2001

Pazzaglia Field Notebook: NM State Map 2001; Lehigh Field Camp 2001; NM State Map + ED Map 2002; Lehigh Field Camp 2002

Frank J. Pazzaglia

SOKKIA™

FIELD BOOK

Frank J. Pazzaglia

Lehigh University

- NM STATEMAP 2001
- Lehigh Field Camp 2001
- NM STATEMAP + EDMAP 2001
- Lehigh Field Camp 2002 (back of book)

No. 8152-60

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★ Reward if found + returned ★

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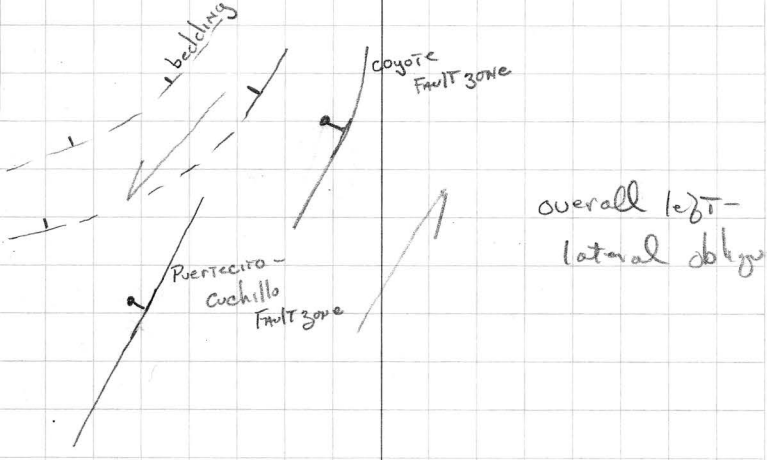
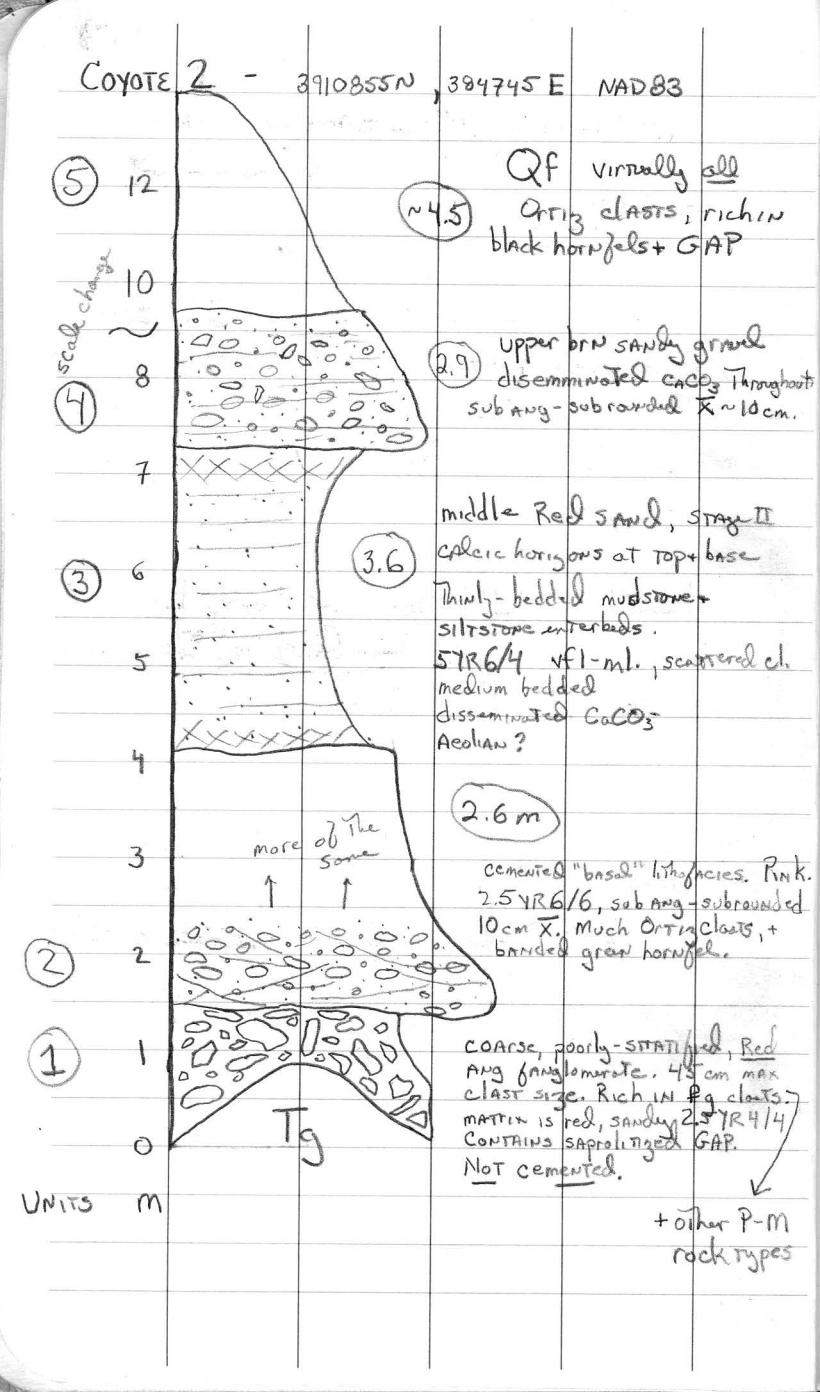
Wednesday, June 13th 2001

warm, sunny, v. breezy.

Arroyo Coyote on Hagan Quad, with Sean Connell.

We dropped into the Arroyo at its head → probably coincident with a fault zone. There are several springs throughout the Arroyo bed. QTt is almost completely cemented, dips subtly to the east and is thick ~20m. Down the Arroyo, QTt thins and rises in elevation. Our interpretation is gentle dip east into the fault zone.




COYOTE 2 - 3910855N, 384745E NAD83
5
4
3
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UNITS m
scale change
~4.5
Qf virtually all Ortig clasts, rich in black hornfels + GAP
2.9
upper brn SANDY gravel disemminated CaCO3 throughout sub ang - subrounded x̄ ~ 10cm.
3.6
middle Red SAND, STAGE II calcic horizons at top + base
Thinly-bedded mudstone + SILTSTONE interbeds.
5YR6/4 vfl-ml., scattered cl. medium bedded
disseminated CaCO3
Aeolian?
2.6m
more of the same
cemented "basal" lithofacies. PINK. 2.5YR6/6, sub ang - subrounded 10cm x̄. Much Ortig clasts, + banded grey hornfels.
COARSE, poorly-STRATified, Red ANG conglomerate. 45cm MAX CLAST SIZE. Rich IN Pg clasts. MATRIX is red, SANDY 2.5YR4/4 CONTAINS SAPROLITIZED GAP. NOT cemented.
+ other P-M rock types
Tg

Photo 16 along Coyote Arroyo illustrating the major units of QTt measured at Coyote 1

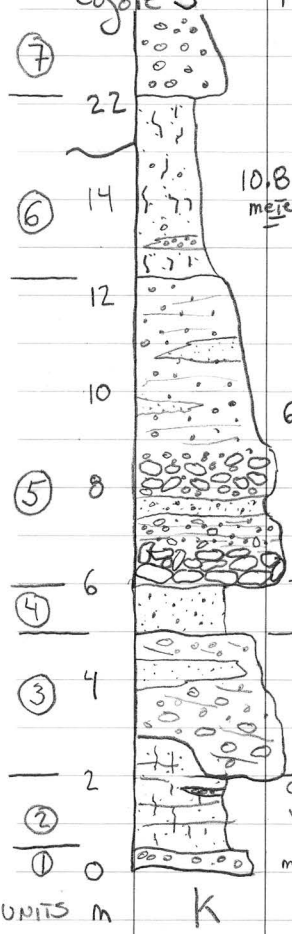
Photo 17 - major thickening of QTt south of Huerfano Butte.

Photo 18 - Te - Tg contact SE of Huerfano Butte

Photo 19 - QTt overlying dipping Tsf (Blackshare(?) Fm), SW fork of Tongue Arroyo. Dips N15W 24° NE

Section Coyote 2 - at the spring, downstream ~100m
? In the footwall of the La Bajada Fault

N3911145, 386535E



Total Thickness = 31.3 m Among the thickest QTc we've encountered.

Thursday, June 14th 2001

Capt. Davis Mt. Quad - Cook Ranch + Stanley Mesa.

Cook Ranch - Access via Mckee Ranch (Don Pope) Gate combo - 1369, 1.7 miles until to ranch, bear left btwn houses, Left (immediate) on line camp Rd. Cross Arroyo de la Jara on steel bridge, stay RT after brige - road passes into Capt. Davis Mt. quad to San Lazaro Flats.

Line Camp is a small house, corral. Nancy Cook, daughter of Bill stays there for a few weeks in the summer. This whole ranch is Awesome. So well maintained - and awful nice people.

Start - middle of escarpment at the water tank at terminous of Road due south of Line camp.

→ Section line mesa - straddles sec 5-6, T12N R9E - very good exposures of basal QTt - 3 major lithofacies -

① A 4-m thick basal pink-pnk 10YR6/6 sand and pebbly sand with numerous buried calcic soils, Krotovina. Hard to imagine this as strictly eolian - but eolian in part - probably a distal fan - alluvial slope sand... ultimately overridden by...

② 5 m thick, cemented fanglomerate, subang - subrounded w/ some rounded. All Ortiz provenance, gray andesitic porphry dominated. Max size ~ 20 cm, Avg ~ 5cm. 2.5Y 7/2 Grey.

③ 6m of poorly consolidated coarse angular fanglomerate. Sand and coarse Ortiz clasts. Brn 10YR colors. X_{max} ~ 30 cm, $\bar{X}$ ~ 8cm

overall - coarsening up.

→ Calcic Arroyo - an arroyo headcut into Stanley mesa.

QTt strath is encountered at precisely the 6620' elevation. The top rises to this location which is at 6680' -

A trend elev completely consistent with the 50' of QTt measured on section line mesa.

... but here - there is an intact soil - A 2-3m petrocalcic consistent, but somewhat less brecciated than the OH-2 site. Provenance here is all ortiz with a conspicuous green quartzite. No granite.
↳ Not Ortega

→ Water Tank Rd. Very good exposures of entire QTt including the 3m petrocalcic. Here there is no separate basal sand - just an interbedded pebbly sand w/ soils and gravel/conglomerates - similar texture to unit 2 of section line mesa. Strath at 6610-6620' - broad paleochannel in cross-section — N 70°-80° E paleoflow

→ Indo Windmill The QTt treads here in sections 11+12 have dropped some 60' ... but more importantly, the straths sit at 6560' somewhere between here and Water Tank Rd, The strath either rises .. or there is an inset

strath. I've also "lost" the petrocalcic horizon - at about the eastern edge of sec 12. There is a distinctive red chalcedony in the gravels here ... maybe ~ 1%.

Photo 20. QTt base @ 6560', section 1, west of water tank Rd.

Friday, June 15th, 2001 Sunny, cool morn, breezy. (13)

Santa Fe Alvis Lisenbee
Artesia

In Field w/ Steve Maynard @ The Dolores / Cunningham Hill gold mine. Met with Melissa Monk with LAC for permission.

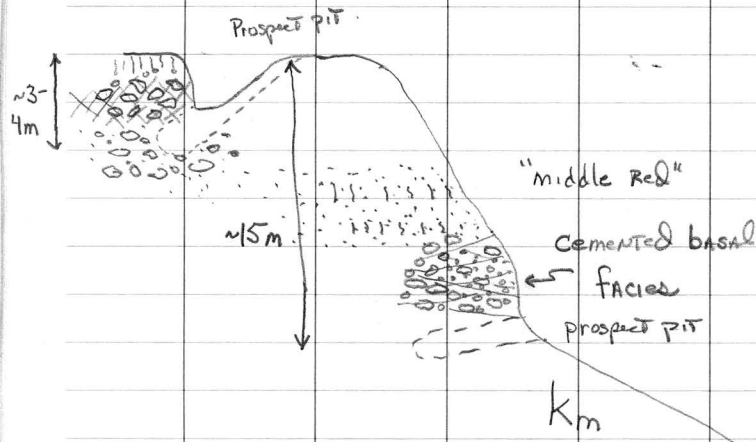
3 targets (1) Head of Dolores Gulch
(2) Cañamo Arroyo
(3) Rich Hill.

→ Head of Dolores Gulch is a typical alluvial - colluvial valley head fill - colluvium is at least 4m thick, and characterized by a non-calcic red argillic soil. Alluvial fans here are v. coarse, v. angular - have a stage III calcic soil. All of this is on the Golden Quad.

→ Cañamo Arroyo Exposures. Good QTz with cemented basal conglomerate unconformably atop Km and Kmv. Locally, the conglomerate is coarse-grained and poorly

sorted with some 60cm boulders.

→ Rich Hill. Outstanding exposures!! Here atop this hill @ ~6700' is a v. coarse, bouldery, angular QTt with 10-20 major rabbit holes-pits. These are old prospect pits for placer gold. The "bonanza" is that the pits expose the soil here. It is a stage III+, (largely non-stage IV) petrocalcic. This is the Stanley Mesa soil! ~3-4 meters thick.



2.26

clear, hot, calm (17)

Saturday, June 16th, 2001

Rt 285 at The County Rt 34 intersection - ~1 mile north of White Lakes. There are some degraded pits here. They expose ~20-40' of To? with a stanly mesa calcic soil.... deposit is rich in granite. Elevation ~6400'

Saturday, June 23rd, 2001 warm, hazy, breezy

Red Hills, Wy; 2001 Lehigh field camp.

Glacial mapping in Crystal Creek watershed.
Ideas for a glacial mapping project

- There are three small lateral moraines dominated by rounded l.s. clasts, (small) opposite the Red Hills C.G.

- There are three nested Pinedale? moraines in the East Miner Ck drainage.

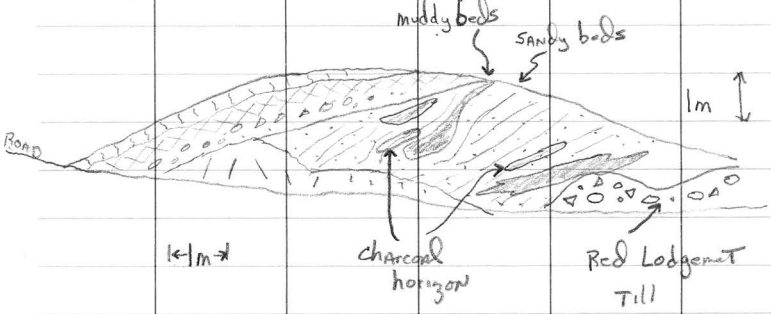
- There are three + nested Pinedale? moraines in the Crystal Ck drainage. The moraines are surrounded by a bulbous-shaped swath of dead-ice features w/ many kettles. (Qdi)

- Nugget knob is capped by a QTug lag - many rounded l.s. clasts + P+E congl. clasts. (quartzites). The "base" of where the upland gravels crop out is a cemented pebble conglomerate. L.S. is dominant composition.

- Wow! IN The fence line slump, EAST SIDE of Nugget knob - LACUSTRINE beds! AT LEAST 4m of Them - very NICELY VARVED.

- Younger LACUSTRINE beds, Till, and 2(?) outwash TERRACE all IN The valley adjacent TO Crystal Ck + The Crystal Ck bridge.

- Alkali Ck charcoal locality IN The Qmo Bull Lake (?) moraine. There IS A STAGE III calcic soil on This morainal/colluvial material. The charcoal IS IN A SANDY, STRATIFIED facies of what looks like A kame...



Sample CCGP-1
(Crystal Creek Glacial Project)

warm, partly cloudy
breezy.

Sunday, June 24, 2001

Grizzly Lake gual, Crystal Ck glacial deposit mapping.

Gravel Pit - river bank exposure into Qt2 - very complex outwash strata.

- Irregular strath
- A young (?) poorly calcic Pinedale? soil inset into a stage II - II+ pre-Pinedale (?) soil. Treads of these two fills, if real, are coincident.
  Photo 3.

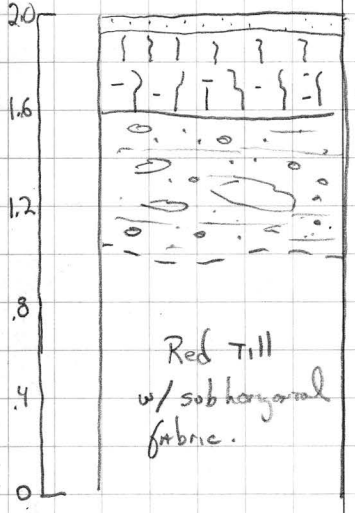
overcast, warm

Tuesday, June 26th

Continue Crystal Ck glacial mapping

Gros Ventre dirt Rd, s. of Slate Ck confluence.

- Outstanding soil! - Red till overlain by a Bull Lake (?) soil + Pinedale loess. - in a paleoswale.



- Road Closure Terrace (Airphoto surface 5) Pinedale soil in outwash. Red Holocene loess over a 10YR stage I Bck ~ 20cm

over stage II $CaCO_3$ Bk. → very gravelly.

This is the same soil as the Red Rock gravel pit exposure.

Till exposure of Morrison outcropping in the Gros Ventre River. - O.C. on NE side of river

2 potential tills here

- ~1m of Pinedale eolian + soil
  stage II carbonate
- ~3m of Pink Pinedale? till -
- unconformity, light colored
- ~3-4 m of pre? Pinedale till.

Saturday, June 30th, 2001

Thoughts on The CCGP

- Day 1 - ½ day in the field - looking primarily at landforms
  - moraine
  - river valley bottoms
  - river terraces
  - landslides
  - fans
  - kettles

  - ½ day back in camp with a lecture on - Rocky Mt glacial stratig.
    - Quaternary Paleoclimatology
    - using air photos
    - exercise of turning in a quick airphoto map of CCGP

- Day 2
  - 1 hr lecture on glacial deposit sedimentology and its link to depositional process.
  - into the field to see examples of
    - Alluvium
    - colluvium
    - Till
    - lacustrine
    - loess

students remain in field all day measuring representative sections, + collecting sedimentologic information. These data should be placed in a hydrostratigraphic + aggregate resource context. - Petrography data

- Day 3

  1 hr lecture on relative weathering criteria, + soils.

  ½ day on field identification of relative weathering criteria

  ½ day students collect relative weathering criteria

- Day 4

  students map, fill in gaps from Days 2+3

- Day 5

  students draft final map + cross-section.

  They turn in

  - map + cross-section
  - measured sections w/ petrography data
  - relative weathering data

- A brief technical report consisting of:
  - An introduction page
  - A methods page, what data were collected
  - The data, including map + x section
  - 1 pg interpreting the data in the context of Rocky Mt. glaciations
  - 1 pg of recommendations on
    - gravel aggregate
    - groundwater resources.
    - landfill location.

April 18, 2002

Stratigraphy of Capt Davis MT, Hagan, + Madrid quads

Tuerto Fm QTt Undivided	Basal matrix + clast supported, poorly-to-well stratified sand + gravel; Ang clasts, well cemented w/ carbonate. Grades up into a cross-stratified sandy gravel and red siltstone w/ paleosols. Unconformably overlain by a brown, pebbly, unconsolidated sandstone that grades upwards, indeterminately to gray Q alluvial fan sand + gravel.
QTtØ QTt1 QTt2	Treads of Tuerto Fm, where mappable, They correspond to distinct straths at different elevations.
Ogallala Fm To	Typically Quartzite + Granite bearing Red gravelly, pebbly sand, overlain by reddish brn sandy gravel w/ 40 cm boulders, and 3+ m of Petrocalcic, laminated, horizon

Terrace Deposits	Qt_o	older Terraces
	Qt_y	younger Terraces
		Numbered where Appropriate
Fan Deposits	Qf_o	older fans
	Qf_y	younger fans
		Numbered where Appropriate
Piedmont alluvium + colluvium undiv.		$Qalp$
Channel alluvium	Qal	

06/05/02 Jemez Springs Quad

Mapping, orientation to mapping for Amanda Ault & Andrew Drabick.

Padre Alonzo Trail, start @ NM state monument.; bear off to North into Church Canyon.

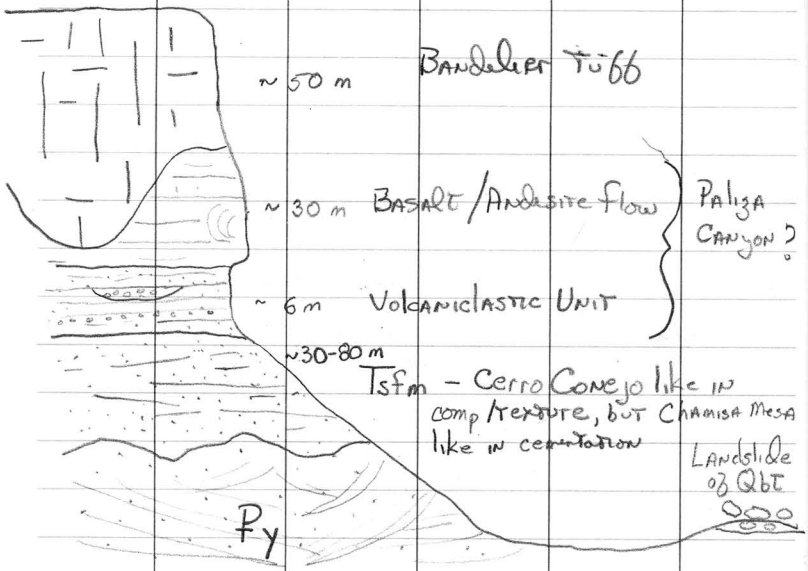
There is definitly a fault in Church Canyon, down to the SE. Juxtaposed Abo in NW against Yeso in SE. offsets Tb, Tvol and Tvol is thicker on hw
Both footwall and hanging wall contain Tertiary sed deposits
↳ white, thin to medium bedded siltstone, sandstone, conglomerate, no obvious cross-bedding, opaline beds, calcareous beds. SS+cong contain clasts of P, Tvolc, & granite. ~10-15 m thick.

Sample JS-1

P + Tsed are overlain by Tvol volcaniclastic & flows. These deposits are incised by paleovalleys trending SE, then everything

is filled by Bandelier Tuff.

Volcaniclastics → well stratified, fining-up medium to thickly bedded cycles of fluvial sand, conq + silt. Very pumice-rich. No granite, but ~1% pink rhyolites. Clast size = pebbles to cobbles to boulders ~ 10 cm across. Interbedded w/ debris flows + lahars.



Monday, July 1, 2002 hot

Albuquerque. Field trip w/ NMBGMR + USGS + Steve Maynard into Hagan Basin + Capt'n Davis Mtn quad.

- Golden Store - Henderson Property, Cañon del Agua - Tijeras Fault, locally water bearing IPm overturned against pC cored horst. Trilisidites - Virgillian Fusilinid

  Just S. of General Store.

- Golden Placer pits - on Cerro del Luz(?) Rd Tuerto Gravels - named for Tuerto (San Pedro) Mts. not Tuerto Arroyo.

- Good overview of Oglivie's conoplain. Ortiz belt plunges to the north. Calc-alkaline laccolithic phase (Phase I) Alkaline stocks - nephaline normative ~5km of Left-lateral stratigraphic separation on the Tijeras Fault.

- L-shaped intrusive in the Capt'n Davis Mtn quad, SW corner - note new To - QTeØ map boundaries. Intrusive rock is a stratiform sill - Kjl outcrops at base of sill.

  Juana Lopez.

Tuesday July 2, 2002

Large group field trip => RT 22 to RT 14 to Madrid, out Waldo Road.

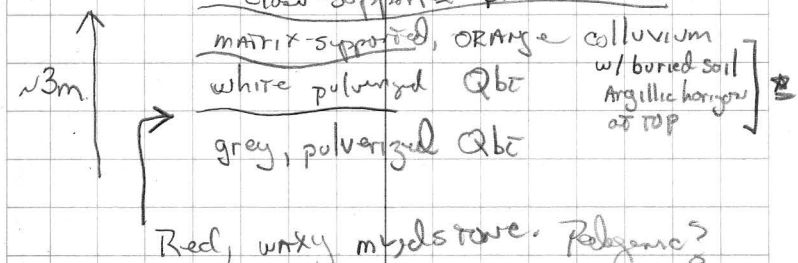
Wednesday July 3rd, 2002

Jemez mts. - morning, lots of errands, including making a contact for Osha Canyon Trail Nate Gilman - Alex Calvert; trail is on a woman's property named Pat.

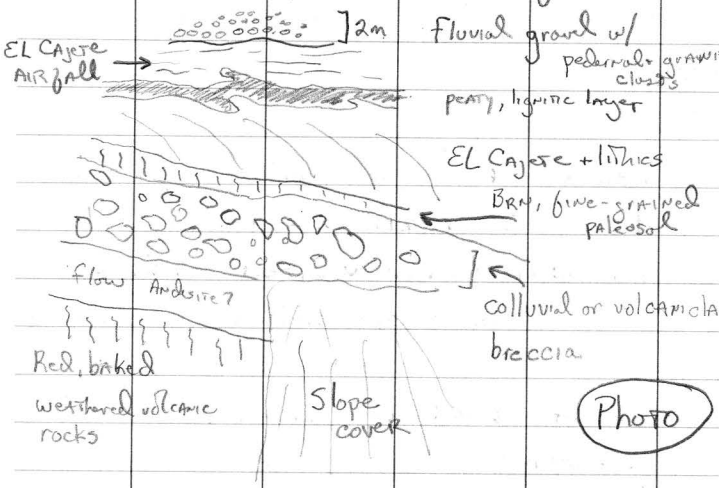
Begin field check of Amanda + Andrew.

Forest Rd 376, NW corner of quad

- Two strange outcrops:
  - Rio Cebolla outcrop - near Porter Landing seems to be a constructional lobe of Abo + pumice dominated debris flow but unconformably overlies a debris flow only Qbt
  - Lake Fork Canyon - right on the map boundary



• LA CUEVA ROADCUT (ONE further SOUTH on RT 126)



View looking EAST, gravel base @ ~ 16m on road, ~ 20 m above stream

Thursday July 4th, 2002

AFT

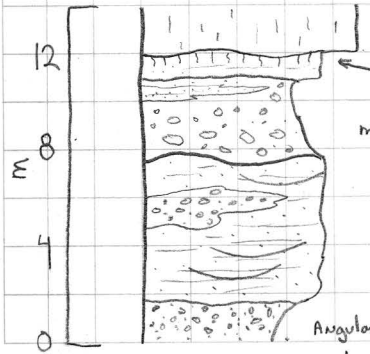
- South-central portion of quad, east side of Jenny River -
  - Flats @ ~ 6200' are underlain by a thin Qfo deposit. Qtzite, limestone, + large, well rounded int. to mafic volcanic rocks. (Qfo1)
  - Flats @ ~ 6160' are underlain by 5-6 m of coarse Qfo (Qfo2) with a stage I+ - II soil. base not exposed, only local trib rock types represented.

Friday July 5th, 2002

morn

Working the region around the town of Jenny Springs.

- Exposure of Qg/Tg @ 6800' "cougar" Array



Qbt pumice-rich does not look like lower - but there are times baked or paleosol horizon

more fan-like, very heterolithic. Volcanics + ss.

"Yeso-orange" pumiceous sand sample. NO limestone or pedernal, but 1 granit clast

Angular, fan-like gravel, cobbles, heterolithic.

Saturday July 6th, 2002 

- Helped Chris put in a fence. Then spent A/T on San Juan (FR 269) + Cat Mesa (FR 135). There are 4 mapable deposits on Cat Mesa: Qbt, colluvium of Qbt, Residual soil of Qbt, + El Cajete deposits of reworked pumice.

- There is a deposit of Banco Bonito "clinker" (?) overlying a Qfo, in The Third Arroyo N of Battleship Rock - NEAT

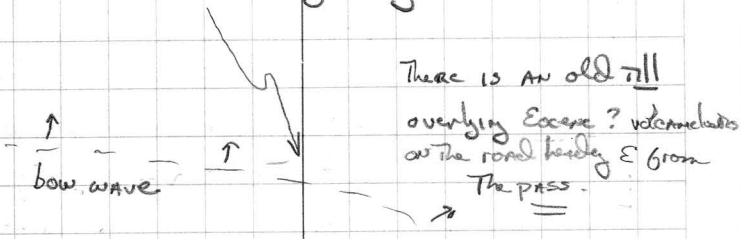
sign + where power lines come close to road.
~ 70' Above river level.

Wednesday July 10, 2002

MT-ID w/ Dave Anastasio + Nate Harkins

- Peterson Ranch – Canyon Ranch
  Dale Tow, David Burke
  ↳ caretaker

Bannock Pass - migrating divide idea



Yellowstone

- in Big Sheep Ck valley – Caboose Ck quad
  look at terrace by Big Sheep Ck near
  Peterson – Canyon Ranch.

Arlene – old Witworth Ranch
downvalley from Peterson Ranch.

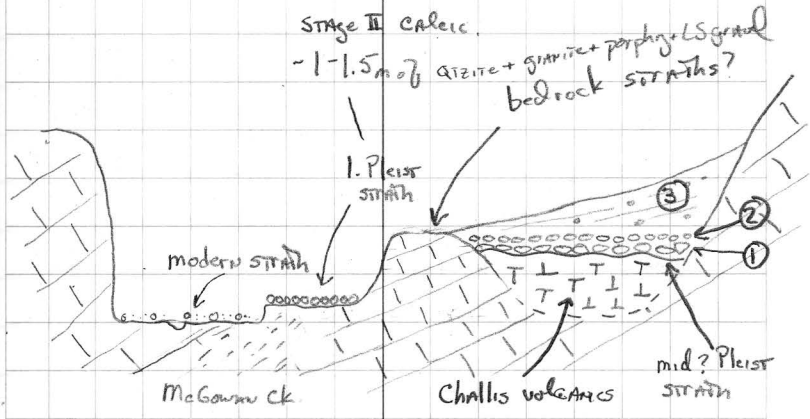
• possible link btwn tectonics, rock type + river behavior:

• Goosenecks are related to meander sweep "bunching" at the upstream sides of gorges.

- Gorges are fostered by (a) harder, more cliffy L.S., + (b) karstic L.S. leading to reduced ω + valley narrowing

- It is also true that the Eocene rocks filled in a significant paleotopography. — you can find it today, tucked up against valley walls, at modern base level, ... as if the current valleys were cut on the Sevier topography, filled w/ Eocene volcanics, then recently re-exhumed.

- I think we got the T-Q strath worked out:

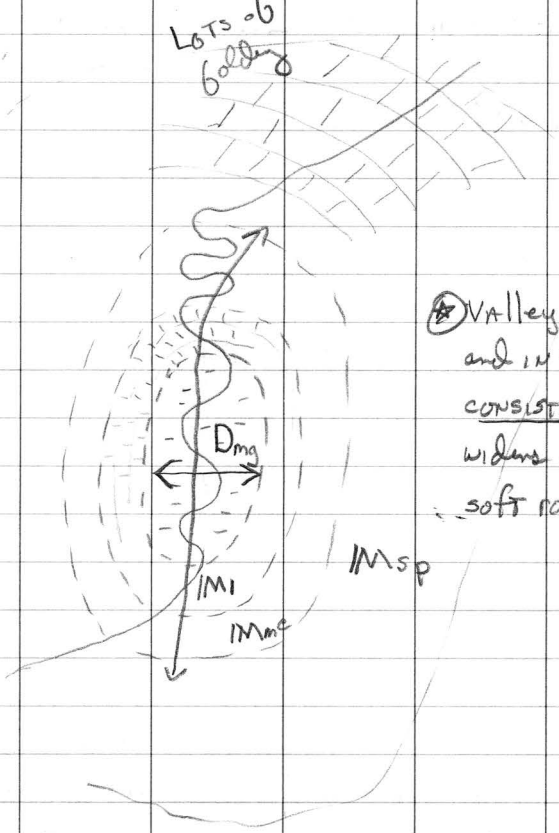


① Qtzite axial stream gravels - Buffalo stage? Till we saw on Bannock Pass

② well rounded L.S. — projects to bedrock straths

③ mid Q fan gravels, especially thick in swaths of Tribs

This is a correction of the gooseneck figure



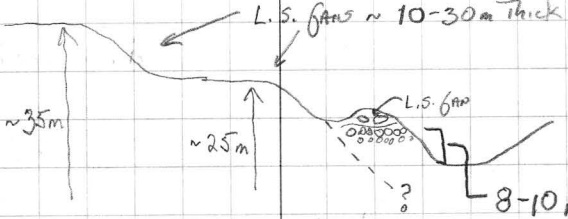
* Valley here and in tribs consistently widens under soft rock type

Dmg - McGowan Gap shale
IMI - Lumbard L.S. - black chert
IMmc - Middle Canyon calcareous shale
IMsp - Scott Peak L.S. - base is three prominent beds, usually w/ brn chert

Thursday, July 11, 2002 hot

- Four eyes canyon & SW portion of quad to figure out terrace stratigraphy.

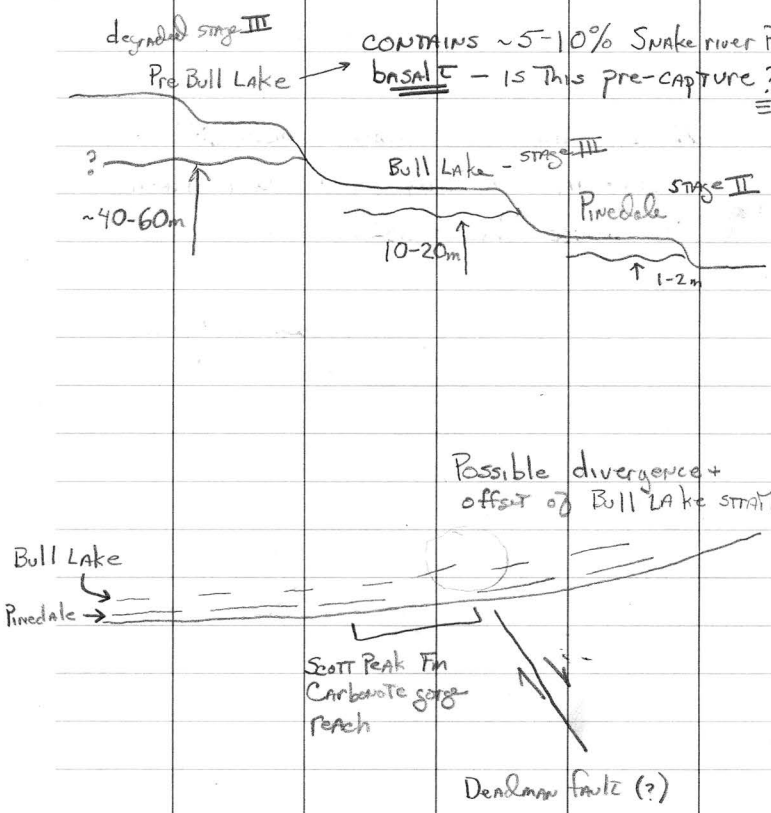
- mouth of Four-eyes canyon



heterolithic, qtzite + gneiss cobbles

? from divide of Four-eyes canyon?

- The head of Big Sheep Ck really has a fine terrace stratigraphy - very likely a Holocene, Pinedale & Bull Lake & at least 1 pre-Bull Lake strath. Morrison Lake, at far western edge of Deadman valley, is a nice little glacially-dammed lake. Moraines appear to be Pinedale... but older stuff might be present. Region around Lake Morrison also is the source for Proterozoic pink Quartzite.



Pinedale strath is well-preserved; gravels are intact w/ a stage II calcic near Peterson Ranch.

Bull Lake strath is best preserved as little bedrock spurs, especially at the confluence of trib drainages (in the gorge reach).

Friday, July 12, 2002 hot

- We will work the lower canyon today - to mouth of Big Sheep Ck + any terraces in the Muddy Ck. graben.

- start @ 7010' hill at SE end of Muddy Ck graben - (NW side of Rd) - outstanding view of Muddy Ck graben + surrounding countryside. Very good view of meanders on Big Sheep Creek. Surface graded down into Muddy Crk graben are pedimends - at least 3 distinct levels. Little or no fans.

- Hidden pasture trail. - Nice hike to see TP - P - Tk stratigraphy. TP quadrant, P phosphoria, Tk Dinwoody, Woodside, + Thaynes. We cross 1 thrust that places Pp + TPq atop TPq.

- There are one or two places, in roadcuts, in the TPq gorge where well-rounded pink granite boulders crop out w/ the colluvium. ~ at about the "Bull Lake" level.

- at the mouth of the canyon, there are 2 "Pinedale" treads, probably 1 "Bull Lake" tread, and 1 certain Pre Bull Lake tread. strath. The pre-Bull Lake strath clearly is in angular unconformity w/ the Beaverhead conglomerate.

Food for way out - cross country trip

Day	B	L	D	
1	Pit Stop	Truck world	Left over	
2	Diner	South Bend	Purchase @	Lunch a sandwich @ Subway.
3	Baraboo	La Crosse	Burrito in Lavern	
4	Lavern	Mitchell	Interior	→ Purchase stuff for lunch next day.
5	Cedar Pass	Pack	Interior	→ or use 1 burner.
6.	Wall	Pack @ wall	Spearfish	→ get some milk + cereal
7	Spearfish	Pack in Spearfish	Chilli	" ——— " Pack a lunch in Spearfish
8	Cereal	Pack	Lodge or use 1-burner.	
9	Cereal(s)	Ten Sleep	Lodge	Purchase lunch for next day.
10	Cereal(s)	Pack + pick up stuff of gas stop.	student / camp	½
11	our camp	Pack	Jackson	
12-20 — our camp				

General notes

- see specific notes for Geology comments
- A camp built on respect, not fear is more functional, let students pick their own cooking groups + group leader - make it a competition. Make cook crews responsible for camp maintenance too. Make them camp "police" for the day. We do an unannounced inspection everyday. Really make it like the Army
+ A regular morning + aft dinner inspection
- "Staff meetings" on the road really undercut our credibility.

Lehigh Field Camp 2002

06/09/02

Day 1, PA + Ohio Leave @ 6:00 not 5:00

STOP 1 Rest Stop at Berwick, hand out guidebooks; 5 minute talk w/ PA Topo map

STOP 2 Carroll Exit 191 for B-fast

STOP 3 Clearfield Exit, The Pit Stop Rt, Texaco for Gas Rt. 879. 228 miles. PA coals + oil.

STOP 4 Truck world 352 miles. 1st exit in Ohio.

STOP 5 Rest Stop @ Exit 9

STOP 6 East Harbor St. Park Arrive @ 5:00, not 4:00

Bring a jacket in cooler for sunset

Topics - Appalachian stratigraphy + structure
Glacial geomorphology; Cincinnati Arch
underfit streams.

Needs a map

we need AAPG of PA-Ohio, Indiana.

Day 2. - Ohio, East Harbor St. Park Needs Richmond et al 1986

Erratics, general glacial stratigraphy, location of ice lobes, ancestral Teays drainage system

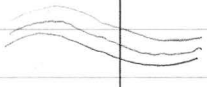
- Travel Through Chicago. Around Chicago
- up to Baraboo
- good time for road discussion of glacial terminology.

Van Hise Rock

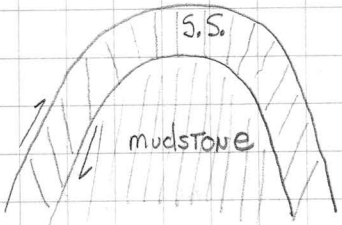
↳ qtzite w/ phyllite : greenschist facies

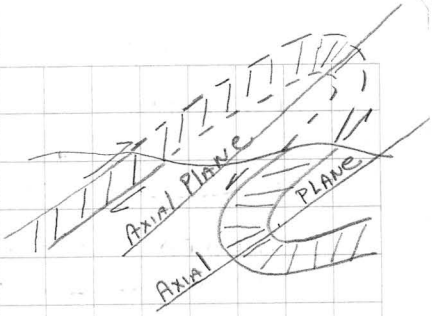
- bedding, rock composition
- cleavage - a foliation or a fabric developed by deformation of the rock
  - penetrative — at the microscopic level
  - spaced - regular spaced intervals
    - crenulation

    - pressure - solution



    - slip cleavage - spaced small faults
    - Axial plane - // in hinge areas, but oblique to axial plane in the limbs; often fans with orientations that correlate to lithology. Imply that cleavage forms during folding.





STRATIGRAPHY

Rowley Ck Slate	~ 45 m
Dake Quartzite	~ 60 m
Freedom Fm (dolostone)	~ 300 m
Seeley Slate	~ 120 m
Baraboo Qtzite	~ 1200 m
Rhyolitic basement	bimodal volcanism - mid Proterozic rifting

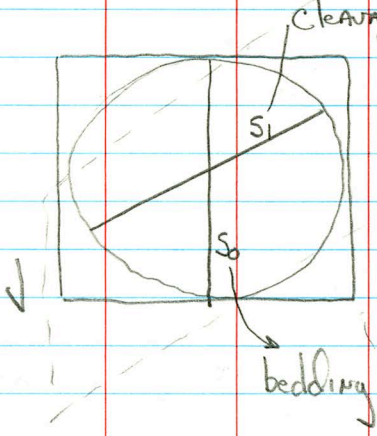
why all the quartzite ... Sioux, Apache Grp, Ortega!... all ~ 800 – 650 Ma ?
Snowball Earth ; Mineral Forks.

O [ST. PETER SS
O [ONEATA Dolomite

(ST. LAWRENCE + JORDAN Fm)

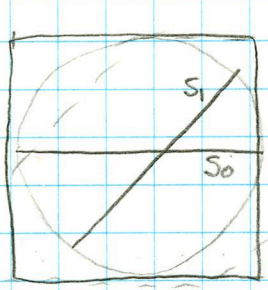
€ [TREMPEALEAU Grp Dolostone + Siltstone
€ [TUNNEL CITY GRP Dolostone + S.S. glauconite
€ [GALESVILLE S.S.
ELK MNT GRP ["SAUK TRANSGRESSION"

STUCTURE P. 103



North limb

Cleavage refraction
Qtz filled tension gashes



south limb

A

North limb
T 60

T80

14 Y

south limb.

L30

pEb

A'

possible K(?) Pliocene (?) sediments in the mtns. SW

Osp

younger pE

Eg

pEb

• COMMENT ON Remarkable preservation of AN Ancestral landscape Gorges cut in E, fill-out w/ E sediment

Day 2 East Harbor ST Park to Baraboo

06/10/02

- Niagara Dolomite
- lecture on general glacial, pre-glacial drainage @ 7:00 AM, general glacial stats + nomenclature
- lecture + visit to glacial grooves + erratics. [I.D. met - ign Rock types]
- B-fast @ 8:00, on Rd. Rt 2 to 53 to I-90 @ 9:00
- staff B-fast @ a diner on Rt. 163 e of park
- 10 min bathroom stop @ Oak openings
- discussion about glacial deposits.
- exit 77 in Indian for lunch.
- long way around Chicago .. ~same time according to Ed.
- exit 147 in Wisconsin for gas + rest
- West Baraboo K-mart shopping + big Parking Lot.

I need Baraboo visuals | WGNH Survey IC 67, 1990, Clayton Atty.

- I need some Proterozoic reconstructions for sed/structure setting of Baraboo.

Day 3 Devil's Lake S.P to Pipestone
06/11/02

- up at 6:00, rolling @ 7:00
- Lecture at Lake. Into West Baraboo @ 8:00
- bfast until 9:00. Roll to Van Hise Rock.
- west out of Baraboo to Rock Springs, RT in downtown Rock Springs. Quarry on either side of road. Van Hise Rock ~1 mile up road Sketch, lecture, 20 min
- Back to Baraboo, use RT 12 to highway
- Stop in La Crosse for lunch
- MN mile 193, first Wall Drug sign

left @ K-Mart

Directions to grain elevator in Rapid 90+16; Exit 60 left hand exit; follow → 16 to 44W, follow signs to 44W to RT turn Grain elevator on RT.; Hubbard MT Rushmore to Omaha St. RT on Omaha

- Gas at Austin, exit 178A - BP - parking S+W of Gas station.
- Luverne @ 5:20. There is a Taco Johns.
- Blue Mounds St Park Group site 1-11(?)
- Talk about The Prairie, tall grass vs. short grass, Lake, paleoecology, forest vs. grasses, agricultural productivity.

DAY 4 BLUE MOUND - PIPESTONE - MITCHELL - BADLANDS
06/12/02

- Mike Montgomery
- 3 MAIDENS - 3 big rocks - erratics, from CANADIAN Shield; VISITOR'S CENTER at ENTRANCE GATE
- CATLINITE - source of PIPESTONE] see handout, mostly KAOLINITE.

Again, do Ign-met ID.

- MITCHELL - follow signs TO CORN PALACE, PARK IN Sunshine Market, CATTY-CORNER TO CORN PALACE.
- RT 75 N TO PIPESTONE; STAY RT 75 N TO McDONALD'S, RT TURN. 3 VANS park in Motel & parking lot - GO TO GANNON'S RESTAURANT 4 VANS go up the street TO LANGE'S RESTAURANT; park on STREET (block) behind restaurant... or TURN AT Amoco, PARKING behind The RESTAURANT.

- PIPESTONE X-bedding on rock - path out N side, make left.
- good sed STRUCTURES at + around falls
- FIRST EXIT IN SD Amoco for fill up
- Exit 332, Continue straight, left onto Haven street, follow signs. left (?) @ TACO JOHNS, Right on Rowley, left (?) INTO Econo foods Parking lot.

WE ARRIVED @ 12:20 PM ON H.W. @ 1:35 PM Again

- INTO Chamberlain @ 2:30, OUT @ 2:55

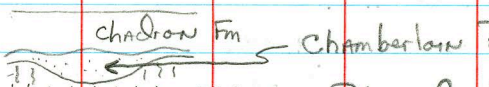
- depart 1:15 - to rest area at Chamberlain
  Glacial map - shaded map - ice marginal
  drainage - High PLAINS surface
  what looks like Black Hills - ISN'T
  maybe a rest stop - stop @ Kadoka
  for gas
- Cedar Pass - eastern entrance
  [Group C.g. is 50 m past info booth -
  [hard left
- landslide in The Pierre, Selenium in Pierre.
- mile 196 for Black Hills; gassed Di's van
  @ Murdo; Texaco + Amoco, easy in out
- IN Kadoka @ 3:38, out 4:00. Cedar Pass
  @ 4:30

at The Cedar Pass Campground IV

Badlands, Holocene story

White River @ 800m
Tables @ 830 m have a complete 3 tier
Holocene dunes atop maybe a late Pleist
sand + lake + fluvial
Table @ 950m - Pleistocene fluvial gravel
+ sand, Then big Holocene dunes
Parabolic dunes. → transport NW to SE
- Look for Pub by Elmo Rawling in The Holocene

Day 5 06/12/02 Badlands



Emmitt Evanoff GSA Special Pap mid 1990's.

Dennis Terry @ Temple

- I could use The Retallick diagrams on a poster board.
- Badlands Tour

STOP 1 - ~ miles SE of Interior on main Rd climb a kp hill N of Road. Ed gives lecture on formations. Does The Badlands stratigraphy.

STOP 2 - Conata Rd north towards Dillon Pass, to Pig Dig.

STOP 3 - Dillon Pass, Yellow Mounds The whole section is exposed here

STOP 4 The Pinnacles - Clastic dikes

STOP 5 Sage Crk Rd Prairie dog town, Sage Crk campground for bathroom. Beautiful Terraces of Sage Crk contrasting with The Pierre Shale hillslopes + colluvium. Supposedly ... These Terraces are late Holocene

STOP 6. Into Scenic, Then South to Sheep mtn Table - take NPS road to Sheep mtn table stop just past first wash - Chert, dolocedony dikes.

STOP 7. Sheep MT Table - Western flank for Holocene dune exposures

STOP 8. Scenic, Then home.

Black Hills Maps

Lisenbee, 1985, MS-13, Tectonic Map of The Black Hills, Geologic Survey of Wyoming.

USGS I-2298 Geologic Map of the Powder River Basin + surrounding area.

USGS I-1910, Geologic Map of the Black Hills, De Witt et al.

AGI - GSA Rocky Mt. Section, 1981, Geology of the Black Hills, SD 2nd edition, F. J. Rich.

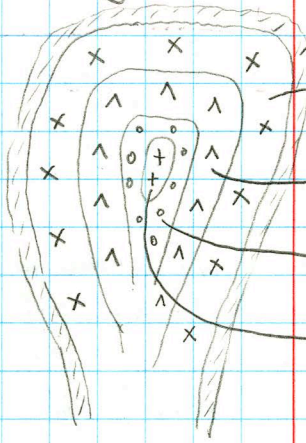
There is time in the Badlands to do a 2 hr exercise on finding yourself on a topo map. - sort of a simple orienteering - it should include a exercise in estimating distances... The "tour" should be shortened and more time should be spent describing the formations. Let them make observations

06/13/02

Day 6 Badlands - Black Hills - Spearfish

- Depart 8:00 AM, sketch fault rolling @ 8:30
- Into Wall - turn left on 5th, left at RR into parking lot., out of Wall @ 10:00 out Floyd street, Rt. on 7th, Rt. on Service Rd to I-90 W
- Hogback, Racetrack, dome, anticline
- Sysco Foods on E. Omaha street - possible place for bulk food buying. → see Day 3
- At Hubbard Grain elevator, drop Trailers Left on Rt 16 W, signs for Mt. Rushmore.
- 16A west to Mt. Rushmore
- Provart logger stays in Kagstone, Park @ info center. (why (?))
- Continue on Rt 16A to turnout + turn around. into Kagstone, Rt on cemetary Rd @ Roosevelt park @ first pull off below sport pile. ETA Mine
- For Spearfish I-90 to exit 12 - into town to main street (main drag) 2nd block after main drag, make a left @ big Texaco station. Gas there. This street takes us right to the city park.
- ☆ We actually gassed outside of Rapid at an Exxon.

ETTA Pegmatite



Sp = Spodumene

- Students out of town @ 11:30

- might be cool to do a (brief) hydro project here in Spearfish with all of the karst... water supply.

Problems w/ bars in Spearfish - too much access to cheap beer. An incentive must be instituted to encourage everyone home by 11:30.

Day 7 Spearfish 06/14/02

Liesegäng banding

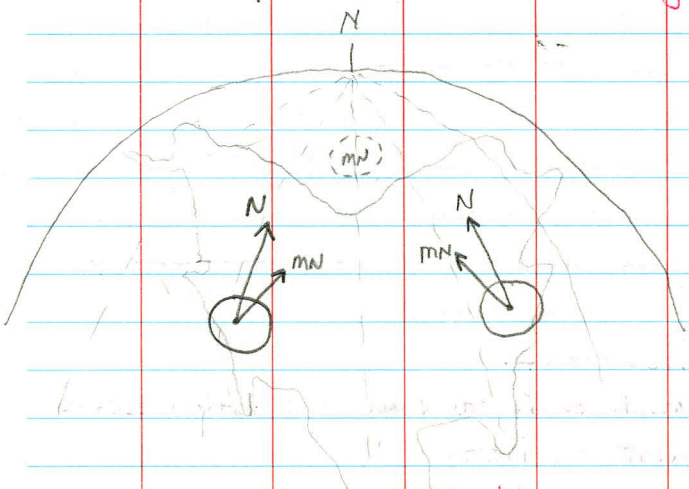
- we went @ 9:00, but we could easily move @ 8:00. Provided all are not hung over + add some substance

Spearfish Canyon - Lead.

- out back entrance to campground, up Spearfish Canyon.
- Pahasapa Fm. Mm - major cliff-former, dark weathering + cave formation - good road outcrop @ The Nat'l Forest Sign

STOP 1

- at The Why Die? sign - left side of Road - stop left. This is CONTACT btwn De + Mp Nice variation in bedding.



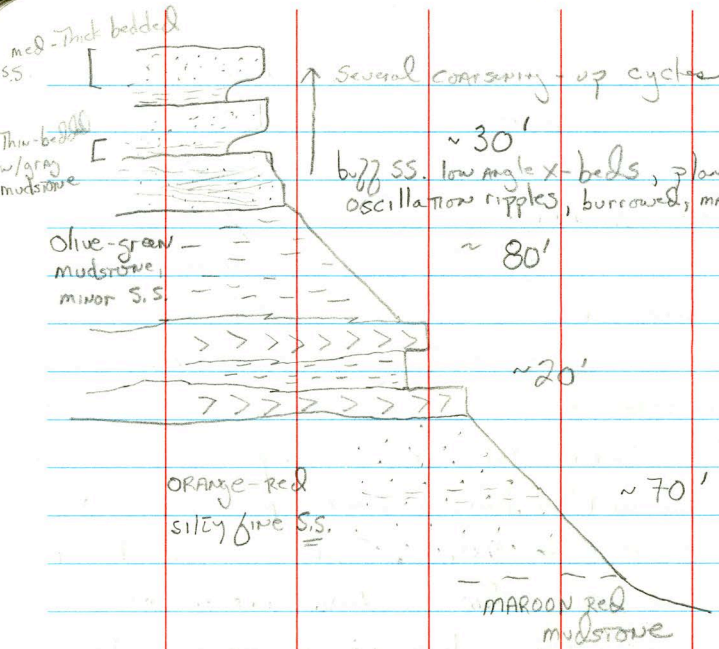
Too much driving, - with too little observations
Start of Black Hills is too esoteric to be of great use... A more general Treatment w/ emphasis on distinctions btwn early Pal late Pal, Mesozoic + Cenozoic Strata is in order

STOP 2 - pull off to right - Bridal Veil Falls
Phonolite intrusive.
€ deadwood - skolithus, glauconite-bearing
- STAY 14A towards Lead good opportunity
- There is a series of nice outcrops after the top crest of Rt. 14A - p€ schist cut by aplite dikes. hard rock opportunity.
- AT the light, past the High School, turn right at the Golden Hills Inn.

STOP 3 - Open Pit overview
- continue down into Lead, into Deadwood
- at The Hampton Inn, turn left onto dirt rd above walking / biking trail - continue to p€ - € boundary...
- Ed asks for a lecture on The Great Unconformity + explosion of life.
- Minne = water
- left, on dirt rd, rt onto main paved, left onto Rt 85

Section Measuring - Lookout Mtn
345° 8° NE

- lecture @ 1 - ~~1:45~~ Brunton - Jake lecture
- 1:~~45~~ - ~~3:00~~ 5:30 measure section
- 6:00 - Chili Dinner.


med - thick bedded SS.
Several coarsening-up cycles
~30'
Thin-bedded w/gray mudstone
buff SS. low angle x-beds, plane// oscillation ripples, burrowed, marine.
Olive-green mudstone, minor S.S.
~80'
~20'
ORANGE-RED silty fine S.S.
~70'
MAROON RED mudstone

DAY 8 Spearfish - Wyodack - Buffalo - Bighorns

- Take I-90 W
- I'll send Topos of our Campsites + 1:100k of Regional
- There is ample opportunity everywhere to speak of env sci issues
- Take Beulah exit, it is ~ 4-5 miles to Buffalo Jump on left. Good gas available at Beulah exit.
- Sundance Fm Redwater Shale, ss at base, LS at top
  Lak, Yellow, soft, calc. ss.
  Hulett SS massive yellow SS
  Stockade Beaver grag
- Exit 185 to Rt. 14 - Devil's Tower
- use Devil's Tower pull off. I need USGS Bulletin on Devil's Tower.
- Talk on Strat., composition of Tower
  alkali fspar, Nephaline + cpx Augite
  Types of plutons., Laramide orgeny, exhumation
- Out of Devil's Tower, up to Devil's Tower Junct, Rt towards Moorcroft on Rt. 14
- Look for little water tank - blue plastic one ~ 5-6 miles from the Junct. Rt side of Road
  Fossil - college site in Sundance Fm - Posted as No Trespassing.
- use Devil's Tower for Bathroom... or Nice rest Area just north of the I-90 Moorcroft exit.
  ~~Just~~ Bathrooms are smelly.

Sundance Fm

Problem w/ parking, drop Trailers? Lead vehicle should go ahead to secure parking

Butter Thin fossil site (posted)

Bighorns (1) Fault exposure, pull off to left
(2) Stop @ the pass
(3) Into camp - Willow Park - Groups only

Powder River basin - Geology of Wyoming or so...

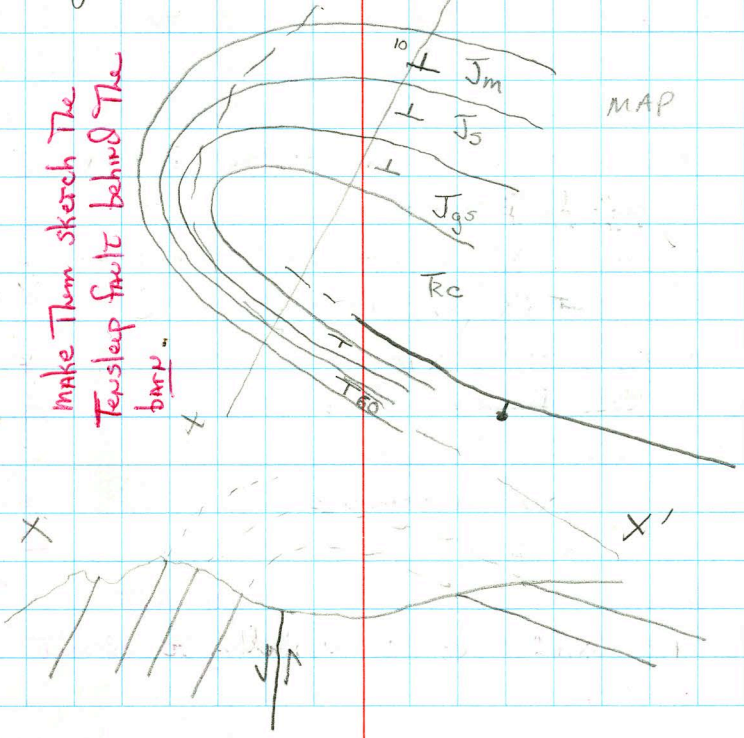
- Wyodack Exit. Wyodack RR. Clinker + Coal.
Roan Seam, Ft. Union Fm - Paleocene.
- To exit 58, RT 16, Buffalo
come around back side of mine to overlook.
Pick up some klinker and play a game in the vans to describe it.
- Down Tensleep to old Hwy 16 FS 18
left hand turn
- Amsden Fm is well exposed at fish hatchery at foot of Tensleep Canyon.
- Stop in the Gypsum Springs - Algal limestone
- collect fossils in the Sundance.
- Show off Ten Sleep fault + Anticlinal nose.
- we need the geologic goods for the Bighorn Basin + mouth of Tensleep Cny.

Tacky gift contest, mulled wine.
build up fire pit, make altar of tack.

Day 9 Bighorns - Tensleep

- Depart @ 9:00 for tour of Bighorn Rocks + stratigraphy - Tensleep Canyon to Tensleep; Tensleep fault, Mesozoic rocks, Flathead SS + migmatite @ Meadowlark lodge; Facies change in Jgs, fossil collecting in Js
- Also.... point out glacial deposits and slumps / landslides.
- The Tensleep visitor's center makes fresh deli sandwiches.

Make them sketch the Tensleep fault behind the barn.



I need good map for here.

- Wy 436 - Nice side drive to see Tensleep dip slope +
- Gneiss + €f

Orthogneiss, from an earlier granite

Gneiss w/ igneous texture in pink seluages

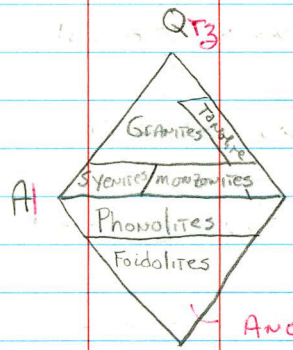
Migmatite - at high P+T at Amphibolite facies ... difference btwn Amphibolite + granulite is that the granulite is dehydrated, making pyroxene.

grant opportunity for more hard rock.

leucosomes - The felsic seluages

melanosome - The Amphibolite phase.

- Archean migmatite - partial melts, parent was a diorite; brittle ductile transition



Anorthosite?

locate with a GPS + Altimeter

Grid on topo map

There is much time left over in AM

41 - should go down valley to collect fossils.

341 - should do a pace + compass map or something with Technology .. like learn how to

Day 10 June 17th

→ park in front of Baptist Church on ~~Main~~ drag.

- Try to Arrive at 4:00 PM
- Worland - 30 min for food, restrooms - in City Hall basement
  - Thermopolis
- Wind River Cny. - Boysen Res (STOP.)
- Dubois - Morrison
- continental divide @ Towogote Pass
- Park on main drag - right in Worland @ courthouse - Baptist Church. 30 min stop
- Parking good for Great Unconformity in Owl Creeks; Normal Fault at Boysen Res - Don Wise Paper
- Get geologic maps for Owl Creeks - we need to be able to do the geology of the S Wind River canyon - Chugwater exposure.
- easy Texaco gas in Shoshoni - BK here too, good for Lunch.
- There is an Exxon in Crowheart that might do in a pinch.
- Nice section ~ 8km SE of Dubois - including Nugget SS.
- Texaco, Sinclair + Exxon (2) in Dubois → ok to gas if we split up.. good for after lunch broom too.
- There is a little roadside rest Area to left w/ monument + ~~Flowers~~ ~ 20 km after Dubois

B-rooms

- Great Volcanic Breccias exposed just before cont. divide, they are preceded by a PICNIC AREA... poor parking, but good parking in the cont divide pull off before the divide.
- Togwottee pull off for picture of Tetonsa bathroom
- There is A big pull off TO RIGHT TO do The Tertiary conglomerates... if we WANTED TO...
- Snake River Overlook

best option

I had them into camp by 5:00PM

- Get Fire Pit made - collect enough wood to split + burn Thereve
- lay out Tents
- stay with kiesh + set-up kitchen
- Ed takes TAs TO Camp DAVIS for A Shower + TWO other TRAILERS.
- set up our camp.

Day 11, Wed June 19, 2002 ☼ cool

Day 66

morning – get wood, set up big tent
make your own b-fast, get TA's
squared away w/ schedule.

Assemble for ride into town @ 1:00 PM

Red Hills mapping schedule.

Day 1, Thursday June 20th.

measure section in the morning, return to camp noonish. Brief lecture on drafting strategies @ 1:00. Draft outside - have 41 students alone. Lecture brief in morn about keeping camp clean, + doing work, like a traditional geologist. + schedule.

Get Mylar boards ready

sections in @ ~~5:00 PM~~ 6:00 PM

Day 2; Friday June 21st

Tour from Kelly Hot Spring to Crystal Creek in morning. Lecture in morning regarding The postage stamp map. Lunch in map area. Kurt will lecture on what he wants them to do. Maps in @ 5:00 PM.

Take colored pencils and pencil

Second tutorial on Bruntons in eve

Day 3, Saturday June 22nd

lecture + feedback on 1st postage stamp, get 2nd

postage stamp topos - into field. Maps due @ 5:00 PM. Take colored pencils into field.

Day 4, Sunday June 23rd
Distribute Airphotos in morning. Feedback on 2nd postage stamp. Kent Creek area - find "open patches" on topo + air photo.
Eve - TAs run a lecture on airphoto use.

Day 5, Monday June 24th
Oil well canyon - Trd + Trc plan traverse - make sure you are taking strike + dips
Swap @ 3:00. Depart for town @ 6:00 PM after early dinner.

Day 6, Tuesday June 25th
Nugget Ridge, lecture on pulling maps together. Full day mapping. Lecture on stereonets in eve.

Day 7, Wednesday, June 26th
Plan your own traverse. Full day mapping.
Evening exercise on pull x-section topography + laying out final map mylar.
Post what final layout should be.

Day 8 Thursday, June 27th

Drafting day. Maps due @ 7:00 PM. My dinner @ 7:00. I will accept maps until 11:00 (with a half a letter grade deduction).

Grading

(1) STRAT Section

40 Accuracy, contacts, correlation
40 unit descriptions
20 column "pen-man, pen-woman-ship. layout

(2) Mapping

10 Postage stamp 1
10 Postage stamp 2
10 Legend
10 stereoplots
15 cross section
40 contacts, map accuracy
5 lay-out

A+	A	A-	B+	B	B-	C+	C	D	F
100	95	90	87	84	80	75	70	60	<60

DAY 12 THURSDAY JUNE 20TH, 2002

MEASURED SECTION TODAY. MAJOR "NEW" OBSERVATIONS.

- GRYPHIA (OYSTERS) IN lower SUNDANCE. V. SIMILAR TO SUNDANCE FM SECTION @ TENSLEEP.
- NICE COARSENING-UP PACKAGES IN UPPER SUNDANCE - very NICE regressional shoreline there.
- BEST TO GET THERE OUT TO THE SECTION AS early as possible - we left @ 12:45 PM.
- remember TO HAVE STUDENTS SIGHT along bedding TO keep themselves oriented along section - dip section.
- MAKE SURE STUDENTS UNDERSTAND symbols, + WAYS TO USE SHADAMS TO correlate.

Sections due @ 6:00 PM

4/5 get wood

DAY 13 FRIDAY JUNE 21ST 2002

- Kelly Hot Springs, slide, Hog shot pull off, Crystal Creek.
- They should be @ Red Hills RANCH TRAL by 12:15

MAP IN @ VANS

DAY 14 SATURDAY, JUNE 22ND hail!

- Horsetail POSTAGE STAMP.
- very NICE! complicated, but STUDENTS are getting IT. NICE fault with ??? SCISSORS ??? motion on IT at THE NOSE of THE FRONTIER jeep TRAIL.

MAPS IN @ VANS.

Day 15, Sunday, June 23rd warm.

- Atherton Creek, Tent Creek area. Half day for me, Atherton Creek, Then into Horsetail + out.
- There is a good trail from Horsetail to the Jm knob in Tent Creek, up the Kc cliff - high danger! No-one is off the trail!! Trail continues all the way up to 7925 + the 8160' triangular peak at the map boundary. 7925 + the flanks of 8160' have Tkp gravels ~ 40' thick.

Day 16 Monday, June 24th warm

- Nugget Ridge, out through one of the ridges east of the 8423 hill.
- collected samples of Tkl and Tk-Jn for the student exam.
- out of field by 3:00 Pm for early dinner + eve in Jackson.
- This is a really good day for the students to see the folds. Keep it as is... maybe change the order of Day 14 + 15..

Day 17 Tuesday, June 25th

- students mapping on their own - oil well drainage
- Tkl is exposed beginning about 7300' through 7400'. Oil well @ 7490'.
- Spend until ~ noon with the kids @ the faults + well

I have it on my map.

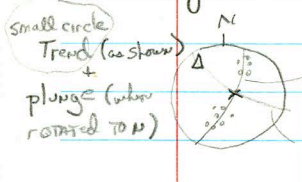
- very nice little fault 250° 60 N at first little side drainage of oil well drainage.
- Do a lecture @ a central location for a down-plunge prediction of what they should see in oil well canyon at the well. Have everyone meet @ noon

Day 18 Wednesday June 26th

hot

aft

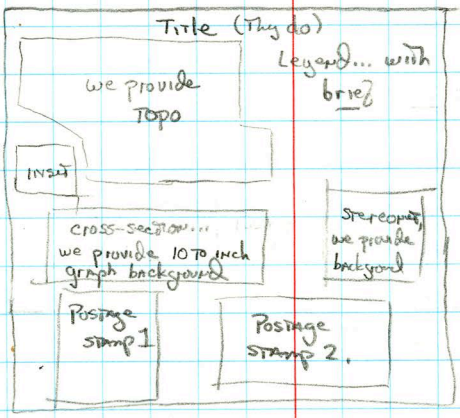
- IN TOWN shopping - for Thursday meal
  - 30 lbs potatos, 30 eggs, 15+ lbs of flour 5 lbs butter, sage, deli meats (4 lbs) cheese (2 lbs), Artichoke, olive, romano (get more!) 5 packages oreos + 4 gallons milk for dessert
- Students mapped on their own
- cross-sections in the evening .... They do not know how to do cross-sections - They need help with this - scales,
- make map 1:18,000 .... Then 1" = 150' and you can fit on the "forbidden outcrop"
- Stereonet plots look pretty good - The fold actually has a porposing axial line



- make them find fold axis too and represent it on X-section. They need to take accurate strikes + dips.

DAY 19 Thursday, June 27th ☀ AFT 3

- DRAFTING DAY - They did complete everything by 8:00PM
- we should make A photomylar with all topo LAND out.



They get This early, + can TRANSfer whenever They want

DAY 20 Friday, June 28th ☀ HOT

- MORNING off - FLOAT TRIP @ 6:30 ~
- drivers needed TO shuttle VANS ~3 needed.
- TOO much free TIME, STUDENTS INTO TOWN @ 2:00 with MAPS IN @ 8:00 PM The previous eve, 341 should lead A fieldTRIP for 41 TO show off ANTICLINE, (10-12), 41 should do A presentation ON The eco/FUNDS data (12:30 - 1:30), VANS off @ 2:00 PM.

F 1.0 3970A

NM 98 NM 75 black SATIN.

NM 498 JBL

KURT kempter

2002 Names + contacts

Chris Jenkins USFS Jemez Springs Archaeologist

Joe(sephine) Wargo - USFS (from Shamokin)
John Peterson - District Ranger
Clyde Landry Fr. Fitzgerald Church
Shari's Brother-in-law property combo 4646
Janice Little - Fr. Fitzgerald Center
Kurt Kempter
Amanda Ault
Andrew Drabick
Shari Kelley
general deliv, Jemez Spgs 87025
Max Sabado - Sheriff Jemez Springs

Rio Grande

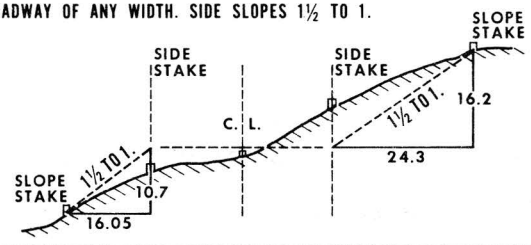
Rio Grande -S TO MATHEW, bends left
Zicart, just before Indian School. Floral
shop. Right on Zicart 4-way stop
Big Cottonwood Trees.

INDEX OF
CURVE AND REDUCTION TABLES

TABLE I. SLOPE STAKE

DISTANCES FROM SIDE STAKES FOR CROSS-SECTIONING

ROADWAY OF ANY WIDTH. SIDE SLOPES 1½ TO 1.



Cut or Fill	Distance out from Side or Shoulder Stake.										Cut or Fill
	0	.1	.2	.3	.4	.5	.6	.7	.8	.9	
0	0 00	0 15	0.30	0.45	0.60	0.75	0.90	1.05	1.20	1.35	0
1	1.50	1 65	1 80	1.95	2.10	2.25	2.40	2.55	2.70	2.85	1
2	3.00	3.15	3.30	3 45	3.60	3 75	3.90	4.05	4.20	4 35	2
3	4.50	4 65	4.80	4.95	5 10	5 25	5 40	5.55	5.70	5.85	3
4	6.00	6 15	6.30	6.45	6.60	6 75	6.90	7.05	7.20	7.35	4
5	7 50	7.65	7.80	7.95	8.10	8.25	8.40	8.55	8.70	8.85	5
6	9 00	9 15	9.30	9.45	9.60	9.75	9.90	10.05	10.20	10.35	6
7	10.50	10 65	10.80	10.95	11.10	11.25	11.40	11.55	11 70	11.85	7
8	12.00	12 15	12.30	12.45	12.60	12.75	12.90	13 05	13.20	13.35	8
9	13 50	13.65	13 80	13 95	14.10	14.25	14.40	14 55	14.70	14.85	9
10	15.00	15 15	15 30	15 45	15.60	15.75	15.90	16.05	16.20	16 35	10
11	16 50	16 65	16 80	16.95	17 10	17.25	17.40	17.55	17.70	17.85	11
12	18 00	18 15	18.30	18 45	18.60	18 75	18.90	19.05	19.20	19 35	12
13	19 50	19 65	19.80	19.95	20.10	20.25	20 40	20.55	20.70	20.85	13
14	21.00	21 15	21.30	21.45	21 60	21.75	21.90	22 05	22 20	22 35	14
15	22 50	22 65	22 80	22 95	23.10	23.25	23.40	23.55	23.70	23.85	15
16	24.00	24 15	24 30	24 45	24 60	24.75	24 90	25 05	25.20	25.35	16
17	25.50	25 65	25.80	25 95	26.10	26 25	26 40	26.55	26.70	26.85	17
18	27.00	27 15	27.30	27 45	27.60	27.75	27.90	28.05	28 20	28.35	18
19	28 50	28 65	28 80	28.95	29.10	29.25	29.40	29.55	29.70	29.85	19
20	30 00	30 15	30.30	30.45	30.60	30.75	30.90	31.05	31.20	31.35	20
21	31 50	31 65	31.80	31.95	32 10	32 25	32.40	32.55	32 70	82 85	21
22	33 00	33 15	33 30	33 45	33.60	33 75	33.90	34.05	34.20	34.35	22
23	34 50	34 65	34.80	34.95	35.10	85 25	35 40	35.55	35.70	35 85	23
24	86 00	86 15	36.30	36 45	36.60	36.75	36.90	37.05	37.20	37.35	24
25	37.50	37.65	37 80	37.95	38.10	38.25	38.40	38.55	38.70	38.85	25
26	39 00	39 15	39.30	39 45	39 60	39.75	39.90	40.05	40.20	40.35	26
27	40 50	40 65	40 80	40.95	41.10	41.25	41 40	41.55	41.70	41.85	27
28	42 00	42 15	42.30	42.45	42.60	42 75	42.90	43.05	43.20	43.35	28
29	43 50	43 65	43.80	43 95	44.10	44 25	44 40	44.55	44.70	44 85	29
30	45 00	45 15	45.30	45 45	45.60	45.75	45.90	46.05	46 20	46.35	30
31	46.50	46.65	46.80	46 95	47.10	47.25	47.40	47.55	47.70	47.85	31
32	48 00	48.15	48.30	48 45	48.60	48 75	48.90	49.05	49 20	49.35	32
33	49.50	49 65	49.80	49.95	50.10	50.25	50.40	50.55	50.70	50.85	33
34	51 00	51.15	51.30	51.45	51.60	51.75	51.90	52.05	52.20	52.35	34
35	52 50	52.65	52.80	52.95	53.10	53.25	53.40	53.55	53.70	53.85	35
36	54 00	54.15	54.30	54 45	54.60	54.75	54.90	55.05	55.20	55.35	36
37	55 50	55 65	55.80	55.95	56.10	56.25	56.40	56.55	56.70	56.85	37
38	57.00	57.15	57.30	57 45	57.60	57 75	57.90	58.05	58.20	58 35	38
39	58 50	58.65	58 80	58.95	59.10	59 25	59.40	59 55	59.70	59.85	39
40	60 00	60.15	60 30	60 45	60 60	60.75	60 90	61.05	61 20	61.35	40

TABLE II. STADIA CORRECTION AND HORIZONTAL DISTANCES

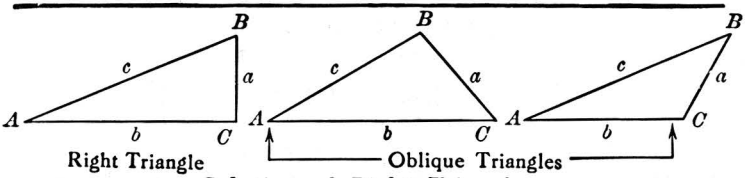
STADIA REDUCTIONS FOR READING 100

Vertical Angle	Horizontal Correction	Difference in Elevation	Vertical Angle	Horizontal Correction	Difference in Elevation
2°—00′	0.1	3.5	18°—30′	10.1	30.1
3°—00′	0.3	5.3	19°—00′	10.6	30.8
4°—00′	0.5	7.0	19°—30′	11.2	31.5
5°—00′	0.8	8.7	20°—00′	11.7	32.1
6°—00′	1.1	10.4	20°—30′	12.3	32.8
7°—00′	1.5	12.1	21°—00′	12.8	33.5
8°—00′	1.9	13.8	21°—30′	13.4	34.1
9°—00′	2.5	15.5	22°—00′	14.0	34.7
10°—00′	3.0	17.10	22°—30′	14.7	35.4
10°—30′	3.3	17.9	23°—00′	15.3	36.0
11°—00′	3.6	18.7	23°—30′	15.9	36.6
11°—30′	4.0	19.5	24°—00′	16.5	37.2
12°—00′	4.3	20.3	24°—30′	17.2	37.7
12°—30′	4.7	21.1	25°—00′	17.9	38.3
13°—00′	5.1	21.9	25°—30′	18.6	39.0
13°—30′	5.5	22.7	26°—00′	19.2	39.4
14°—00′	5.9	23.4	26°—30′	19.9	39.9
14°—30′	6.3	24.2	27°—00′	20.6	40.5
15°—00′	6.7	25.0	27°—30′	21.3	41.0
15°—30′	7.2	25.8	28°—00′	22.0	42.0
16°—00′	7.6	26.5	28°—30′	22.8	41.9
16°—30′	8.1	27.2	29°—00′	23.5	42.4
17°—00′	8.5	28.0	29°—30′	24.3	42.9
17°—30′	9.0	28.7	30°—00′	25.0	43.3
18°—00′	9.5	29.4			

Chains to Feet	
1	66
2	132
3	198
4	264
5	330
6	396
7	462
8	528
9	594
10	660

Feet to Chains	
100	1.515
200	3.030
300	4.545
400	6.060
500	7.575
600	9.090
700	10.606
800	12.121
900	13.636
1,000	15.151

TABLE III. TRIGONOMETRIC FORMULAE



Solution of Right Triangles

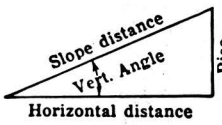
For Angle A. $\sin = \frac{a}{c}$, $\cos = \frac{b}{c}$, $\tan = \frac{a}{b}$, $\cot = \frac{b}{a}$, $\sec = \frac{c}{b}$, $\operatorname{cosec} = \frac{c}{a}$

Given	Required	
a, b	A, B, c	$\tan A = \frac{a}{b} = \cot B, c = \sqrt{a^2 + b^2} = a\sqrt{1 + \frac{b^2}{a^2}}$
a, c	A, B, b	$\sin A = \frac{a}{c} = \cos B, b = \sqrt{(c+a)(c-a)} = c\sqrt{1 - \frac{a^2}{c^2}}$
A, a	B, b, c	$B = 90° - A, b = a \cot A, c = \frac{a}{\sin A}$
A, b	B, a, c	$B = 90° - A, a = b \tan A, c = \frac{b}{\cos A}$
A, c	B, a, b	$B = 90° - A, a = c \sin A, b = c \cos A$

Solution of Oblique Triangles

Given	Required	
A, B, a	b, c, C	$b = \frac{a \sin B}{\sin A}, C = 180° - (A + B), c = \frac{a \sin C}{\sin A}$
A, a, b	B, c, C	$\sin B = \frac{b \sin A}{a}, C = 180° - (A + B), c = \frac{a \sin C}{\sin A}$
a, b, C	A, B, c	$A + B = 180° - C, \tan \frac{1}{2}(A - B) = \frac{(a-b)\tan \frac{1}{2}(A+B)}{a+b}$, $c = \frac{a \sin C}{\sin A}$
a, b, c	A, B, C	$s = \frac{a+b+c}{2}, \sin \frac{1}{2}A = \sqrt{\frac{(s-b)(s-c)}{bc}}$, $\sin \frac{1}{2}B = \sqrt{\frac{(s-a)(s-c)}{ac}}, C = 180° - (A+B)$
a, b, c	Area	$s = \frac{a+b+c}{2}$, area $= \sqrt{s(s-a)(s-b)(s-c)}$
A, b, c	Area	area $= \frac{b c \sin A}{2}$
A, B, C, a	Area	area $= \frac{a^2 \sin B \sin C}{2 \sin A}$

REDUCTION TO HORIZONTAL



Horizontal distance = Slope distance multiplied by the cosine of the vertical angle. Thus: slope distance = 319.4 ft. Vert. angle = 5° 10′. From Table, IV. cos 5° 10′ = .9959. Horizontal distance = 319.4 × .9959 = 318.09 ft.

Horizontal distance also = Slope distance minus slope distance times (1 − cosine of vertical angle). With the same figures as in the preceding example, the following result is obtained. Cosine 5° 10′ = .9959. 1 − .9959 = .0041. 319.4 × .0041 = 1.31. 319.4 − 1.31 = 318.09 ft.

When the rise is known, the horizontal distance is approximately: — the slope distance less the square of the rise divided by twice the slope distance. Thus: rise = 14 ft., slope distance = 302.6 ft. Horizontal distance $= 302.6 - \frac{14 \times 14}{2 \times 302.6} = 302.6 - 0.32 = 302.28$ ft.

TABLE IV. NATURAL TRIGONOMETRICAL FUNCTIONS

Angle	Sin	Tan.	Sec.	Cosec.	Cotg.	Cosin.		Angle	Sin.	Tan.	Sec.	Cosec.	Cotg.	Cosin.	
° ′								° ′							
0	0	0	1.	∞	∞	1.	90	8	.1392	.1405	1.0098	7.185	7.115	.99027	82
10	.0029	.0029		343.8	343.8	1.	50	10	.1421	.1435	1.0102	7.040	6.968	.98986	50
20	.0058	.0058		171.9	171.9	.99998	40	20	.1449	.1465	1.0107	6.900	6.827	.98944	40
30	.0087	.0087		114.6	114.6	.99996	30	30	.1478	.1495	1.0111	6.766	6.691	.98902	30
40	.0116	.0116	1.0001	85.94	85.94	.99993	20	40	.1507	.1524	1.0115	6.636	6.561	.98858	20
50	.0145	.0145	1.0001	68.76	68.75	.99989	10	50	.1536	.1554	1.0120	6.512	6.435	.98814	10
1	.0175	.0175	1.0002	57.30	57.29	.99985	89	9	.1564	.1584	1.0125	6.394	6.314	.98769	81
10	.0204	.0204	1.0002	49.11	49.10	.99979	50	10	.1593	.1614	1.0129	6.277	6.197	.98723	50
20	.0233	.0233	1.0003	42.98	42.96	.99973	40	20	.1622	.1644	1.0134	6.166	6.084	.98676	40
30	.0262	.0262	1.0003	38.20	38.19	.99966	30	30	.1650	.1673	1.0139	6.059	5.976	.98629	30
40	.0291	.0291	1.0004	34.38	34.37	.99958	20	40	.1679	.1703	1.0144	5.955	5.871	.98580	20
50	.0320	.0320	1.0005	31.26	31.24	.99949	10	50	.1708	.1733	1.0149	5.855	5.769	.98531	10
2	.0349	.0349	1.0006	28.65	28.64	.99939	88	10	.1736	.1763	1.0154	5.759	5.671	.98481	80
10	.0378	.0378	1.0007	26.45	26.43	.99929	50	10	.1765	.1793	1.0160	5.665	5.576	.98430	50
20	.0407	.0407	1.0008	24.56	24.54	.99917	40	20	.1794	.1823	1.0165	5.575	5.485	.98378	40
30	.0436	.0437	1.0010	22.93	22.90	.99905	30	30	.1822	.1853	1.0170	5.488	5.396	.98325	30
40	.0465	.0466	1.0011	21.49	21.47	.99892	20	40	.1851	.1883	1.0176	5.403	5.309	.98272	20
50	.0494	.0495	1.0012	20.23	20.21	.99878	10	50	.1880	.1914	1.0181	5.320	5.226	.98218	10
3	.0523	.0524	1.0014	19.11	19.08	.99863	87	11	.1908	.1944	1.0187	5.241	5.145	.98163	79
10	.0552	.0553	1.0015	18.10	18.07	.99847	50	10	.1937	.1974	1.0193	5.164	5.066	.98107	50
20	.0581	.0582	1.0017	17.20	17.17	.99831	40	20	.1965	.2004	1.0199	5.089	4.989	.98050	40
30	.0610	.0612	1.0019	16.38	16.35	.99813	30	30	.1994	.2035	1.0205	5.016	4.915	.97992	30
40	.0640	.0641	1.0020	15.64	15.60	.99795	20	40	.2022	.2065	1.0211	4.945	4.843	.97934	20
50	.0669	.0670	1.0022	14.96	14.92	.99776	10	50	.2051	.2095	1.0217	4.877	4.773	.97875	10
4	.0698	.0699	1.0024	14.34	14.30	.99756	86	12	.2079	.2126	1.0223	4.810	4.705	.97815	78
10	.0727	.0729	1.0027	13.76	13.73	.99736	50	10	.2108	.2156	1.0230	4.745	4.638	.97754	50
20	.0756	.0758	1.0029	13.23	13.20	.99714	40	20	.2136	.2186	1.0236	4.682	4.574	.97692	40
30	.0785	.0787	1.0031	12.75	12.71	.99692	30	30	.2164	.2217	1.0243	4.620	4.511	.97630	30
40	.0814	.0816	1.0033	12.29	12.25	.99668	20	40	.2193	.2247	1.0249	4.560	4.449	.97566	20
50	.0843	.0846	1.0036	11.87	11.83	.99644	10	50	.2221	.2278	1.0256	4.502	4.390	.97502	10
5	.0872	.0875	1.0038	11.47	11.43	.99619	85	13	.2250	.2309	1.0263	4.445	4.331	.97437	77
10	.0901	.0904	1.0041	11.10	11.06	.99594	50	10	.2278	.2339	1.0270	4.390	4.275	.97371	50
20	.0929	.0934	1.0043	10.76	10.71	.99567	40	20	.2306	.2370	1.0277	4.336	4.219	.97304	40
30	.0958	.0963	1.0046	10.43	10.39	.99540	30	30	.2334	.2401	1.0284	4.284	4.165	.97237	30
40	.0987	.0992	1.0049	10.13	10.08	.99511	20	40	.2363	.2432	1.0291	4.232	4.113	.97169	20
50	.1016	.1022	1.0052	9.839	9.788	.99482	10	50	.2391	.2462	1.0299	4.182	4.061	.97100	10
6	.1045	.1051	1.0055	9.567	9.514	.99452	84	14	.2419	.2493	1.0306	4.133	4.011	.97030	76
10	.1074	.1080	1.0058	9.309	9.255	.99421	50	10	.2447	.2524	1.0314	4.086	3.962	.96959	50
20	.1103	.1110	1.0061	9.065	9.010	.99390	40	20	.2476	.2555	1.0321	4.039	3.914	.96887	40
30	.1132	.1139	1.0065	8.834	8.777	.99357	30	30	.2504	.2586	1.0329	3.994	3.867	.96815	30
40	.1161	.1169	1.0068	8.614	8.556	.99324	20	40	.2532	.2617	1.0337	3.949	3.821	.96742	20
50	.1190	.1198	1.0072	8.405	8.345	.99290	10	50	.2560	.2648	1.0345	3.906	3.776	.96667	10
7	.1219	.1228	1.0075	8.206	8.144	.99255	83	15	.2588	.2679	1.0353	3.864	3.732	.96593	75
10	.1248	.1257	1.0079	8.016	7.953	.99219	50	10	.2616	.2711	1.0361	3.822	3.689	.96517	50
20	.1276	.1287	1.0082	7.834	7.770	.99182	40	20	.2644	.2742	1.0369	3.782	3.647	.96440	40
30	.1305	.1317	1.0086	7.661	7.596	.99144	30	30	.2672	.2773	1.0377	3.742	3.606	.96363	30
40	.1334	.1346	1.0090	7.496	7.429	.99106	20	40	.2700	.2805	1.0386	3.703	3.566	.96285	20
50	.1363	.1376	1.0094	7.337	7.269	.99067	10	50	.2728	.2836	1.0394	3.665	3.526	.96206	10
							82								74
							° ′								° ′
	Cosin	Cotg.	Cosec.	Sec.	Tan.	Sin.	Angle		Cosin.	Cotg.	Cosec.	Sec.	Tan.	Sin.	Angle

TABLE IV CONTD. NATURAL TRIGONOMETRICAL FUNCTIONS

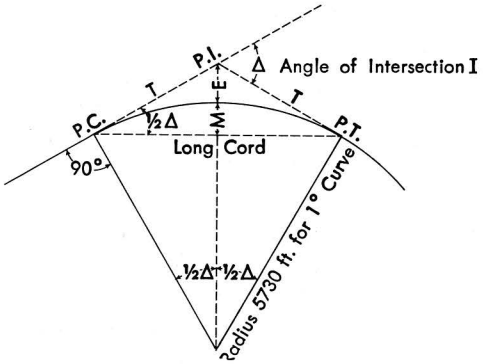
Angle	Sin.	Tan.	Sec.	Cosec.	Cotg.	Cosin.		Angle	Sin.	Tan.	Sec.	Cosec.	Cotg.	Cosin.	
° ′								° ′							
16	.2756	.2867	1.0403	3.628	3.487	.96126	**74**	**24**	.4067	.4452	1.0946	2.459	2.246	.91355	**66**
10	.2784	.2899	1.0412	3.592	3.450	.96046	50	10	.4094	.4487	1.0961	2.443	2.229	.91236	50
20	.2812	.2931	1.0423	3.556	3.412	.95964	40	20	.4120	.4522	1.0975	2.427	2.211	.91116	40
30	.2840	.2962	1.0429	3.521	3.376	.95882	30	30	.4147	.4557	1.0989	2.411	2.194	.90996	30
40	.2868	.2994	1.0438	3.487	3.340	.95799	20	40	.4173	.4592	1.1004	2.396	2.177	.90875	20
50	.2896	.3026	1.0448	3.453	3.305	.95715	10	50	.4200	.4628	1.1019	2.381	2.161	.90753	10
17	.2924	.3057	1.0457	3.420	3.271	.95630	**73**	**25**	.4226	.4663	1.1034	2.366	2.145	.90631	**65**
10	.2952	.3089	1.0466	3.388	3.237	.95545	50	10	.4253	.4699	1.1049	2.351	2.128	.90507	50
20	.2979	.3121	1.0476	3.357	3.204	.95459	40	20	.4279	.4734	1.1064	2.337	2.112	.90383	40
30	.3007	.3153	1.0485	3.326	3.172	.95372	30	30	.4305	.4770	1.1079	2.323	2.097	.90259	30
40	.3035	.3185	1.0495	3.295	3.140	.95284	20	40	.4331	.4806	1.1095	2.309	2.081	.90133	20
50	.3062	.3217	1.0505	3.265	3.108	.95195	10	50	.4358	.4841	1.1110	2.295	2.066	.90007	10
18	.3090	.3249	1.0515	3.236	3.078	.95106	**72**	**26**	.4384	.4877	1.1126	2.281	2.050	.89879	**64**
10	.3118	.3281	1.0525	3.207	3.048	.95015	50	10	.4410	.4913	1.1142	2.268	2.035	.89752	50
20	.3145	.3314	1.0535	3.179	3.018	.94924	40	20	.4436	.4950	1.1158	2.254	2.020	.89623	40
30	.3173	.3346	1.0545	3.152	2.989	.94832	30	30	.4462	.4986	1.1174	2.241	2.006	.89493	30
40	.3201	.3378	1.0555	3.124	2.960	.94740	20	40	.4488	.5022	1.1190	2.228	1.991	.89363	20
50	.3228	.3411	1.0566	3.098	2.932	.94646	10	50	.4514	.5059	1.1207	2.215	1.977	.89232	10
19	.3256	.3443	1.0576	3.072	2.904	.94552	**71**	**27**	.4540	.5095	1.1223	2.203	1.963	.89101	**63**
10	.3283	.3476	1.0587	3.046	2.877	.94457	50	10	.4566	.5132	1.1240	2.190	1.949	.88968	50
20	.3311	.3508	1.0598	3.020	2.850	.94361	40	20	.4592	.5169	1.1257	2.178	1.935	.88835	40
30	.3338	.3541	1.0608	2.996	2.824	.94264	30	30	.4617	.5206	1.1274	2.166	1.921	.88701	30
40	.3365	.3574	1.0619	2.971	2.798	.94167	20	40	.4643	.5243	1.1291	2.154	1.907	.88566	20
50	.3393	.3607	1.0631	2.947	2.773	.94068	10	50	.4669	.5280	1.1308	2.142	1.894	.88431	10
20	.3420	.3640	1.0642	2.924	2.747	.93969	**70**	**28**	.4695	.5317	1.1326	2.130	1.881	.88295	**62**
10	.3448	.3673	1.0653	2.900	2.723	.93869	50	10	.4720	.5354	1.1343	2.119	1.868	.88158	50
20	.3475	.3706	1.0665	2.878	2.699	.93769	40	20	.4746	.5392	1.1361	2.107	1.855	.88020	40
30	.3502	.3739	1.0676	2.856	2.675	.93667	30	30	.4772	.5430	1.1379	2.096	1.842	.87882	30
40	.3529	.3772	1.0688	2.833	2.651	.93565	20	40	.4797	.5467	1.1397	2.085	1.829	.87743	20
50	.3557	.3805	1.0700	2.811	2.628	.93462	10	50	.4823	.5505	1.1415	2.073	1.816	.87603	10
21	.3584	.3839	1.0711	2.790	2.605	.93358	**69**	**29**	.4848	.5543	1.1434	2.063	1.804	.87462	**61**
10	.3611	.3872	1.0723	2.769	2.583	.93253	50	10	.4874	.5581	1.1452	2.052	1.792	.87321	50
20	.3638	.3906	1.0736	2.749	2.560	.93148	40	20	.4899	.5619	1.1471	2.041	1.780	.87178	40
30	.3665	.3939	1.0748	2.729	2.539	.93042	30	30	.4924	.5658	1.1490	2.031	1.767	.87036	30
40	.3692	.3973	1.0760	2.709	2.517	.92935	20	40	.4950	.5696	1.1509	2.020	1.756	.86892	20
50	.3719	.4006	1.0773	2.689	2.496	.92827	10	50	.4975	.5735	1.1528	2.010	1.744	.86748	10
22	.3746	.4040	1.0785	2.670	2.475	.92718	**68**	**30**	.5000	.5774	1.1547	2.000	1.732	.86603	**60**
10	.3773	.4074	1.0798	2.650	2.455	.92609	50	10	.5025	.5812	1.1566	1.990	1.720	.86457	50
20	.3800	.4108	1.0811	2.632	2.434	.92499	40	20	.5050	.5851	1.1586	1.980	1.709	.86310	40
30	.3827	.4142	1.0824	2.613	2.414	.92388	30	30	.5075	.5890	1.1606	1.970	1.698	.86163	30
40	.3854	.4176	1.0837	2.595	2.394	.92276	20	40	.5100	.5930	1.1626	1.961	1.686	.86015	20
50	.3881	.4210	1.0850	2.577	2.375	.92164	10	50	.5125	.5969	1.1646	1.951	1.675	.85866	10
23	.3907	.4245	1.0864	2.559	2.356	.92050	**67**	**31**	.5150	.6009	1.1666	1.924	1.664	.85717	**59**
10	.3934	.4279	1.0877	2.542	2.337	.91936	50	10	.5175	.6048	1.1687	1.932	1.653	.85567	50
20	.3961	.4314	1.0891	2.525	2.318	.91822	40	20	.5200	.6088	1.1707	1.923	1.643	.85416	40
30	.3987	.4348	1.0904	2.508	2.300	.91706	30	30	.5225	.6128	1.1728	1.914	1.632	.85264	30
40	.4014	.4383	1.0918	2.491	2.282	.91590	20	40	.5250	.6168	1.1749	1.905	1.621	.85112	20
50	.4041	.4417	1.0932	2.475	2.264	.91472	10	50	.5275	.6208	1.1770	1.896	1.611	.84959	10
							66								**58**
							° ′								° ′
	Cosin.	Cotg.	Cosec.	Sec.	Tan.	Sin.	Angle		Cosin.	Cotg.	Cosec.	Sec.	Tan.	Sin.	Angle

TABLE IV CONTD. NATURAL TRIGONOMETRICAL FUNCTIONS

Angle	Sin.	Tan.	Sec.	Cosec.	Cotg.	Cosin.		Angle	Sin.	Tan	Sec.	Cosec.	Cotg.	Cosin.	
° ′							° ′	° ′							° ′
32	.5299	.6249	1.1792	1.887	1.600	.84805	58	39	.6293	.8098	1.2868	1.589	1.235	.77715	51
10	.5324	.6289	1.1813	1.878	1.590	.84650	50	10	.6316	.8146	1.2898	1.583	1.228	.77531	50
20	.5348	.6330	1.1835	1.870	1.580	.84495	40	20	.6338	.8195	1.2929	1.578	1.220	.77347	40
30	.5373	.6371	1.1857	1.861	1.570	.84339	30	30	.6361	.8243	1.2959	1.572	1.213	.77162	30
40	.5398	.6412	1.1879	1.853	1.560	.84182	20	40	.6383	.8292	1.2991	1.567	1.206	.76977	20
50	.5422	.6453	1.1901	1.844	1.550	.84025	10	50	.6406	.8342	1.3022	1.561	1.199	.76791	10
33	.5446	.6494	1.1924	1.836	1.540	.83867	57	40	.6428	.8391	1.3054	1.556	1.192	.76604	50
10	.5471	.6536	1.1946	1.828	1.530	.83708	50	10	.6450	.8441	1.3086	1.550	1.185	.76417	50
20	.5495	.6577	1.1969	1.820	1.520	.83549	40	20	.6472	.8491	1.3118	1.545	1.178	.76229	40
30	.5519	.6619	1.1992	1.812	1.511	.83389	30	30	.6494	.8541	1.3151	1.540	1.171	.76041	30
40	.5544	.6661	1.2015	1.804	1.501	.83228	20	40	.6517	.8591	1.3184	1.535	1.164	.75851	20
50	.5568	.6703	1.2039	1.796	1.492	.83066	10	50	.6539	.8642	1.3217	1.529	1.157	.75661	10
34	.5592	.6745	1.2062	1.788	1.483	.82904	56	41	.6561	.8693	1.3251	1.524	1.150	.75471	49
10	.5616	.6787	1.2086	1.781	1.473	.82741	50	10	.6583	.8744	1.3284	1.519	1.144	.75280	50
20	.5640	.6830	1.2110	1.773	1.464	.82577	40	20	.6604	.8796	1.3318	1.514	1.137	.75088	40
30	.5664	.6873	1.2134	1.766	1.455	.82413	30	30	.6626	.8847	1.3352	1.509	1.130	.74896	30
40	.5688	.6916	1.2158	1.758	1.446	.82248	20	40	.6648	.8899	1.3386	1.504	1.124	.74703	20
50	.5712	.6959	1.2183	1.751	1.437	.82082	10	50	.6670	.8952	1.3421	1.499	1.117	.74509	10
35	.5736	.7002	1.2208	1.743	1.428	.81915	55	42	.6691	.9004	1.3456	1.494	1.111	.74314	48
10	.5760	.7046	1.2233	1.736	1.419	.81748	50	10	.6713	.9057	1.3492	1.490	1.104	.74120	50
20	.5783	.7089	1.2258	1.729	1.411	.81580	40	20	.6734	.9110	1.3527	1.485	1.098	.73924	40
30	.5807	.7133	1.2283	1.722	1.402	.81412	30	30	.6756	.9163	1.3563	1.480	1.091	.73728	30
40	.5831	.7177	1.2309	1.715	1.393	.81242	20	40	.6777	.9217	1.3600	1.476	1.085	.73531	20
50	.5854	.7221	1.2335	1.708	1.385	.81072	10	50	.6799	.9271	1.3636	1.471	1.079	.73333	10
36	.5878	.7265	1.2361	1.701	1.376	.80902	54	43	.6820	.9325	1.3673	1.466	1.072	.73135	47
10	.5901	.7310	1.2387	1.695	1.368	.80730	50	10	.6841	.9380	1.3711	1.462	1.066	.72937	50
20	.5925	.7355	1.2413	1.688	1.360	.80558	40	20	.6862	.9435	1.3748	1.457	1.060	.72737	40
30	.5948	.7400	1.2440	1.681	1.351	.80386	30	30	.6884	.9490	1.3786	1.453	1.054	.72537	30
40	.5972	.7445	1.2466	1.675	1.343	.80212	20	40	.6905	.9545	1.3824	1.448	1.048	.72337	20
50	.5995	.7490	1.2494	1.668	1.335	.80038	10	50	.6926	.9601	1.3863	1.444	1.042	.72136	10
37	.6018	.7536	1.2521	1.662	1.327	.79864	53	44	.6947	.9657	1.3902	1.440	1.036	.71934	46
10	.6041	.7581	1.2549	1.655	1.319	.79688	50	10	.6967	.9713	1.3941	1.435	1.030	.71732	50
20	.6065	.7627	1.2577	1.649	1.311	.79512	40	20	.6988	.9770	1.3980	1.431	1.024	.71529	40
30	.6088	.7673	1.2605	1.643	1.303	.79335	30	30	.7009	.9827	1.4020	1.427	1.018	.71325	30
40	.6111	.7720	1.2633	1.636	1.295	.79158	20	40	.7030	.9884	1.4061	1.422	1.012	.71121	20
50	.6134	.7766	1.2661	1.630	1.288	.78980	10	50	.7050	.9942	1.4101	1.418	1.006	.70916	10
38	.6157	.7813	1.2690	1.624	1.280	.78801	52		.7071	1.	1.414	1.414	1.	.70711	45
10	.6180	.7860	1.2719	1.618	1.272	.78622	50								
20	.6202	.7907	1.2748	1.612	1.265	.78442	40								
30	.6225	.7954	1.2778	1.606	1.257	.78261	30								
40	.6248	.8002	1.2808	1.601	1.250	.78079	20								
50	.6271	.8050	1.2838	1.595	1.242	.77897	10								
	Cosin.	Cotg.	Cosec.	Sec.	Tan.	Sin.	Angle		Cosin.	Cotg.	Cosec.	Sec.	Tan.	Sin.	Angle

CURVE TABLE

Table of Tangent and External to a 1° Curve



To find Tangent and External for curve of any other degree, divide by degree of curve and add correction found in column of corrections.

Degree of curve with a given I may be found by dividing tangent, (or external), opposite I by given tangent, (or external).

The distance from a point on the tangent to the curve is very nearly the square of the tangent length divided by twice the radius.

CURVE FORMULAS

Radius: $R = \frac{50}{\sin \frac{1}{2} D}$

Length of Curve: $L = 100 \frac{\Delta}{D}$

also $L = .0174533 \times \Delta \times R$

Degree of Curve: $D = 100 \frac{\Delta}{L}$

Tangent: $T = R \tan \frac{1}{2} \Delta$

Long Cord: $LC = 2R \sin \frac{1}{2} \Delta$

Middle Ordinate: $M = R\ (1 - \text{Cos}\ \frac{1}{2} \Delta)$

External: $E = T \tan \frac{1}{4} \Delta$

TABLE V. TANGENTS AND EXTERNALS TO A 1° CURVE

I	T	E	I=10°	I	T	E	I=20°	I	T	E	I=30°
1°	50.00	.218	+	11°	551.70	26.500	+	21°	1061.9	97.577	+
10′	58.34	.297	5° C.	10′	560.11	27.313	5° C.	10′	1070.6	99.155	5° C.
20′	66.67	.388	T	20′	568.53	28.137	T	20′	1079.2	100.75	T
30′	75.01	.491	.03	30′	576.95	28.974	.06	30′	1087 8	102.35	.10
40′	83.34	.606	E	40′	585.36	29.824	E	40′	1096.4	103.97	E
50′	91.68	.733	.001	50′	593.79	30.686	.006	50′	1105.1	105.60	.013
2°	100.01	.873		12°	602.21	31.561		22°	1113.7	107.24	
10′	108.35	1.024		10′	610.64	32.447		10′	1122.4	108.90	
20′	116.68	1.188		20′	619.07	33.347		20′	1131.0	110.57	
30′	125.02	1.364		30′	627.50	34.259		30′	1139.7	112.25	
40′	133.36	1.552		40′	635.93	35.183		40′	1148.4	113.95	
50′	141.70	1.752		50′	644.37	36.120		50′	1157.0	115.66	
3°	150.04	1.964	10° C.	13°	652.81	37.070	10° C.	23°	1165.7	117.38	10° C.
10′	158.38	2.188	T	10′	661.25	38.031	T	10′	1174.4	119.12	T
20′	166.72	2.425	.06	20′	669.70	39.006	.13	20′	1183.1	120.87	.19
30′	175.06	2.674	E	30′	678.15	39.993	E	30′	1191.8	122.63	E
40′	183.40	2.934	.003	40′	686.60	40.992	.011	40′	1200.5	124.41	.025
50′	191.74	3.207		50′	695.06	42.004		50′	1209.2	126.20	
4°	200.08	3.492		14°	703.51	43.029		24°	1217.9	128.00	
10′	208.43	3.790		10′	711.97	44.066		10′	1226.6	129.82	
20′	216.77	4.099		20′	720.44	45.116		20′	1235.3	131.65	
30′	225.12	4.421		30′	728.90	46.178		30′	1244.0	133.50	
40′	233.47	4.755		40′	737.37	47.253		40′	1252.8	135.35	
50′	241.81	5.100	15° C.	50′	745.85	48.341	15° C.	50′	1261.5	137.23	15° C.
5°	250.16	5.459	T	15°	754.32	49.441	T	25°	1270.2	139.11	T
10′	258.51	5.829	.09	10′	762.80	50.554	.19	10′	1279.0	141.01	.29
20′	266.86	6.211	E	20′	771.29	51.679	E	20′	1287.7	142.93	E
30′	275.21	6.606	.004	30′	779.77	52.818	.017	30′	1296.5	144.85	.038
40′	283.57	7.013		40′	788.26	53.969		40′	1305.3	146.79	
50′	291.92	7.432		50′	796.75	55.132		50′	1314.0	148.75	
6°	300.28	7.863		16°	805.25	56.309		26°	1322.8	150.71	
10′	308.64	8.307		10′	813.75	57.498		10′	1331.6	152.69	
20′	316.99	8.762		20′	822.25	58.699		20′	1340.4	154.69	
30′	325.35	9.230		30′	830.76	59.914		30′	1349.2	156.70	
40′	333.71	9.710	20° C.	40′	839.27	61.141	20° C.	40′	1358.0	158.72	20° C.
50′	342.08	10.202	T	50′	847.78	62.381	T	50′	1366.8	160.76	T
7°	350.44	10.707	.13	17°	856.30	63.634	.26	27°	1375.6	162.81	.39
10′	358.81	11.224	E	10′	864.82	64.900	E	10′	1384.4	164.86	E
20′	367.17	11.753	.006	20′	873.35	66.178	.022	20′	1393.2	166.95	.051
30′	375.54	12.294		30′	881.88	67.470		30′	1402.0	169.04	
40′	383.91	12.847		40′	890.41	68.774		40′	1410.9	171.15	
50′	392.28	13.413		50′	898.95	70.091		50′	1419.7	173.27	
8°	400.66	13.991		18°	907.49	71.421		28°	1428.6	175.41	
10′	409.03	14.582		10′	916.03	72.764		10′	1437.4	177.55	
20′	417.41	15.184	25° C.	20′	924.58	74.119	25° C.	20′	1446.3	179.72	25° C.
30′	425.79	15.799	T	30′	933.13	75.488	T	30′	1455.1	181.89	T
40′	434.17	16.426	.16	40′	941.69	76.869	.32	40′	1464.0	184.08	.49
50′	442.55	17.065	E	50′	950.25	78.264	E	50′	1472.9	186.29	E
9°	450.93	17.717	.007	19°	958.81	79.671	.028	29°	1481.8	188.51	.065
10′	459.32	18.381		10′	967.38	81.092		10′	1490.7	190.74	
20′	467.71	19.058		20′	975.96	82.525		20′	1499.6	192.99	
30′	476.10	19.746		30′	984.53	83.972		30′	1508.5	195.25	
40′	484.49	20.447		40′	993.12	85.431		40′	1517.4	197.53	
50′	492.88	21.161		50′	1001.7	86.904		50′	1526.3	199.82	
10°	501.28	21.887	30° C.	20°	1010.3	88.389	30° C.	30°	1535.3	202.12	30° C.
10′	509.68	22.624	T	10′	1018.9	89.888	T	10′	1544.2	204.44	T
20′	518.08	23.375	.19	20′	1027.5	91.399	.39	20′	1553.1	206.77	.59
30′	526.48	24.138	E	30′	1036.1	92.924	E	30′	1562.1	209.12	E
40′	534.89	24.913	.008	40′	1044.7	94.462	.034	40′	1571.0	211.48	.078
50′	543.29	25.700		50′	1053.3	96.013		50′	1580.0	213.86	

$T = R \tan \frac{1}{2}I$ $E = R \operatorname{exsec} \frac{1}{2}I$

TABLE V CONTD. TANGENTS AND EXTERNALS TO A 1° CURVE

I	T	E	I=40°	I	T	E	I=50°	I	T	E	I=60°
31°	1589.0	216.3	+	41°	2142.2	387.4	+	51°	2732.9	618.4	+
10′	1598.0	218.7	5° C.	10′	2151.7	390.7	5° C.	10′	2743.1	622.8	5° C.
20′	1606.9	221.1	T	20′	2161.2	394.1	T	20′	2753.4	627.2	T
30′	1615.9	223.5	.13	30′	2170.8	397.4	.17	30′	2763.7	631.7	.21
40′	1624.9	226.0	E	40′	2180.3	400.8	E	40′	2773.9	636.2	E
50′	1633.9	228.4		50′	2189.9	404.2		50′	2784.2	640.7	
32°	1643.0	230.9	.023	42°	2199.4	407.6	.037	52°	2794.5	645.2	.056
10′	1652.0	233.4		10′	2209.0	411.1		10′	2804.9	649.7	
20′	1661.0	235.9		20′	2218.6	414.5		20′	2815.2	654.3	
30′	1670.0	238.4		30′	2228.1	418.0		30′	2825.6	658.8	
40′	1679.1	241.0		40′	2237.7	421.4		40′	2835.9	663.4	
50′	1688.1	243.5		50′	2247.3	425.0		50′	2846.3	668.0	
33°	1697.2	246.1	10° C.	43°	2257.0	428.5	10° C.	53°	2856.7	672.7	10° C.
10′	1706.3	248.7	T	10′	2266.6	432.0	T	10′	2867.1	677.3	T
20′	1715.3	251.3	.26	20′	2276.2	435.6	.34	20′	2877.5	682.0	.42
30′	1724.4	253.9	E	30′	2285.9	439.2	E	30′	2888.0	686.7	E
40′	1733.5	256.5	.046	40′	2295.6	442.8	.075	40′	2898.4	691.4	.112
50′	1742.6	259.1		50′	2305.2	446.4		50′	2908.9	696.1	
34°	1751.7	261.8		44°	2314.9	450.0		54°	2919.4	700.9	
10′	1760.8	264.5		10′	2324.6	453.6		10′	2929.9	705.7	
20′	1770.0	267.2		20′	2334.3	457.3		20′	2940.4	710.5	
30′	1779.1	269.9		30′	2344.1	461.0		30′	2951.0	715.3	
40′	1788.2	272.6		40′	2353.8	464.6		40′	2961.5	720.1	
50′	1797.4	275.3	15° C.	50′	2363.5	468.4	15° C.	50′	2972.1	725.0	15° C.
35°	1806.6	278.1	T	45°	2373.3	472.1	T	55°	2982.7	729.9	T
10′	1815.7	280.8	.40	10′	2383.1	475.8	.51	10′	2993.3	734.8	.63
20′	1824.9	283.6	E	20′	2392.8	479.6	E	20′	3003.9	739.7	E
30′	1834.1	286.4	.070	30′	2402.6	483.4	.116	30′	3014.5	744.6	.168
40′	1843.3	289.2		40′	2412.4	487.2		40′	3025.2	749.6	
50′	1852.5	292.0		50′	2422.3	491.0		50′	3035.8	754.6	
36°	1861.7	294.9		46°	2432.1	494.8		56°	3046.5	759.6	
10′	1870.9	297.7		10′	2441.9	498.7		10′	3057.2	764.6	
20′	1880.1	300.6		20′	2451.8	502.5		20′	3067.9	769.7	
30′	1889.4	303.5		30′	2461.7	506.4		30′	3078.7	774.7	20° C.
40′	1898.6	306.4	20° C.	40′	2471.5	510.3	20° C.	40′	3089.4	779.8	T
50′	1907.9	309.3	T	50′	2481.4	514.3	T	50′	3100.2	784.9	.84
37°	1917.1	312.2	.53	47°	2491.3	518.2	.68	57°	3110.9	790.1	E
10′	1926.4	315.2	E	10′	2501.2	522.2	E	10′	3121.7	795.2	.225
20′	1935.7	318.1	.093	20′	2511.2	526.1	.151	20′	3132.6	800.4	
30′	1945.0	321.1		30′	2521.1	530.1		30′	3143.4	805.6	
40′	1954.3	324.1		40′	2531.1	534.2		40′	3154.2	810.9	
50′	1963.6	327.1		50′	2541.0	538.2		50′	3165.1	816.1	
38°	1972.9	330.2		48°	2551.0	542.2		58°	3176.0	821.4	
10′	1982.2	333.2	25° C.	10′	2561.0	546.3	25° C.	10′	3186.9	826.7	25° C.
20′	1991.5	336.3	T	20′	2571.0	550.4	T	20′	3197.8	832.0	T
30′	2000.9	339.3	.67	30′	2581.0	554.5	.85	30′	3208.8	837.3	1.05
40′	2010.2	342.4	E	40′	2591.0	558.6	E	40′	3219.7	842.7	E
50′	2019.6	345.5	.117	50′	2601.1	562.8	.189	50′	3230.7	848.1	.283
39°	2029.0	348.6		49°	2611.2	566.9		59°	3241.7	853.5	
10′	2038.4	351.8		10′	2621.2	571.1		10′	3252.7	858.9	
20′	2047.8	354.9		20′	2631.3	575.3		20′	3263.7	864.3	
30′	2057.2	358.1		30′	2641.4	579.5		30′	3274.8	869.8	
40′	2066.6	361.3		40′	2651.5	583.8		40′	3285.8	875.3	
50′	2076.0	364.5		50′	2661.6	588.0		50′	3296.9	880.8	
40°	2085.4	367.7	30° C.	50°	2671.8	592.3	30° C.	60°	3308.0	886.4	30° C.
10′	2094.9	371.0	T	10′	2681.9	596.6	T	10′	3319.1	892.0	T
20′	2104.3	374.2	.80	20′	2692.1	600.9	1.02	20′	3330.3	897.5	1.27
30′	2113.8	377.5	E	30′	2702.3	605.3	E	30′	3341.4	903.2	E
40′	2123.3	380.8	.141	40′	2712.5	609.6	.227	40′	3352.6	908.8	
50′	2132.7	384.1		50′	2722.7	614.0		50′	3363.8	914.5	.340

$T = R \tan \frac{1}{2} I$ $E = R \operatorname{exsec} \frac{1}{2} I$

TABLE V CONTD. TANGENTS AND EXTERNALS TO A 1° CURVE

I	T	E	I=70°	I	T	E	I=80°	I	T	E	I=90°
61°	3375.0	920.2	+	71°	4086.9	1308.2	+	81°	4893.6	1805.3	+
10′	3386.3	925.9	5° C.	10′	4099.5	1315.6	5° C.	10′	4908.0	1814.7	5° C.
20′	3397.5	931.6	T	20′	4112.1	1322.9	T	20′	4922.5	1824.1	T
30′	3408.8	937.3	.25	30′	4124.8	1330.3	.30	30′	4937.0	1833.6	.36
40′	3420.1	943.1	E	40′	4137.4	1337.7	E	40′	4951.5	1843.1	E
50′	3431.4	948.9		50′	4150.1	1345.1		50′	4966.1	1852.6	
62°	3442.7	954.8	.080	72°	4162.8	1352.6	.110	82°	4980.7	1862.2	.149
10′	3454.1	960.6		10′	4175.6	1360.1		10′	4995.4	1871.8	
20′	3465.4	966.5		20′	4188.5	1367.6		20′	5010.0	1881.5	
30′	3476.8	972.4		30′	4201.2	1375.2		30′	5024.8	1891.2	
40′	3488.3	978.3		40′	4214.0	1382.8		40′	5039.5	1900.9	
50′	3499.7	984.3		50′	4226.8	1390.4		50′	5054.3	1910.7	
63°	3511.1	990.2	10° C.	73°	4239.7	1398.0	10° C.	83°	5069.2	1920.5	10° C.
10′	3522.6	996.2	T	10′	4252.6	1405.7	T	10′	5084.0	1930.4	T
20′	3534.1	1002.3	.51	20′	4265.6	1413.5	.61	20′	5099.0	1940.3	.72
30′	3545.6	1008.3	E	30′	4278.5	1421.2	E	30′	5113.9	1950.3	E
40′	3557.2	1014.4	.159	40′	4291.5	1429.0	.220	40′	5128.9	1960.2	.299
50′	3568.7	1020.5		50′	4304.6	1436.8		50′	5143.9	1970.3	
64°	3580.3	1026.6		74°	4317.6	1444.6		84°	5159.0	1980.4	
10′	3591.9	1032.8		10′	4330.7	1452.5		10′	5174.1	1990.5	
20′	3603.5	1039.0		20′	4343.8	1460.4		20′	5189.3	2000.6	
30′	3615.1	1045.2		30′	4356.9	1468.4		30′	5204.4	2010.8	
40′	3626.8	1051.4		40′	4370.1	1476.4		40′	5219.7	2021.1	
50′	3638.5	1057.7	15° C.	50′	4383.3	1484.4	15° C.	50′	5234.9	2031.4	15° C.
65°	3650.2	1063.9	T	75°	4396.5	1492.4	T	85°	5250.3	2041.7	T
10′	3661.9	1070.2	.76	10′	4409.8	1500.5	.91	10′	5265.6	2052.1	1.09
20′	3673.7	1076.6	E	20′	4423.1	1508.6	E	20′	5281.0	2062.5	E
30′	3685.4	1082.9	.240	30′	4436.4	1516.7	.332	30′	5296.4	2073.0	.450
40′	3697.2	1089.3		40′	4449.7	1524.9		40′	5311.9	2083.5	
50′	3709.0	1095.7		50′	4463.1	1533.1		50′	5327.4	2094.1	
66°	3720.9	1102.2		76°	4476.5	1541.4		86°	5343.0	2104.7	
10′	3732.7	1108.6		10′	4489.9	1549.7		10′	5358.6	2115.3	
20′	3744.6	1115.1		20′	4503.4	1558.0		20′	5374.2	2126.0	
30′	3756.5	1121.7		30′	4516.9	1566.3		30′	5389.9	2136.7	
40′	3768.5	1128.2	20° C.	40′	4530.4	1574.7	20° C.	40′	5405.6	2147.5	20° C.
50′	3780.4	1134.8	T	50′	4544.0	1583.1	T	50′	5421.4	2158.4	T
67°	3792.4	1141.4	1.02	77°	4557.6	1591.6	1.22	87°	5437.2	2169.2	1.45
10′	3804.4	1148.0	E	10′	4571.2	1600.1	E	10′	5453.1	2180.2	E
20′	3816.4	1154.7	.321	20′	4584.8	1608.6	.445	20′	5469.0	2191.1	.603
30′	3828.4	1161.3		30′	4598.5	1617.1		30′	5484.9	2202.2	
40′	3840.5	1168.1		40′	4612.2	1625.7		40′	5500.9	2213.2	
50′	3852.6	1174.8		50′	4626.0	1634.4		50′	5517.0	2224.3	
68°	3864.7	1181.6		78°	4639.8	1643.0		88°	5533.1	2235.5	
10′	3876.8	1188.4		10′	4653.6	1651.7		10′	5549.2	2246.7	
20′	3889.0	1195.2	25° C.	20′	4667.4	1660.5	25° C.	20′	5565.4	2258.0	25° C.
30′	3901.2	1202.0	T	30′	4681.3	1669.2	T	30′	5581.6	2269.3	T
40′	3913.4	1208.9	1.28	40′	4695.2	1678.1	1.53	40′	5597.8	2280.6	1.83
50′	3925.6	1215.8	E	50′	4709.2	1686.9	E	50′	5614.2	2292.0	E
69°	3937.9	1222.7	.403	79°	4723.2	1695.8	.558	89°	5630.5	2303.5	.756
10′	3950.2	1229.7		10′	4737.2	1704.7		10′	5646.9	2315.0	
20′	3962.5	1236.7		20′	4751.2	1713.7		20′	5663.4	2326.6	
30′	3974.8	1243.7		30′	4765.3	1722.7		30′	5679.9	2338.2	
40′	3987.2	1250.8		40′	4779.4	1731.7		40′	5696.4	2349.8	
50′	3999.5	1257.9		50′	4793.6	1740.8		50′	5713.0	2361.5	
70°	4011.9	1265.0	30° C.	80°	4807.7	1749.9	30° C.	90°	5729.7	2373.3	30° C.
10′	4024.4	1272.1	T	10′	4822.0	1759.0	T	10′	5746.3	2385.1	T
20′	4036.8	1279.3	1.54	20′	4836.2	1768.2	1.84	20′	5763.1	2397.0	2.20
30′	4049.3	1286.5	E	30′	4850.5	1777.4	E	30′	5779.9	2408.9	E
40′	4061.8	1293.6	.485	40′	4864.8	1786.7	.671	40′	5796.7	2420.9	.910
50′	4074.4	1300.9		50′	4879.2	1796.0		50′	5813.6	2432.9	

$T = R \tan \frac{1}{2}I$ $E = R \operatorname{exsec} \frac{1}{2}I$

TABLE V CONTD. TANGENTS AND EXTERNALS TO A 1° CURVE

I	T	E	D=100°
91°	5830.5	2444.9	+
10′	5847.5	2457.1	5° C.
20′	5864.6	2469.3	T
30′	5881.7	2481.5	.43
40′	5898.8	2493.8	E
50′	5916.0	2506.1	
92°	5933.2	2518.5	.200
10′	5950.5	2531.0	
20′	5967.9	2543.5	
30′	5985.3	2556.0	
40′	6002.7	2568.6	
50′	6020.2	2581.3	
93°	6037.8	2594.0	10° C.
10′	6055.4	2606.8	T
20′	6073.1	2619.7	.86
30′	6090.8	2632.6	E
40′	6108.6	2645.5	.401
50′	6126.4	2658.5	
94°	6144.3	2671.6	
10′	6162.2	2684.7	
20′	6180.2	2697.9	
30′	6198.3	2711.2	
40′	6216.4	2724.5	
50′	6234.6	2737.9	15° C.
95°	6252.8	2751.3	T
10′	6271.1	2764.8	1.30
20′	6289.4	2778.3	E
30′	6307.9	2792.0	.604
40′	6326.3	2805.6	
50′	6344.8	2819.4	
96°	6363.4	2833.2	
10′	6382.1	2847.0	
20′	6400.8	2861.0	
30′	6419.5	2875.0	20° C.
40′	6438.4	2889.0	T
50′	6457.3	2903.1	1.74
97°	6476.2	2917.3	E
10′	6495.2	2931.6	.809
20′	6514.3	2945.9	
30′	6533.4	2960.3	
40′	6552.6	2974.7	
50′	6571.9	2989.2	
98°	6591.2	3003.8	
10′	6610.6	3018.4	25° C.
20′	6630.1	3033.1	T
30′	6649.6	3047.9	2.18
40′	6669.2	3062.8	E
50′	6688.8	3077.7	
99°	6708.6	3092.7	1.02
10′	6728.4	3107.7	
20′	6748.2	3122.9	
30′	6768.1	3138.1	
40′	6788.1	3153.3	
50′	6808.2	3168.7	
100°	6828.3	3184.1	30° C.
10′	6848.5	3199.6	T
20′	6868.8	3215.1	2.62
30′	6889.2	3230.8	E
40′	6909.6	3246.5	
50′	6930.1	3262.3	1.22

I	T	E	D=110°
101°	6950.6	3278.1	+
10′	6971.3	3294.1	5° C.
20′	6992.0	3310.1	T
30′	7012.7	3326.1	.51
40′	7033.6	3342.3	E
50′	7054.5	3358.5	
102°	7075.5	3374.9	.268
10′	7096.6	3391.2	
20′	7117.8	3407.7	
30′	7139.0	3424.3	
40′	7160.3	3440.9	
50′	7181.7	3457.6	
103°	7203.2	3474.4	10° C.
10′	7224.7	3491.3	T
20′	7246.3	3508.2	.103
30′	7268.0	3525.2	E
40′	7289.8	3542.4	.536
50′	7311.7	3559.6	
104°	7333.6	3576.8	
10′	7355.6	3594.2	
20′	7377.8	3611.7	
30′	7399.9	3629.2	
40′	7422.2	3646.8	
50′	7444.6	3664.5	15° C.
105°	7467.0	3682.3	T
10′	7489.6	3700.2	1.56
20′	7512.2	3718.2	E
30′	7534.9	3736.2	.806
40′	7557.7	3754.4	
50′	7580.5	3772.6	
106°	7603.5	3791.0	
10′	7626.6	3809.4	
20′	7649.7	3827.9	
30′	7672.9	3846.5	20° C.
40′	7696.3	3865.2	T
50′	7719.7	3884.0	2.08
107°	7743.2	3902.9	E
10′	7766.8	3921.9	1.08
20′	7790.5	3940.9	
30′	7814.3	3960.1	
40′	7838.1	3979.4	
50′	7862.1	3998.7	
108°	7886.2	4018.2	
10′	7910.4	4037.8	25° C.
20′	7934.6	4057.4	T
30′	7959.0	4077.2	2.61
40′	7983.5	4097.1	E
50′	8008.0	4117.0	1.36
109°	8032.7	4137.1	
10′	8057.4	4157.3	
20′	8082.3	4177.5	
30′	8107.3	4197.9	
40′	8132.3	4218.4	
50′	8157.5	4239.0	
110°	8182.8	4259.7	30° C.
10′	8208.2	4280.5	T
20′	8233.7	4301.4	3.14
30′	8259.3	4322.4	E
40′	8285.0	4343.6	1.63
50′	8310.8	4364.8	

I	T	E	D=120°
111°	8336.7	4386.1	+
10′	8362.7	4407.6	5° C.
20′	8388.9	4429.2	T
30′	8415.1	4450.9	.62
40′	8441.5	4472.7	E
50′	8468.0	4494.6	
112°	8494.6	4516.6	.360
10′	8521.3	4538.8	
20′	8548.1	4561.1	
30′	8575.0	4583.4	
40′	8602.1	4606.0	
50′	8629.3	4628.6	
113°	8656.6	4651.3	10° C.
10′	8684.0	4674.2	T
20′	8711.5	4697.2	1.25
30′	8739.2	4720.3	E
40′	8767.0	4743.6	.721
50′	8794.9	4766.9	
114°	8822.9	4790.4	
10′	8851.0	4814.1	
20′	8879.3	4837.8	
30′	8907.7	4861.7	
40′	8936.3	4885.7	
50′	8965.0	4909.9	15° C.
115°	8993.8	4934.1	T
10′	9022.7	4958.6	1.93
20′	9051.7	4983.1	E
30′	9080.9	5007.8	1.09
40′	9110.3	5032.6	
50′	9139.8	5057.6	
116°	9169.4	5082.7	
10′	9199.1	5107.9	
20′	9229.0	5133.3	
30′	9259.0	5158.8	20° C.
40′	9289.2	5184.5	T
50′	9319.5	5210.3	2.52
117°	9349.9	5236.2	E
10′	9380.5	5262.3	1.46
20′	9411.3	5288.6	
30′	9442.2	5315.0	
40′	9473.2	5341.5	
50′	9504.4	5368.2	
118°	9535.7	5395.1	
10′	9567.2	5422.1	
20′	9598.9	5449.2	25° C.
30′	9630.7	5476.5	T
40′	9662.6	5504.0	3.16
50′	9694.7	5531.7	E
119°	9727.0	5559.4	1.83
10′	9759.4	5587.4	
20′	9792.0	5615.5	
30′	9824.8	5643.8	
40′	9857.7	5672.3	
50′	9890.8	5700.9	
120°	9924.0	5729.7	30° C.
10′	9957.5	5758.6	T
20′	9991.0	5787.7	3.81
30′	10025.0	5817.0	E
40′	10059.0	5846.5	2.20
50′	10093.0	5876.1	

$T = R \tan \frac{1}{2} I$ $E = R \operatorname{exsec} \frac{1}{2} I$

USEFUL RELATIONS

Lineal feet	$\times .00019$	=	miles
Lineal yards	$\times .0006$	=	miles
Square inches	$\times .007$	=	square feet
Square feet	$\times .111$	=	square yards
Square yards	$\times .0002067$	=	acres
Acres	$\times 4840$	=	square yards
Cubic inches	$\times .00058$	=	cubic feet
Cubic feet	$\times .03704$	=	cubic yards
Links	$\times .22$	=	yards
Links	$\times .66$	=	feet
Feet	$\times 1.5$	=	links

$360° = 21600' = 1296000''$

Radius = arc of 57.2957790°

Arc of 1° (radius = 1) = .017453292

Arc of 1′ (radius = 1) = .000290888

Arc of 1″ (radius = 1) = .000004848

Curvature of Earth's surface = about 0.7 feet in 1 mile

Curvature in feet = 0.667 (Dist. in miles)^2

Difference between arc and chord length, 0.05 feet in 11½ miles

Probable error of a single observation = $0.6754\sqrt{\frac{\Sigma v^2}{n-1}}$

Error in chaining of 0.01 feet in 100 feet:

Due to—

1. Length of tape error of 0.01 feet
2. Alignment. One end 1.4 feet out of line
3. Sag of tape at center of 0.61 feet.
4. Temperature difference of 15°
5. Difference of pull of 15 lbs.

SQUARE MEASURE

144 sq. inches = 1 sq. ft.
9 sq. ft. = 1 sq. yard
30¼ sq. yds. = 1 sq. rd.
40 sq. rds. = 1 rood.
4 roods = 1 acre
640 acres = 1 sq. mile.

SURVEYORS' MEASURE

7.92 inches = 1 link.
25 links = 1 rod.
4 rds. = 1 chain.
10 sq. chains or 160 sq. rods = 1 acre.
640 acres = 1 sq. mile.
36 sq. miles (6 miles sq.) = 1 township.

TABLE VI. INCHES TO DECIMALS OF A FOOT

In.	0	1	2	3	4	5	6	7	8	9	10	11	In.
0	Foot	.0833	.1667	.2500	.3333	.4167	.5000	.5833	.6667	.7500	.8333	.9167	0
1-32	.0026	.0859	.1693	.2526	.3359	.4193	.5026	.5859	.6693	.7526	.8359	.9193	1-32
1-16	.0052	.0885	.1719	.2552	.3385	.4219	.5052	.5885	.6719	.7552	.8385	.9219	1-16
3-32	.0078	.0911	.1745	.2578	.3411	.4245	.5078	.5911	.6745	.7578	.8411	.9245	3-32
1-8	.0104	.0938	.1771	.2604	.3438	.4271	.5104	.5938	.6771	.7604	.8438	.9271	1-8
5-32	.0130	.0964	.1797	.2630	.3464	.4297	.5130	.5964	.6797	.7630	.8464	.9297	5-32
3-16	.0156	.0990	.1823	.2656	.3490	.4323	.5156	.5990	.6823	.7656	.8490	.9323	3-16
7-32	.0182	.1016	.1849	.2682	.3516	.4349	.5182	.6016	.6849	.7682	.8516	.9349	7-32
1-4	.0208	.1042	.1875	.2708	.3542	.4375	.5208	.6042	.6875	.7708	.8542	.9375	1-4
9-32	.0234	.1068	.1901	.2734	.3568	.4401	.5234	.6068	.6901	.7734	.8568	.9401	9-32
5-16	.0260	.1094	.1927	.2760	.3594	.4427	.5260	.6094	.6927	.7760	.8594	.9427	5-16
11-32	.0286	.1120	.1953	.2786	.3620	.4453	.5286	.6120	.6953	.7786	.8620	.9453	11-32
3-8	.0313	.1146	.1979	.2813	.3646	.4479	.5313	.6146	.6979	.7813	.8646	.9479	3-8
13-32	.0339	.1172	.2005	.2839	.3672	.4505	.5339	.6172	.7005	.7839	.8672	.9505	13-32
7-16	.0365	.1198	.2031	.2865	.3698	.4531	.5365	.6198	.7031	.7865	.8698	.9531	7-16
15-32	.0391	.1224	.2057	.2891	.3724	.4557	.5391	.6224	.7057	.7891	.8724	.9557	15-32
1-2	.0417	.1250	.2083	.2917	.3750	.4583	.5417	.6250	.7083	.7917	.8750	.9583	1-2
17-32	.0443	.1276	.2109	.2943	.3776	.4609	.5443	.6276	.7109	.7943	.8776	.9609	17-32
9-16	.0469	.1302	.2135	.2969	.3802	.4635	.5469	.6302	.7135	.7969	.8802	.9635	9-16
19-32	.0495	.1328	.2161	.2995	.3828	.4661	.5495	.6328	.7161	.7995	.8828	.9661	19-32
5-8	.0521	.1354	.2188	.3021	.3854	.4688	.5521	.6354	.7188	.8021	.8854	.9688	5-8
21-32	.0547	.1380	.2214	.3047	.3880	.4714	.5547	.6380	.7214	.8047	.8880	.9714	21-32
11-16	.0573	.1406	.2240	.3073	.3906	.4740	.5573	.6406	.7240	.8073	.8906	.9740	11-16
23-32	.0599	.1432	.2266	.3099	.3932	.4766	.5599	.6432	.7266	.8099	.8932	.9766	23-32
3-4	.0625	.1458	.2292	.3125	.3958	.4792	.5625	.6458	.7292	.8125	.8958	.9792	3-4
25-32	.0651	.1484	.2318	.3151	.3984	.4818	.5651	.6484	.7318	.8151	.8984	.9818	25-32
13-16	.0677	.1510	.2344	.3177	.4010	.4844	.5677	.6510	.7344	.8177	.9010	.9844	13-16
27-32	.0703	.1536	.2370	.3203	.4036	.4870	.5703	.6536	.7370	.8203	.9036	.9870	27-32
7-8	.0729	.1563	.2396	.3229	.4063	.4896	.5729	.6563	.7396	.8229	.9063	.9896	7-8
29-32	.0755	.1589	.2422	.3255	.4089	.4922	.5755	.6589	.7422	.8255	.9089	.9922	29-32
15-16	.0781	.1615	.2448	.3281	.4115	.4948	.5781	.6615	.7448	.8281	.9115	.9948	15-16
31-32	.0807	.1641	.2474	.3307	.4141	.4974	.5807	.6641	.7474	.8307	.9141	.9974	31-32
	0	1	2	3	4	5	6	7	8	9	10	11	

TABLE VII. MINUTES IN DECIMALS OF A DEGREE

0′ 30″	.00833	10′ 30″	.17500	20′ 30″	.34167	30′ 30″	.50833	40′ 30″	.67500	50′ 30″	.84167		
1 00	.01667	11 00	.18333	21 00	.35000	31 00	.51667	41 00	.68333	51 00	.85000		
30	.02500	30	.19167	30	.35833	30	.52500	30	.69167	30	.85833		
2 00	.03333	12 00	.20000	22 00	.36667	32 00	.53333	42 00	.70000	52 00	.86667		
30	.04167	30	.20833	30	.37500	30	.54167	30	.70833	30	.87500		
3 00	.05000	13 00	.21667	23 00	.38333	33 00	.55000	43 00	.71667	53 00	.88333		
30	.05833	30	.22500	30	.39167	30	.55833	30	.72500	30	.89167		
4 00	.06667	14 00	.23333	24 00	.40000	34 00	.56667	44 00	.73333	54 00	.90000		
30	.07500	30	.24167	30	.40833	30	.57500	30	.74167	30	.90833		
5 00	.08333	15 00	.25000	25 00	.41667	35 00	.58333	45 00	.75000	55 00	.91667		
30	.09167	30	.25833	30	.42500	30	.59167	30	.75833	30	.92500		
6 00	.10000	16 00	.26667	26 00	.43333	36 00	.60000	46 00	.76667	56 00	.93333		
30	.10833	30	.27500	30	.44167	30	.60833	30	.77500	30	.94167		
7 00	.11667	17 00	.28333	27 00	.45000	37 00	.61667	47 00	.78333	57 00	.95000		
30	.12500	30	.29167	30	.45833	30	.62500	30	.79167	30	.95833		
8 00	.13333	18 00	.30000	28 00	.46667	38 00	.63333	48 00	.80000	58 00	.96667		
30	.14167	30	.30833	30	.47500	30	.64167	30	.80833	30	.97500		
9 00	.15000	19 00	.31667	29 00	.48333	39 00	.65000	49 00	.81667	59 00	.98333		
30	.15833	30	.32500	30	.49167	30	.65833	30	.82500	30	.99167		
10 00	.16667	20 00	.33333	30 00	.500000	40 00	.66667	50 00	.83333	60 00	1.00000		

TABLE VIII. MIDDLE ORDINATES OF RAILS

Length of Rail (feet)

C ° ′	R Feet	30 Inch	28 Inch	26 Inch	24 Inch	22 Inch	20 Inch	C °	R Feet	30 Inch	28 Inch	26 Inch	24 Inch	22 Inch	20 Inch
0–20	17189	.08	.07	.06	.05	.04	.03	8	716.8	1.88	1.64	1.42	1.20	1.01	.84
0–40	8594	.16	.14	.12	.10	.08	.07	9	637.3	2.12	1.84	1.60	1.35	1.14	.94
1–0	5730	.24	.20	.18	.15	.13	.10	10	573.7	2.36	2.05	1.78	1.50	1.27	1.04
1–20	4297	.31	.27	.23	.20	.17	.13	11	521.7	2.59	2.26	1.95	1.65	1.39	1.15
1–40	3438	.39	.34	.29	.25	.21	.17	12	478.3	3.83	2.47	2.15	1.81	1.54	1.26
2–0	2865	.47	.41	.35	.30	.25	.20	13	441.7	3.05	2.66	2.30	1.96	1.66	1.36
2–20	2456	.55	.48	.41	.35	.29	.23	14	410.3	3.30	2.87	2.48	2.10	1.78	1.46
2–40	2149	.63	.55	.47	.40	.33	.27	15	383.1	3.54	3.08	2.68	2.26	1.91	1.57
3–0	1910	.71	.62	.53	.45	.38	.31	16	359.3	3.76	3.28	2.83	2.40	2.04	1.67
3–20	1719	.78	.68	.59	.50	.42	.35	17	338.3	4.00	3.48	3.02	2.57	2.16	1.78
3–40	1563	.86	.75	.65	.55	.46	.38	18	319.6	4.21	3.67	3.18	2.70	2.28	1.87
4–0	1433	.94	.82	.71	.60	.50	.42	19	302.9	4.45	3.89	3.36	2.86	2.41	1.98
4–20	1323	1.02	.89	.77	.65	.55	.45	20	287.9	4.70	4.09	3.55	3.00	2.54	2.09
4–40	1228	1.10	.96	.83	.70	.59	.48	22	262.0	5.16	4.44	3.84	3.30	2.80	2.29
5	1146	1.18	1.03	.89	.75	.63	.52	24	240.5	5.64	4.92	4.20	3.59	3.04	2.50
6	955.3	1.41	1.23	1.06	.90	.76	.62	26	222.3	6.07	5.29	4.58	3.88	3.29	2.70
7	819.0	1.65	1.44	1.24	1.05	.89	.73								

TABLE IX. SHORT RADIUS CURVES

Radius Feet	Chord Feet	Central Angle	Deflection Angle	Deflection for 1 Foot
35	10	16-26	8-13	49.3
45	10	12-46	6-23	38.3
50	15	17-16	8-38	34.5
60	15	14-22	7-11	28.8
75	15	11-30	5-45	23.0
100	20	11-30	5-45	17.3
120	20	9-34	4-47	14.3
150	20	7-39	3-49	11.5
190	25	7-32	3-46	9.15
200	25	7-10	3-35	8.6
225	25	6-25	3-12	7.7
240	25	5-58	2-59	7.2
250	25	5-44	2-52	6.9
275	25	5-12	2-36	6.2
288	50	9-58	4-59	6.0
300	50	9-32	4-46	5.7
350	50	8-12	4-06	4.9
376	50	7-40	3-50	4.6
400	50	7-10	3-35	4.3
410	50	7-00	3-30	4.2

To find length of curve divide angle from P. C. to P. T. by central angle of chord, and multiply by length of chord.

TABLE X. RODS IN FEET, 10THS AND 100THS OF FEET

Rods	Feet	Rods	Feet	Rods	Feet	Rods	Feet	Rods	Feet
1	16.50	21	346.50	41	676.50	61	1006.50	81	1336.50
2	33.00	22	363.00	42	693.00	62	1023.00	82	1353.00
3	49.50	23	379.50	43	709.50	63	1039.50	83	1369.50
4	66.00	24	396.00	44	726.00	64	1056.00	84	1386.00
5	82.50	25	412.50	45	742.50	65	1072.50	85	1402.50
6	99.00	26	429.00	46	759.00	66	1089.00	86	1419.00
7	115.50	27	445.50	47	775.50	67	1105.50	87	1435.50
8	132.00	28	462.00	48	792.00	68	1122.00	88	1452.00
9	148.50	29	478.50	49	808.50	69	1138.50	89	1468.50
10	165.00	30	495.00	50	825.00	70	1155.00	90	1485.00
11	181.50	31	511.50	51	841.50	71	1171.50	91	1501.50
12	198.00	32	528.00	52	858.00	72	1188.00	92	1518.00
13	214.50	33	544.50	53	874.50	73	1204.50	93	1534.50
14	231.00	34	561.00	54	891.00	74	1221.00	94	1551.00
15	247.50	35	577.50	55	907.50	75	1237.50	95	1567.50
16	264.00	36	594.00	56	924.00	76	1254.00	96	1584.00
17	280.50	37	610.50	57	940.50	77	1270.50	97	1600.50
18	297.00	38	627.00	58	957.00	78	1287.00	98	1617.00
19	313.50	39	643.50	59	973.50	79	1303.50	99	1633.50
20	330.00	40	660.00	60	990.00	80	1320.00	100	1650.00

TABLE XI. LINKS IN FEET, 10THS AND 100THS OF FEET

Links	Feet	Links	Feet	Links	Feet	Links	Feet	Links	Feet	Links	Feet
1	0.66	18	11.88	35	23.10	52	34.32	69	45.54	86	56.76
2	1.32	19	12.54	36	23.76	53	34.98	70	46.20	87	57.42
3	1.98	20	13.20	37	24.42	54	35.64	71	46.86	88	58.08
4	2.64	21	13.86	38	25.08	55	36.30	72	47.52	89	58.74
5	3.30	22	14.52	39	25.74	56	36.96	73	48.18	90	59.40
6	3.96	23	15.18	40	26.40	57	37.62	74	48.84	91	60.06
7	4.62	24	15.84	41	27.06	58	38.28	75	49.50	92	60.72
8	5.28	25	16.50	42	27.72	59	38.94	76	50.16	93	61.38
9	5.94	26	17.16	43	28.38	60	39.60	77	50.82	94	62.04
10	6.60	27	17.82	44	29.04	61	40.26	78	51.48	95	62.70
11	7.26	28	18.48	45	29.70	62	40.92	79	52.14	96	63.36
12	7.92	29	19.14	46	30.36	63	41.58	80	52.80	97	64.02
13	8.58	30	19.80	47	31.02	64	42.24	81	53.46	98	64.68
14	9.24	31	20.46	48	31.68	65	42.90	82	54.12	99	65.34
15	9.90	32	21.12	49	32.34	66	43.56	83	54.78	100	66.00
16	10.56	33	21.78	50	33.00	67	44.22	84	55.44	101	66.66
17	11.22	34	22.44	51	33.66	68	44.88	85	56.10	102	67.32

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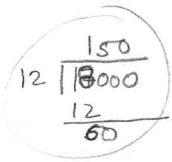

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