASON THAT THE PRE-WISCONSIN DISCHARGE EVER MADE A CHANNEL HERE IS THE SAME REASON WHICH MUST BE USED TO EXPLAIN THE PRESENCE OF SEVERAL PRE-WISCONSIN SPILLWAYS;—THE PRE-WISCONSIN ICE CROSSED THE COLUMBIA IN SEVERAL PLACES AND HAD NO LONG E-W VALLEY IN FRONT OF IT, ALONG WHICH ALL ITS WATERS COULD MOVE TO THE LOWEST PASS.

THE SLOPES OF THE WALL DOWN TO THE COLUMBIA ARE GENTLER BY FAR ON THE AVERAGE THAN THE SLOPES OF THE GRAND COULEE WALLS. THEY ARE MORE GENTLE IN PLACES THAN THE SLOPES OF PRE-WISCONSIN GLACIAL DRAINAGE CHANNELS. THEY ARE DOUBTLESS PREGLACIAL. BUT NO FIRST CYCLE AND SECOND CYCLE PORTIONS WERE OBSERVED. FIRST CYCLE UPLAND, NOT WELL DEVELOPED, EAST OF THE HEAD OF THE COULEE.

FROM HEAD OF GRAND COULEE TO LEAHY AND MANSFIELD AUG 21 1922  
BASALT PLATEAU AT HEAD OF BARKER CANYON, IS MUCH BROKEN FOR A MILE OR SO BACK FROM EDGE OF GRAND COULEE. PRESENCE OF "HOLES" AMONG THESE BROKEN TRACTS SUGGESTS STRONGLY THAT GLACIAL DRAINAGE SPREAD OVER THIS SIDE OF THE COULEE, AS IT DID ON THE EAST SIDE. BUT THE WISCONSIN OKANOGAN LOBE HAS OVERRIDDEN THIS AREA AND THE ORIGINAL DALLES CHANNEL FORMS HAVE BEEN MODIFIED BY BOTH EROSION AND DEPOSITION BY THE ICE.

SIX TO EIGHT MILES FROM THE COULEE, THE SURFACE IS ENTIRELY COVERED WITH GLACIAL DRIFT, AND SO CONTINUES TO MANSFIELD, EXCEPT FOR TWO VALLEYS IN WHICH BEDROCK IS EXPOSED. THE DRIFT IS IRREGULARLY DISPOSED AND THE ORDINARY RIDGE MORaine FORM IS DIFFICULT TO RECOGNIZE. ESKERINE RIDGES AND LARGE KAME PILES DOMINATE. SOME OF THESE KAMES, WEST OF LEAHY, REMIND ONE FORCIBLY OF THE BIG MINE DUMPS ABOUT BRAIDWOOD, ILL. "HAYSTACK ROCKS" WHICH ARE HUGE BLDRS OF BASALT LIKE PILOT ROCK, ARE ABUNDANT IN SOME TRACTS AND MAKE A STRIKING BEATURE OF THE LANDSCAPE. TWO PHOTOGRAPHED, ONE OF THEM RESTING ON A MOUND OF GLACIAL TILL, CUT IN SECTION IN MAKING THE ROAD EAST OF MANSFIELD. GLACIAL STRIAE ON A WELL-SMOOTHED SURFACE OF BASALT THREE MILES EAST OF LEAHY, STRIKE N 20°W. THESE STRIAE ARE DOWN ON THE SLOPE OF A VALLEY 80 FT DEEP, THE GLACIATED SURFACE DESCENDS ALMOST TO THE BOTTOM OF THE VALLEY WHICH THEREFORE IS OF PRE-WISC. AGE

THE GENERAL SURFACE OF THE BASALT PLATEAU SLOPES NNWARD FOR MANY MILES WEST OF THE GRAND COULEE. FOSTER CREEK IS THE CONSEQUENT STREAM WHICH DRAINS THIS SLOPE. AT LEAHY, THE VALLEY IS 250 FT DEEP AND, WERE IT NOT FOR THE BIG MORAINIC HILLS IN IT, WOULD BE CAPACIOUS. IT WAS IMPOSSIBLE IN THE HASTY EXAMINATION MADE ENROUTE TO IDENTIFY FEATURES OF THE FIRST EROSION CYCLE. GLACIAL EROSION AND DEPOSITION HAVE GREATLY MODIFIED THE ORIGINAL TOPOGRAPHY.



"DRAWS" OF NOT NOTABLE PROPORTIONS CONSTITUTE THE HEADWATERS OF MOSES COULEE DRAINAGE DIRECTLY EAST OF MANSFIELD. THEY MAY NOT BE DOWN TO BEDROCK. WHATEVER THE HISTORY OF MOSES COULEE PREVIOUS TO THE MAXIMUM OF WISCONSIN GLACIATION, IT IS OBVIOUS THAT DURING THE ABLATION OF THE OKANOGAN LOBE, NO NOTEWORTHY VALLEYS WERE FORMED BY ESCAPING GLACIAL WATERS ACROSS THE GROUND MORAINE. FURTHERMORE, THERE IS NO PLACE APPARENT WHERE A PRE-WISCONSIN MOSES COULEE DRAINING SOUTHWARD, WOULD BE COMPLETELY OBLITERATED.

THE GLACIATED COUNTRY BETWEEN GRAND COULEE AND MANSFIELD AND THAT ABOUT PILOT KNOB SHOWS MANY GREAT BLDRS OF BASALT AND BUT BEW, COMPARATIVELY, OF GRANITE. YET THE BERG-DRIIFTED ERRATICS SOUTH OF SOAP LAKE AND SOUTH OF QUINCY ARE NEARLY ALL OF GRANITE. THIS SIGNIFICANT DIFFERENCE SUGGESTS THAT THE BERGS AND THEIR BURDENS DID NOT COME FROM THE OKANOGAN LOBE. AFTER A SURVEY OF THE GREAT KNOBS OF SHEETED GRANITE, SOME OF THEM NEARLY AS HIGH AS THE COULEE IS DEEP AND WITH PRECIPITOUS SIDES, IN THE RANGE NORTH OF STEAMBOAT ROCK, AND AFTER THE CONVINCING EVIDENCE OF GLACIAL OVERRIDING OF MOST OF THESE KNOBS IS CONSIDERED, IT SEEMS VERY PLAUSIBLE THAT THE BERG-BORNE BLDRS WERE SECURED, IN LARGE PART AT LEAST, IN THE BED OF UPPER GRAND COULEE AT THE MAXIMUM ADVANCE OF THIS EASTERN EDGE OF THE OKANOGAN LOBE.

MANSFIELD TO COLUMBIA RIVER VIA MOSES COULEE AUG 22-23 1922

BROAD CAPACIOUS TRIBUTARY VALLEYS ERODED IN BASALT BUT LITTLE ALTERED BY GLACIATION, LEAD SOUTHWARD TO MOSES COULEE FROM A LATITUDE A FEW MILES SOUTH OF MANSFIELD. THE COULEE ITSELF BEGINS NOT MORE THAN FIVE MILES SOUTH OF MANSFIELD— THESE TRIB VALLEYS ARE MEMBERS OF THE PRE-COULEE DRAINAGE SYSTEM, PRE-GLACIAL OF COURSE, AND PROBABLY FIRST CYCLE. THE BROAD FLOOR OF THE MAIN VALLEY OF THE OLDER SYSTEM IS EASILY RECOGNIZED AS FAR DOWN AS THE FIRST LAKE. COULEE IS ENTRENCHED IN IT.

MORAINIC AND OUTWASH ACCUMULATIONS NOT NOTEWORTHY NORTH OF JAMESON LAKE. COULEE HAS BROAD AGGRADED FLOOR, NO ROCK ANYWHERE. LAKE BASINS ARE SHALLOW AND TALUS PILES OUT IN THE LAKE. BUT SOUTH OF JAMESON LAKE FOR THREE MILES, THE COULEE IS BLOCKED BY THE T.M. AND ASSOCIATED OUTWASH. THE CREST OF THE MORAINE IS AT THE SOUTHERN PART OF THIS TRACT. THE EAST WALL OF THE COULEE IS NEARLY (AND IN PLACES QUITE) OBLITERATED BY THE MORAINIC HILLS. SPLENDID MORAINIC TOPOGRAPHY, MANY OF THE HILLS RISE HALF THE HEIGHT OF THE CLIFFS, SOME OF THEM 2/3. ONE PYRAMIDAL KAME, OUT IN THE MIDDLE OF THE VALLEY AND ON THE SOUTHERN EDGE OF THE MORAINE, IS 150 FEET ABOVE THE VALLEY FLOOR AND THE WALLS HERE DO NOT EXCEED 200 FT IN HEIGHT.

OUTWASH, WITH PITTED AND INTERRUPTED SURFACE, LIES NORTH OF THE MORAINE, CLOSE TO JAMESON LAKE. IT LOOKS LIKE THE MORAINE IN PLACES BUT APPARENTLY IS SIMPLY A VARIETY OF PITTED PLAIN. OUTWASH IN FRONT OF THE MORAINE IS TYPICALLY TERRACED AND EXTENDS AS TERRACES AND AS BOTTOM FILL FAR BELOW THE MORAINE. IT IS MANY FEET DEEP 5 MILES SOUTH OF SPENCER.

AT THE SUNSET HIWAY CROSSING, NEAR THE OLD PO OF SPENCER, A GLIMPSE OF THE MORAINE ON THE SUMMIT OF THE CLIFFS TO THE NORTH, CAN BE OBTAINED, BUT THE MORAINE IN THE VALLEY IS AROUND A CURVE AND CANNOT BE SEEN.

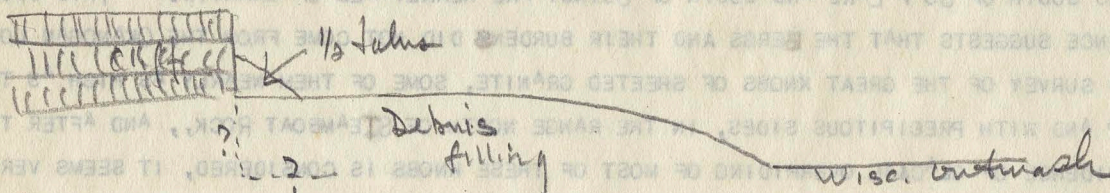
A GRAVEL PIT ALONG SUNSET HIWAY ON EAST SLOPE OF THE COULEE, GRAVEL IS WHOLLY OF BASALT AND VERY LITTLE ROLLED. THE BEDDED STRATA DIP UP THE VALLEY. CLEARLY ONLY A FINE TALUS OR ALLUVIAL FAN GRAVEL. ON WEST SLOPE OF THE COULEE, THE HIWAY ASCENDS OVER A LONG DEBRIS SLOPE WHICH LEADS DOWN FROM A HANGING TRIB VALLEY. THE MATERIAL ABOVE THE LEVEL OF THE WISCONSIN VALLEY TRAIN, IS USUALLY OF BASALT AND NOT MUCH WORN. IF THIS WERE A SIMPLE



DEBRIS CONE OR FAN, THE MATTER WOULD BE TRIFLING ENOUGH. BUT TWO FEATURES ABOUT IT ARE PUZZLING. (1) ITS SIZE (2) ITS RELATION TO THE COULEE WALLS AND THE POST-WISCONSIN TALUS.

(1) IT IS TWO MILES LONG AND IN WIDTH AVERAGES ABOUT TWO-THIRDS THE TOTAL WIDTH OF THE VALLEY. ITS SURFACE ALONG THE WEST WALL IS FLAT. THIS PASSES EASTWARD INTO A CONVEX CURVE, DESCENDING TO THE WISCONSIN OUTWASH FLAT. BUT THE FLAT UPPER SURFACE IS 100 FT ABOVE THE OUTWASH FLAT.

(2) THE FLAT UPPER SURFACE APPEARS TO HAVE BEEN BUILT ALONGSIDE VERTICAL ROCK WALLS. ONLY POST-WISCONSIN TALUS, OF USUALLY PROPORTIONS, INTERVENE BETWEEN WALL AND FLAT.



THE FILL IS OLDER THAN THE WISCONSIN GLACIATION FOR IT OBVIOUSLY IS BUT A TERRACE REMNANT OF A ONCE CONTINUOUS VALLEY FILL AND THE WISCONSIN OUTWASH LIES IN THE VALLEY ERODED IN IT.

(SEE 1925 AND 1926 NOTES)

YET TALUS HAS NOT BEEN ACCUMULATING ON ITS UPPER FLAT FROM THE BOUNDING WESTERN CLIFF ANY LONGER THAN IT HAS AT CONTACT OF EAST WALL AND WISCONSIN TERRACE. DID WISCONSIN WATERS SWEEP THIS OLDER FEATURE CLEAN? DID THEY ERODE THE 100FT VALLEY IN IT? OTHERWISE HOW EXPLAIN THE TALUS OF SAME AGE ON IT AND ON WISCONSIN OUTWASH? YET NOT A SINGLE FRAGMENT OF ROCK FOUND ON ITS SURFACE TO SHOW THAT GLACIAL WATERS EVEN SWEEPED OVER IT.

ANOTHER FRAGMENT OF THE SAME FILLING, LYING ON THE EAST SIDE OF THE VALLEY TWO MILES BELOW THE LARGE ONE ABOVE DESCRIBED. MORE DISSECTED, BUT ALTITUDE OF SUMMIT THE SAME. DOES NOT HAVE HIGH CLIFFS BACK OF IT, HENCE DOES NOT SHOW THE POST-WISCONSIN TALUS ON IT.

THE OUTWASH FROM THE OKANOGAN LOBE'S T.M. WAS NOT FOUND BELOW SECTION 6, T 23 N., R 25 E. HERE LEDGES OF BASALT APPEAR, THE GRAVEL FILL HAVING THINNED OUT AND DISAPPEARED. AT MRS. CAMPBELL'S RANCH IS A LARGE SPRING JUST AT THE SOUTHERN EDGE OF THE V.T. THE WATER IS SLIGHTLY ALKALINE AND IS CLEARLY SURFACE WATER OF THE VALLEY BOTTOM ABOVE, WHICH HAS SEEPED DOWN TO THE BEDROCK FLOOR AND MOVED SOUTHWARD ALONG THIS IMPERVIOUS (OR SATURATED) BASE.

THERE IS SO LITTLE OUTWASH IN MOSES COULEE AND ON THE GROUND MORaine TO THE NORTH EAST THAT ONE GETS THE IMPRESSION THAT THE OKANOGAN LOBE MUST HAVE LARGELY EVAPORATED, INSTEAD OF MELTING. MORE EVIDENCE FOR THIS PAUCITY OF ESCAPING WATER IS FOUND FARTHER DOWN MOSES COULEE.

SOUTH OF THE TERMINUS OF THE OUTWASH, ABOVE NOTED, THE CHARACTER OF THE COULEE CHANGES GREATLY FOR A FEW MILES. ABOVE THIS TERMINUS, THE COULEE IS A SIMPLE, BROAD, VERTICALLY WALLED CANYON. BELOW, THE STRAIGHT ITS GREAT BOUNDING WALLS DISAPPEAR BECAUSE OF A SOUTHWARD DIP OF THE BASALT AND THE COULEE BECOMES A MAZE OF ANASTOMOSING CHANNELS/CHANNELS, IRREGULAR ROCK ISLANDS AND BUTTES AND DRY CATARACTS. THIS TRACT OF DALLES TYPE CHANNELS IS FIVE TO SIX MILES LONG AND TWO TO THREE MILES WIDE. IN IT THE COULEE FLOOR DESCENDS ABOUT 600 FT TO THE BROAD-FLOORED LOWER COULEE, HEADING ABOUT FOUR MILES EAST OF PALISADES STA. ON THE MANSFIELD BRANCH RR. THIS DESCENT OF 100 FT TO THE MILE IS NOT FOUND IN ANY OTHER PART OF THE COULEE. AND IT IS IN THIS PART ONLY THAT ROCK BOTTOM IS EXPOSED IN MOSES COULEE. ABOVE AND BELOW THE BROAD VALLEY, BOUNDED BY STEEP HIGH WALLS, IT IS FLOORED WITH GRAVEL, SAND AND SILT.

See July 26 1925



THE TALUS SLOPES OF THE "DALLES" PORTION ARE LARGELY OF PRE-WISCONSIN AGE, REACHING UP 3/4 TO 4/5 OF THE TOTAL HEIGHT OF THE WALLS, AND BEARING MORE FINE MATERIAL THAN THE POST-WISCONSIN TALUS PILES. ONE OF THE CHANNELS OF THE PLEXUS WAS FOLDED DOWN FROM THE HIGHEST LEVEL AT WHICH THEY OCCUR TO THE FLOOR OF THE LOWER COULEE. THE DESCENT WAS 600 FT ALL TOLD, AND WAS MADE LARELY OVER DRY FALLS AND CASCADES, NOW MANTLED WITH TALUS, FIVE SUCH FALLS IN THE TRAVERSE, EACH SEPARATED BY 1000 FT OR SO OF FLAT-FLOORED CHANNEL. THE PRE-WISCONSIN TALUS LIES ALONG ALL CLIFFS OF THIS CHANNEL FOR THE UPPER 500 FT ONLY. ONLY THE LAST 100 FT OF THE DESCENT IS OVER A YOUNGER CLIFF AND TALUS.

THERE IS VERY LITTLE STREAM GRAVEL ALONG THIS CHANNEL OR ON THE STREAM-SWEPT UPPER FLAT (THE SYNCLINE FLOOR) IN WHICH THIS CHANNEL HAS BEEN FORMED BY WATERFALL RECESSION. BUT HERE AND THERE ARE QTZITE AND GRANITE COBBLES AND PEBBLES UP ON THE SYNCLINAL FLOOR.

IT IS CLEAR, THEN, THAT WATERS FROM THE PRE-WISCONSIN GLACIATION SWEEPED DOWN ACROSS THIS DALLES TRACT IN GREAT VOLUME, FOUND NO DEFINITE, WELL-CUT STREAM VALLEY, SPREAD OUT WIDELY AND INITIATED A LARGE NUMBER OF INCIPIENT CHANNELS. AS THESE DEEPENED, THE MORE FAVORABLY SITUATED ONES DEEPENED AT THE EXPENSE OF THE OTHERS AND DREW OFF THE WATERS INTO THEM. BEFORE THIS FLOOD CEASED, AT LEAST 500 FT OF EROSION IN THE BASALT HAD BEEN ACCOMPLISHED IN THE LOWER PART OF THE TRACT. SUCH VIGOROUS CURRENTS LEFT NO GRAVEL DEPOSITS, ALL COURSES WERE SWEEPED CLEAN. ONLY IN THE BROAD, SIMPLE CANYON PORTIONS ABOVE AND BELOW THIS TRACT COULD GRAVEL BE DEPOSITED.

SINCE MOSES COULEE DRAINAGE DOES NOT HEAD MUCH NORTH OF THE LATITUDE OF MANSFIELD AND DID NOT IN PREGLACIAL TIMES, IT IS CLEAR THAT THE PRE-WISCONSIN ICE MUST HAVE ADVANCED AT LEAST AS FAR AS MANSFIELD IN ORDER TO DISCHARGE INTO THE COULEE. THE WISCONSIN OKANOGAN LOBE HAS DESTROYED ALL EVIDENCE OF THIS EARLIER GLACIATION OF THE NORTHWARD PART OF DOUGL'S CO.

WHILE ALL EVIDENCE OF THE PRE-WISCONSIN ICE MAY HAVE BEEN WIPED OUT ON THE GLACIATED PLATEAU, QUITE THE CONTRARY IS THE CASE WITH THE WORK OF ESCAPING WATERS. THE WISCONSIN DRAINAGE HAS HARDLY MODIFIED THE PRE-WISCONSIN CHANNELS. THERE COULD NOT HAVE BEEN MUCH VOLUME TO THE DISCHARGE AT ANY TIME.

A MILE ABOVE PALISADES STATION IS A GRAVEL TERRACE ON THE NORTH SIDE OF THE COULEE, 60 FT ABOVE THE AGGRADED FLOOR OF THE COULEE. THE GRAVEL CONTAINS GRANITE AND QTZITE PEBBLES AND COBBLES. IT IS NOT HALF THE WIDTH OF THE COULEE HERE AND IS CONSIDERABLY GULLIED. IT IS IN ALL PROBABILITY A REMNANT OF PRE-WISCONSIN FILLING IN THE LOWER COULEE. IT IS HARDLY POSSIBLE THAT IT IS A WISCONSIN TERRACE.

THE ABRUPT HEAD OF THE LOWER COULEE IS STRIKING. TWO GREAT CASTELLATED BUTTRESSES FACE DOWN THE COULEE, WITH LESSER WALLS BRIDGING ACROSS BETWEEN THEM. THESE WALLS WERE CLEARLY WATERFALLS. INDEED, BEFORE THE CHANNELLING WHICH SEPARATED THE BUTTRESSES, THERE APPEARS TO HAVE BEEN A "GREAT FALLS" HERE, COMPARABLE IN PROPORTIONS TO THE GRAND COULEE GRAND FALLS. RECESSION OF THESE FALLS PERHAPS FORMED THE LOWER COULEE, AT LEAST THAT PART ABOVE PALISADES.

STRUCTURE OF THE BASALT ALONG MOSES COULEE. A GENTLE DIP NORTHWARD AT CROSSING OF THE MORaine. THIS BRINGS THE BASALT SURFACE HIGHER FARTHER SOUTH AND THE COULEE BECOMES A FINE, VERTICALLY-WALLED FLAT-FLOORED CANYON TO A POINT ABOUT 5 MILES SOUTH OF SPENCER. HERE THE DIP IS SOUTHWARD AND IN TWO MILES CARRIES THE BASALT SUMMIT DOWN SO THAR THE ENCLOSING CLIFFS ARE INCONSEQUENTIAL AFFAIRS. HERE THE UPPER, WASTE-FLOORED COULEE ENDS AND THE DRAINAGE PASSES INTO THE DALLES TRACT IN THE SYNCLINE. THE COURSE CHANGES HERE AND LIES IN THE AXIS OF THE SYNCLINE AS FAR AS PALOSADES, AGAIN BECOMING NEARLY N-S, CROSSING AN ANTICLINE SOUTH OF THE



SYNCLINE AND LYING THENCE ACROSS A TRACT OF UPLIFTED BUT ESSENTIALLY HORIZONTAL BASALT FLOWS. ANOTHER ANTICLINE LIES NORTH OF THE SYNCLINE BUT ITS AXIS APPEARS TO SWING EASTWARD AROUND INTO A NE-SW DIRECTION AND TO SHOW IN THE COULEE WALLS AS THE BROAD, FLAT-TOPPED UPLIFT BETWEEN THE MORAINE AND THE LOWER END OF THE UPPER COULEE.

FOR FOUR MILES BELOW PALISADES, THERE ARE ROCK LEDGES OR TERRACES AT THE FOOT OF THE 900-FT CLIFFS. THESE NARROW THE VALLEY FLOOR TO ABOUT HALF THE COMPLETE WIDTH OF THE COULEE BOTTOM AND THEY STAND 50-100 FT ABOVE THE FLOOR. GRAVEL ON THEIR SURFACE HERE AND THERE. CONTAINS GRANITE COBBLES. WHERE BARE ROCK, THE SURFACE SHOWS CLEARLY THE INCIPIENT CHANNELS AND ISLANDS SO FAMILIAR IN GLACIAL DRAINAGE SPILLWAYS IN THIS COUNTRY.

A MILE SOUTH OF PALISADES IS A DEPOSIT OF VERY POORLY SORTED MATERIAL, RANGING FROM BLDRS 10 FT IN DIAMETER TO SAND AND CLAY, WITH SOME VERY STRIKING HUMMOCKS AND RIDGES ON ITS SURFACE. THE DEPOSIT IS AT LEAST 50 FT THICK. GRANITE PRESENT, THO SPARINGLY. MATERIAL IS ROLLED SOMEWHAT, NO FRAGMENTS STRIATED. AT SOUTHERN PART, EXPOSED IN RR CUT, THERE IS FORESET BEDDING POORLY DEFINED, DIPPING DOWN THE COULEE. THE WHOLE THING LOOKS MUCH LIKE A TILL AND OUTWASH BUT EVIDENCE ISNT CONVINCING. (HYDE LATER DECIDED THAT THIS WAS A DISSECTED GRAVEL FAN)

THE CHARACTER OF THE COULEE FROM PALISADES DOWN DIFFERS IN ONE MARKED WAY FROM THAT OF ITS UPPER PART AND FROM UPPER GRAND COULEE. IT HAS MANY TRIBUTARY VALLEYS, HANGING BUT A SHORT DISTANCE ONLY ABOVE THE FLOOR OF THE COULEE. MOST OF THESE VALLEYS ARE BUT WIDE OPEN VS, AND ARE NOT LONG. BUT THEY HAVE GRADED SLOPES WITH ROCK LEDGES UNCOMMON. THEY PROBABLY BELONG TO THE FIRST CYCLE. AT LEAST THEY ANTEDATE THE MAIN COULEE VERY CONSIDERABLY. ALLUVIAL FANS LIE AT THE MOUTH OF EACH.



DIAGRAM SHOWS RELATION OF THESE FEATURES TO EACH OTHER. THE INTERPRETATION OF THE HISTORY OF LOWER MOSES COULEE IS AS FOLLOWS.

- (1) A SECOND CYCLE CANYON LIKE ROCK ISLAND CREEK POSSESSES, WITH FIRST CYCLE PARTIALLY RE-JUVENATED TRIBUTARIES.
- (2) SPILL FROM THE SPOKANE (PRE-WISCONSIN) ICE DIRECTLY. NO LAKE OR NOTABLE DIVERSION. CONTRIBUTION DIRECT FROM THE ICE.
- (3) WIDENING OF PREGLACIAL CANYON BY TRUNCATION OF SPURS, THUS PRODUCING THE GREAT ROUND-EDGED CLIFFS.
- (4) ENTRENCHMENT IN FLOOR BY SPOKANE SPILLAGE (OR POSSIBLY BY OKANOGAN (WISCONSIN) SPILLAGE. PERHAPS AN ESPECIALLY RESISTANT FLOW RESPONSIBLE FOR THE ROCK TERRACE. THIS SUGGESTED BY THE FACTS THAT THE LAST FEW MILES OF THE COULEE SHOW NO ROCK TERRACE AND THAT THE FLOWS DIP SOUTHWARD A LITTLE MORE STEEPLY THAN THE VALLEY FLOOR DESCENDS. ENTRENCHMENT AND WIDENING THEREFORE



~~MAY HAVE BEEN SIMULTANEOUS. WISCONSIN~~

MAY HAVE BEEN SIMULTANEOUS.

(5) MODIFICATION BY WISCONSIN WATERS NOT RECOGNIZABLE BELOW "THREE DEVILS" (THE 600 FT DESCENT). THIS, IF THE NEAR-TILL AND NEAR-MORaine BELOW PALISADES BE CORRECTLY GUESSED AT. OTHERWISE, THIS ITEM TO BE OMITTED.

ROCK BOTTOM TO MOSES COULEE UNKNOWN IN MOST PLACES EXCEPT THE DALLES PORTION. A WELL 200 FT DEEP THREE MILES BELOW THE HEAD OF THE LOWER COULEE PENETRATED SOIL AND SAND AND COARSE GRAVEL ALL THE WAY. <sup>See map p. 123</sup> THE BROAD TERRACE ON WHICH THE COULEE OPENS IN THE COLUMBIA VALLEY IS ALL SAND AND GRAVEL. ITS SURFACE IS DISSECTED BY GULLIES AND BY THE WORK OF THE COLUMBIA BUT REMAINING PORTIONS OF THE ORIGINAL SURFACE ARE FROM 950 TO 990 FT A.T. THE RIVER HERE IS 575 A.T. AND THE TERRACE GRAVEL DEPOSIT WHICH REACHES DOWN AT LEAST TO RIVER LEVEL IS THEREFORE 400 FT THICK. AND IT IS ALL ONE DEPOSIT, NOT A SUPERPOSITION RECORD OF SEVERAL EPODES OF AGGRADATION. ITS EXTENT UP AND DOWN THE COLUMBIA IS UNKNOWN BUT IT IS WELL SHOWN ON THE MALAGA MAP UP THE COLUMBIA AND ON THE WEST SIDE AND IT EXTENDS FROM MOSES COULEE DOWN AS FAR AS TRINIDAD WHERE ITS ALTITUDE IS ABOUT 970. THUS IT IS CLEAR THAT, SUBSEQUENT TO THE FORMATION OF MOSES COULEE, PERHAPS IN THE CLOSING STAGES OF ITS SPOKANE HISTORY, THE COULEE HAS BEEN FILLED SEVERAL 100 FT WITH RIVER MATERIAL. THE FILL PROBABLY IS CONSIDERABLY YOUNGER THAN THE SPOKANE DEVELOPMENT, THE EVIDENCE IS FOUND IN THE YOUTHFUL, SHARP PROFILES OF THE TERRACES.

VICINITY OF TRINIDAD FRIDAY AUG. 25 1922

TOWN OF TRINIDAD STANDS ON A TERRACE WHICH IS CONTINUOUS UP-VALLEY WITH THE COLUMBIA RIVER (TOWN) TERRACE AND THE MOSES COULEE FILL. AT TRINIDAD, THE MATERIAL IS FINE, ALMOST ALL BASALT AND BEDDED THRUOUT WITH DOWNVALLEY DIP. NO DELTA FORESETS BUT THE STRUCTURE PROBABLY EXISTING IN THE GIANT CURRENT RIPPLES OF GRAVEL BARS AND FLATS. SOME PORTIONS HAVE FORESETS PROBABLY 40 FEET IN DEPTH.

A LARGE GRAVEL PIT BETWEEN TRINIDAD AND VULCAN ALONG THE GNRR EXCAVATED IN THIS TERRACE. THE TERRACE FRONT HERE IS VERY STEEP AND DESCENDS FROM 950 ABOUT, TO THE RIVER (ALT )

BUT DOWNVALLEY FROM TRINIDAD, THE TERRACE CAN NOT BE RECOGNIZED. EITHER IT HAS ALL BEEN SWEEP AWAY, OR NEVER WAS DEPOSITED. IF NEVER DEPOSITED, IT MUST BE CONSIDERED A DELTA TERRACE AND THE STRUCTURE DOES NOT BEAR OUT THIS INTERPRETATION. STUDY QUINCY AND BEVERLY MAPS FOR FEATURES WHICH CAN BE CORRELATED WITH IT. CONSIDER POSSIBILITY OF CORRELATING IT WITH RUSSELL'S "GREAT TERRACE" AT CHELAN.

A LOWER TERRACE, OPPOSITE TRINIDAD, NOT MORE THAN 75-100 FT ABOVE THE RIVER, BEARS ON ITS SURFACE THE GIANT CURRENT RIPPLES WHICH WERE FORMED THE LAST SEASON THE TERRACE WAS STREAM BOTTOM NO CHANNELLING ACROSS IT, NO GULLYING IN IT. SEEN VERY PLAINLY IN LATE AFTERNOON LIGHT.

THE HIGH TERRACE ON WHICH TRINIDAD STANDS EXTENDS BACK UP WILLOW SPRINGS DRAW BEYOND THE APEX OF THE GNRR HORSESHOE CURVE. ALL TRIBUTARY VALLEYS SHOULD SIMILARLY SHOW THE EFFECTS OF THE AGGRADATION. *Is there any record of higher, earlier terraces?*

AT TRINIDAD STATION, A BOWLDERY ACCUMULATION OF ROUNDED BASALTS WITH A DARK BROWN CLAY MATRIX IS EXPOSED IN THE RR CUT. BLDRS SUBANGULAR. COLOR APPARENTLY DUE TO OXIDATION. NO PLACE FOR IT IN THIS HISTORY.



*Err.* N-S ROAD CROSSING GNRR 1 1/2 MILES EAST OF CRATER STATION WAS FOLLOWED SOUTHWARD TO THE POTHoles. AT ROAD CROSSING ONE MILE SOUTH OF RR, ALTITUDE 1344, TWO ERRATIC BLDRS, PILED UP AT CORNER OF ROAD. FARTHER SOUTH AT SAME ALTITUDE ARE OTHERS. SOME CLEARLY STRIATED. GRANITE, GNEISS, SCHIST, QZITE, SLATE, BASALT, ARGILLITE ARE REPRESENTED. 1344 IS HIGHEST ALTITUDE AT WHICH ANY HAVE BEEN FOUND. IT ALSO IS THE HIGHEST ALTITUDE REACHED ALONG THIS ROAD AND MAY NOT BE THE UPPER LIMIT OF THE BERG-BORNE BLDRS.

*Err.* ON STEEP SLOPES DIRECTLY EAST OF HORSESHOE CURVE IN GNRR, EAST OF TRINIDAD, AT ALTITUDE OF 1400 A.T. (CHECKED BY USGS BM) IS A "NEST" OF GLACIAL ERRATICS. 12 GRANITES, SUBANGULAR TO ROUNDED, AND ONE QZITE FOUND. NONEGLACIATED. RANGE IN SIZE FROM PEBBLES TO MAX. DIAMETER OF 16 INCHES. ALL IN RADIUS OF 15 FEET. EROSIONAL TOPOGRAPHY OF FOLDS IN THIS REGION MATURE, EXCEPT ON LOWER STEEPER SLOPES WHERE RAVINES REPLACE THE MORE OPEN DRAINAGE LINES ON THE UPPER SDOOPES.

VICINITY OF "THE POTHoles" AUGUST 25 1922

THE POTHoles CONSTITUTE THE BEST EXAMPLE MAPPED OF A RECEDED WATERFALL OVER HORIZONTAL FLOWS OF BASALT. THE ANCIENT STREAM SPILLED OVER THE COLUMBIA CLIFFS AT AN ALTITUDE OF 1200 OR 1250. THE CLIFFS WERE MADE UP OF TWO GREAT LEDGES, THE UPPER BLUFF ABOUT 200-250 FT HIGH AND THE LOWER EQUALLY HIGH, IF NOT HIGHER. <sup>LOWER</sup> BASE OF THE CLIFF IS NOW BURIED IN A GRAVEL TERRACE AND ITS ORIGINAL HEIGHT CANNOT BE DETERMINED.

THE AMOUNT OF ~~RECESSION~~ RECESSION IN THE TWO LEDGES IS QUITE UNEQUAL. IN THE UPPER LEDGE THE FALLS RECEDED NEARLY TWO MILES WHILE IN THE LOWER THERE APPEARS TO HAVE BEEN A SOMEWHAT GREATER SPREAD OF THE WATERS OVER THE EDGE AND CERTAINLY WAS A LESSER OPPORTUNITY FOR SAPPING AND PLUCKING. THUS ONLY 1/4 MILES, MAXIMUM, OF RECESSION OCCURRED IN THE FIVE SEPARATE NOTCHES WHICH WERE DEVELOPED.

THE UPPER FALLS WERE DOUBLE, OF ALMOST EQUAL PROPORTIONS. THEIR PARALLEL RECESSION LEFT A GREAT BLADE OF ROCK, A MILE AND A HALF LONG, 1000 FT WIDE AND 375 FT MAX HEIGHT BETWEEN THEM. THE POTHoles AT THE FOOT OF THE FALLS ARE LARGELY FILLED WITH GREAT GRAVEL BARS, THE DEEPEST PORTIONS BEING AT THE FOOT OF THE FALLS.

ABOVE THE UPPER FALLS IS A CHANNLED TRACT EXTENDING TWO MILES FARTHER EAST AND VERY MUCH DIVERSIFIED BY RAMIFYING CHANNELS AND THEIR SEPARATING ISLANDS. AN ISLAND STUDDED RAPIDS! "HOLES" COMMON, SOME OF THEM 40 FEET DEEP IN THE BASALT. OTHER PRELIMINARY CHANNELS, MADE BEFORE THE FALLS HAD REACHED THEIR MAXIMUM RECESSION, EXIST ON THE SOUTH SIDE, HANGING ABOVE THE CANYON PRODUCED BY RECESSION OF THE SOUTHERN FALL.

THE BASALT IN THE WALLS OF THE POTHoles CARRIES A VERY CONSPICUOUS MEMBER OF EXCEPTIONALLY WELL-DEVELOPED AND EXCEPTIONALLY LARGE COLUMNS. THESE COLUMNS ARE UNIFORM IN DIAMETER FROM BOTTOM TO TOP AND IN PLACES ARE 75 FEET LONG. THEY POSSESS A PLATY PARTING ACROSS THE COLUMN WHICH IS VERY CONSPICUOUS IN WEATHERED FACES. THIS PLATINESS CAUSES THIN SLABBY TALUS FRAGMENTS, ALMOST CHIPS INSTEAD OF SLABS. THE TRUNCATED ENDS OF FALLEN COLUMNS LOOK LIKE AN ADZED SURFACE OF WOOD. COMMONLY A COLUMN GOES ALL TO CHIPS WHEN IT FALLS.

THERE IS AN EASTWARD DIP OF THE BASALT AT THE POTHoles OF A FEW DEGREES. IF THE EDGES OF THE FALLS WAS HELD UP BY THE SAME LAYER DURING THE WHOLE OF ITS HISTORY, IT MUST HAVE BECOME LOWER ~~DURING ITS HISTORY~~ AS IT RECEDED.



AS THE SURFACE NOW STANDS, IT LOOKS AS THO THE ELONGATED POTHOLAS HAD BECOME PROGRESSIVELY DEEPER AND WIDER DURING RETREAT, BUT THIS IS BECAUSE THE WESTERN, EARLIER-FORMED PORTIONS HAVE BEEN FILLED TO A GREATER EXTENT WITH GRAVEL. A MAXIMUM DEPTH OF 200 FEET OF GRAVEL LIES IN THE SOUTHERN CHANNEL.

THE TALUS ACCUMULATIONS OF THE POTHOLAS ARE SOMEWHAT IRREGULAR BUT THERE ARE FAR TOO MANY CLIFFS WITH TALUS 3/4 OR MORE OF THEIR HEIGHT TO PERMIT THE HYPOTHESIS OF FORMATION BY WISCONSIN WATERS. THE POTHOLAS WERE FORMED AT THE TIME OF THE SPOKANE GLACIATION. THE COLUMBIA VALLEY WAS THEN AS DEEP OR NEARLY AS DEEP AS NOW. THO THE LOWER LEDGE IS NOT MARKED BY RETREATING FALLS IN A WAY AT ALL COMPARABLE TO THE OTHER, YET WATER CERTAINLY WENT OVER IT FROM THE POTHOLAS FALLS. THE ONLY ALTERNATIVE HYPOTHESIS MUST CONSIDER THAT THERE WERE TWO EPISODES OF SPILLAGE OVER THE POTHOLAS, THE FIRST WHEN THE COLUMBIA VALLEY FLOOR WAS AT THE LEVEL OF THE LOWER LEDGE AND THE SECOND WITH A DEEPER COLUMBIA VALLEY AND A ~~1/2~~ SMALLER DISCHARGE TO MODIFY THE NEWLY EXPOSED LOWER LEDGE. BUT IF THE UPPER CHANNELS ~~OF THE~~ AND THE BIG FALLS ARE SPOKANE, THERE IS NOTHING IN THE ENTIRE REGION TO SUPPORT THIS IDEA OF A PRE-SPOKANE DISCHARGE, GREATER THAN THAT OF THE SPOKANE EPOCH.

THAT THE LOWER LEDGE IS PECULIARLY RESISTANT AND THE UPPER ONE LESS SO IS CLEAR IF ONE STUDIES THEM BETWEEN THE POTHOLAS AND TRINIDAD. THEY ARE BOTH WELL SHOWN ON THE QUINCY QUAD. THE UPPER CLIFF IN PLACES HAS RETREATED MORE THAN A MILE FARTHER BACK FROM THE COLUMBIA THAN THE LOWER AND AVERAGES HALF A MILE FARTHER BACK. AND THIS RETREAT ISNT MERELY A VAGARY OF RIVER MEANDERING AT A CERTAIN STAGE IN DEVELOPING ITS VALLEY, FOR THE LOWER RESISTANT LEDGE SHOWS ALSO AT THE TOP OF THE EASTERN WALL OF WILLOW SPRINS DRAW WHERE IT OCCUPIES A WHOLLY DIFFERENT LEVEL (375 FT) ABOVE ITS LEVEL AT THE POTHOLAS AND A DIFFERENT RELATION TO THE TOPOGRAPHIC DEVELOPMENT OF THE REGION. HERE IT CONSTITUTES A HILLSIDE FEATURE, WELL ABOVE ALL POSSIBILITY OF LATERAL EROSION BY THE COLUMBIA AT THE TIME THE SAME LEDGE WAS FLOODED NEAR THE POTHOLAS.

EXAMINATION OF THE LEDGE IN THE FIELD SHOWS IT AS EXCEPTIONAL IN ITS WAY AS IS THE STRIKINGLY COLUMNAR PART OF THE UPPER LEDGE ALREADY DESCRIBED. THIS LOWER LEDGE IS COMPOSED OF AN EXCEPTIONALLY THICK FLOW, (MORE THAN 100 FT) WITH UNIFORMLY SMALL-COLUMNED BASALT FROM BOTTOM TO TOP. SUCH A STRUCTURE APPARENTLY HAS NOT LENT ITSELF TO PULLUCKING IN ANYTHING LIKE THE DEGREE TO WHICH THE UPPER LEDGE HAS BEEN AFFECTED.

THERE IS STILL MORE OF INTEREST REGARDING THE LOWER LEDGE. IT RISES NORTHWARD NEARLY 400 FT IN FIVE MILES. IN THE NORTHWEST PORTION OF QUINCY QUAD., THE SLOPES OF THE UPPER LEDGE ARE COMPLETELY GRADED. NO BED ROCK SHOWS. THE SLOPES ARE RAVINED SO MUCH THAT THE EFFECT OF A CLIFF OR MASSIVE LEDGE IS LOST. THEN FOR TWO MILES SOUTH OF THE ROAD UP FROM THE CRESCENT BAR FRUIT RANCHES THE UPPER LEDGE BEARS TALUS TO THE TOP AND SOIL COVERS AND FILLS THE TALUS TO SUCH AN EXTENT THAT SAGE GROWS ALL OVER IT. ONLY HERE AND THERE DOES BEDROCK OUTCROP. THIS PORTION OF THE UPPER LEDGE IS CONSIDERABLE YOUNGER THAN THAT PORTION TO THE NORTH ABOVE DESCRIBED BUT MUCH OLDER THAN THE SPOKANE EPOCH. NO WATER FROM THE COLUMBIA RIVER HAS FLOWED OVER THE LOWER TERRACE TOP AND UNDERCUT THE UPPER LEDGE HERE SINCE A MUCH EARLIER TIME THAN THE SPOKANE EPOCH.

THEN FOR THE NEXT TWO MILES TO THE SOUTH (THE STRETCH EXTENDING TO THE POTHOLAS) THE UPPER LEDGE HAS TYPICAL POST-SPOKANE TALUS AND THE TERRACE TOP OF THE LOWER TERRACE IS GREATLY CHANNELED AND ETCHED, WITH "HOLES" AND ROCK ISLANDS IN PROFUSION AND COMPLEXITY. THE MAP SHOWS THE LARGER OF THESE BUT MOST OF THEM ARE NOT CAUGHT BY ANY CONTOUR. THE COLUMBIA ENTERED



ON THE SURFACE OF THE LOWER TERRACE AT ABOUT 1200 A.T. IN SECTION 31, T 20N., R23E.

THESE FEATURES OF THE SURFACE OF THE LEDGE IN THE TWO MILES ABOVE THE POTHOLES APPEAR TO BE OF SPOKANE AGE. SO DOES THE TALUS AGAINST THE UPPER CLIFF. YET IT IS CLEAR THAT WHEN THE SPOKANE DRAINAGE WENT OVER THE POTHOLES THE RIVER LEVEL WAS SOMEWHAT BELOW THE SURFACE OF THE LOWER LEDGE AT THE POTHOLES. THE ONLY (?) HARMONIOUS INTERPRETATION OF THESE APPARENT INCONSISTENCIES IS THAT THE CHANNELED SURFACE NORTH OF THE POTHOLES IS BUT SLIGHTLY OLDER AND POSSIBLY THAT THE COLUMBIA VALLEY HAD PREVIOUSLY BEEN CUT BELOW IT, THEN FILLED TO ITS LEVEL WITH DEBRIS, AND THEN DURING THE SPOKANE EPOCH CLEANED OUT AGAIN, AT LEAST IN PART.

THE TWO MILE PORTION NORTH OF THE CHANNELED SURFACE, AND SOUTH OF THE CRESCENT BAR ROAD, BEARS CONSIDERABLE FINE RIVER GRAVEL, DISPOSED IN ROUNDED HILLS. NO GOOD TERRACE FORMS OR BAR FORMS EXTANT, THO THE ROUNDED HILLS ARE PROBABLY THE RESULT OF SOFTENING DOWN OF THE ORIGINAL BAR AND TERRACE FORMS. THIS GRAVEL DEPOSIT LIES IN FRONT OF THE PRE-SPOKANE TALUS ABOVE DESCRIBED AND MUST BE CORRESPONDINGLY OLD. IT SHOWS ONE THING CLEARLY— THAT THE TERRACE TOP HERE IS THE RESULT OF LATERAL PLANATION BY THE COLUMBIA AND NOT AN AFFAIR OF CLIFF RESSION UNDER THE ATTACK OF THE WEATHER AND REMOVAL OF DEBRIS BY SLOPE WASH.

IN SUMMARY, THE PROMINENCE OF THE LOWER LEDGE IS TO BE ASCRIBED TO THE PRESENCE OF A MORE THAN USUALLY RESISTANT MEMBER OF THE BASALT FORMATION, COMBINED WITH THE PRESENCE OF A MORE EASILY SAPPED MEMBER ABOVE, NOT TO SIMPLE MEANDER SWINGING WITHOUT CONTRASTS IN MATERIAL ABOVE AND BELOW. THE WARPING BY WHICH THIS TERRACE SURFACE RISES NORTHWARD WAS LARGELY COMPLETED BEFORE THE SPOKANE EPOCH, ELSE THE RIVER WOULD HAVE COVERED THE NORTHERN HIGHER PART. THE WHOLE TERRACE AND THE NEIGHBORING POTHOLES ARE PRE-WISCONSIN AND UNTOUCHED ~~AND UNTOUCHED~~ BY WISCONSIN FLOODS.

RELATION OF THE POTHOLES TO THE GRAND COULEE DRAINAGE. AUG 26 1922

BEFORE THE SPOKANE EPOCH, THE MOSES LAKE STRUCTURAL VALLEY MUST HAVE CONTAINED A LAKE, (HAVE SCHWENNESEN AND MEINZER FOUND ITS RECORD IN THEIR PLEISTOCENE FOSSIL SHELLS FROM WELL BORINGS) WHOSE DISCHARGE WAY IS UNCERTAIN. PERHAPS AN ALKALINE LAKE! THEN AN INDUBITABLE RECORD SHOULD BE FOUND IN DEEP WELLS. AT THIS TIME GRAND COULEE DID NOT EXIST AS A DRAINAGE LINE. THERE WAS BUT AN INSIGNIFICANT STREAM VALLEY HEADING SOMEWHERE NEAR COULEE CITY AND DEBOUCHING NEAR SOAP LAKE. TRANSECTION OF THE MINOR SOAP LAKE ANTICLINE DEMANDS A STREAM VALLEY HERE AT THE TIME OF WARPING.

THEN CAME THE SPOKANE FLOODING, THE OVERFLOW AT THE NORTH END OF GRAND COULEE, THE EROSION OF MOSES COULEE AND GRAND COULEE, THE DEPOSITION OF ERODED MATERIALS IN THE MOSES LAKE/QUINCY STRUCTURAL VALLEY, AND DISCHARGE OVER THE POTHOLES AND THE OLD FALLS AT FRENCHMAN SPRINGS A FEW MILES SOUTH, AND PROBABLY AT THE DRUMHELLER PLEXUS. THE CURIOUS FEATURE OF THIS LAKE DISCHARGE WAS THAT TWO AND PROBABLY THREE OUTLETS WERE MAINTAINED LONG ENOUGH TO ALLOW SUCH RESSION AS THE POTHOLES SHOW AND SUCH PRE-WISCONSIN EROSION AS UPPER GRAND COULEE SHOWS. THE CONCLUSION IS UNAVOIDABLE THAT THE FLOODS WERE LARGE, THE GRADIENTS STEEP, AND THE PLUCKING OF THE COLUMNAR BASALT VERY RAPID. EROSION OF HARD ROCK WITHOUT HIGH-ANGLE JOINTING, EVEN WITH STEEP GRADIENTS AND LARGE VOLUMES OF WATER WOULD BE VERY, VERY MUCH SLOWER. THE BASALT WASNT WORN AWAY, IT WAS TORN AWAY



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COLUMBIA VALLEY TERRACES: CHELAN TO POTHOLES AUG 26 1922

AT CHELAN, THE GREAT TERRACE OF RUSSELL, ALTITUDE ABOUT 1300, NOT ON ANY TOPOGRAPHIC MAP. PARDEE CARRIES IT UP THE COLUMBIA TO THE OKANOGAN VALLEY AND THENCE UP THIS TRIBUTARY VALLEY. GET GRADIENTS FROM HIS PAPER. NO ONE HAS TRACED IT DOWN THE COLUMBIA. BUT THERE ARE TERRACES DOWN FROM CHELAN AS FOLLOWS.

- (1) SOUTH SIDE OF COLUMBIA—2-3 MI FROM E. EDGE CHELAN QUAD. ALT. 1200+ VERY MARKED THO NOT EXTENSIVE.
  - (2) EAST SIDE COLUMBIA—FOR SEVERAL MILES BELOW TROY. ALT. 1100 AT UPPER END, 1000 AT LOWER. VERY LARGE AND VERY DEFINITE AND SHARP.
  - (3) EAST SIDE COLUMBIA—2-3 MILES FROM SOUTH EDGE CHELAN QUAD. ALT. 900+ VERY DEFINITE AND SHARPLY OUTLINED.
  - (4) AT COLUMBIA RIVER STATION—900+ VERY DEFINITE, COMPOSED OF GRAVEL WITH LARGE FALLEN BLOX OF BASALT FROM NEIGHBORING CLIFFS. GRAVEL PREVAILINGLY FINE. THIS THE SAME FILLING AS THE LOWER MOSES COULEE, THO IN THE COULEE ITS SURFACE HAS BEEN LOWERED SOMEWHAT BY SUBSEQUENT EROSION.
  - (5) TRINIDAD—ALT. 900 APT. (HIGHER ALONG FLANKS OF HILLS) PREVIOUSLY DESCRIBED. ESSENTIALLY CONTINUOUS FROM COLUMBIA RIVER STATION TO TRINIDAD. FINER AT TRINIDAD.
  - (6) THE POTHOLES—GRAVEL TERRACE AGAINST FACE OF LOWER LEDGE, ALT. OF TOP 800+
- ARE NOT ALL THESE TERRACES REMNANTS OF ONE FORMERLY CONTINUOUS FILLING? THEY ALL APPEAR TO BE LATE WISCONSIN IN AGE, AND, ALLOWING FOR DIFFERENT LEVELS OF BARS AND OF MID-CURRENT AND OF EDGE-CURRENT CONTEMPORANEOUS DEPOSITS, THEY ALL FALL INTO A CONTINUOUS PROFILE. IF PARTS OF A COLUMBIA VALLEY TRAIN, WHERE ARE THE PORTIONS ABOUT BEVERLY, HANFORD OR KENNEWICK? WORK THIS OUT OF EARLIER NOTES AND TOPOGRAPHIC MAPS. ARE NAVARRE AND KNAPP COULEES RELATED TO THIS TERRACE? SEE WILLIS.

VICINITY OF WENATCHEE AUG 26 1922

PRE-BASALT FORMATIONS ON BOTH SIDES OF THE COLUMBIA RIVER. SS AND SHALE NEAR WENATCHEE, META-ROCKS IN NARROW VALLEY ABOVE WENATCHEE, GRANITES NEAR CHELAN. ON ALL OF THESE, COLUMBIA LAVA RESTS WITH FAIRLY EVEN CONTACT. BASALT ESCARPMENT VERY WELL SHOWN ON MALAGA QUAD., WHERE IT DESCRIBES A GREAT RIGHT ANGLE WITH THE RIVER BISECTING IT AND FLOWING OUT AT THE CONVERGENCE OF THE LIMBS. THE ESCARPMENT APPEARS IN THE NORTHWEST CORNER OF THE QUAD., TRENDS SOUTHEASTWARD AND REACHES THE COLUMBIA AT ROCK ISLAND STATION.

ROCK ISLAND RAPIDS PROBABLY THE FARTHEST UPSTREAM OF ALL THE RAPIDS CAUSED BY THIS FORMATION. THENCE THE ESCARPMENT TRENDS SOUTHWEST AND LEAVES THE QUAD, AT LAUREL HILL.

THE WEAKER SS AND SHALE OF THIS REGION HAS CAUSED THE SAPPING OF THE CLIFFS AND THE RECESSION FOR MILES AWAY FROM THE RIVER. BUT JUST ABOVE JCT OF COLUMBIA AND WENATCHEE RIVERS, METAMORPHICS REPLACE THE WEAKER SEDIMENTARIES AND THE COLUMBIA VALLEY NARROWS TO ITS USUAL CANYON-LIKE PROPORTIONS. THE COLUMBIA LAVA ESCARPMENT CAPS THE EASTERN VALLEY WALL AND THENCE UPSTREAM TO CHELAN. CHELAN MAP SHOWS WHAT MAY BE A BASALT CAP IN ACUTE ANGLE BETWEEN ENTIAT AND COLUMBIA RIVERS. SEE WILLIS. RIBBON CLIFF, SCENE OF A GREAT SLIDE ABOUT 90 YEARS AGO., A SLIDE WHICH DAMMED THE COLUMBIA FOR A DAY OR TWO, OWES ITS NAME TO THE IRREGULAR SILLS AND DIKES AND STRINGERS OF COLUMBIA LAVA, FEEDERS FOR THE FLOWS, WHICH HERE CUT THE OLDER, LIGHT-COLORED GRANITE.



COLUMBIA LAVA, AS SEEN FROM RR AND HIGHWAY AT BOTTOM OF COLUMBIA VALLEY, LIES NOT FAR FROM HORIZONTALITY AT THE SUMMIT BT THE EASTERN BLUFFS, THE WESTERN EDGE OF THE WATERVILLE PLATEAU. THO IT RESTS ON HIGHLY INCLINED AND DIVERSE ROCKS, IT SHOWS NO IRREGULARITIES IN ITS BASE. THESE OLDER FORMATIONS APPEAR TO HAVE BEEN ERODED DOWN TO A FAIRLY EVEN SURFACE, ON WHICH THE BASALT RESTS.

THIS IS NOT THE CASE IN THE SPOKANE AND PALOUSE COUNTRY. MUCH DATA SHOULD BE COLLECTED ON THIS QUESTION. IT HAS AN IMPORTANT BEARING ON THE CORRELATION OF PLAINS IN FLANKING MOUNTAINS.

AT MALAGA OR JUST BELOW, ARE LEDGES OF TILTED BASALT, (APPARENTLY) WITH DIP OF ABOUT 45° SW WARD AND STRIKE ALONG STREAM COURSE. BUT THIS PROBABLY ISNT COLUMBIA BASALT, THE ESCARPMENTS OF WHICH ARE BACK FROM THE RIVER HERE.

CHELAN AUG 26 1922

KNAPP COULEE IS A NARROW CANYON WITH "HOLES" IN ITS FLOOR FROM ITS HEAD DOWN TO 1440 AT ITS GRADIENT MUST HAVE DETERMINED A HIGH VELOCITY STREAM, SIMILAR TO CHELAN RIVER TODAY. AT 1440 THIS NARROW CHANNEL FLOOR ENDS IN A GENTLY SLOPING FLAT, THO STILL WALLED IN BY PRECIPITOUS SLODES. THE FLAT IS CLEARLY A FILL IN THE ROCK-WALLED CANYON. BUT IN A SHORT DISTANCE FARTHER THE FLAT ITSELF DIPS DOWN THE VALLEY WITH AS HIGH A GRADIENT AS THE SCOURED CHANNEL ABOVE. THIS CONTINUES TO ABOUT 1000 A.T., BELOW WHICH THE VALLEY ENDS, HANGING ON THE WALLS OF THE MASTER VALLEY. A FURTHER DESCENT OF ABOUT 300 FEET BY A VERY TORTUOUS ROAD DOWN THE FACE OF THE COLUMBIA VALLEY CLIFF BRINGS ONE TO THE RR LEVEL.

INTERPRETATION MADE AT THE TIME OF THE EXAMINATION WAS THAT THE LAKE SPILLED THRU THE COULEE IN A FASHION SIMILAR TO ITS PRESENT SPILL DOWN CHELAN RIVER, BUT THAT AT 1440 THE DISCHARGE ENTERED STANDING WATER WHICH BACKED IN FROM COLUMBIA VALLEY. DEPOSITION IN THE PRE-CHELAN HILLSIDE BORGE WHICH THE COULEE ENTERS TOOK PLACE AT AND BELOW THIS STANDING WATER LEVEL AND PRODUCED THE STEEPLY SLOPING FILL. THIS STANDING WATER COULD ONLY HAVE BEEN THE COLUMBIA SUBMERGENCE. IT MUST HAVE OCCURRED WHILE THE OKANOGAN LOBE STILL BLOCKED THE MOUTH OF CHELAN VALLEY PROPER AND FORCED DISCHARGE THRU KNAPP COULEE. THIS DATES THE SUBMERGENCE AS OCCURRING DURING THE EARLY WAINING OF THE WISCONSIN GLACIATION. IT IS PREVIOUS TO THE BLDG OF THE GREAT TERRACE AND ITS CORRELATIVE TERRACES FARTHER DOWN THE VALLEY. THIS, ACCORDING TO PARDEE, OCCURRED AFTER THE WISCONSIN ICE HAD RETREATED TO OMAK, AT WHICH TIME THE SUBMERGENCE HAD LOWERED, THE OKANOGAN LOBE HAD DISAPPEARED, AND THE CHELAN DISCHARGE HAD FOUND ITS PRESENT ROUTE. SINCE THE MOSES LAKE TERRACES ARE THE RESULT OF GRAND COULEE OPERATION, AT TIME OF DAMMING OF THE COLUMBIA BY THE OKANOGAN LOBE, THEY ARE OLDER THAN THE GREAT TERRACE AND CORRELATIVES (THE COLUMBIA VALLEY TRAIN). FURTHER CONFIRMATION IS FOUND IN THE PRESENCE OF THE BERG-CARRIED ERRATICS ON THE MOSES LAKE TERRACES BELOW 1250 OR SO, AND THEIR ABSENCE ON THE COLUMBIA VALLEY TRAIN.

THE WISCONSIN WATERBODY BACK OF GRAND COULEE SHOULD BE MAPPED AND NAMED. ITS EXTENT CAN BE DETERMINED BY USING THE 1500 (APPROX) CONTOUR FROM GRAND COULEE EASTWARD ON THE SOUTH SIDE OF COLUMBIA VALLEY, AND THE SAME CONTOUR, OR THE WISCONSIN MORaine WHERE LOWER THAN 1500, ON THE NORTH SIDE OF THE COLUMBIA EASTWARD. IF THE NESPELEM SILT CAN BE SHOWN TO BE SEASONALLY BANDED, IT MUST FOLLOW THAT IT IS A RECORD OF THIS LAKE. IF THE SPOKANE V.T. WAS BUILT WITH A DELTA FRONT IN THIS LAKE, IT SHOULD BE LOCATED. THE OUTLET, THE SEDIMENTS AND A GOOD DELTA SHOULD ESTABLISH IT WELL ENOUGH TO NAME IT. IF A GOOD CASE CAN BE MADE OUT AND THE LAKE SHOWS UP AS



A MAJOR FEATURE, CONSIDER NAMING IT FOR SALISBURY.

SEATTLE . AUG. 27 1922

BEACON HILL SECTIONS IN NEW AND OLD REGRADES RE-EXAMINED. UNDOUBTED SEASONAL BANDING IN THE BASAL CLAYS, BUT BOTH WINTER AND SUMMER DEPOSITS IMPALPABLY FINE, EVEN TO THE TEETH. DIFFERENCE IN FINENESS INDICATED BY WATER-CONTAINING ABILITY, THE THINNER WINTER LAYERS DARKER AND MORE MOIST. ROUGHLY 20 YEARS IN ACCUMULATION OF 6 FEET OF THE CLAY.

OTHER PHASES OF THE ADMIRALTY SERIES, NEWLY EXPOSED, VERIFY FORMER INTERPRETATIONS IN EVERY DETAIL, EVEN TO CONTAINING A THREE FOOT LAYER OF ADMIRALTY TILL IN THE SAND AND GRAVEL.

ESQUATZEL COULEE AUG 28 1922

GOOD GRAVEL TERRACES AT AND A FEW MILES BELOW CONNELL. TERRACES LOOK FAIRLY FRESH AND DEFINITE. SCOUR OF CHANNEL AND CHARACTER OF COULEE WALLS AND TALUS SLOOES LOOKS AS OLD AS SPOKANE EPOCH.

GLACIAL DRAINAGE (IF IT IS SUCH?) CAME THRU WASHTUCNA COULEE FROM KAHLOTUS, AND THIS FROM PALOUSE RIVER. ESQUATZEL COULEE ABOVE CONNELL HAS GRADED, GRASSED AND SAGE-COVERED SLOPES ALMOST WHOLLY AND IS AS CLEARLY NON-GLACIAL AND PRE-GLACIAL AS LIND COULEE. FIRST CYCLE WITHOUT QUESTION. MATURE TOPOGRAPHY VERY OBVIOUS AT SUMMIT OF DIVIDE BETWEEN ESQUATZEL AND LIND COULEE THO THE WATER WAYS WERE MORE WIDELY SPACED AND THE DIVIDES BROADER AND MORE GENTLY SLOPED THAN IN THE PALOUSE COUNTRY.

RITZVILLE TO SPRAGUE AUG 28 1922

ALONG NRRR EAST OF RITZVILLE, THE FIRST CYCLE HILLS ARE FAR APART AND A WIDE TRACT BETWEEN IS ESSENTIALLY SCABLAND. NUMEROUS LOW ROCK KNOBS AND ROCKY SURFACES. MUCH SUBDUED IN EXPRESSION, LOOKS MUCH OLDER THAN SPOKANE. CAN HARDLY BE SPOKANE SPILLWAY FOR ANOTHER REASON, THE DESCENT IS EASTWARD OR NORTHWESTWARD TOWARD THE SPOKANE GROUP OF SPILLWAYS, AND IF THE TRACT HAD BEEN OVERRUN BY GLACIAL WATERS, THEY WOULD HAVE BEEN CONCENTRATED IN LIND COULEE, DRAINING WESTWARD. LIND SHOWS NO SIGNS WHATEVER OF OCCUPANCY OF GLACIAL WATERS.

FARTHER EAST, THE HILL-LESS TRACT IS STILL WIDER, 5-8 MILES WIDE, AND BEARS A SOIL DEEP ENOUGH AND SUFFICIENTLY FREE FROM ROCKS TO BE CULTIVATED FOR WHEAT. GENTLE SLOPES ON SURROUNDING HILLS CLEAR DOWN TO THE FLAT. ARE WE NOT HERE DEALING WITH A FLAT LIKE MICHIGAN PRAIRIE ON THE CONNELL MAP? DO NOT MANY OF THESE BROAD GAPS AMONG THE HILL TRACTS OWE THEIR EXISTENCE TO PRE-WISCONSIN CHANGES? IF SO, DARE WE ASCRIBE TO THE SCRUBBING OF GLACIAL WATERS THE WIDE FLAT TRACTS OF NEARLY BARE ROCK AMONG THE FIRST CYCLE HILLS ALONG THE CM AND STP NORTH OF MARENGO?

APPROACHING SPRAGUE, HOWEVER, THE FLAT REGION ABRUPTLY TAKES ON THE CHARACTER OF GLACIAL DRAINAGE SCOUR, CHANNELS APPEAR, HILLOCKS BECOME HILLS, CLIFFS AND TALUS ARE CONSPICUOUS. COLVILLE (SPRAGUE) LAKE IS A LARGE WATER BODY LYING IN THIS TRACT, ELONGATED WITH THE ROCKWALLED CHANNELS. THIS IS THE LAMONT-SPRAGUE DRAINAGE TRACT, WHICH DISCHARGED SW TO COW CREEK AND NOT WEST TO LIND OR ESQUATZEL COULEES.

HERE, THEN IS THE EVIDENCE, CLEARLY PRESENTED, THAT THE FLAT TRACTS AMONG THE HILLS WERE ALREADY THERE ((LATER— QUITE WRONG))) AND THAT THE LOWER ONES ONLY WERE USED AND WERE MODIFIED BUT SLIGHTLY IN THIS REGION BY GLACIAL DRAINAGE. THE FIRST CYCLE HILLS WERE NOT HERE WHEN THE SPOKANE GLACIATION OCCURRED, AND THEIR ABSENCE CANNOT BE ASCRIBED TO SCOUR OF THE SPOKANE



WATERS. TO SEE THE EROSION ACTION OF GLACIAL WATERS IN FULL MEASURE, AN AREA WITH HIGHER GRADIENTS MUST BE EXAMINED. FOR EXAMPLE— GRAND OR MOSES COULEES. ROCK LAKE APPEARS TO BE THE BEST EXAMPLE OF THIS WORK IN THE SPOKANE DISTRICT. GLACIAL WATERS CUT DOWN JUST AS DO ORDINARY STREAMS, THEY DIDN'T SPREAD WIDELY AND ERODE LATERALLY MORE THAN THE AMOUNT SHOWN IN THE STEEPENED LOWER SLOPES OF THE HILL TRACTS WHERE BORDERING THE GLACIAL DRAINAGE WAYS.

CHENEY TO SPANGLE MON AUG 28 1922

TRAVERSE MADE TO LEARN IF ANY WISCONSIN WATER EVER WENT OUT/THRU THE SPOKANE SPILLWAY GROUP. ALTITUDE ACROSS THE SCOURED TRACT NOWHERE 50 FEET BELOW THAT OF CHENEY AND NOWHERE IS THERE A SIGN OF ESCAPING GLACIAL WATERS SINCE THE SPOKANE EPOCH. IT FOLLOWS THEREFORE, FROM WHAT IS KNOWN OF THE CHARACTER OF THE SPILLWAYS FARTHER WEST THAT THE ONLY WISCONSIN DISCHARGE ROUTES WERE GRAND COULEE, MOSES COULEE AND THE COLUMBIA BELOW CHEBAN. WHEN THE OKANOGAN LOBE ADVANCED INTO THE HEAD OF GRAND COULEE AND GLACIATED THE GRANITE KNOBS AND HILLS THERE, WATERS FROM THE PONDED COLUMBIA TO THE EAST MUST HAVE KEPT AN ESCAPEWAY OPEN UNDER, THRU OR OVER THE ICE. PERHAPS THIS IS WHY THE EASTERN GRANITE OUTCROPS IN THE COULEE ARE NOT GLACIATED. THE STREAM WAS CROWDED TO THAT SIDE BY THE DEPLOYING OKANOGAN LOBE FROM THE WEST BUT MAY BE ASSUMED TO HAVE KEPT AN OPEN CHANNEL HERE.

THE MOST PRONOUNCED OF THE CHANNELS IN THE VICINITY OF CHENEY IS THAT IN WHICH FARRINGTON (FISH) LAKE LIES. THIS CHANNEL PORTION IS WELL SEEN FROM ANY OF THE THREE RAILROADS ENTERING SPOKANE FROM THE SW. BUT THE MARKED CHANNEL CHARACTER CEASES NEARER CHENEY AND THE BOTTOM OF THE SPILLWAY SOUTHWARD IS ABOUT 50 FEET HIGHER. THIS IS SIMPLY ANOTHER ILLUSTRATION OF THE EXCAVATION OF "HOBES" IN THE BOTTOM OF A BIG STREAM OVER JOINTED BASALT.

SOME GLACIATED QTZITE BLDRS AND MANY GRANITES ~~74~~ AS MUCH AS 8 FT IN DIAMETER LIE ON THE BASALT PLAIN AT 2450 TO 2500 BETWEEN THIS DRAINAGE TRACT AND THE EMPIRE HIWAY TO THE EAST. SURELY THIS SURFACE OF THE BASALT HAS BEEN GLACIATED. THESE BLDRS ARE TOO LARGE AND ANGULAR TO HAVE ROLLED IN A STREAM, AND THERE IS NO EVIDENCE THAT THIS PART OF THE BASALT WAS FLOODED BY THE SPOKANE GLACIAL WATERS. BUT CAN WE BE SURE THAT THEY WERE DEPOSITED BY THE SPOKANE ICE AND NOT THE CHENEY ICE. THE PROBABILITIES ARE ALL IN FAVOR OF THAT INTERPRETATION, BUT THE CASE ISN'T CLINCHED YET.

THERE IS ONE HILL OF THE PALOUSE TYPE RISING ABOVE THE BASALT PLAIN (BROWNS BUTTE) TO THE NORTH WHICH MUST HAVE BEEN OVERRIDDEN WHEN THE ICE LEFT THESE QTZITE AND GRANITE BLDRS HERE. SINCE IT IS A CLEAR CASE OF THIS, IT SHOULD BE EXAMINED IN DETAIL TO SEE

- (1) IF A CHARACTERISTIC SHAPE HAS BEEN GIVEN IT,
- (2) IF TILL LIES AT OR NEAR THE SURFACE,
- (3) IF LOESS COVERS THE TILL,
- (4) IF ERRATIC BLDRS OCCUR ON ITS SURFACE.

THESE FEATURES CAN THEN BE USED AS CRITERIA ON OTHER FIRST CYCLE HILLS WHICH LIE NEAR THE SOUTHERN LIMIT OF THE SPOKANE INVASION AND WHICH MAY BE SUSPECTED OF HAVING BEEN OVERRIDDEN.

GRAVEL WHICH MUST BE OUTWASH OF THIS GLACIATION IS EXPOSED IN TWO OR THREE PITS ALONG THE HIGHWAY. IT AND ITS TOPOGRAPHY AND ALTITUDE SHOULD BE STUDIED. AND COMPARED WITH THE PANTOPS DEPOSIT.



THE TRACT OF LOW GRANITE HILLS NORTH OF DAVENPORT RISES PERHAPS 100 FT ABOVE THE GENERAL LEVEL OF THE HILL TOPS OF THE BASALT. HOWEVER,

CRESTON TO PEACH TO DAVENPORT AUG 29 1922

LARGE GRANITE BLDRS, MAX DIA, 8 FT. ALONG SUNSET HIWAY EAST OF CRESTON. ALSO LARGE BLDR OF IMPURE SILICIFIED LIMESTONE. SMALLER ONES OF A GREAT VARIETY OF IGNEOUS AND METAMORPHIC ROCKS SCATTERED ALL THE WAY TO PEACH. SOIL IS THIN, MUCH SCABROCK, BASALT CLOSE TO SURFACE, NO TILL IN ANY CUTS. THE COUNTRY NORTH OF CRESTON IS A PLAIN OF BASALT, NO FIRST CYCLE HILLS. HAS A SCRUBBED APPEARANCE BUT NOT ETCHED IN CHANNELWAYS AND ISLANDS.

THE NORTHWARD PORTION OF THIS PLAIN IS DEEPLY GASHED BY HAWK CREEK, INDIAN CREEK AND THEIR TRIBUTARIES. THE SCRUBBED-OFF PLAIN OF BASALT WITH MUCH SCABROCK AND MANY SCATTERED GLACIAL ERRATICS ALSO ABOUT THE HEAD OF INDIAN CREEK (ENTERS HAWK FROM THE EAST). ANOTHER SIMILAR TRACT, FLANKED ON SOUTH, EAST AND WEST, BY FIRST CYCLE HILLS AND BEARING SEVERAL FEET OF COARSE GRAVELLY DEBRIS AT LORENE, 6-7 MILES NORTH OF DAVENPORT. MUCH FOREIGN MATERIAL AT LORENE ALSO. THESE FLAT TRACTS ON THE BASALT ARE A PUZZLE. IT IS BELIEVED, HOWEVER, THAT THEY ANTEDATE THE SPOKANE GLACIATION AND ARE A FAVORING CONDITION, RATHER THAN A RESULT, OF THE GLACIAL OR FLUVIO-GLACIAL ACTION WHICH SPREAD THE ERRATIC MATERIAL OVER THEM NORTH OF CRESTON AND ABOUT LORENE. NO FACETTED OR STRIATED STONES WERE FOUND ANYWHERE ON THEM.

THE LORENE TRACT HAS A GRAVEL PIT BUT THE SIDES HAVE BECOME COVERED WITH LOOSE MATERIAL AND NO SECTIONS NOW ARE VISIBLE. IN THE BOTTOM OF THIS PIT WERE FOUND FRAGMENTS TWO FEET IN DIA. OF A BRINK RED-TO-YELLOW-TO-WHITE CLAYEY MATERIAL CONTAINING ANGULAR PIECES OF GRANITE AND BASALT, THE BASALT PERFECTLY FRESH THO THE CLAY IS VERY MUCH DECAYED. THE CLAY LOOKS LIKE THE RESIDUUM OF GRANITE, CONTAINS MICA AND APPARENTLY MUCH KAOLIN. WHEN FIRST FOUND, IT WAS THOT TO BE AN EXTREMELY WEATHERED TILL BUT THE FRESH BASALT IN IT SEEMS TO RULE OUT THIS HYPOTHESIS. AND THE PREFERRED HYPOTHESIS IS RENDERED MORE PROBABLE SINCE LOW GRANITE HILLS LIE IMMEDIATELY TO THE SOUTH AND THE DRAINAGE OF THEIR NORTHERN SLOPES GOES BY WAY OF LORENE.

THE FOREIGN MATERIAL, ABUNDANT ENOUGH ON THE FLAT TRACTS NOTED, IS TOTALLY ABSENT FROM THE FIRST CYCLE HILLS WEST OF LORENE (4 MILES TRAVERSE OF THEM) AND BETWEEN LORENE AND DAVENPORT. THERE ARE NUMEROUS ROAD CUTS 6 TO 10 FEET DEEP, ALONG THE ROUTE AND NOTHING IS EXPOSED SAVE THE YELLOW-BROWN LOESS AND A FEW SHOULDERS OF DECAYED GRANITE IN SITU BENEATH THE LOESS. EITHER THE FOREIGN MATERIAL IS ABSENT OR IT IS COVERED BY LOESS. IF COVERED, THERE SHOULD BE HERE AND THERE SOME STRAY FRAGMENTS SHOWING. FURTHERMORE, EVIDENCE COLLECTED DURING THIS FIELD SEASON STRONGLY INDICATES THAT THE LOESS IS OLDER THAN THE SPOKANE AND WISCONSIN GLACIATIONS AND HAS SUFFERED EROSION MORE RAPIDLY THAN IT HAS ACCUMULATED IN POST-SPOKANE TIME.

THE PREFERRED INTERPRETATION OF THE GLACIAL ERRATICS SCATTERED ON THE BASALT PLAIN IS THAT FLOOD WATERS OF THE SPOKANE EPOCH, DISCHARGING BY WAY OF HELLGATE AND WILBUR, BACKED UP OVER THE PLAIN BUT DID NOT FLOOD THE VALLEYS AMONG THE HIGHER FIRST CYCLE HILLS. IT MAY BE POSSIBLE, HOWEVER, THAT THE SPOKANE ICE PUSHED OVER ON THE PLAIN TRACTS, PERHAPS AS FAR AS CRESTON. THE TALUS ACCUMULATIONS IN THE HEADS OF THE RAVINES 3-4 MILES NORTH OF CRESTON APPEAR OLDER THAN IN THE SPOKANE SPILLWAYS OF NORTH CENTRAL WASHINGTON. THIS, HOWEVER, MAY BE DUE TO ACCUMULATION ON ROCK SLOPES, INSTEAD OF AT THE FOOT OF VERTICAL CLIFFS. NO CLIFFS OF THE GLACIAL SPILLWAY SORT ARE TO BE EXPECTED HERE.

SHOW NO SPOKANE DISCHARGE AND FURTHER SHOW NO WISCONSIN INTERGLACIAL WARRING OF SLIGHT AMOUNT LOWERED DRUMHELLER TRACT AND RAISED OTHERS TRACT SUFFICIENTLY TO INVERT THE LATTER DISCHARGE TO THE YOUNGER SPILLWAY.



THE TRACT OF LOW GRANITE HILLS NORTH OF DAVENPORT RISES PERHAPS 100 FT ABOVE THE GENERAL LEVEL OF THE HILL TOPS OF THE BASALT FIRST CYCLE TOPOGRAPHY. THE MATURE TOPOGRAPHY, HOWEVER, GOES COMPLETELY ACROSS, NOT DIFFERENT IN ANY ESSENTIAL FROM THAT ON THE BASALT. AND THE LOESSIAL SOIL, IDENTICAL IN APPEARANCE (?) IS ON GRANITE AND BASALT ALIKE. THE TRACT UNDERLAIN BY GRANITE IS SEVERAL MILES WIDE AND ISLAND-LIKE IN SITUATION IN THE BASALT.

PARDEE'S NESPELEM SILT LIES IN TERRACE FRAGMENTS AND HILLS IN HAWK CREEK AND INDIAN CREEK VALLEYS, FOR 6 OR 7 MILES BACK FROM THE COLUMBIA. THERE IS VERY LITTLE TRUE LAKE CLAY IN IT. IT IS PREVAILINGLY OF SAND AND CLAYEY SAND, WITH SOME GRAVEL. THERE SEEMS TO BE NO GRADATION FROM TOP TO BOTTOM, THE DIFFERENT MATERIALS OCCUR IRREGULARLY AT ALL HORIZONS. IT MUST BE SEVERAL HUNDRED FEET ABOVE THE RIVER. ON NORTH SIDE OF THE COLUMBIA AT PEACH, IT CONSTITUTES A FINE TERRACE SHARPLY TERMINATING AGAINST GRANITE CLIFFS AND WITH SHARP EDGE OF FLAT AND SCARP TOWARD THE RIVER.

NOTHING WHICH COULD BE CALLED SEASONAL BANDING WAS FOUND IN THE CLAY. IN SOME SECTION (THERE ARE MANY GOOD ONES ALONG THE OLD RR GRADE) THERE IS AN ALTERNATION OF SAND AND CLAY LAYERS EACH NOT TO EXCEED 3 FEET IN THICKNESS, WHICH SUGGESTS THAT THE SAND IS THE RECORD OF SUMMER MELTING AND THE CLAY OF WINTER CLEARING OF SHALLOW PONDED WATERS. IF THE NESPELEM SILT IS A RECORD OF THE WISCONSIN FLOODING, IT SEEMS TO RECORD A GRADUAL RISING OF THE WATER, AND A RATE OF SEDIMENTATION WHICH KEPT PACE WITH IT. NOT A LAKE, SO MUCH AS A BROAD RIVER FLAT, APPEARS ON THIS INTERPRETATION TO HAVE LAIN BACK OF THE OKANOGAN ICEDAM !!! THE TERRACES IN THE MAIN COLUMBIA VALLEY ALSO APPEAR TO BE FRAGMENTS OF A COMPLETE FILLING, ONCE OCCUPYING THE COLUMBIA UP TO THEIR LEVEL.

THE NESPELEM SILT CLEARLY IS OF GLACIAL ORIGIN. THE CLAY IS A LIGHT COLORED ROCK FLOUR, IMPALPABLY FINE, AND WHOLLY FREE FROM BITS OF MICA WHICH SHOULD BE PRESENT IF WERE A CLAY DERIVED FROM EROSION OF RESIDUAL SOILS. AND THERE ARE COBBLES AND EVEN BLDRS IN THE DEPOSIT, BRUISED AND STRIATED AND OBVIOUSLY NEVER ROLLED AFTER RELEASE FROM GLACIAL ICE. THEY MUST HAVE FLOATED IN ICEBERGS OR FLOES TO THEIR PRESENT LOCATION.

#### SPOKANE FALLS AUG 30 1922

THE CASCADES OR RAPIDS, COMMONLY KNOWN AS SPOKANE FALLS, CONSTITUTE A DALLES TYPE OF RIVER CHANNEL, HAVING A GRADIENT STEEPER THAN THE AVERAGE, BUT A VOLUME SMALLER THAN THE AVERAGE. THE CHANNELS NOW IN USE DIVIDE AND UNITE AND BEND ABOUT THE BASALT ISLANDS AMONG THEM. THEY ARE NOT ALL CUT TO THE SAME DEPTH. THERE ARE FEW FALLS AND MOST OF THE DESCENT IS BY STEEP CHUTES.

ISLAND HILLS OF BASALT, NOW ABOVE THE REACH OF FLOOD WATERS, OCCUR IN THE BUILT-UP BLOCKS MARGINING THE RIVER ON THE NORTH. <sup>(+ south)</sup> THEY BELONG TO THE SERIES AND RECORD THE EARLIEST STAGES WHEN THE RIVER HAD NOT SELECTED ITS FUTURE ROUTE AND WAS EXPERIMENTING WITH A NUMBER OF CHANNELS AT HIGHER LEVELS.

#### DRUMHELLER CHANNELS

SHOW NO SPOKANE DISCHARGE, AND POTHoles SHOW NO WISCONSIN. INTERPRETATION IS THAT INTERGLACIAL WARPING OF SLIGHT AMOUNT LOWERED DRUMHELLER TRACT AND RAISED POTHoles TRACT SUFFICIENTLY TO DIVERT THE LATER DISCHARGE TO THE YOUNGER SPILLWAY.