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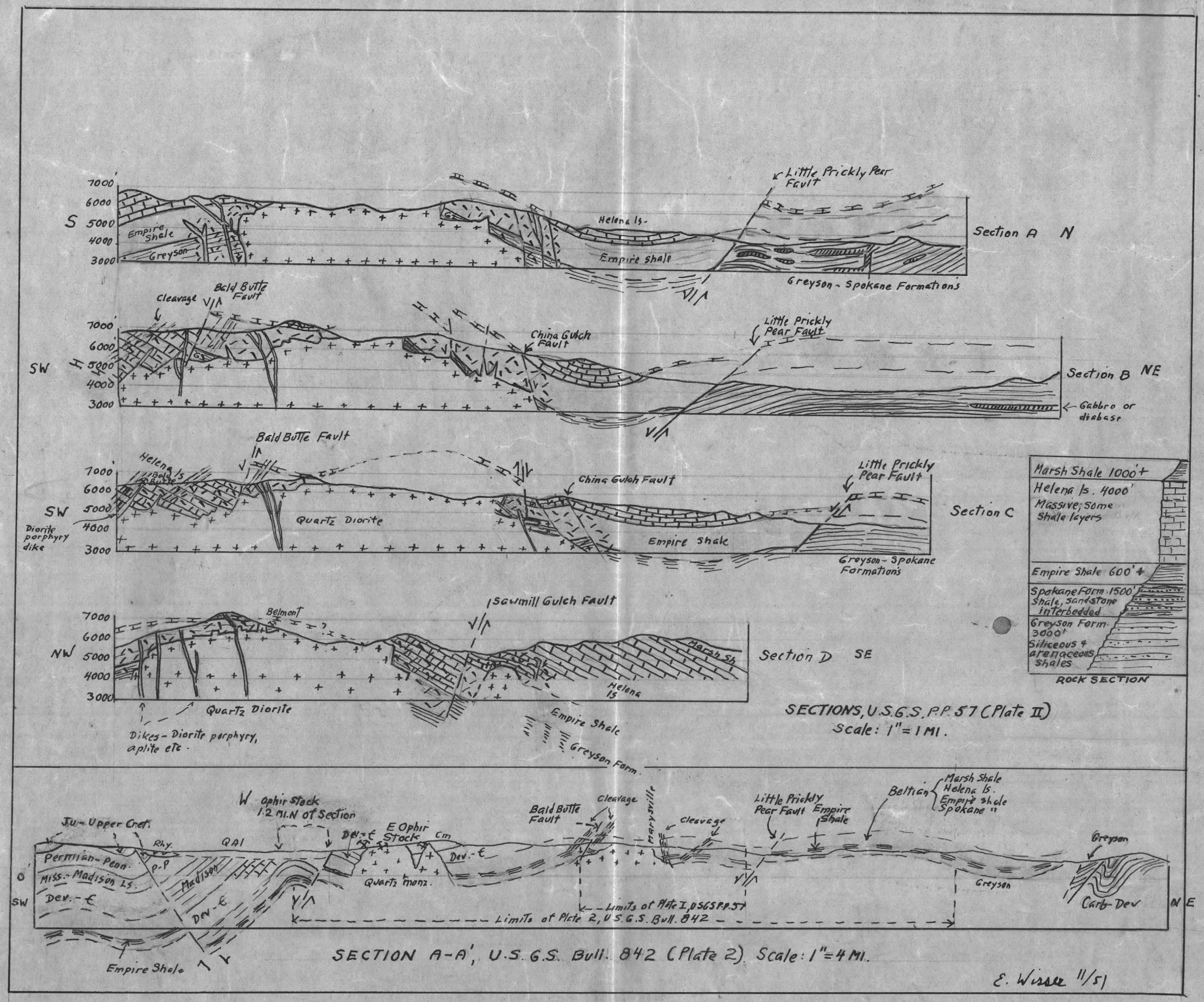

7000'
6000
5000
4000
3000
S
Empire Shale
Greyson
Helena ls.
Empire shale
Little Prickly Pear Fault
Greyson - Spokane Formations
Section A
N
Cleavage
Bald Butte Fault
China Gulch Fault
Little Prickly Pear Fault
SW
Section B
NE
Gabbro or diabase
Bald Butte Fault
Helena ls
Bald Butte
China Gulch Fault
Little Prickly Pear Fault
Quartz Diorite
Empire Shale
Greyson - Spokane Formations
Diorite porphyry dike
Section C
Marsh Shale 1000'+
Helena ls. 4000'
Massive; some Shale layers
Empire Shale 600'+
Spokane Form. 1500'
Shale, sandstone interbedded
Greyson Form. 3000'
Siliceous & arenaceous shales
ROCK SECTION
Sawmill Gulch Fault
Belmont
Marsh Sh
Helena ls
Quartz Diorite
Empire Shale
Greyson Form.
Dikes - Diorite porphyry, aplite etc.
NW
Section D
SE
SECTIONS, U.S.G.S. P.P. 57 (Plate II)
Scale: 1" = 1 MI.
W Ophir Stock 1.2 MI. N of Section
Ju - Upper Cret.
Rhy.
QAl
Permian - Penn.
Miss. - Madison Ls.
Dev. - Є
Madison
Dev. - Є
Dev. - Є
E Ophir Stock
Cm
Dev. - Є
Quartz monz.
Bald Butte Fault
Cleavage
Marysville
Cleavage
Little Prickly Pear Fault
Empire Shale
Beltian
Marsh Shale
Helena ls.
Empire shale
Spokane "
Greyson
Greyson
Carb - Dev
SW
NE
Limits of Plate I, USGS P.P. 57
Limits of Plate 2, U.S.G.S. Bull. 842
Empire Shale
SECTION A-A', U.S.G.S. Bull. 842 (Plate 2) Scale: 1" = 4 MI.
E. Wisser 11/51

MINING 111A MARYSVILLE, MONTANA

References:

Geology of the Marysville Mining Distr.,Montana.Joseph Barrell,USGS PP 57,1907.

Ore Deposits of the Helena Mining Region,Mont.Adolph Knopf, USGS Bull. 527,1913,61-76.

Metalliferous Deposits of the Greater Helena Mining Region,Mont. J.T.Pardee & F.C.Schrader. USGS Bull.842,1933. 63-76

Regional,Chronological Setting.-

Marysville lies only 8 miles N of N edge of Boulder batholith. Rocks Beltian within Marysville quad.and most of large map. In S part big map,rale up to Ku. (In Ku Boulder batholith region along W edge of 5000' trough).

Rocks folded into major NW anticlines and synclines,broad,gentle.Tendency for both anticlines and synclines to plunge to SE, rise to NW.Thus SE-plunging syncline shown,SW part of big map. Pardee & Schrader,1933,state tha a NW anticline ~~in extreme~~ W of the SW corner of big map shown at SW end Sec.A-A', Bull.842 rises to NW until it brings Beltian rocks to surface. Sharp anticline shown,extreme SW corner big map and on Sec.A-A8,then the gentle SE-plunging syncline shown on map and sectior

This gentle syncline is a feature superimposed on a major uplift,exposing Belt rocks over 25 mi.wide,extending from near Helrna (just SE of SE corner map)clear to Canadian border, 200 mi.and beyond. This major uplift shown on Section A-A8.SW border,partly flexing,partly synthetic fault.NE border is actually the SE extension of the Lewis thrust zone,but in Marysville region seems to be a series of steep reverse faults.

Shallow syncline shown on map actually a part of this uplift,shown in Section A-A'. Stocks,including the Gould stock,invaded this uplift;the Boulder batholith however invaded a broad basin in the pre-Cambrian basement,except that its N end intruded the SW flank of the uplift.

Chronology.

No mid-K orogeny in W Montana.Deformation in Marysville area probably Laramide in restricted sense-about at end of K. Age of Boulder batholith probably late K or more likely,early Eocene.(Invades Colo K,is pre-Oligo.)

This region shows but one orogeny,barring late Tertiary etc.,for no unconformities or cgl evidence of orogeny between Belt (15,000') and Paleo-Meso,to Ku,13,000',although it was low land in Lower Ju and along shore of shallow sea to E,upper Ju.

According to Pardee & Schrader:

Geologic History.

Ku or early Eocene: Folding, elevation.
Early Eocene: Thrusting on NE.
" " : Extrusion of flows S of Helena, cover of BB.
" " : Intrusion of BB in a broad basin, elevation of cover over center but discordant, stoping contacts on sides.
Au-Ag-Pb-Zn-Cu metallin →
Mid-Eo-early Oligo: Stability, reduction to low relief.
Early or Mid-Oligo: Intrusion of Marysville, Gould etc. outlying stocks.
Au-Ag →
Middle Oligo: Extrusion in NE.
" " : Gentle warping and/or fltg., made depressions which became present intermontane valleys. Tuffs.
Erosion interval.
Au, Ag →
Mio or Plio: Uplift of present mts., continued depression of intermontane basins, general regional uplift. Rhy, dacite, basalt.
Plio-Pleisto: Dissection of mts.

References on BB:

Paul Billinsgley: The Boulder Batholith of Montana. TAIME 51, 1916, 31-54

--- -------- & J.A.Grimes: Ore deposits of the Boulder batholith. TAIME 58, 1917, 284-368.

F.F.Grout & R.Balk: Internal Steuctures of the BB. Bull. GSA 45, 1934, ~~112-117.~~ 877-896

Roof of BB probably not thick: reached nearly to then surface. Plateau type of intrusion, accompanied by but little crustal compression. (Intruded in wide equant basin),

Grout & Balk: BB mass rose steeply from depths, true batholith "with wid direct connection with great depths" p.889. Related ore deposits produced to 1933 5 million tons Cu, 1 million tons Zn, 100,000 T Pb, 16,000 T Ag, 470 Au. Of these nearly all Cu and Zn, most of Ag came from Butte.

BB probably did not make room for itself by shattering roof, stoping. Mor likely by thrusting hard, competent Belt etc. rocks aside. Deep-seated plutons crowd their walls so intensely that they yield by recystallization BB found hard, brittle walls that would br ak rather than flow at these high levels with slight confining P. "The idea is supported by the flts. in considerable numbers around the border". p.891.

Contrast of Shallow and Deep Batholiths: Canadian shield plutons deeply eroded, S.N. intruded high into the folded crust. These contrasted with BB, intrided into rocks only gently folded, but "elevated as a plateau region, the present mountains being carved by erosion rather than folded under com pression. Although the country rocks have been folded, there is little sign that the regional deformation by compression was in progress during the invasion of the batholith." p.894.

Barrell. Marysville.

Rock Formations:

Seds. all Beltian, remarkably free from regional metamorphism. Great age, deep burial; alteration no greater than with Paleo seds. moderately disturbed.

5 major formations gradational, one intomthe next,

For sed.formations see Vert.Sections.

Igheous Rocks.- Oldest,except gabbros sills in Spokane & Greyson,are microdiorite dikes,sheets,Bald Butte. Flds.porph.dikes,Mt.Belmont area and Drumlummon Mine. Disrinct from QD baholith but whether older or younger not known.

Qtz Diorite.

Granitic texture. Not marked chilled edges but in outlying tongues, wedges,more porph.,more basic. Sheets of aplite intruded intruded in Empire shale hornstone along bed planes,NE side batho. Center of batho free of aplite.

Structure:

Pre-Batholith Structure

Structure connected with the intrusion superimposed on a much earlie structure,the folding and elevation which took place in late Cret.or early Eocene,already described in a general way.Intrusion may have been after considerable erosion of the uplift,possibly early Oligocene.

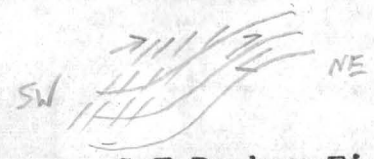
Paleo,Meso formations stripped during the erosion.Ku map shows up to 5000' Ku deposited here.

N ofthe 59° E-W flt.on the Structural Map,exposed rock is Greyson. Uplift partly by this fault,but also by arching. This was formerly called the Prickly Pear dome but is now known to be a NW series of kinor folds on an arch.Structure more complicated, series of basins with curving ridges betweenas shown on small map.This major uplift in reality extends SW past Marysville,at least to the gentle,SE-plunging syncline in which Ophir stocks intruded,and possibly to the NW flt.west of these stocks,as suggested in Sec.A-A'.

Earlier Structure? Cleavage.

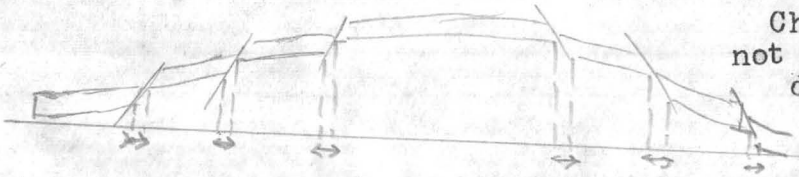
Away from batholith, joint,cleavage structure ,slaty cleavage in the Empire and Marsh shales has a regional attitude, NW strike,35-45°SW dip. Shaly beds in Helena ls.also. No true cleavage in N part of district, expept sympathetic to flts. Cleavage everywhere subordinate tobbedding. This cleavage probably antedates batholith.

Flow Cleavage:Van Hise,Leith. Cleavage in plane of max.extension,perp. to direction max.compression.Flow cleavage.If horiz.compression to same extent at different depths,crust suffers simple shortening,vertical elements simple extension,cleavage planes vertical. But if an upper part moves laterally with respect to a lower,sliding between layers,parallel cleavage results.Hence inclinedined cleavage signifies (1) horiz.compression(2)sliding of upper portions with respect to lower,lower having moved relatively down dip of cleavage.For Marysville,means relative movement to NE of upper portions,as would occur on limbs of compressional dome:



Fracture Cleavage:G.F.Becker:Finite homogeneous strain,flow and rupture of rocks.Bull.GSA 4,1995,13-90.Also Experiments on schistosity and slaty cleavage.USGS Bull.241,1904. Cleavage on planesof maximum sliding ("shear") Homogeneous body under simple compression these planes at any moment inclined 45°to direction comp. Dominance of one direction of cleavage due to rotation with compression (shear).Cleavage is an evenly distributed faulting,may be same in attitude as faults,along which deformation is concentrated.

If cleavage is result of distributive fltg.,has been progressive uplift to NE,since cleavage dips SW.Agrees with major flts. Also agrees with Marysville on SW side of great "dome" or arch. But following Becker,formation of arch wouldbe byconcentrated and distributive faults around its margin with horizontal extension of the crust (opposite of compression), "the chief cause of the uplift being a vertical ~~uplift~~ upthrust combined with horizontal extension and not tangential compression..." p.94.



Checks field because beds do not dip away from center of dome or CL of arch,but if anything,toward it:uplift by step synthetic fltg.

Local check:On E side of batholith,cleavage dips 80E near contact (Sec.A-A') Indicates up thrust of batho resulting in normal fltg and some cleavage which should dip away from batholith(uplift by synthetic fltg).Agrees with other lines of evidence on domal thrust of batho.

Conclusion:Vertical upthrust with distributive fltg.agrees best with f field evidence. Cleavage not flow,recrystallization,but fissility.Agrees with major flt.planes and lack of anticline.Compares Prickly Pear dome with Bighorn,Uinta:"This would ally the Prickly Pear Dome with other characteristic cordilleran uplifts such as the Bighorn and Uinta mountains,whose broad, flat,anticlinal arches have apparently been lifted not by horizontal compression,but by a vertical upthrust along their axes,in places

attened by marginal fltg.of a normal nature." p.94.

~~Earlier Structures?~~ Normal Faults.

Little Prickly Pear Flt: Probable normal throw about 1500'mdown to S. No evidence as to age except far older than broad Tertiary valley and lavas that filledit (Miocene?). Author thinks this fault connected with uplift of Prickly Pear dome ;quite likely in part.But note flattening NE of stock & tendency to curve slightly,convex to NE,where it flattens. Utilized as antithetic flt. by stock uplift.

Bald Butte Fault: Thinks this was another of the distributive faults that made the Prickly Pear uplift. Dip agrees with steeper dip of L.P.P.fault on W,not affected by late antithetic fltg. Thinks dip-slip may be 3600',as suggested on Sec.B.

Shape of Stock.

Belmont area:flat contact ,parallel to bedding in Empire shale,but rectangular upward projections cross bedding. On plan,NE arm of Empire hornstone very shallow.

Drumlummon: Contact flat NW of mine,top of granite nearly follows beds dipping gently down to SE.But below 4th or Main tunnel level contact contact cuts across beds,locally contorted,going down in general vertically but with salients and reentrants,~~xxxxxxxx~~ bottom of a rentrant often paralleling the bedding.

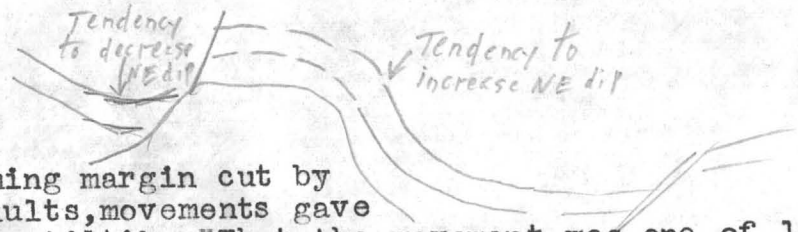
In general then stock has both flat and steep contacts,and as shown on the sections,it extends its area with depth,but so flatly that surrounding rocks represent former cover over a large batholith,only a relatively small part of which ~~xxxxxxxxxxxx~~ is exposed.

Former Top of Batholith

From several lines of evidence,about as shown on Sec.C near Marysville; extreme S end,cover sloped S away from batholith at 10-15°. This flatter part of cover ends going N along line 800' SW of Sec.D.

Doming of Batholithic Cover.

Batho.entered preexisting sed.s dipping moniclinally 20°NE. Modifications strikingly shown on structural map:contours sweep around batho on N and E esp.



Beside the doming margin cut by many normal faults,movements gave unequal lifting,tiltibg."That the movement was one of lifting rather than subsidence is shown especially by the two large faults north of Gloucester,the crust block between them having moved upward with respect to the adjacent walls. The tilting or doming and the faulting have therefore ao worked in the same direction and are presumably due to the same intrusive cause." p.88. Total doming about 3000'.

Not a laccolith:essence is penetration of magma along horiz.parting planes,lifting of cover by pure doming,not marginal fltg.,latter called bysmalith. Marysville batho belongdto neither type,in form: Upper surface shows steep or vertica; surfaces alternating with flat surfaces,whole has roughly pyramidal form,steplike surface from which project dik s,sills chimneys. Drumlummon mine exposes vert.wall for 1300',probably originally extended upward here another 1000'.

Block Faulting Surrounding Qtz-Diorite.

Absence of intrusions into fault planes;such planes do not form contacts of main igneous massive.To the contrary,batho cuts across several flt.blocks with no regard to presence of the flts.Shows flts.older than intrusion but probably associated in origin.

All normal,major and minor,latter have throw of only a few ft. General effect has been to raise the blocks on the side toward the batho,steepening dip of seds where it was originally away from batho.,flattening it where it was torard latter. These flts.do not cut the batho. Fltg.immediately preceded granite invasion,"being caused by upward pressure of the igneous mass,but that when batho reached its final limit it cut across the various blocks,making a contact which showslittle or no relation to them." p.104.

Must have been change of form in crustal blocks (flow) to still fit compactly after rotation,adjustments along abundant joint planes within meta zone. F.L.Ransome, Geology of Globe Cu Distr.,Ariz.USGS PP 12,1903, p.105: Number of dislocations,small size of flt.blocks shows beds at time or rupture under light load;facility with which blocks sfiftedby magma showslatter also intruded under light load.Most flts normal,IMP.Beds normallt flted occupy greater area than before dislocation,but horizontal tens on in crust improbable. "The only conceivable stresses that can offer any satusfactory explanation of the fltg....are those acting in directions more nearly vertical than horizontal,such as would result from differential elevations or subsidencesover the area. ".

Method of Intrusion of the Batholith.

Believes passive invasion by subsidence of roof blocks. ~~However it came in the magma certainly made use of preexisting faults~~. It is hard to account thus for the doming,which in my opinion is due to a centralized uplift of the congealed stock.It is always difficult to explain why great batholiths such as BB approach the cover so nearly without breaking thru it;but Daly's stoping theory,involving cracking of the cover and the breaking free and sinking of fragments from the roof(the magma wells up passively,filling the spaces left by the foundered frags) fails to explain what stops the stoping short of the then surface.

Grout & Balk as stated rject this theory for the BB,thinking BB broke and thrust aside its walls and cover;this explains lack of peripheral schistosity. Applies to Marysville. However the stock formed,note on sections that the intrusion stopped often against a particular shale bed,giving flattish surface;it stopped also against steep surfaces suggesting pre-batho flts;some contacts (Sections A,B,C) appear flt.contacts.

Without trying to solve the mystery of intrusion, it may be noted that some effects shown on the Sections may be explained as follows:

1.Stopping of the intrusion along a gougy slip,however slight the gouge.
2.After intrusion has congealed, uplift of intrusion,doming cover where marginal faults not available;where latter available,regeneration of faulti along the steep,smooth side of the intrusion;propogation of the fault upward and sideways from the steep,smooth intrusion side,which acts as a cutting tool. Baguio,Lordsburg, clay experiments.

Bald Butte flt.antedates the intrusion;may be an antithetic fault associated with NW anticline on SW edge of district,as suggested in Secion B,C.Intrusion may have utilized this and parallel faults now gone.The Sawmill Gulch fault,paralleling intrusion on E,is an antithetic fault of later date,formed when the uplift of the congealed mass occurred.Its raised footwall has exposed QD mass (Section D). China Gulch flt.a synthetic flt. hepling to raise the intrusion. Horst shown N of Gloucester example of lifting and outward shoving of wall of intrusion in manner postulated by Grout and Balk for BB.

Contact Metamorphism.

Contact metasomatism governed by fracturing,permeability;even pneumatolitic emantations have changed the rock, only to depth of a few mm.from fracture faces,but fractures may be so close together as to result in alteration of whole body of rock. More extension aletaration of ls.due to greater depth of permeation from fracture walls and to a closer fracturing Light load;few thousand feet of erosion have exposed stock.

Limits of contact metasomatism variable.s.t extending to or beyond limits of recrystallization;in general more restricted,may extend but a few feet from stock.

Peculiar meta mineral assemblage:changed to dense,hard,tough rocks called hornstones:diopside,wollastonite,tremolite, biotite,not visible.

Ore Deposits

Production to 1932, $31,000,000, Au,Ag.,$16,000,000 from Drumlummon mine.

Veins,characteristically parallel or at right angles to the granite contact. Gold,native,very fine, 60% value;silver,probably as argentite and sulphantimonides. Drumlummon, tetrahedrite,ccpy; Bald Butte,py.,sphalerite,galena. Lamellar qtz,calcite in briad,thin lamellae. Fluorite in Bald Butte. Sugary qtz.,pseudomorphic after calcite lamellae.Typical epithermal. Ores $10-20.

Late Tertiary by analogy. By time table,stock intruded,after much erosion,in early Oligocene. Mineralization Miocene,much later,throws out Barrel theory of contraction fissures,as shown by Knopf,op.cit.p.66-67.Says well known that contacts of dissimilar rocks good loci for dynamic action,deposits in brittle hornstones along QD contact. Similar to late Tertiary veins cutting flows,fracturing under light load: qtz-cemented rock breccias;fissures as parallel & branching sets;en echelon pattern. Knopf quotes S.F.Emmons,Suggestions for field observations of ore deposits,MSP 95,1907, p.18: "Some writers speak of vein fissures as sometimes resulting from contraction,but I have yet to learn of a well-authenticated instance. I regard a certain amount of movement as necessary to break the cohesion bet-

ween the respective walls of a joint or fissure sufficiently to make a water channel. This I hold to be true also of eruptive contacts."

Knopf,p.67:"..numerous mechanical features,such as brecciation & fltg. --all prior to the filling of the veins-indicate considerable movement,even if only of oscillatory character,during the opening of the fissures."

Fluorite being deposited by hot springs,Ojo Cliente,N.M.:W.Lindgren,L. C.Graton,C.H.Gordon, Ore Deps.of N.M.,USGS PP 68,1910,70-73. Lamellar qtz in late tertiary deps.De Lamar,Idaho, deepest OBs deposited at 700' depth.W.Lindgren, Gold and silver veins of Silver City, De Lamar & other mining districts in Idaho.USGS 20th A.R. pt.3(65-256),p.165.

Dense porcelain qtz. CM minerals further evidence:little garnet,no tourmaline,so conspiduous with older BB deposits;no css sericite.

ORIGIN OF VEIN FISSURES.

Go with uplift,doming. Ophir dome,concentric and radial fissures. Note that where QD contact steep,a major concentric fissure,Drumlummon,altho a radial one as well. Where contact flat,radial fissures:Cruse,Belmont, Penobscott & others. Steep contact,preexisting surface of weakness, pulls apart,breccia. Flat sloping contact,new radial fissures form because oover pulled apart laterally.

Drumlummon Mine: Strong vertically corrugated FW,bumps show FW moved relatively up:synthetic fault. Vein a qtz-cemented breccia;in places barren of VM,25 wide,rubble of CR boulders. Vein wavy,causing swelling,pinching on strike & dip;main swelling due to vein structure pitches down to S, as do others,so ore shoots pitch to S.Dependence on openings. Ore Shoots ave. 20' wide Rich ore above 200' level,2ndary enrichment combined with primary,according to Knopf, some good ore down to 1000'. Freibergite,argentiferous tetrahedrite, most imp.sulph.Fg saccharoidal white qtz.,drusy. Frags altered WR in q z. Primary ore on 400.

North Star veih,the radial fissure,narrower,but similar.Banded.

Cruse Mine: Radial fissure,cuts contact.Main shoot was in granite, 5-30',500'.Vein splits,narrows on entering hornstone on W.QD flat here, Sec.B top tended to split open under uplift of hard,tough hornstone.

Belmont Mine:Short radial fissures in both hornstone and granite.More a sheeted zone in granite,typical;ore sticks closer to cleaner,simpler fissures in the very brittle hornstone.

Bald Butte Mine: Vein along HW of Bald Butte diorite porph.dike, in hornstone.Old antithetic fault.

GENERAL

Since radial fissures tend to bottom in tight QD,solutions must have come up stock contacts.Greatest vein,Drumlummon,along steep contact,1100' of ore. No genetic relation between stock and ore deposits,latter much later. Active erosion,uplifted region,probable in Pliocene. No ore deposits associated with original intrusion. Structural, not geneticmcontrol. Probable IM movements to keep channels open. Typical concentric and radial doming fractures,modified by faults connected with intrusion to give very imperfect dome.

L - CMJ

Drumlummon Mine, Montana.

From "Some Gold Desposits of the Northwest" by Francis Church Lincoln, EMJ 8-26-11.

Location. Marysville, 17 miles NW of Helena. Near the continental divide, which here is a broad soil-clad axis, with ave. elev of 7000'. Mature mountanous topography, well-dissected.

General Geology. Central mass of coarse-grained qtz diorite surrounded by thin-bedded argillaceous ss and slatey shales, altered to hornfels near the contact. These belong to the Belt group (Algonkian). They were domed toward close of Cretaceous, and intruded by wide-spread but small basic and intermedaiet sheets and dikes. Later the intrusion of qtz-diorite occurred (Marysville batholith, exposed for a length of 2 1/2 mi. Outlier of the great Boulder batholith a short distance south. Invasion of the Marysville batholith accompanied and succeeded by 1st pegmatitic and 2nd pornhyritic dikes. Mt formation, accompanied by an andesite flow, occurred in Miocene or Pliocene. Since then erosion.

Ore Deposits. Contact gold veins, within the contact metamorphosed seds, either near the batholith or adjacent to dikes. Veins later than the dikes, which were formed just after intrusion of the batholith, and appear to have originated from peripheral shrinkage cracks thru which hot waters escaped, depositing the the ore in passing. Three vein systems near Marysville. NE system, ex. North Star vein, which cuts thru the seds into the the qtz-diorite. NW system prominent in the batholith but unimportant. N-S system-Drumlummon vein.

Drumlummon Vein. Roughly parallel to the irregular igneous contact. Tends not to cut the larger intrusive masses which project into its path, but to curce around them. developed for 3000' horiz; splits to N and S., Dev vertically for 1600'. Walls distinct and rather wavy, 2-20' apart. Vein filling mainly qtz enclosing angular frags of hornstone CR. These frags st unaltered, at other times decomposed. In lower levels st occur uncemented and constitute the only filling of the vein.

Ore occurs in well defined shoots, pitching to the right as one lokks down the dip of the vein. Structure of ore differs from that of of the waste filling in that the frags of hornstone in the ore have been completely replaced, and their former presence is only indicated by a banding of the qtz. No ore below 1000' in the Drumlummon.

Ore is auriferous qtz, with silver, copper and iron sulphs, fluorite and calcite. Gold makes 60% of total value, silver the rest.

See W.H.Weed, USGS Bull. 213, pp 88-89; J.Barrell, USGS PP 57.

REPORT ON U.S.G.S. PROFESSIONAL PATER No. 37, A STUDY OF GEOLOGY OF THE MARYSVILLE MINING DISTRICT, MONTANA (A STUDY OF IGNEOUS INTRUSION AND CONTACT METAMORPHISM) BY JOSEPH BARRELL (1907)

The district is located northeast of the Philipsburg District about 60 miles. The highest portion of the district is Mount Belmont 7,329' above sea level. Marysville is in the central-eastern portion of the mountainous region of Montana. It is 17 miles northwest of Helena. The continental divide crosses the southwest portion of the area studied.

The region is fairly well dissected mature mountainous region with few cliff exposures. The soil is thin and there was little glaciation so that careful work makes mapping reasonable.

Stratigraphy: Sedimentary

Quaternary	——	Alluvium ~~G~~ qtzite cobbles plus hillside wash
Tertiary	——	River Gravels -(Uncemented conglomerate of Cambrian and other earlier cobbles)
	——	Resifual Boulders and silicified river gravels(congl-silic basic prtn of Q_{rg})
	500'	Silicified River Gravels (River origin, rstg on Sp sh, & extr andst; hs pnk G bldrs; crs n East, fin n Wst)
	1000'+	Marsh Shale (smotth-bdd unif rd sh, lo bds calc places-qtzitic others; unconf undert G outside region)
Algonkian (Belt Series)	4000'±	Helena Limestone, calcareous-argillaceous (Impure blu-gra & gra ls- wthrs buff, lt gra & pnk. Oolitic etc in places)
	600'+	Empire Shale, argillaceous-calcareous (finely laminal limey gra-green or buff + rd, meta'd to gra or brn hornstn)
	3000' (Gr) 1500' (Sp)	Greyson-Spokane formations, argillaceous-arenaceous Greayson is dk gra to black shales with some cherty strata, while the Spoken is well bedded shales (red) and sandstones (alternate)

Igneous Rocks and their Structural Relations:

Microdiorite Dikes of Bald Butte: This is a fine grained crystalline rock, porphyritic in places, chiefly lime-soda feldspar and several dark minerals, hornblende, biotite and locally pyroxene. Conforming generally with bedding planes of Belt formations. These are considered Cretacous in age or Early Tertiary, the later more likely.

Gabbro Intrusions: These are dark igneous (granitic textured) rocks withpyroxene and triclinic feldspar the chief minerals. Intruded conformably with stratigraphy in places, they are probably outliers of a large body of this rock at depth. They are among the earliest igneous intrusions in the district. Age dificult to determine because they intersect no other igneous rocks.

Belmont Porphyry (Feldspar Porphyry) Dikes: have conspicuous phenocrysts of plagioclase and some biotite and hornblende imbeded in a dark gray microcrystalline groundmass which is tabular feldspars (plagioclase mainly), qtz filling and plae green biotite. These dikes cross-cut the district but grade in places down to dikkats. Age about that of batholith.

Drumlummon Porphyry Dikes: Are spotted with small feldspar phenocrysts about ⅜" in diameter. Mostly the rock is plagioclase (? species) One of the dikes is found intruding the granite and it is therefore younger. In places it is found in the hornstone as bedding dike. Various relations show that these dikes are closely related to the batholith.

Porphyry Sheets of Piegan Gulch: Three feldspar Porphyry sheets, conformable with the bedding and with phenocrysts about 3 mm in diameter (now altered largely to calcite) with a microgranitic groundmass of qtz and feldspar, are found a mile north of Gloucester on hills facing piegan Gulch. Age relations unknown.

Quartz Diorite of the Marysville Batholith: is commonly referred to as granite with a typical granitic texture and containing qtz, feldspar and some dark minerals. Since the feldspar is largely plagioclase, the rock is technically a quartz diorite. A second phase with a finer grain is found about a quarter of a mile from the edge of the intrusion. Little difference in composition.

Aplites and Pegmatites: Sheets and dikes of white, fine to coarse grained igneous rock mainly of orthoclase and quartz. These intrude the batholith and the contact rocks around it being restricted to marginal regions (of the batholith). The composition of the very course grained material (pegmatite) and the fine grained aplites are almost identical and gradations are noted. These intrusions are restricted to the eastern border of the batholith and in some places intrude the hornstone as bedding sheets.

Basic Post-Batholithic rocks: are restricted to two vertical dikes about 50 feet apart, one being 3 inches and the other 15 feet. They cut granite and aplite so are post batholithic.

Lavas: In the northern part of the district, there are a number of patches of Tertiary lava flows which are glasses in places and in others have phenocrysts of plagioclase, hornblende and biotite in a microgranitic ground mass. All now altered greatly. Their age is assumed Tertiary and they underlie the Tertiary gravels etc. making them the oldest Tertiary rocks here.

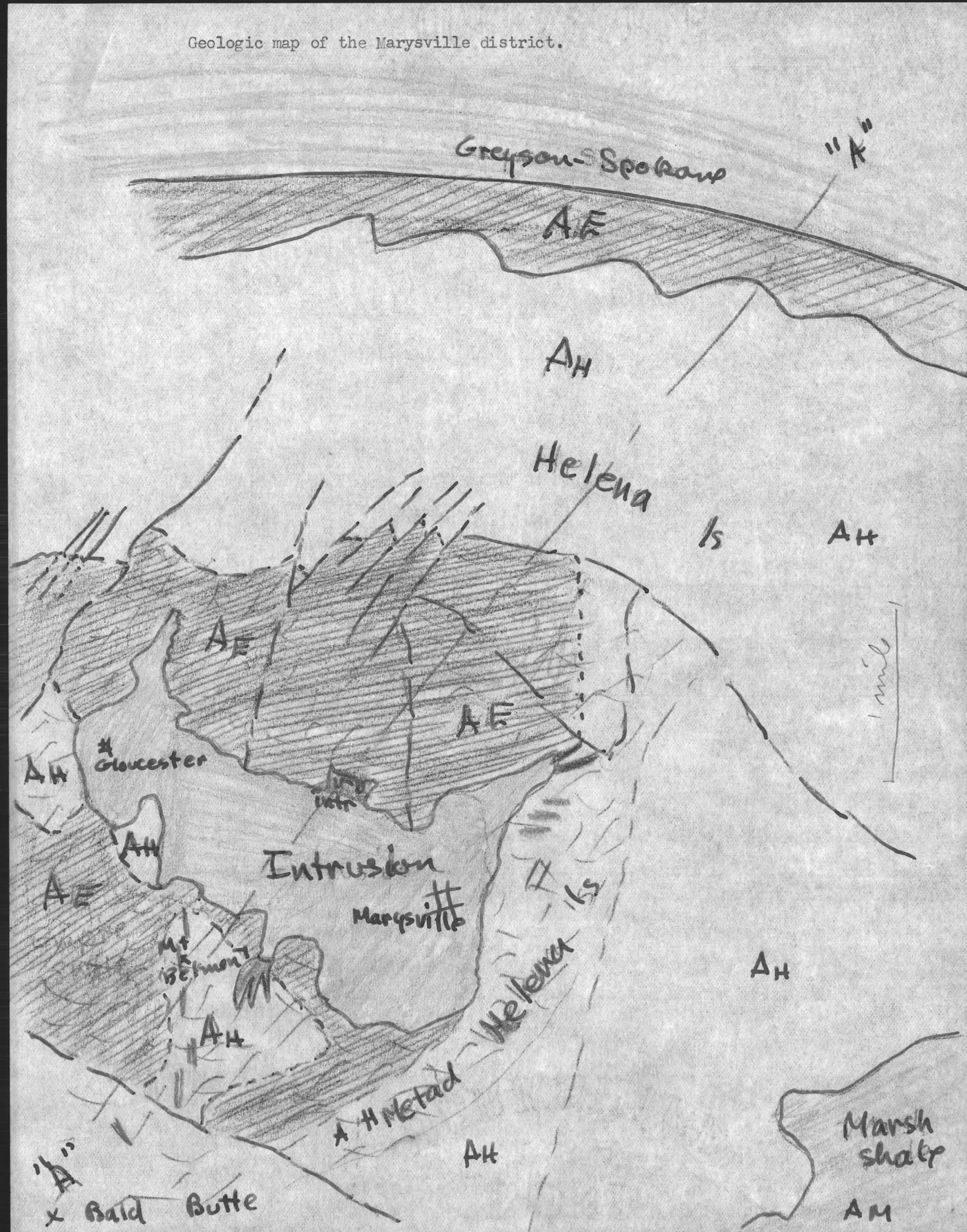
Structure of the Region

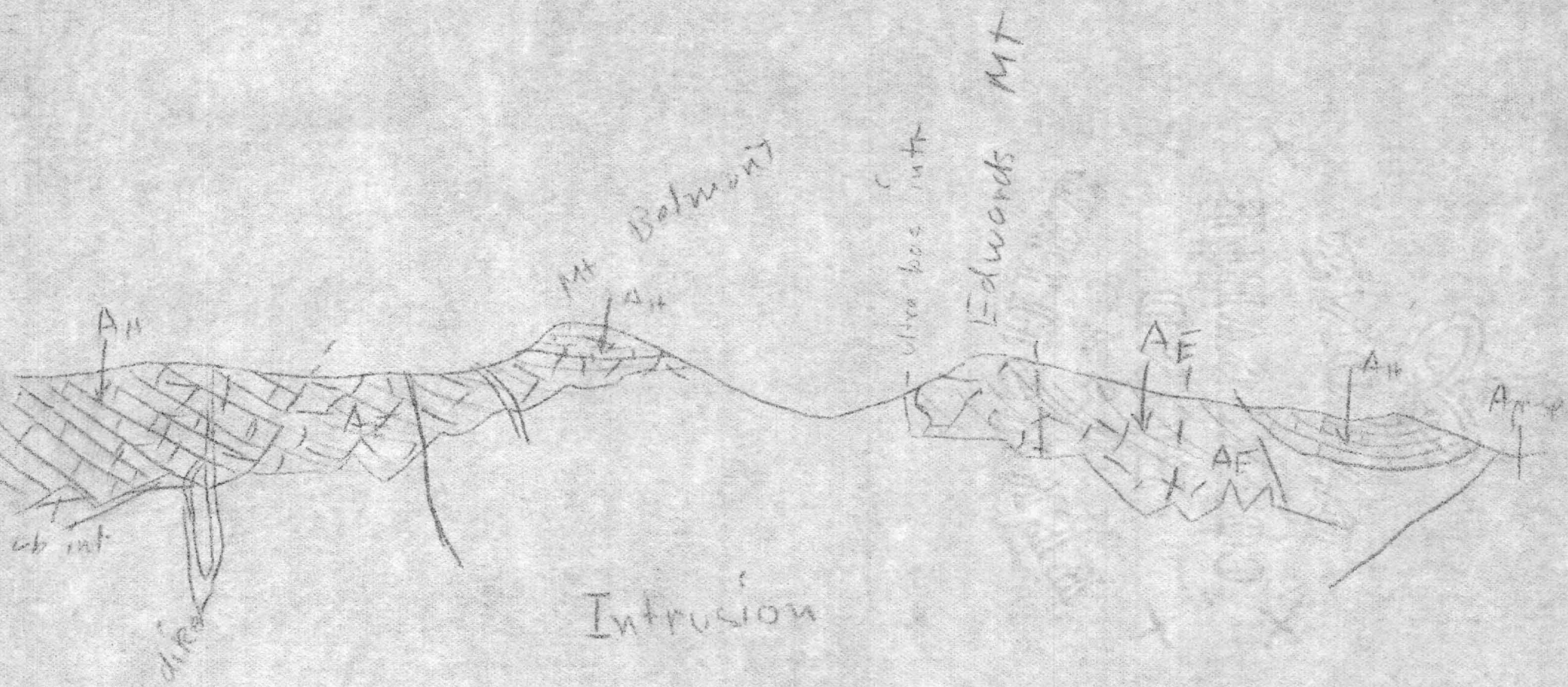
Folds and Faults: The movements were at diferent times with different effects. The first movement was a downwarp with accumulation of Beltian rocks. General uplift and folding has removed Paleozoic and Mesozoic rocks which were once in this area and are now found elsewhere not far away. The Prickly Pear dome was though to have been raised in late Cretaceous or early Tertiary presumably before the intrusions, aided by faults.

Faults are fairly numerous but some of the realtions have been lost due to the intrusion which cuts off the bottom of the sediments. It may be assumed that the greatest number of faults came before the intrusion but block faults in the metamorphic zone are probably directly connected to the intrusion.

History: The important thing is that the region has been one of comparative quiet throughout time to allow ancient Beltian rocks to remain un-metamorphosed. There are few faults also (comparatively few).

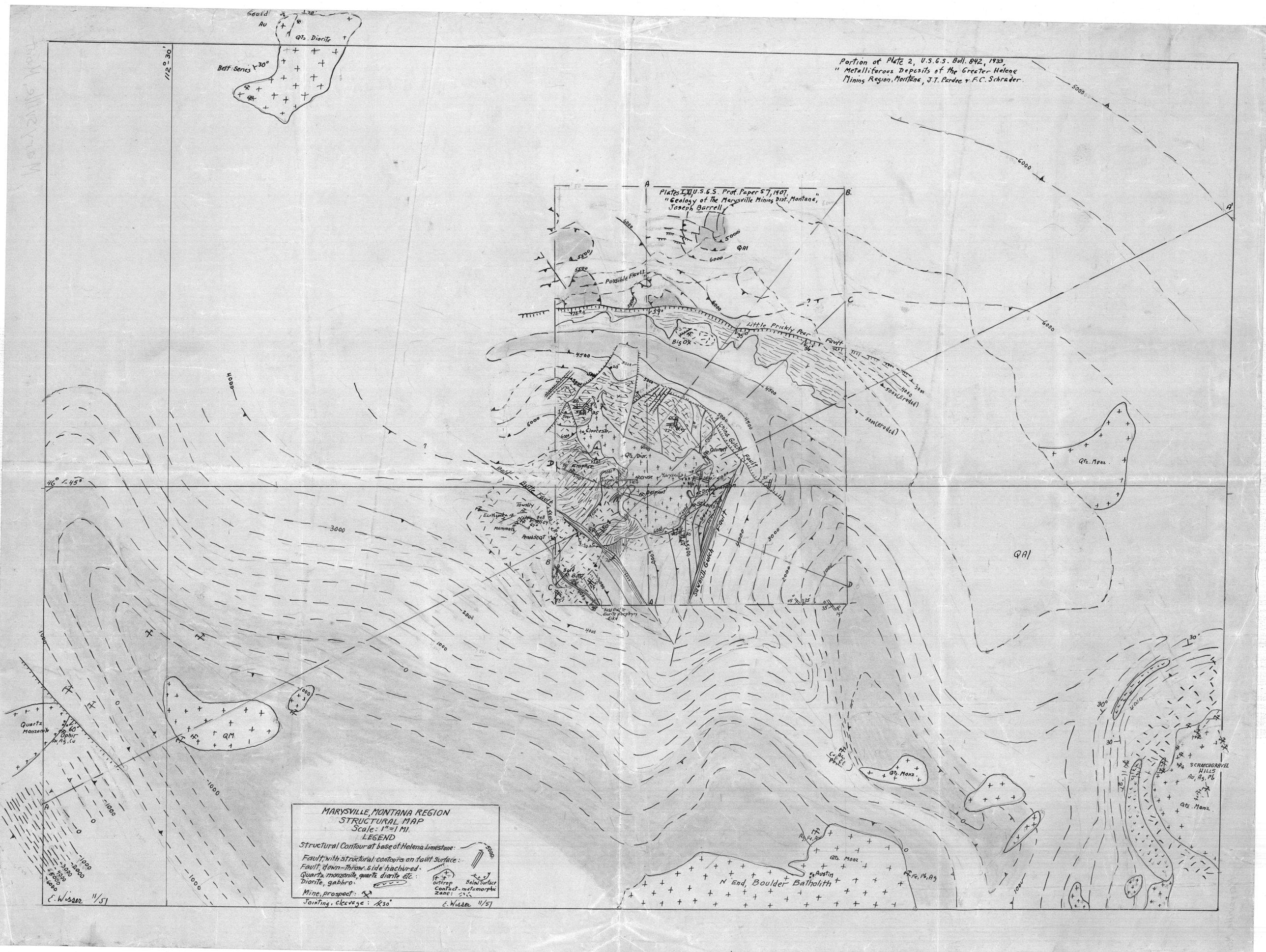
Geologic map of the Marysville district.





Intrusion

Section A A



Portion of Plate 2, U.S.G.S. Bull. 842, 1933,
" Metalliferous Deposits of the Greater Helena
Mining Region, Montana, J.T. Pardee & F.C. Schrader.
Plates I, XI, U.S.G.S. Prof. Paper 57, 1907,
"Geology of the Marysville Mining Dist., Montana,"
Joseph Barrell
Gould
Au
Qtz. Diorite
Belt Series
112°-30'
46°-45'
Possible Fault
Little Prickly Pear Fault
Big Ox
Gloucester
Qtz. Dior.
Empire
Cruse
Marysville
Belmont
Calumet
China Gulch Fault
Sawmill Gulch Fault
Bald Butte Fault
Towsley
Earthquake
Mammoth
Penobscot
Bald Butte
Bald Butte diorite porphyry dike
Qtz. Monz.
QAl
QM
Quartz Monzonite
Ophir
Au, Ag, Cu
Cu, Ag, Pb, Fe
Austin
Fe, Pb, Ag
N End, Boulder Batholith
SCRATCHGRAVEL HILLS
Au, Ag, Pb
MARYSVILLE, MONTANA REGION
STRUCTURAL MAP
Scale: 1" = 1 MI.
LEGEND
Structural Contour at base of Helena Limestone:
Fault, with structural contours on fault surface:
Fault, down-throw side hachured:
Quartz monzonite, quartz diorite etc.:
Diorite, gabbro:
Mine, prospect:
Jointing, cleavage:
outcrop
Below Surface
Contact-metamorphic zone:
E. Wisser 11/51