1999

Pazzaglia Field Notebook: Alps; Italy

Frank J. Pazzaglia

(ALPS)

SOKKIA™ F.J. Pazzaglia

TRANSIT FIELD BOOK

ALPS → ITALY

No. 8152-00

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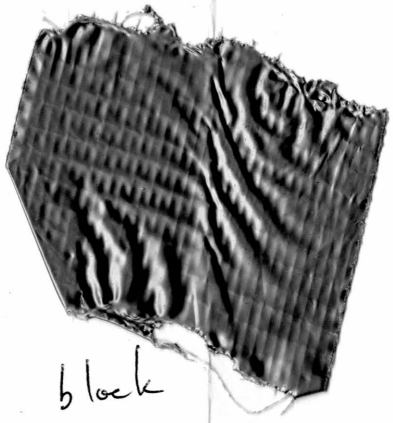
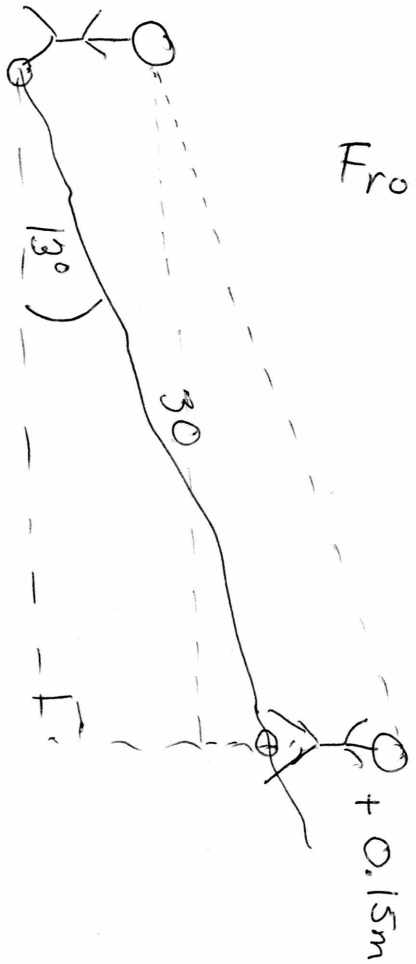
(★) Reward $$ if found and returned (★)



		1.83	2.74	black
Schraubm	0.347	1.22	1.98	Red
Chrysotile	0.334		1.52	Green
Sand	0.097	1.07	1.37	Yellow
	0.482	1.07	1.52	Blue
Egsa		~~0.76~~	~~1.52~~	
Silicon	0.214	1.07	1.52	Pink
Uberwasser	0.134	0.76	1.22	Gray
Valbirwa	0.435	0.91	1.52	Gray
Masseria	0.387			



$$\sin 13 = \frac{\text{Rise}}{30}$$

Frohliche Weihnachten

DAY 1 6/29/99 WARM, OVERCAST ①
humid

Begin Alps work with
- JANE
- MOUSUMI
- KURT STEFFAN

STOP 1 AXEN AREA - AXEN NAPPE.
PHOTO 1.

STOP 2 FURKAPASS - head of the Rhone
PHOTO 2
PHOTOS 3-5 Rhone GLACIER, head of the Rhone.

STAYING at Simplon, at the MONASTERY.
GREAT PLACE. EASY TO FIND - big building at the pass, TO the East of the Road. Wonderful folks here - friendly French-speaking. They seem happier than your average SWISS. PRICE ~ 43 SWISS FRANCS / NIGHT. (~$35)

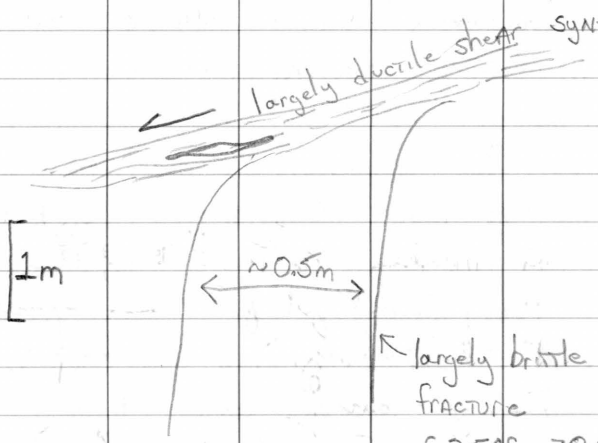
② DAY 2 JUNE 30, 1999

clear, cool, a slight north breeze

STOP 2.1 Engeloch - A few km south of Simplon PASS.

Exposures are in the footwall of the Simplon fault.

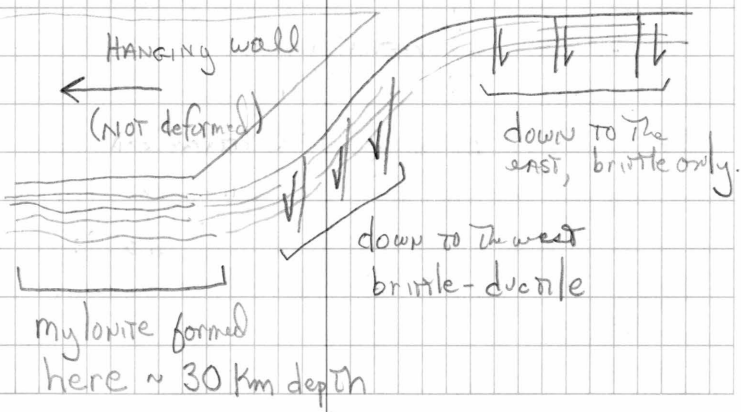
- Rock type - basement gneiss
- down-to-the-west mylonite fabric, asymmetric, stretched phenocrysts



STOP 2.2 Zwitzberg "between the mts"

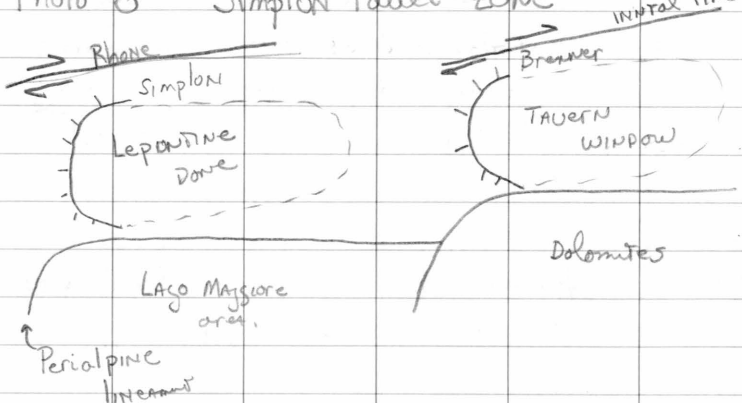
- ROAD @ reservoir that make several switch backs along the fault.
- HANGING wall rocks are albite-garnet schists, but IN OUTCROP scale, these rocks are very similar TO the footwall rocks AT STOP 2.1 These rocks are NOT mylonitized. AND while they have MANY FRACTURES, including vertical, these fractures are NOT organized. They have NUMEROUS ORIENTATIONS.

- ~ 100m up the road from the "NO TRESPASSING" SIGN, you clearly pass INTO the footwall rocks. They make the TRANSITION TO a clear, well organized mylonitic fabric



Photos 6,7 – Seehorn -SE face

Photo 8 – Simplon fault zone



STOP 2.3 Discussion + Lunch on switch back overlooking the Seehorn.

Photo 9, View up the Zwischbarg valley into the hanging wall, illustrating lack of systematic gullies.

Photo 10, hanging wall rocks, with a fold

Photo 11, footwall rocks, illustrating mylonitic fabric.

STOP 2.4 - upvalley at the hydropower station.
Here we are well into the hanging wall.
There are no well-developed vertical fractures.
In fact - numerous talus cone, alluvial fans + several hillslope regolith mantles the S-facing slope.
- Photos 12-14

STOP 2.5 Furggu Pass - from here the topographic distinction btwn the hanging wall + footwall is very clear.

GLATTHORN - Photo 15

- Photos 16-19, views of the N-facing valley side from the road to Furggu Pass.
Qualitatively, the N-facing slopes are similar in expression to the S-facing slopes.

STOP 2.6 Sistilmatta. A metasedimentary septa (marbles) between the two gneissic nappes. Here, the faults are evident as the sed rocks are offset.

- Photo 20 - view down valley to Gonda + the Italian border.

DAY 3 July 1, 1999 foggy, cool morning
clear ceiling

STOP 3.1

Today's objective is to ascend the high country above + east of Simplon Pass, north of Mt. Leone. The GLATTHORN

The S-facing slopes have grassed gullies, full of talus. The upper 1/3 of the slope is exposed bedrock. Jane records both small east-down faults (~0.5m) separation and larger west-down breccia zone faults. Interfloves are narrow, pointed, leading to a prismatic slope texture

The N-facing slopes have bare talus gullies. The gullies are NOT recessed nearly as much as on the S-facing side. Interfloves are broader + rounder. AND there appears to be a strong distinction in rock hardness because the upper 1/4 of the slope is very crumbly. It weathers very differently.

(8)

Where the upper hackly unit is in free face, ~10-20m scale, west dipping fractures are very apparent.

Photo 22. - North-facing hillslope.

S-facing Slope

measurement of interfluve septa to septa

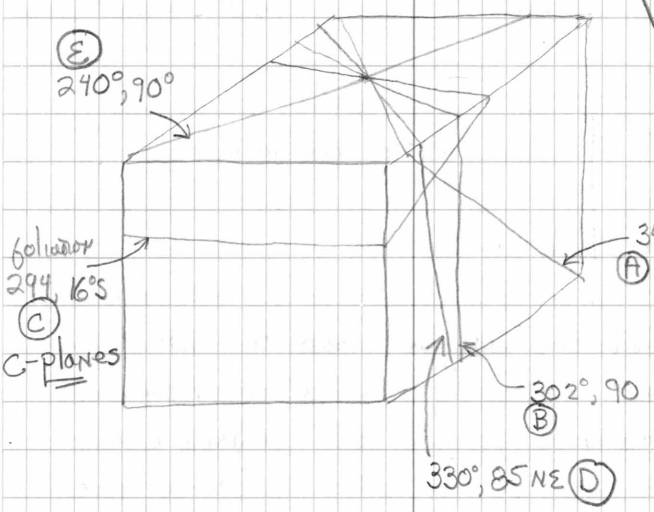
S-facing Slope			N-facing slope		
#	dist (m)		#	dist (m)	comment
1	65	½ measured	1	48	½ dist → minor crack to major crack.
2	73		2	43	
3	98		3	88	
4	83				
5	111				
6	115				

From the N-facing slope, it is more apparent that there are more similarities rather than differences. The aplite is harder, expresses only the faults; the overlying "schist" is softer and expresses the faults, brittle-ductile shears, + small fractures.

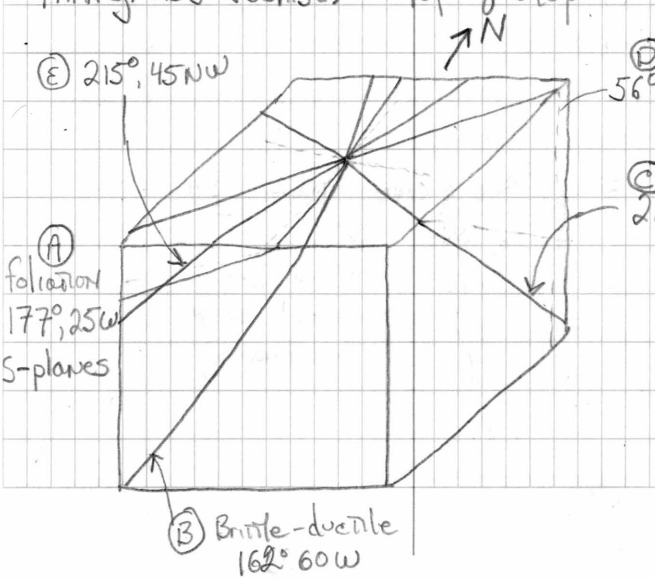
(3.2) - Road outcrop slope rock-mass strength

See Day 7 for more Deeds

Aplite – at base of slope



Paragneiss (schist) – Top of slope



(10) DAY 4 July 2, 1999 Absolutely beautiful clear, sunny, warm, slight breeze

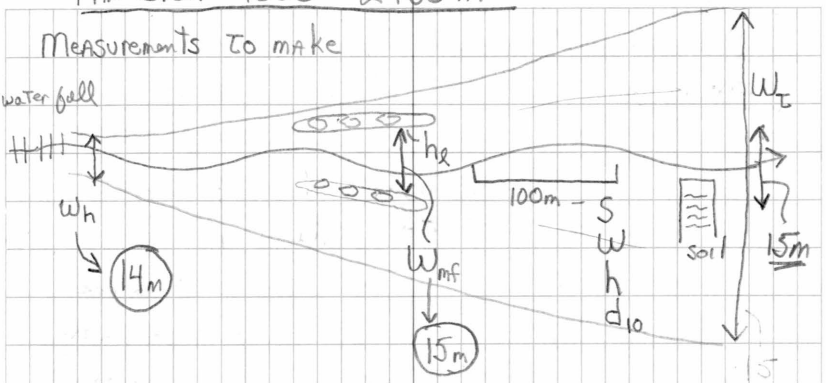
START of 36 exp roll.

Today we are up a MAIN valley south and west of Simplon. IT is the MAIN valley immediately north of Furggu PASS. The objective was TO look at CHANNEL hydraulic geometries for STREAMS IN the HANGING wall; but IT IS clear that this will be impossible. All "channels" are VIRTUAL waterfalls and are shaped far more by debris-flow processes than anything else. Thus, IT will be far better TO characterize the deposits, rather than the channels. We will do this for TWO drainages IN the hanging wall and TWO IN the footwall, with N+S ASPECT considered.

HANGING WALL localities

Fan Elev. 1600 – 2400 m

Measurements to make



In both foot wall + hanging settings, it is important to demonstrate that the fans have accomodation space; that is, they fill paleo-glacial bowls.

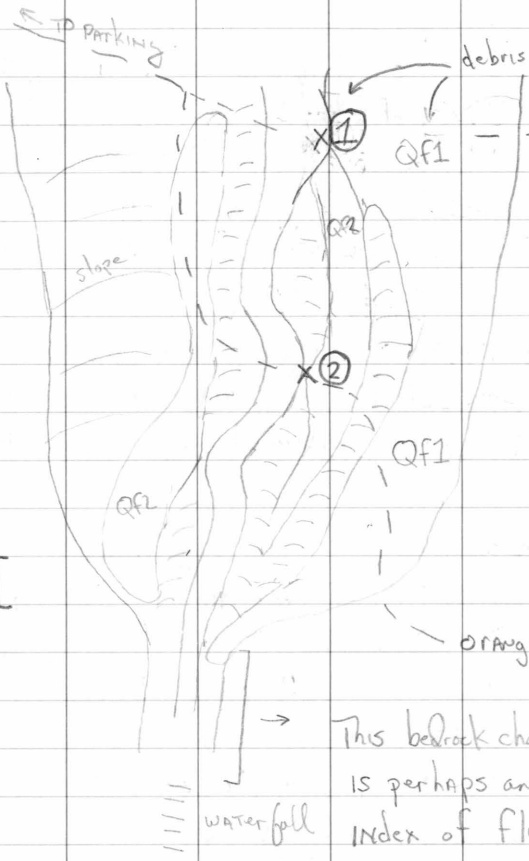
Eye heights - Jane 1.65 ; FJP 1.8 TO

30m reach	elev. correction	slope
1	0) at stream level	13
2	0	16
3	FJP is 2m above stream	23
4	JS is +2m	15
5	0	26
6	FJP is +1m	26
7	JS is +2m	21
8	0	28
9	0	

fan is ~210m long; h varies from 1 to 4m.

(12) Photos 1-4

Sketch of Schrabach fan

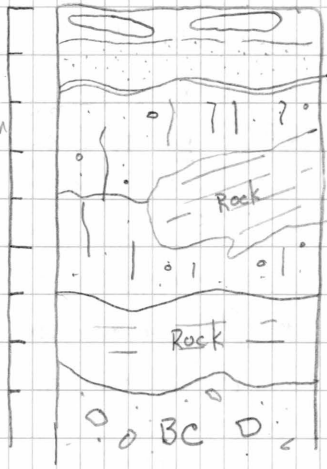


fans are very well vegetated debris flow lobes appear quite old + inactive

→ This bedrock channel reach is perhaps an important index of fluvial incision. It is a measure of knickpoint retreat.

Photo 5

Qf1 soil exposure (moist color / consistence)



silt lfsbk → sg 2.5Y 5/6

7.5YR 5/6

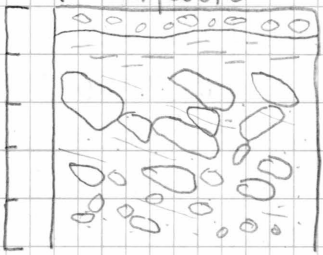
silty clay loam

2msbk, 1mpf,

10YR 5/8

loam lfsbk

Qf2 exposure



A_b silty clay loam 10YR 3/3

NO STRUCTURE.

gravelly loam.

2.5Y 4/4

Basin Rock-Type = paragneiss + minor ultramafic

(14) (4.2)

Jane has photos of these

Second Fan - at reservoir at Zwischbergen

- lots to say about this tonight ... for now

Ameistola-Chapfsite Elev = 1400 - 2200m

width at base = 17 m (active "channel" - width within the "Little Ice Age" valley bottom.)

Δ eye height = .2m (FJP up to MK)

30m #	Slope°	Comments.
1	19	
2	20	↖ 18m reach to break in slope
3	16	
4	17	
5	19	w = 11 m
6	21	break in slope
7	16	
8	18	upper end of LIA terrace
9	21	w = 10m

Fan surface slopes

↳ large trees + 80+% lichen coverage.

Qf1 - Pre little Ice Age 24° over 25m

Qf2 - little ice Age proximal 20° over 30m
v. bouldery

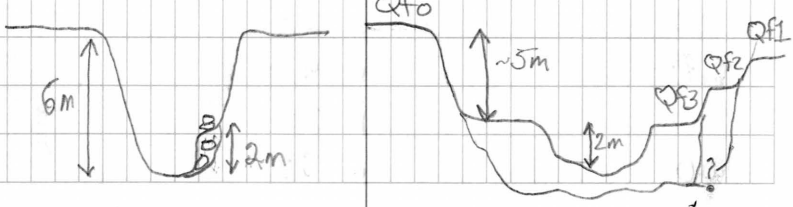
Qf3 - little ice Age distal 19° over 30m
more fine grained

Sample Simplon-1 from Qf1

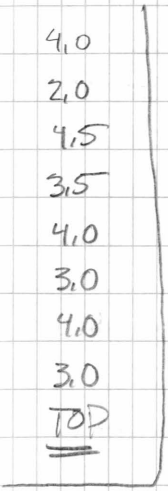
Wood - tree trunk buried in deposit.

OK, general thoughts -

- we worked two drainages on the hanging wall. These drainages are v. steep - essentially waterfalls. Their alluvial fans are the only hope for quantifying differences in hillslope behavior?
- We worked both a north + south-facing drainage.
- In both cases, the drainages supported fans with numerous indicators of stability including
  - vegetation
  - Red soils w/ Bt horizons + E horizons
  - lichen covered debris flow lobes
- The fans are debris-flow dominated and have 1 to 4 surfaces ... My guess is that the highest + oldest is late glacial, with the others being mid-Holocene + little Ice age. Clearly, I think that the inset fan surfaces are climatic in origin. The Little Ice Age fans are clearly inset into a much larger + stable late glacial (?) fan.



B-AXIS metric	from Schrabach 6t to nearest 0.5 6t.			from Chapfsite metric 6t. within or on the leaves	
			BASE		
14	base	4.0	3.5	2	2.5
5		3.0	4.0		4.5
6.5		4.5	6.5		2.5
4.5		5.0	5.0		3.0
4.0		5.0	3.0		9.5
4.75		10.0	7.0		4.5
4.25		10.5	3.0		5.0
10.0		8.0	3.5		3.0
6.5		8.0	2.5		4.0
2.5		6.0	3.5		4.0
3.5	↑	4.5	5.5		3.5
4.0	lower	8.0	4.0		4.0
6.0	← 6AN	4.0	6.5		5.5
4.0	upper	3.5	6.0		5.0
5.0	6AN	3.5	4.0		4.0
6.0	↓	6.5	6.8		7.0
6.5		7.5	13.5		6.0
4.0		TOP	3.5		5.0
8.0			2.5		4.5
6.0			4.0		3.5
8.0			2.5		3.5
8.0			3.5		5.0
9.0			3.0		4.5
7.0					



BASIN Rock-type = PARA GNEISS + MINOR MICA SCHIST

(18)

DAY 5 July 3, 1999

WARM, clear humid, calm.

GRAINSIZE DATA ON PG. 29

Today we will work two fans in the SAND AREA.... up valley from Sistilmotta. In the footwall.

(5.1)

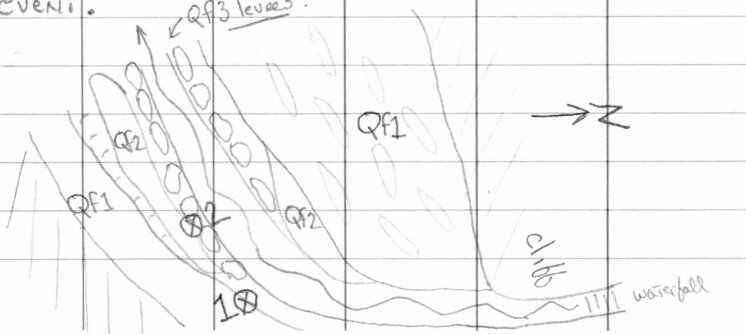
Drainage 1 - Sand fan

- fan + drainage are larger than fans observed on hanging wall

Qf1

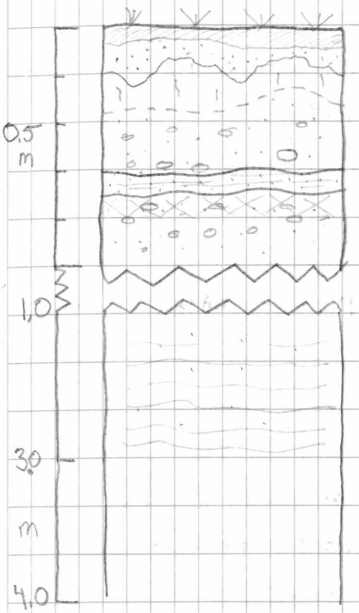
- The abandoned, highest fan surface is characterized by:
  - unmodified bar + swale
  - clast w/ <20% lichen coverage
  - NO soil beyond a 20cm OA, Cox
  - large trees, likely several decades to centuries old.
  - composed of fluvial facies exclusively.

Qf1 is likely an aggradational little ice age event.



Soil Location 1

Dry colors



wavy bedded pebbly, micaceous sand. Redox, gleyed colors.

Soil Location 2 -
· virtually identical ... locally missing Bw

FAN Slope 30m $\Delta h = 0.2m$ $S = 7.5°$

BASIN Rock-Type = PARAgneiss + minor MICA Schist

FAN surface slopes. ($\Delta h = 0.05m$)

Qal			Qf1		
	30m	4°		30m	5°
	60m	5°		60m	6°
	90m	7.5°		90m	8°
	110m	8.0°		110m	8.5°

5.2

FAN #2 Egga FAN

- much steeper than other three fans
- 20% lichen cover on clasts
- TOE IS burying LGM (?) moraine.
- AS far as I can tell, IT IS A NICE, conical aggradation surface. No cut-fill stratigraphy. No compelling evidence for old deposits or surfaces.

Rock-type IS PARAGNEISS + METASeds including marble.

$\Delta h = 0.2$ m MR TO FJP

30m-seg	S°	comments
1	20	smaller distributary.
2	25	
3	25	
4	24.5	NOW IN MAIN DRAINAGE
5	26	X = 19m - TO gully bed
6	35	X = 11m
7	28	
8	29	

There is a very nice, small slump on the south side of the stream at Essa.

Travel into Domodossola. This is a quite large city with some accomodations. The train station provides a simple point of reference, being located at the east side of town. There are 5 hotels in and around centro. Domus and sempione (★★) (near central walking market; via GG Gallettì at via Cavallotti). Others are 3 ★★, including the Eurossola at the train station. We stayed at the Europa, ~ 3 km south of town on the main drag (Via Torino). ~25/person

There are 4 nice restaurants in centro, near the walking market.

(22) Day 6 July 4th, 1999 v. humid, calm, cool in mts, hot in valleys

LAST visit to Zwischbergen → description of fan soil + re-look at surface characteristics.

- much better developed soil. Parent material (deposit) is a micaceous, brownish-red, clay-rich, matrix-supported diamicton. Likely a debris-flow. Much of the color + clay is inherited from the source. But.... There is a nice soil developed here too.

Reoccupation of (4.2)

Photo 16

Remainder of day was a drive to the Eastern Alps, from Domodossola to Tonale Pass. Along the way, at Finero (actually ~1 km east of Finero) we stopped to look

at, and swim through the mantle. Very impressive site for geology + swimming. It is accessed by a local "National Park" trail. After Finero, we proceeded slowly past Lago Maggiore, Lago Luonso and Lago di Como. Very nice lakes, disgusting tourist towns. Then we continued east, along the Peri-Alpine lineament through Solano, Aprica Pass and to a delightful, small town just west of Temú for dinner at a Pizza restaurant. Now we are in a two star hotel called Hotel Edn (~ $20/person). At the Tonale Pass.

DAY 7 July 5th 1999 warm, humid pt. cloudy.

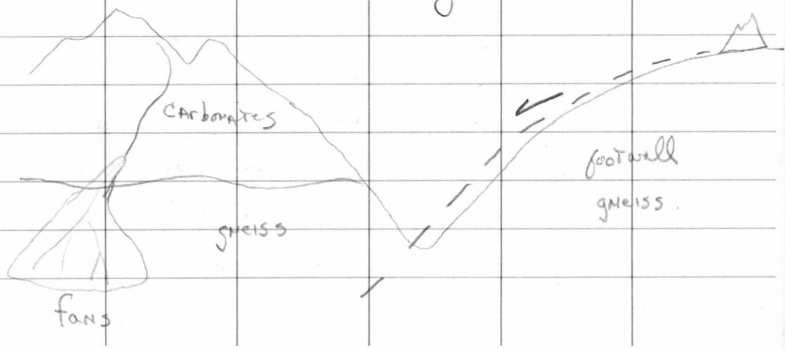
We began with a drive from TONALE PASS to BOLZANO (slow), then proceeded to STERZING (NICE) and up to the BRENNER Pass region.

→ VIPITENO. JUST north of VIPITENO is the small town of Colle Isarco (GOSSENSAß). A road proceeds west up the R. di Fleres valley. VAL DI FLERES

STOP 7.1

AT ANICÉ, the road crosses the river. TO the north is an old gravel pit in the toe of a large FAN IN the Kaimcraber drainage. This FAN, and others like it here are all v. steep (~30°) and composed of CARBONATE clasts, reflecting the rock-type underlying most of their drainages.

view looking NE



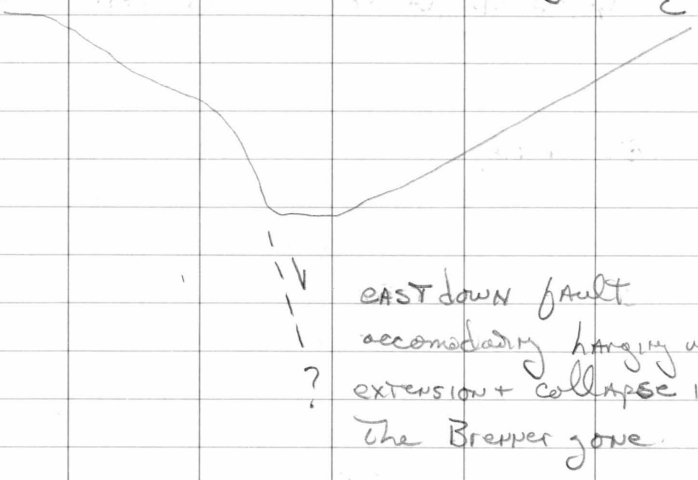
The fan stratigraphy shows very well stratified + sorted deposits. - It is a bouldery, gravelly sand. A surface soil + buried soils are not particularly evident. These south-facing fans are at least 50m thick.

The north-facing slopes are completely different - virtually no fans, no soil, deeply entrenched drainages. No soil creep.

Toffingss drainage heads to a small reservoir and alpine meadow at ~1600 m. These present the best hope of making direct fan comparisons to the Simplon area. The Toffingss drainage is very likely fault controlled, but its tribs are not.

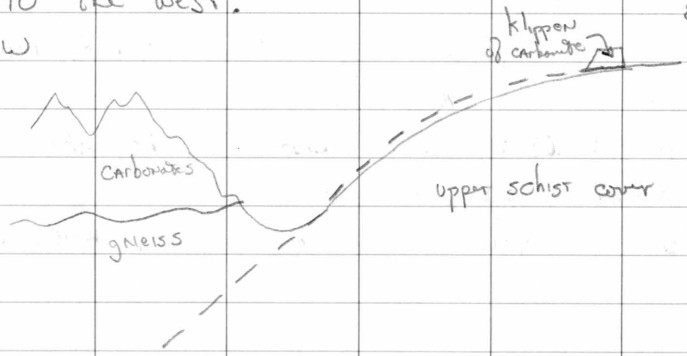
Alluvial fan stratigraphy in Toffingss is pretty unremarkable. One major surface w/ 80% lichen coverage on clasts that are NOT carbonate. The fan is carbonate-dominated, and decidedly fluvial or hyperconc. process facies. Soil is moderately well-developed with a A, AE, Bw(?) C. ~40cm total depth of weathering. I am very uncertain as to the local effect of carbonate rock type.

Only other remarkable geomorphic expression is that the west valley wall is steeper in its toe than the east valley wall.



STOP 7.2

Dip slope of Hühnersphiel. At a location where the Brenner fault begins its big roll over to the west.



The fault plane appears to be very well preserved on the interfluves. Why? There is nothing capping it. Why the hanging wall would be so effectively removed with no turtle back-like silica carapace.

Rock-Type Characteristics

Gully spacing

#	distance (m)
1	47
2	39
3	27
4	28
5	48
6	37

Basic Fracture data

Orientation		Fracture width	Fracture weathering	Fracture Spacing
C-foliation	154-194 16-20W	0	0	1cm
west-down	152-168 75W-90	~1-2mm	0 - moderate	10cm
325-329	53-60E	"	"	5cm
262	40N	0-1mm	moderate	0.5m

more Rock type data STOP 7.2

		Schmidt Hammer #'s.
Foliation	194 16W	32, 26, 27, 24.5, 42, 34,
	165 16W	26, 46, 40, 42, 46
	154 20W	
High angle	152 77W	54, 55, 57, 51, 60, 58,
	162 75W	45, 56, 39, 16
High angle weathered	325 60E	24, 34, 30, 58, 27, 54,
	339 58E	45, 40, 58, 51
	335 53E	
crop //	262 38N	37, 34, 39, 38, 50, 48,
	265 43N	34, 38, 43, 40

more Rock-type info from Simplon Area.

STOP 3.1

	Orientation		Fracture	Fract. X	
1	336	59 NE	1-2mm	30cm	48, 62, 64, 64, 62, 64, 68, 60, 52, 63
2	302	90	1-2mm	30cm	62, 62, 58, 66, 66, 64, 62, 67, 66, 61
3	294	165 foliation	O	15cm	25, 26, 28, 35, 28, 31, 32, 36, 43
4	330	86 NE	"	40cm	62, 58, 59, 50, 56, 60, 60, 58, 60, 60
5	240	87 N	"	50cm	44, 36, 60, 39, 32, 41, 37, 34, 39, 38

STOP 3.2

	(foliation)	fracture w	frac X	schmidt hammer
1	177 20W	10cm	0	22, 36, 55, 45, 42, 28, 22, 32, 40, 56
2	162 60W	50cm	1-2mm	61, 61, 48, 32, 58, 56, 69, 42, 49, 38
3	285 70N	1.5m	"	64, 66, 54, 58, 62, 63, 54, 44, 65, 47
4	60 85E	25cm	"	36, 44, 45, 30, 39, 35, 53, 35, 24, 52
5	215 45NW	2m	"	45, 44, 48, 45, 35, 34, 34

SAND FAN d_{50} (metric (?))

N. levee, TOP

4.5 →	3.0
5.5	3.0 ← 30m from bottom
3.0	3.5
6.0	3.0
4.0	2.0
4.5	2.0
4.5	2.5
5.0	1.5
4.5	3.0
2.5	base
6.0	
3.0	
3.0	
3.5	

S. levee TOP

3.5 →	5.0
2.5	4.0
2.5	3.5
4.5	3.5
4.0	4.0
5.5	2.5 ← 30m from base
3.0	
4.0	
4.5	
5.0	
4.0	
4.5	
3.5	
4.5	

Essa	Fan top	
4.5	3.0	← @ 130m from base.
4.0	3.0	
3.5	5.5	
3.5	2.5	
5.5	4.5	
2.5	4.0	
2.5	2.0	
3.5	3.5	
3.0	3.5	
6.5	3.5	
2.5	2.5	
4.0	4.0	
4.5	1.5	
4.5	2.0	
4.5	3.0	
4.0	3.5	
3.0	3.5	
2.5	1.5	
4.0	2.5	
2.0	3.5	
4.0	3.5	base.
1.5		
3.0		
4.0		

Vipiteno (Sterzing) is a great town. Totally bi-lingual and a nice mix of Italian & Tirolian things. This area is called the South Tirol = Südtirol. It is vibrant, alive, + beautiful. It is really unclear where the prosperity comes from... but it is an intoxicating mix of Italian vivacity and Tirolian (German) work-ethic. The people here settled these valleys in Roman + post-Roman times. They are a mix of French, Spanish, German + minor Italian peoples that speak an ancient version of Latin-heavy German called Ladino. Although each individual valley has its own dialect + language. Some valleys speak something more closely allied w/ Romansche, a Latin-based language similar to French, that is spoken in parts of Switzerland. The towns of St. Jakob and particularly Kematten (Caminata) are beautiful vacation destinations in the Pfitschtal (Val di Vizze).

The Pfitschtal is interesting from the perspective that a large landslide supported a lake in Roman times. A catastrophic failure of the dam in Roman times took out ~ 10,000 Roman soldiers camped at Vipiteno.

Day 8 July 6, 1999

cool, breezy, pt. sunny. Aft rain + sleet + fog.

At the Alpine hut at the head of the Rio d. Vizze valley. Passo di Vizze. Pfitscher-joch-Haus.

Today is a long hike around the head of the Fleures valley, looking at and sampling a shear zone. I am going to focus more on the fractures exposed in N-S oriented valleys to try to illustrate if they are faults.

Site 1 - Kurt's sampling Area 1.

035	5°SE
330	79°NE - This is a pervasive fracture - it is valley wall // and appears to increase in frequency towards the valley wall. Is it a sheeting joint?
310	85°NE
305	28° NE fold surface?
331	76° NE

Sample	Locality 2
334	79 NE
345	33° NE
157	89° SW

Sample locality 4

140° 70°SW

138° 78°SW

240 73° NW

A hike to the head of Fuchsboden valley did not reveal a fault, but rather that the valley is decidedly asymmetric - being steeper on the west (east facing) valley side than on the east valley side.

This hut is outstanding. Sepp and his family are quite the hosts. Good food + good company.

Pfitscherjoch Haus
Passo Vizze 2276 m
St. Jakob 103
Italy - 39040 Pfitsch - Val di Vizze

Josef Volgger
Prüska
Magdelena

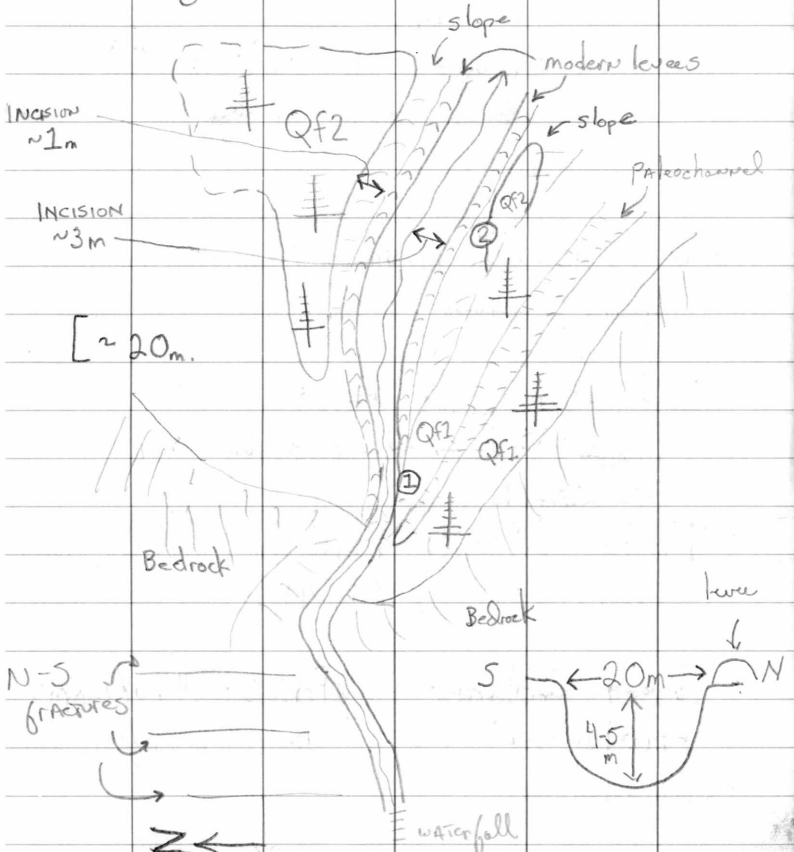
Price ~ $40/night.
Includes breakfast + dinner.

(34) Day 9 July 7, 1999 breezy, foggy, cool at elevation

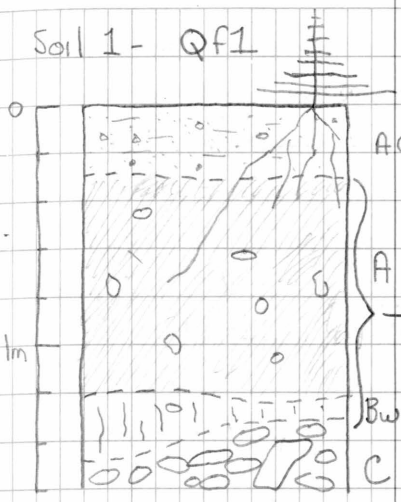
We wish to work two fans on the footwall rocks in the Rio d. Vyse valley.

STOP 9-1

First Fan - S-facing. Sfinol graben Elev ~1400m (just west of Bargone)



Soil 1 - Qf1



moist colors

AC 2.5Y 3/2

A 2.5Y 2.5/1

Bw 2.5Y 4/3 1vfsbk

C 2.5Y 3/3

Soil 2 - Qf2 Photo 25

A 10YR 2/2

Bw1 1fsbk 10YR 4/4

Bw2 sg 2.5Y 5/4

Cox 2.5Y 4/3

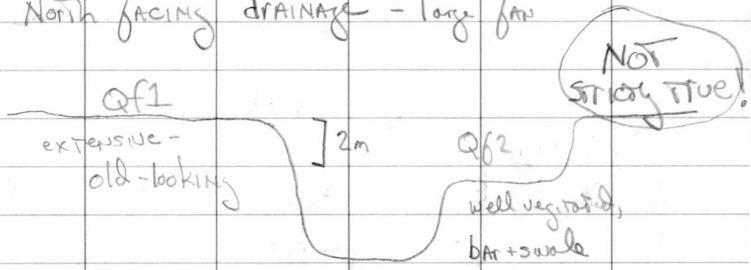
No meaningful soil on Qf3. It is a very youthful deposit, probably <25 yrs old.

The Sifinol Fan is similar to the Simplon footwall fans in that it is composed of mostly gravelful deposits. However, Qf2 is inset into Qf1, a feature not observed at Simplon. We need to look at a second fan in this valley....

My best guess for deposit ages here are:
Qf1 late (?) Holocene.
Qf2 little Ice Age ~500 yrs?
Qf3 modern.

The lack of any datable material in deposits contrasts with the modern channel and speaks to perhaps the lack of vegitation during fan aggradation.

STOP 9-2 Uberwasser Graben at Pingst
North facing drainage - large fan



both surfaces are very bouldery. It is extremely difficult to find a good soil

exposure. What you do find are v. bowldy exposures w/ A massive root mat + a thick black, organic soil. (~1m)

Nix some of that... what we really have here is:

Photo 26

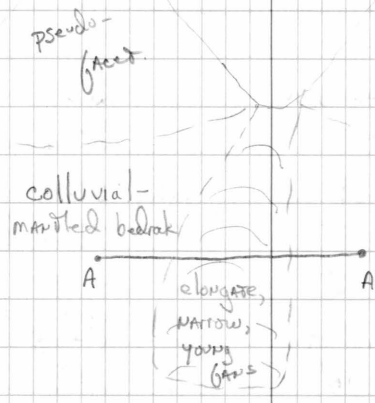
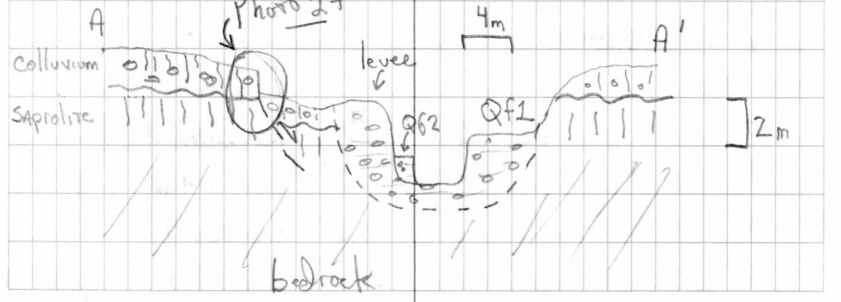


Photo 27



There is virtually no soil development in Qf1, it is late Holocene or younger, most likely, younger.

9-3 A walk up the Obergrube drainage, just east of Caminada. This search for faults was largely in vain. The drainage is choked with colluvium / alluvium undivided.

DATA for 9.1

Channel Slope		levee slope
30m	7°	9°
60m	9°	9°
90m	12°	13°
120m	15°	15°
150m	15°	16°
170m	15°	16°
200m	18°	14°

Qf3	Slope
30m	13°
60m	10°
downhill	

Qf1 gully	
30m	22°
47.7m	22°

working upstream

b-axis top

2	5	4	2	3.5	2.5	2.0			
2	7	3.5	2.5	2.5	2.0	2.5	3.5	1.5	1.5
2.5	3.5	2.5	2.5	4.0	5.0	5.5	2.0	1.5	4.0
2.5	3.5	2.5	4.0	4.5	5.5	3.5	2.5	2.5	bottom
2.5	3.5	5.5	2.5	3.0	3.0	4.0	2.0	2.5	

Qf1 surface	
30m	17°

Data for 9.2

Bedrock / colluvial slope

30m	7°
60m	7°
90m	10°
120m	11°
150m	10°
180m	10°
210m	10°
240m	11°
270m	9°
300m	9°
330m	9°

downhill ↓

Stream channel

30m	7°
60m	8°
90m	8°

↓ upstream

bottom - at cow bridge

3.5	2	3.5
3.0	3.5	5
3.0	4	4
4.0	6.5	2.5
3.5	2.5	2.5
3.5	3.5	3.0
10	3.5	4.0
4	2.5	
3	5	
2	4.5	

all clast sizes are in metric feet

(40) DAY 10 7/8/99 cold + fog + rain at elev. cool + overcast in valleys.

We are in the hanging wall today to work at least one hanging wall fan. Valle di RAGLINES

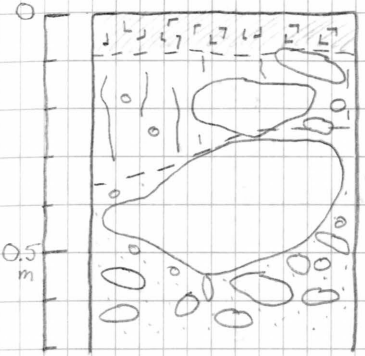
STOP 10-1 Region around Colle (Bichl) is not good for fan work... mostly, N-flowing drainage are incised through a till-mantled bedrock.

STOP 10-2 South flowing drainage + fan east of Flading (Valletinna). A mixed carbonate - schist drainage w/ headwaters in the schist. This is a marginally workable fan. A recent debris flow has created some exposure.

Soil 1 is very poorly-developed.
Just a 5-10cm A, organic-rich over a Cox.

Qf3 is well-stratified - looks like a good fluvially-dominated fan.

Soil 2



moist colors

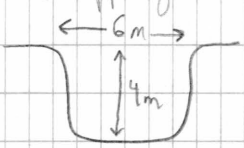
A 10YR 2/2 2vfsbk

Bt 1fsbk, 1nbr 10YR 4/3

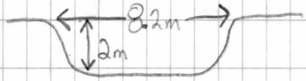
BC 2.5Y 4/4

photo 29

mid-upper fan



Upper fan



This station is ~150m from Bedrock cliff-face.

Slope data

bottom				
20m	15°	140	19°	
40	15°	157	16°	
60	15°	177	10°	
80	16°			
100	16°			
120	21°			

water returns to channel middle

main channel goes dry

equal pt.

197	13°	
217	19	
237	19	
257	23	
277	15	
297	20	
317	18	TOP

Qf1

30m	19°
56m	16°

shown upstream

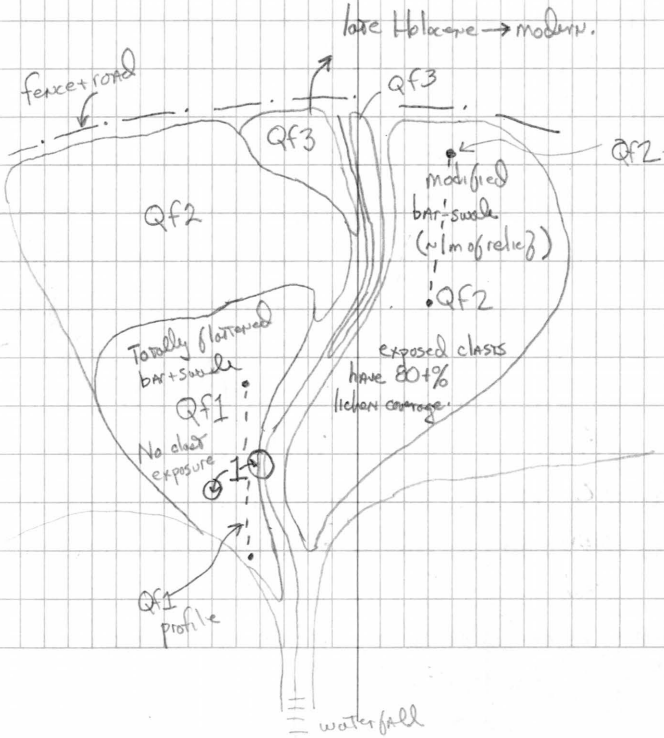
grassy dune - bottom

2.5	3	2.5	3	3
1.5	4.5	3.5	2	4
3.0	3.5	2	2.5	4
2	2.5	3	1.5	3.5
3	3	3.5	3	6.5
2.5	1.5	4	2	3.5
2.5	2.5	3	3	1.5
2.5	2.0	4	3.5	2
2.2	2	3.5	2.5	3
2	2	2	2.5	2
1	2	4.5	2.5	3
1.5	2	4.5	4	2
2	2	3.5	2.5	3.5
2	3	3	2.5	4.5
2.5	2.5	2	2.5	3
2.5	3.5	2	2.5	4.5
2	2.5	2.5	5 middle	3
2.5	1.5	2	4.5	2
2.5	2	2	4	2.5 top
2	2	2	6	
2	3	2	4	
3	2	3	2	
2.5	1.5	4	3.5	
1.5	4.5	2.5	3	
2.5	2.5	2	3	
2.5	2	2.5	2.5	

STOP 10-3 FAN (s-flowing) at head of Val di Ridanna. ~1 km upvalley from MASSERIA. (AT MINERAL MUSEUM).

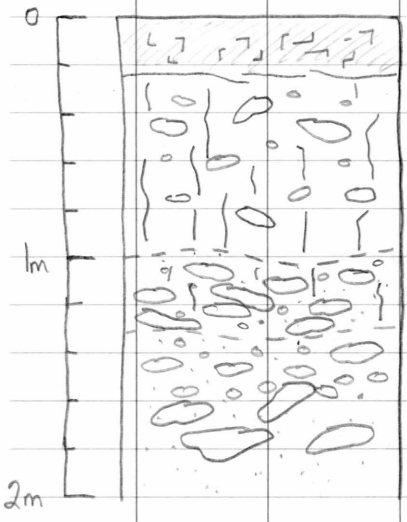
The FAN SURFACES are very well expressed here. I don't know if that is an expression of a youthful FAN, or simply a logged-PASTURE FAN. This DRAINAGE is all IN GNEISSIC + schistose rock-types.

- ONE THING for sure... There are NO equally-spaced DRAINAGES and there are NO "prismatic" hillslopes at + NEAR the divide.



I've got to scrape together small pits to get a feel for the soil on Qf1. - what is clear is that it is old + very well developed. The best soil we have viewed so far.

Qf1 soil — moist colors

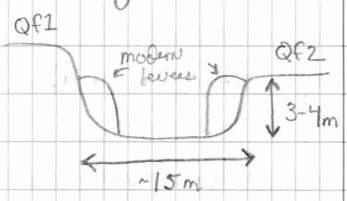


A local farmer has confirmed that the big incision occurred last summer ('98).

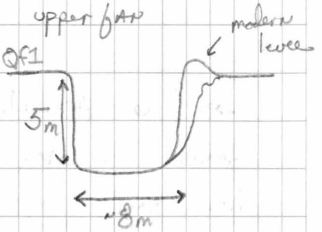
Photo 30 is of the fan
Photo 31 is of a Rouche Mountaine.

Channel cross-sections are not truly accurate

given the youthful nature of the drainage. But at midfan:



looking downstream



GOTO PAGE (49) for slope + grainsize data

Drive from Vipiteno into the Ahrntal or Valle Aurina takes ~2 hrs. There are numerous opportunities for rooms + accomodations in every town that we pass. We have opted to stay at Lutago (Luttach). Actually, we are in Lutago di Sopra, ~1 km north of town. We are in a great 2* Pensione called: Pension Erlhof

Im Anger 7
I-39030 Lutago
Valle Aurina
Alto Adige

~$40/night
breakfast + dinner

Folks + food here are decidly more reserved + German. But all are still v. friendly.

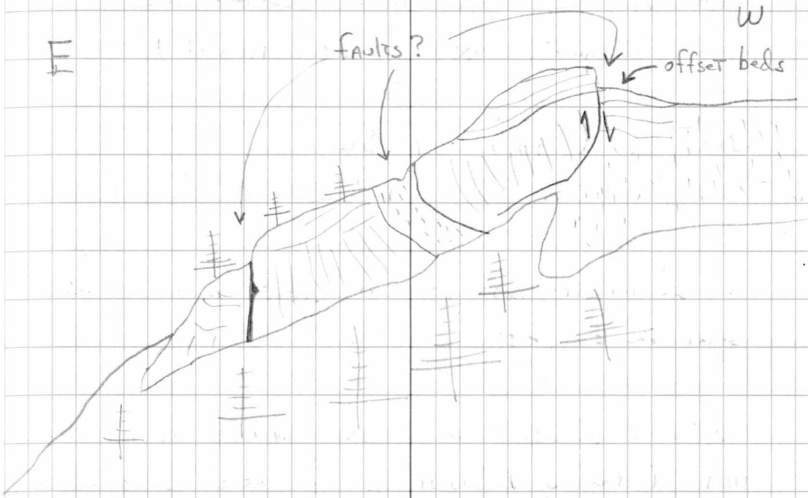
(46) Day 11 July 9, 1999

warm, clear breezy in the valley. Foggy + snow at elev. - beautiful up aft.

In the Arentihal valley. Beautiful. Will devote the day to trying to substantiate high-angle faults in the Schwartzenbachtal valley. This S-flowing drainage is one of several that appear to be equally-spaced within the Taveran Window. We choose this drainage because the lower Schist unit is exposed. Perhaps the contact of lower schist with gneiss could be observed.

The hike began primarily in a micaceous marble unit. There is virtually no expression of any high angle faults. The side valley fans are exploiting drainages aligned with the foliation. They seem to have characteristics (i.e. old surfaces) more in common with hanging-wall fans. The trail passes into lower schist at about 1 km from the parking area (end of paved road). Again, there is little expression of high angle faults. About 2 km into the hike, the trail climbs to a house. At this point, a prominent cliff band strikes across

The valley. There are some fine targets visible from this vantage. Up valley, we can explore prominent cracks in the cross-valley cliff band. Down valley, the west valley wall looks like:



STOP 11-1 cross-valley cliff band. Several small E-down + W-down faults were observed. Jane measured orientations on them and found them to be NOT exactly parallel to other E+W down faults in the Brenner footwall.

STOP 11-2. First (big) waterfall upstream of the cross-valley cliff band. At least two west-down faults were measured. They occur west of the waterfall. Jane sampled one of 3 vein

from these faults. Sample # 99-10-2.

STOP 10-3. Beyond the second waterfall, the high cirque headwall has numerous high-angle fractures. We have ascended the most prominent, grassy fracture. (widest)

S65°E (294) 67° SW

Day 12 July 10, 1999 RAIN all day.

Good day to travel. Very soggy. It has taken all day to travel from the Valle Aurina to Breitahner Hut in Austria via the Fen-tunnel. Austria gives me the creeps. It is really sedate. Everyone wispers during dinner and no-one seems happy.

Slope of Massetia Fan

30m	17°	208.5	36°
60	19.5°	238.5	23°
90	17°	268.5	25.5°
120	18°	298.5	21°
150	19°	shooty upstream.	
180	21°		
197.1	21°		

Qf1 - shooty downhill

30m	22.5°
60m	23°
90m	24°

Qf2 shooty downhill, START OF Qf1 TERMINOUS.

30	21.5°
60	19.5°
90	17°

Grainsize data of Massetia Fan

TOP	3,0	4	5	3	2,5	6	3	3	3
	3	3,5	4	4,5	2,5	3	4	4	3
	2,5	4	4	2,5	3	3	3	3	4
	4	4	4	4	3	12	2	3	3
	2,5	3	2,5	2,5	3	5	4	2	3
	2,5	2	2,5	4	5	4	3	3	3
	3,5	4	2,5	4	3,5	4	7	2	4
	3	3,5	5	4	3	3	5,5	3,5	2

(50)

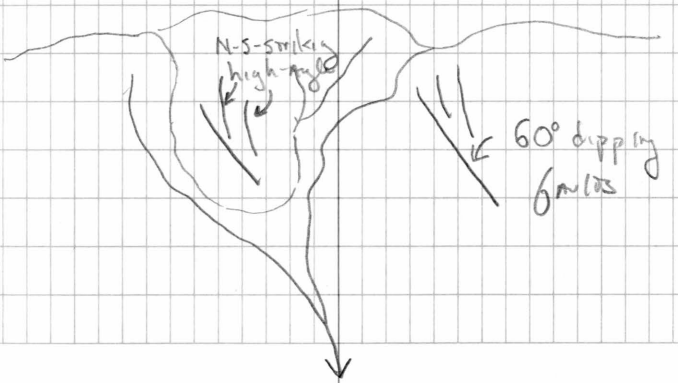
6
5
3
2,5
4
4
3
4
3
4
3,5
3
5
4
6
3
6

Day 13 July 11, 1999 High overcast + drizzle

In the Schleegeis Grund. The valley with the reservoir. Lots of evidence for west-dipping fractures along the reservoir road and in the exposed cirque lip. Photo 34.

Some early AFT data from this valley - in the hydro tunnel argue for 5-6 Ma cooling ages. (Central Gneiss).

- What a washout! All day in the rain - up to the cirque lip.... The data are just overwhelming. At the cirque lip, there are low angle (~60°) fractures aligned with mafic rocks + qtz veins. Some of the more mafic rock looks like fault rock, but it is not so very convincing.



The "Answer" to drainage location may lie in fracture traces... That is, drainage localization by fracture intersection.

- Look for the book on Groundwater Geomorph.

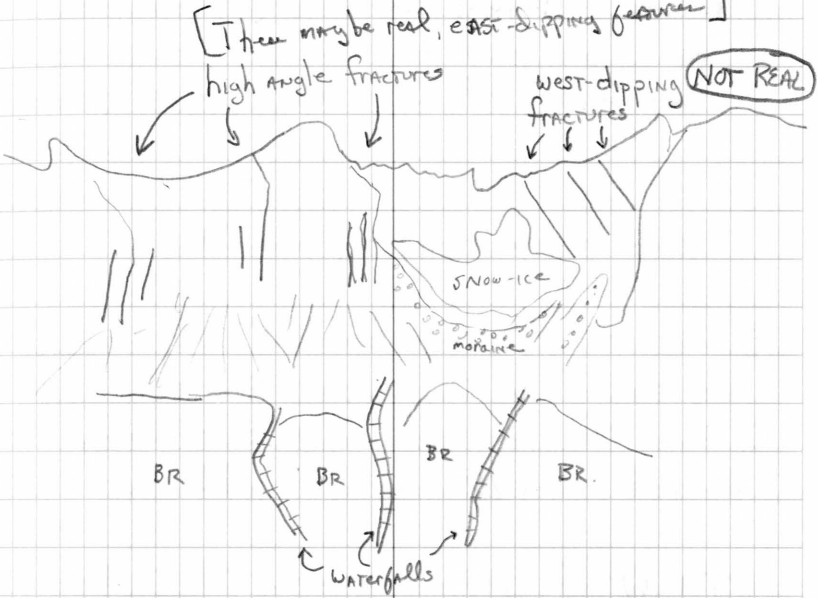
- Lastly, consider that the drainage may have developed on upper Schist cover and been superimposed...

Day 14, July 12, 1999

high overcast, cool, humid.

Im Gunggcal valley - A short, steep valley nested within the large N-S oriented drainages like the Schleeges Grund we were in yesterday. Again, we are looking for some evidence of faults.

View looking South from MAXHÜTTE.



STOP 14-1

Ridges developed normal to foliation display a gulling with no particular spacing or orientation, in contrast to the proximal foot wall.

Photo 35

Also at this stop we have climbed a grassy talus slope to investigate a wide crack on the west side of the valley. It is unconvincing as a fault. Like most cracks, it appears to be more of an exfoliation crack, many of which wrap around + line these valley walls.

- Actually - There is one polished fracture here which looks much like a fault. - continuous, corrugated, polished. 000, 76°E 26°S rake on fault lineations.

seems to have strike-slip movement.

I wish to get some "baseline" on rock mass strength of the Central Gneiss. I choose the rock outcrop on the south side of the road, about 200m east of Breitlaher Hut.

Set #	Spacing (m) / Crack width	Weathering	Orientation	Schmidt Hammer
1	0.5-1 / 1cm	mod.	120/25°SW	50, 50, 60, 50, 52, 52, 56
2	4 / 5mm	low	355/75°E	20, 22, 40, 38, 50, 58
3	0.4-0.5 / <1mm	low	255/85°N	38, 42, 41, 41, 41, 48

1 = "exfoliation"; 2 = is parallel to the Gungpal E-dipping fracture.

7/31	Bfast	11.5
7/31	Diesel	55
7/31	Drink	3.
7/31	Cheese	20 NO reimburse
7/31	Tools	22

IN Thousands of Lire.

Record of Money Spent on Italy Trip 2000

(record especially that for Paola to reimburse the map purchase)

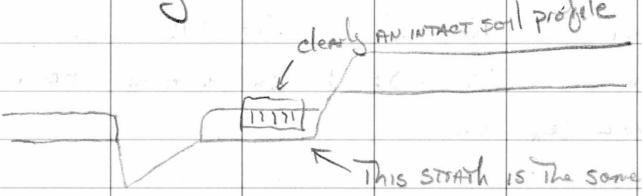
7/18	Dinner - Pizza	40	
7/19	Lunch - Bread etc	18.5	
7/20	Colagiove	11.7 (3)	
7/20	Camping	46 (23)	
7/19	Tolls	32	
7/19	Dinner	62 (24)	
7/20	Lunch	25 (8)	
7/20	Fruit	1.3 (0.4)	
7/20	Gas	44.3	
7/20	Diesel	67.5	
7/20	Gelato	9 (3)	
7/20	Groceries	56 (19)	
7/20	Car Repair	50 (no Receipt)	
7/21	Bread	3.1	
7/21	Gelato	13.6 (4)	
7/21	Wine	10 (3)	
7/22	Groceries	44.4 (15)	
7/22	Gelato	12 (4)	
7/23	Agrituristica	270 (90)	
Paola Paite		196.4	
7/23	Gas	10	
7/23	Dinner	43	
7/24	Camping	30	
7/23	Tolls	45	
7/24	Dinner	47	
7/24	Gas	64	
7/24	Tolls	9	
7/24	Lunch - Bfast food	26.9	
7/24-25	Camping	29	
7/25	Autogrill	8.6	
7/25	Diesel	47	
7/25	Tolls	10	
7/26	Caldigoco lodge	50	no receipt
7/26	Bfast	10.3	
7/26	Tolls	5.5	
7/26	Frasassi	33	
	At Rome	1284.7	
7/27	Dinner for 4	134 (32)	
7/27	Diesel	55	
7/27	Tolls	22	
7/28	Camping	68 (18)	
7/29	Diesel	50	
7/29	Lunch	18 (4)	
7/29	Dinner	126 (42)	
7/30	Lunch	18 (4)	
7/30	Payback Paula for me, missg. her dinner		

Field Work 2000 - Apennines

First Entry July 20th - w/ Paola and Martha Cary.

June 17th - 19th Travel, Arrival to Rome. Hooked-up with Paola, Nicola, Dramis at Roma Tre. We have topomaps at 1:100,000 and some of the geologic maps of Emiglia-Romagna regions.

Stayed with Paola - great place! And got on the road at about noon on the 19th. Took the Highway to the Marzabotto Region to revisit the five exposures of terraces observed in 1997. Lighting was much better this afternoon! Very good exposures of at least 5 terraces / strahs. The alluvium is very distinctive from the underlying white P-Q (?) beds. It is yellow, to orange for the higher deposits. Presumably, this is a weathering color.



View facing the Terraces (facing east) from the Etruscan Ruins at Marzabotto.

July 20th 2000 Warm, clear, but hazy

Stayed at a campground in the Sasso Marconi area called "Piccola Paradiso". Non che' male. Did not find any 2-star pensione and the 3-star hotels in the area were full and too expensive.

We begin with travel up to Bologna to get maps. Then into the northern Apennines - make our way to the Alpi Apuane region, then back towards Bologna.

Bologna trip was most successful in that we made the aquaintace with Maria Teresa di Nardo who was most helpful in getting us set-up with 1:10,000 maps of the Reno and Silente basins. She works for the Regional (Emigha-Romagna) survey. The claim is that the Reno has the best terraces by far... and that they in fact do not extend up the basin much farther than Marzabotto. The trib of the Reno called Fiume Setta also has a well-preserved terrace sequence.

The trip to Bologna took a bit longer than I expected we were not out of there until about 3:00. Then I precipitated a real delay by putting in 0.5 tank

of gas into a car that runs on diesel. Bad idea. Thankfully, we realized what we were doing, stopped, got the car to the side. Finally we determined that we could get the gas out by removing the in-hose and starting a siphon. So... up a hill the car went. By 5:00 finally, we had that problem fixed.

We spent a few hours before dark driving the road up the Reno basin. Terraces do fall off significantly, but there are some nice exposures
Road Km ~61 [of well-stratified fan gravels that are clearly graded to former valley levels. Best observation is that these deposits have nicely developed soils that "appear" late Pleistocene to us. There has been some 30m of incision below a presumably late Pleistocene trend some 20 ka? for an incision rate of ~1mm/yr.

We are staying at an incredible Agriturismo B+B for 30,000L an evening. Azienda Agrituristica Il Cerro.

July 21st 2000 Beautiful, clear, cool morning

We will spend the day in the Reno valley, checking out the deposits + soils to the best of our ability to reach them.

STOP R-1 directly west of Sasso Marconi, on the so-called "bll-12" terrace. The tread is really quite rounded. There is a brown, clay-rich soil w/ good structure, but virtually devoid of gravel clasts. We find rounded gravel in the colluvium exposed along the road.

There is an abrupt boundary, at least in color between or within these Epiligurian sediments of map unit 8. (brn/buff over gray)

- sedimentologic?
- paleo water table?

Colluvium derived from this bedrock weathers brownish red. Locally calcareous. Up to 3m thick. The buff-colored facies is rich in pectin + barnacle fossils. Looks alot like a beach, neritic environment. Flooding surfaces have local meta-greywacke, rounded cobbles.

R-2 Rupa Road SW of Sasso Marconi. The bedrock here is a coarse fluvial unit mapped as RUM_2. Coarse conglomerate ss + conglomerate. Polymictic. More matrix (sand) rather than clast-supported. Moderately well indurated.

Almost certainly, the mapped Terrace levels of "b7-12" are of but fluvial lags cut on Bedrock. I think thy are "morphological" rather than depositional features.

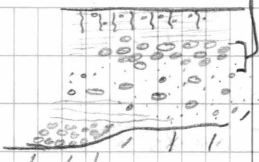
Photo 4 of Reno-Setta confluence

R-3 Marzabotta opp.

The terraces can be reached from the Panico side. There is a small Park / Game Preserve ~ 2 km S of Panico, on the main Lama (edge) Reno Road.

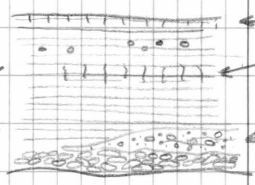
The Terrace deposits are underwhelming; basic moderately to well sorted sandy gravel, both Axial stream and fan facies.
The mapped b3 and b4 deposits are likely the same.... certainly they share the same strath.

b4 -



Virtually no weathering rinds on locally-derived ss. & gr., fine-grained matrix, but... oxidized gravel horizon....

b5 -



~1-2mm weathering rinds on locally-derived ss.

b3 looks like b5, only it is thinner, and at the b4 level.

It remains possible that the yellow-filled hollows on the ridge above b5 are buttressed valley side, fine-grained fills associated w/ b6 or b7 terraces present downstream of this pt.

R-4 Panico "b6". This is a classic potato stone exposure. Very few, scattered l.s., rounded cobbles. Maybe this is representative of all pre-b5 terraces.

R-5 Pioppe gravel Pit. km 61

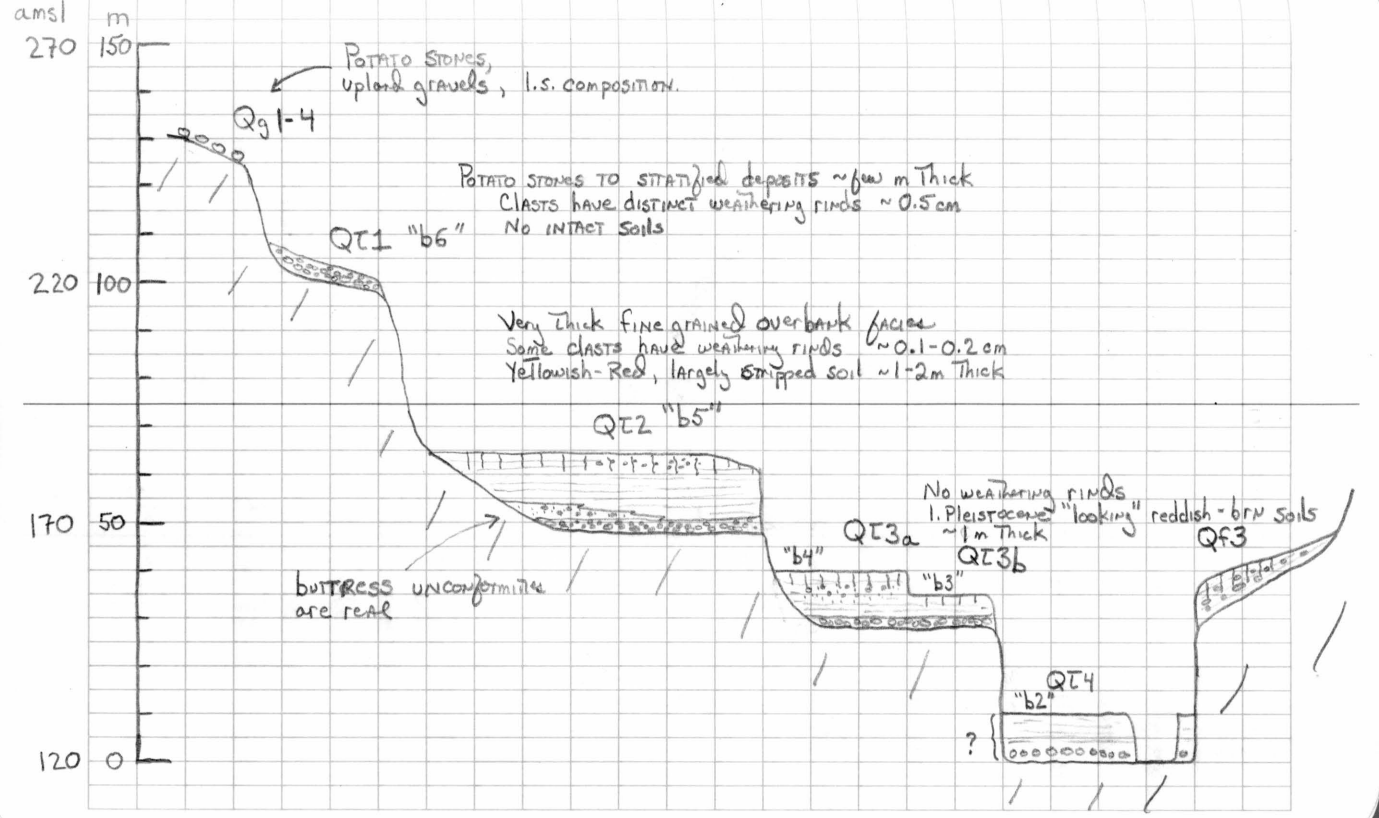
Well stratified, moderately well-sorted side tributary fan gravels ~ 6 m thick with a 1 m, reddish brown intact soil profile. Both debris flow + fluvial facies are present, but it is not axial stream facies.

Photo 10.

R-6 Camungone ~Km 62

A small, limited knob of "b6" stratified ~3-4 m of Alluvial Fan deposits, admitted with a fair bit of rounded cobbles.

These clasts are, on average much more weathered - they have weathering rinds of ~0.5 cm. I did not observe any l.s. clasts.


amsl
m
270
150
220
100
170
50
120
0
Potato stones, upland gravels, l.s. composition.
Qg1-4
Potato stones to stratified deposits ~few m Thick
Clasts have distinct weathering rinds ~0.5cm
No intact soils
Qt1 "b6"
Very Thick fine grained overbank facies
Some clasts have weathering rinds ~0.1-0.2 cm
Yellowish-Red, largely stripped soil ~1-2m Thick
Qt2 "b5"
No weathering rinds
1. Pleistocene "looking" reddish-brn soils
~1m Thick
Qt3a
Qt3b
Qf3
"b4"
"b3"
Qt4
"b2"
?
buttress unconformities are real

July 22, 2000 — Partly cloudy, warm; cool at elevation

At Mt. Cimone today. The drive here is really nice and revealing geologically. Marzabotto – Vergato – Silla – Lizzano. Lizzano is a great place. – Fanano – Canevare – L. d. Ninfa. We walk from here.

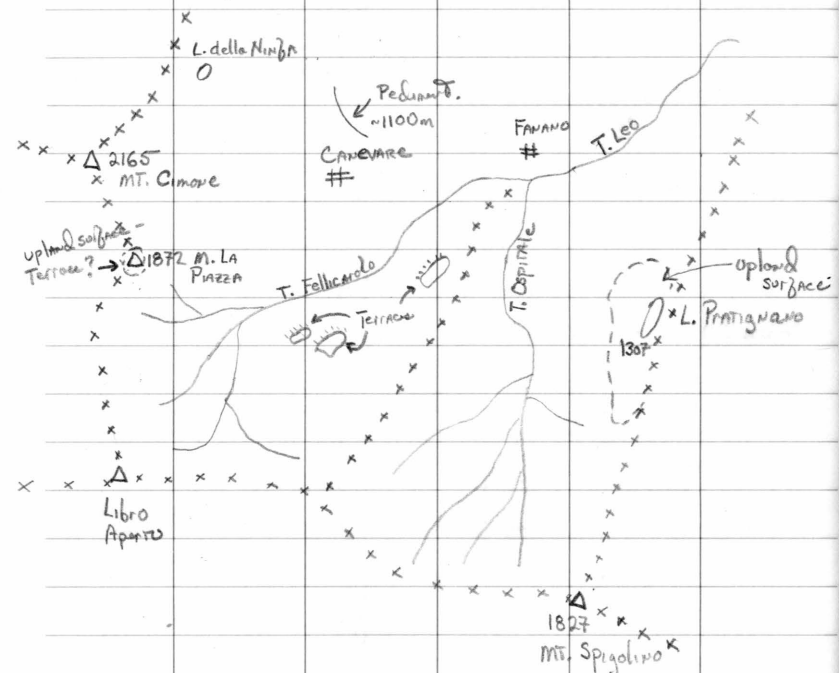
- There are many landslide / earthflows coming into and around Lizzano. At Fanano, the T. Leo and its headwaters are deeply incised, but there are numerous flat benches that look like terraces. And there is something that can pass as an upland surface to the NE.

Several photos around #20

Mt Cimone area (2165m). There is an access road, closed to vehicles, but open to foot traffic that goes up to the Meteorological Observatory on Mt. Cimone. The head waters of T. Leo, the T. Fellicarolo head into a N-S ridge between Mt. Cimone and the drainage divide to the south. There are very convincing

- Pediments
- upland surface of low relief.
- Terraces

The cross valley profile here for T. Leo and T. Fellicarolo are very much mimic the mouth of F. Reno where the river traverses hard rocks. Both the UNIT 8 of the lower Reno valley and Marnoso Arenacea of the Mt. Cimone area hold slopes; landslide + earth flows are limited. In contrast, the argillites in between are very prone to landslide and do not preserve terrace etc.



Bottom line is That The similar cross valley profiles likely imply That This area was like The current Reno-Po region, and has since been uplifted - migrating welt idea. All assume similar rock-type.

July 23, 2000 Sunday Overcast, passing shower

We will investigate the lower Secchia valley today, then drop Paola off near Modena. Then Martha and I will continue up the Secchia or Enza to the NE flank of Alpi Apuane.

S1 Between the bridges at Sassuolo. Just downstream of the bridge/dam. Exposed in the channel are well indurated, inclined strata of fluvial sandy gravel w/ local interbeds of sandy silt. The deposit is weathered; locally cemented into travertine-like horizons. Rock-types are dominated by sandstone, marble, breccia and conglomerate. There are few, but noticable clasts of gabbro and a chloritized or augite-bearing granite.

It appears that these are old deposits of the Po valley, likely of an ancestral Secchia source, given that the clast imbrication is all to the north. But the source of the granite (?) is unclear.

It is also not clear if these deposits are exposed only because of the dam.

S2 Veggia - Across the river from Sassuolo
There are several surfaces in this region - all are mantled with gravel. They are both terraces as well as fans
stream is at ~120m
~123m (~3-4m above the stream)
~192m
~290m

Cerrdiolo - The river makes a turn to the west here. The city is located on unit 6 bedrock, several surfaces are preserved.

Gatto - Again, the river traverses unit 6. There maybe a surface to the north of town, at a tib confluence.

Passo del Cerreto - We climb up out of the Secchia basin. Hinderites are in marble. Distinct valley in valley profile. Lots of possibilities for upland surfaces.
Salsabo. Photo 2-5
↖
Now on Toscana side of divide. It looks different here from the standpoint that there is no real valley in valley profile. The picture is of active debris flows.

Next we continued down into the Magra Valley on the SW side of Alpi Apuane. Terraces here are either absent or simply not obvious. There are some sand + gravel operations, but they appear to be limited to the floodplain and modern stream.

So we retrace our steps back towards the town of Fivizzano and then proceed E-SE on the East flank of Alpi Apuane. Alpi Apuane has Teton-like ruggedness + relief. - very impressive. I can see how Brandon made the connection to the Olympics.

We pass into the Serchio basin and into a thick gabbroic pile of the Ligurian nappe. There are numerous outcrops preserved, but virtually no exposure. This valley is steep → not like the Tuscan side of Passo del Cerreto. We wonder if there are not some valleys on the Toscana side that have outcrops, and underfit streams because formerly, they were longer N-flowing drainages before beheaded by drainage divide migration.

The afternoon ended rather eventfully in our efforts to find a place to stay. There are few options in and most places were either full or closed. Eventually, we made our way to Castelnuovo and after ~ hr of searching, found a campground to the north, ½ km above the city (La Pella). There is a road / foot trail into town. We ate at the town's July festival. Only saving grace was the discovery of very weathered upland gravels in a roadcut ~ 100m from the campground on the road leading into town.

There is a possible Pensione in Pieve Fosciana, N of Castelnuovo ~ 3-km.

July 24, 2000 Monday. RAINY, overcast.

We will begin today at the upland gravels at CASTELNUOVO, Then head out into ALpi Apuane, remainder of Serchio valley, and out to PISA. Then we make some time to the east towards the Bisuta valley.

SR1 Upland Gravels of CASTELNUOVO

Classic "Olympic-style" Quaternary deposit. Ridiculously well-weathered. Clasts are completely saprolitized. Dominant rock-type is a micaceous meta? sandstone, buff colored. Clasts are well-rounded-to subrounded

A very productive, but rainy morning in Alpi Apuane.

Catelnuovo – Gallicano – Grotta del Vento

The panoramic road to the cave takes you through Vergemoli – just one of several towns perched hundreds of meters above the valley bottom on straths? I have taken many pictures of these straths – some are quite convincing in their flatness and extent. There are numerous small caves, alcoves etc throughout the valley, at many different levels. Grotta del Vento is but one of them. It sits at least 150m off the valley bottom. The valley is ridiculously narrow + steep. It is essentially, a gorge. Rock type is L.S., marble, and smaller amounts of carbonaceous clastics – shale

Remainder of day was spent in the Serchio Valley. Exposures are very poor, but you get the impression that there are some terraces, especially in the area between Lucca and Ponte a Moriano. A traffic accident really slowed our progress. The Serchio alternately traverses broad, open valleys, and steep, narrow gorges.

From Lucca, we took the Highway to southeast of Firenze to the Incisa exit and proceeded north on Rt No 67 to Dicomano. This is the upper Val d'Arno along the Fiume Sieve. A nice wide valley bottom with one or two low terraces is evident, but little else.

We stayed at a campground in the Dicomano area, on the Sieve, near Vicchio.

There is a nice 2-star hotel in (just at downstream) in San Godenzo

Portico di Romagna - convent w/dining, lodging

July 25th, 2000 Tuesday overcast, warm,

Today it is up over Alpe di S. Benedetto and then into the Montone basin, then into the Bidente.

Divide characteristics

Km 152 Bocconi - up to 3 high surfaces. Some very nice straths for the higher one, gravel-mantled treads for lower 2.

Rocca - north (downstream) of town the terraces are again well-exposed. "b3 and b4" Photo 2-19 Some yellow alluvium + soils.

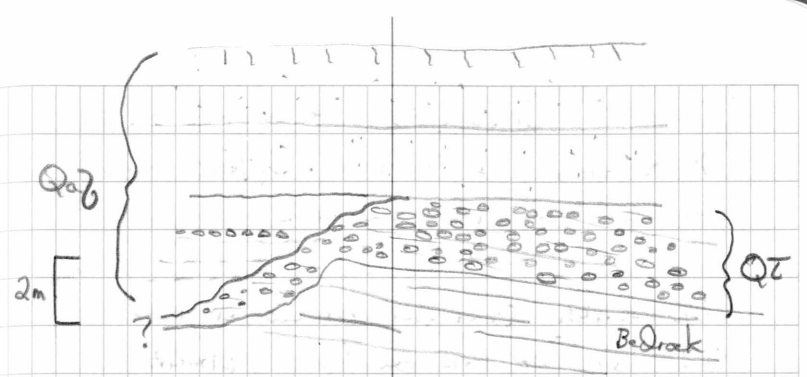
Now, the road from Rocca to Galeata drops first into the Rabbi drainage, then into the Bidente. Descending into the Rabbi, there is one place where yellowish Alluvium/colluvium sits atop dipping bedrock. Possible high terrace?

Dropping into the Bidente, a very high surface, likely underlain by alluvium "b10" east of Galeata. Nice exposure of yellow gravels and underlying Marnoso Arenacea "b8" on the 1:10,000

B1 "b8" upland gravel. Private Road behind the Km 59 store, just South of CIUTELLA di Romagna. The upland surface appears as a rolling topography with up to 30m of relief. Conceivably, there are gravels up here, but they were not apparent in a plowed field at edge of the mapped surface. But we do find them reworked in colluvium on Qaf at lower elevations from gullies that lead to the upland surface.

B2 "b5" terrace. Store sits on top of it. Again just south of bridge leading into

A new road cut exposes a strath with stratified, imbricated gravels (dip to the S). Strath has ~ 2m relief. Gravels are ~ 2m thick. No soil. deposit is buried by up to 6-8 m of fine-grained Qaf locally containing beds of angular clasts and occasional reworked(?) b8 gravel.



B3. ~1 km north of Nespoli. Really outstanding exposures of "b4" and "b3" on opposing bank (west side). These terraces clearly have different straths, separated by at least 5 m. Similar stratigraphy to the Reno terraces in that there is ~1m of basal gravel and lots of fine-grained yellow fill. Here "b4" looks like Reno "b5". Photos 3-1, 3-2

The #310 main road is on "b2". It is plowed, but no potato stones!

All treads slope - they do not always look like treads.

The lower valley showed some more of the Sasso terraces, but they end rather abruptly before Foglio.

Drive to Coldigioco - we have met all here.
Olivia Nesci - University Urbino has
work much on Terraces here.

Osservatorio Geologico di Coldigioco
62020 Frontale di Apiro, Italia

July 26, 2000 Wednesday. clear, sunny, breezy.

Coldigioco - Frassasi - Spoleto - Roma.

Mauro Cramaschi
Soils in Northern Apennines, Univ. of Milan.

Was really spent as a travel day. We had lunch with Fausto and his family. Very nice people and Spoleto is a good place.

The road to Roma - Via Flaminia is absolutely packed with trucks - it is rather slow going.

July 27, 2000 Thursday Hot, humid

Petina Exit, Then left, right at warehouse.
Tanagro Valley - Fiume Tanagro and Fiume Bianco
Ascione, Cinque + Tozzi
Studi Geologica Camerti volume speciale 1992/1

- Classic extensional valley - like Fucino, source of The 1982 Salerno earthquake 6.9 M. important from The standpoint That it was one of The first eqs. To have a documented surface rupture. Photo 3-8

There are issues in the gorge

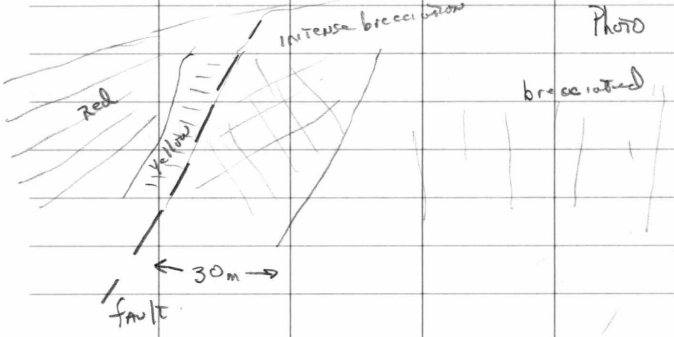
The mappers here Argue for 3 major geomorphic surfaces. This basin is exhumed - The drainages have been integrated. To The SW, Valle di Diano remains filled - it is not yet completely integrated.

General structure here mimics The Northern Apennines - Ligurian + Sicilian nappes sit atop Mio-Pliocene incipient foredeep marls, which sits atop imbricated Apulian plate platform carbonates.

Geologic Map of Southern Apennines 1988
Boenzi, D'Argenio 1:250,000

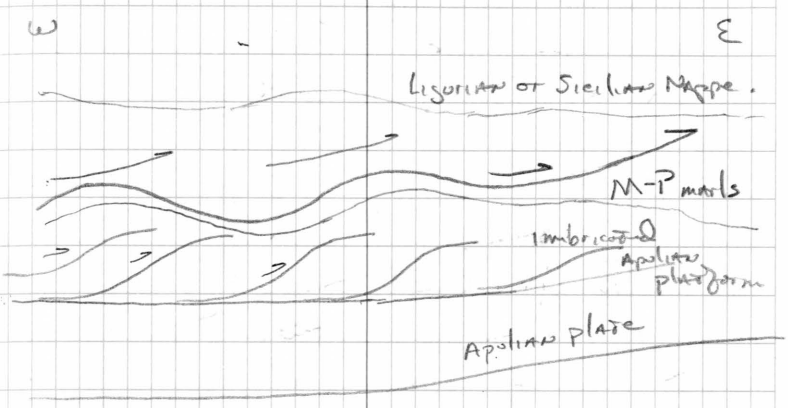
GROTTE di PERTOSA - really cool "hanging" tribs. and bedrock knickpoint. Streams have high base flow because of karst hydrology. Knickpoints here mark the path of base level fall. Gravels are like Pliocene terrestrial basin fill (rift fill)

ATENA LUCANA, Vallo di Diano - very nice outcrop of a fault scarp + colluvial wedge. This is some of the most red, weathered soil we have seen (in alluvial wedge).

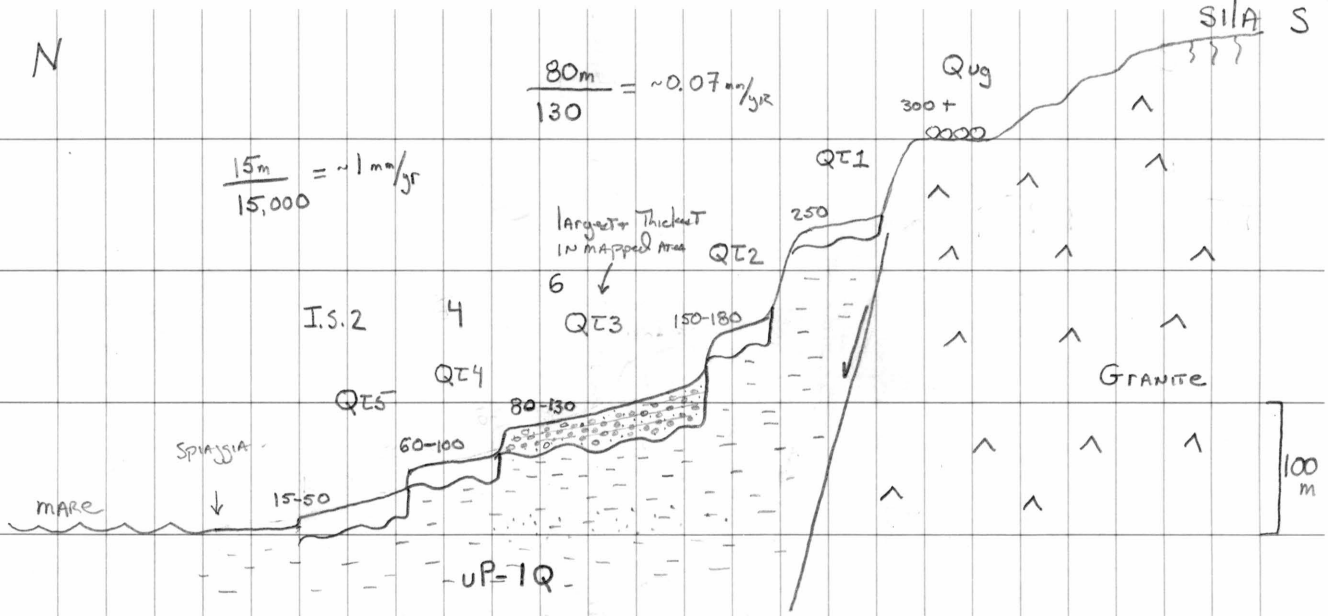


The Southern Apennines are very impressive in both relief and elevation. The Basilicata portion of the Southern Apennines are the most beautiful. What a rugged, isolated and beautiful country. The Region around

Napoli is a disaster. Try can have it.



general x-section of the Basilicata portion of southern Italy. The imbricated Apulian platform results in the largest onshore oil field in the Med. basin.


N
S
SILA
$\frac{80m}{130}$ = ~0.07 mm/yr
$\frac{15m}{15,000}$ = ~1 mm/yr
Qug
300 +
QT1
250
Largest Thickest
IN MAPPED AREA
6
QT2
I.S.2
4
QT3
150-180
QT4
QT5
80-130
60-100
SPIAGGIA
15-50
MARE
GRANITE
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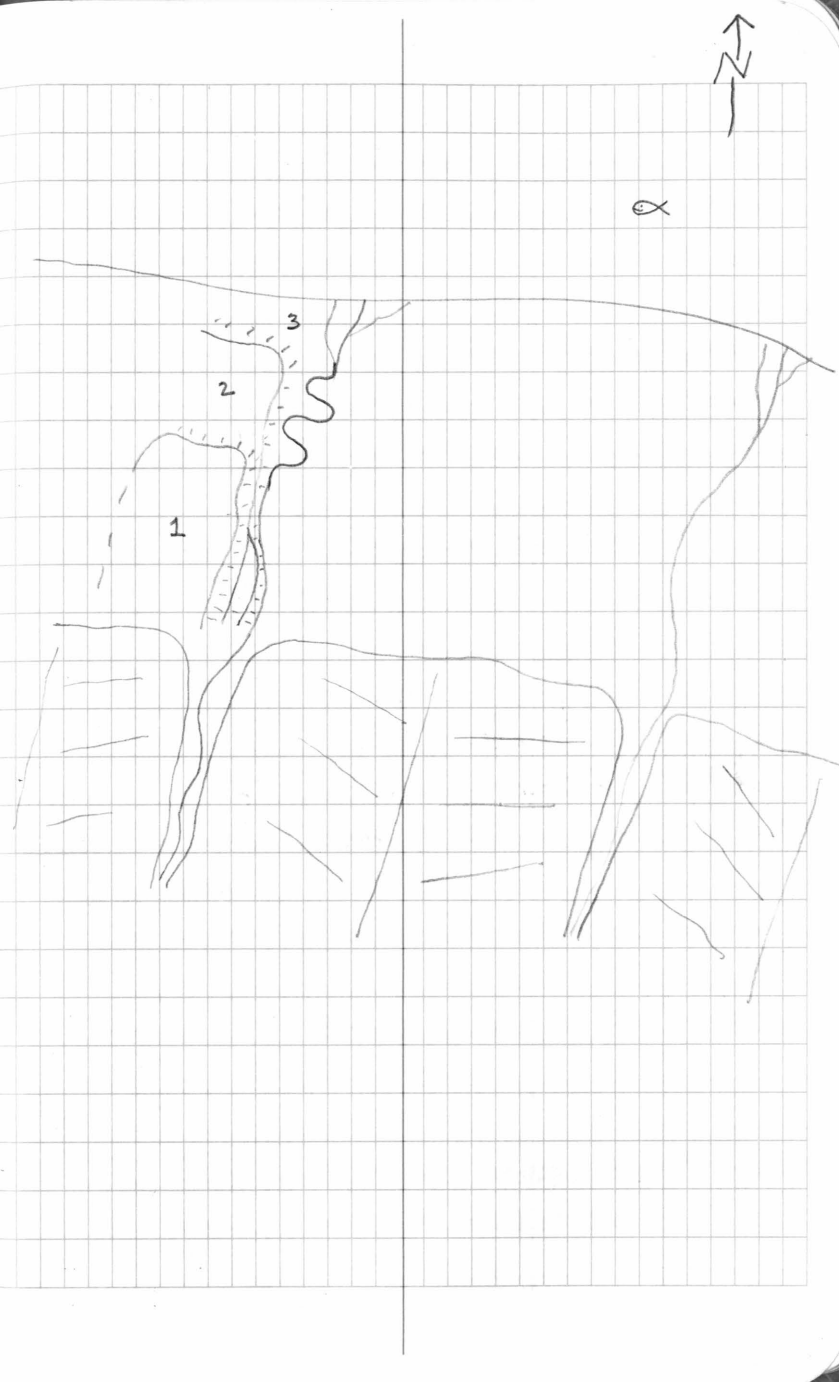
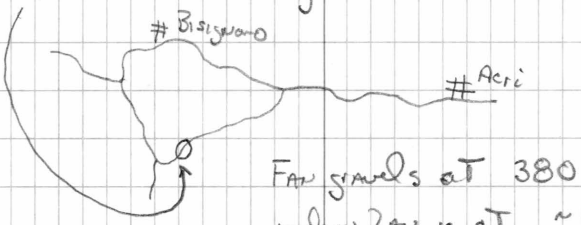

N
1
2
3

July 28th 2000 Friday Sunny, humid

At Rossatio, at the beach in Calabria.
Preceeding two pages summarize what we know about her study area.

Photo 3-12 overview of Ciatti Valley and Catanzaro Costiera. Ciatti Valley is filled with P-Q marine deposits and Q fan/alluvium.

STOP - Between Bisignano and Acri



Fan gravels at 380 m, modern fan is at ~150 m.
These represent some of Paola's highest + oldest deposits.
Outcrop is next to the Il Carpaccio Restaurant

There are 4 distinct, inset fans at the mouth.
So far - no usable soils.

The Qf3 deposit is very coarse, Texturally immature.
The tread is intact - A reddish soil.

Qf2 is very interesting - it is fundamentally a different facies → looks completely fluvial. Is it a huge, river dominated fan or axial stream facies of the Crati?

We found some outstanding, large upland gravels on flats along the Mucone.

□ = location of likely lacustrine deposits, dammed behind a fault of Catagna Drainis.

July 29, 2000 Saturday

warm, clear
humid, breezy

Remind me someday to record the paradox that is Italy. Good geology, great, great, spicy Calabrese fish dinner, unbelievable problems w/ just finding a place to stay.

STOP 1 Piana dei Venti. Ancient, stratified upland gravels and sand. Very mature texturally and compositionally. A target for burial dating.

The road west of Rossano take you up onto Sila. In most places, exposures of granite + other crystalline rocks are very deeply weathered. Lots of Saprolite. This stuff is like a combination of modern soils + ancient weathering profiles.

ST. Onofrio Area of Sila. There are very suspicious flats through this reach, all are about 200 m above the stream and on the west side. The church of St. Onofrio itself sits on perhaps the best terrace.

Photos 3-21, 3-22

From this perspective, the valley appears to be asymmetric, steeper on the east, more gentle on the west.

Some really outstanding exposures of QTZ(?) and the FAULT escarpment between the COAST and NORTH flank of SILA along the road west of ROSSANO, between PIRAGINETI and SANTA MARIA di PATIRE.

PHOTOS that finish out Roll 3 were taken here.

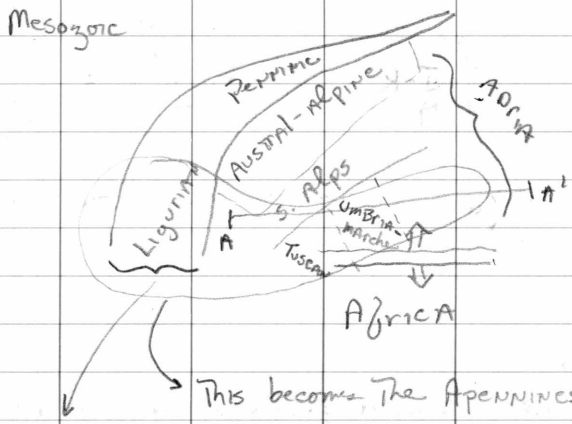
WARM, SUNNY, humid.

July 30, Sunday

Today is the drive back to Rome. Along the way, we will stop at some terrace outcrops west of Rossano, then at PAESTUM - Grek ruins south of BATTIpaglia.

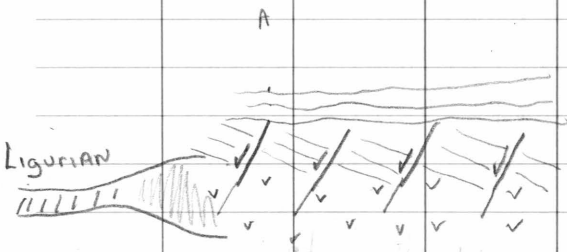
Feb 14, 2001 Italy Trip cool, breezy hazy

STOP 1 Cetona Ridge, southern Toscana
extended Terrane NEAR SARTEANO.
Rocks of The Tuscan Nappe, overturned
Tr - J carbonates.

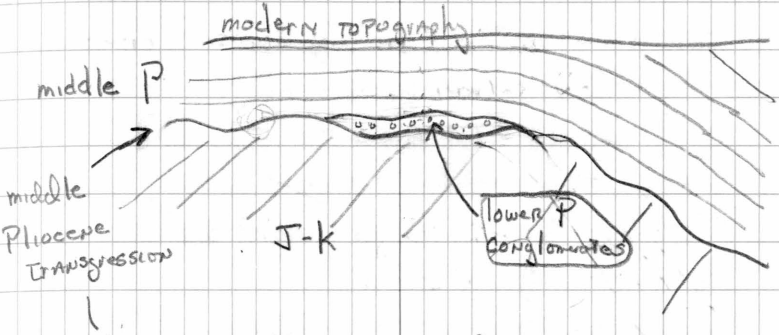


This becomes The Apennines

OCEAN BASIN

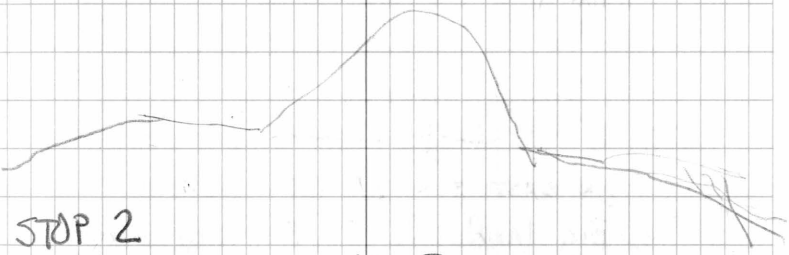


~700m - exhumed UNCONFORMITY - middle Pliocene calcarenites atop J-K carbonates
The P is flat, the UNCONFORMITY is flat



8-10 km of section removed .... TECTONIC? erosional

CETONA was an island in the mid-Pliocene
There are shoreline features with mussel borings



STOP 2

"dipping" middle P beach ....
I THINK THIS IS A bend atop A NORMAL fault

STOP 3

Crossing Cetona Ridge. A stop to see the gravels beneath the mid Pliocene marine limestone

STOP 4- in the "sea" of lower P clays Radicofani basin and volcanic plug - 1.1 Ma - Photo 1

Photo 2 - "beveled" ranges west of Sarteano
Photo 3 - Mt. Cetona

STOP 5 Exhumed Pliocene (?) fault scarp west-dipping. It is "sealed" to the north

*Idea The bulge is both migrating and changing its wavelength → getting wider.

STOP 6 - back rotated talus deposits on east side of Mt. Cetona
Big landslide? Or keep in mind that this is the location of where Barchi's east-dipping low angle detachment

Day 2 - Italy '01 Feb 15th 2001

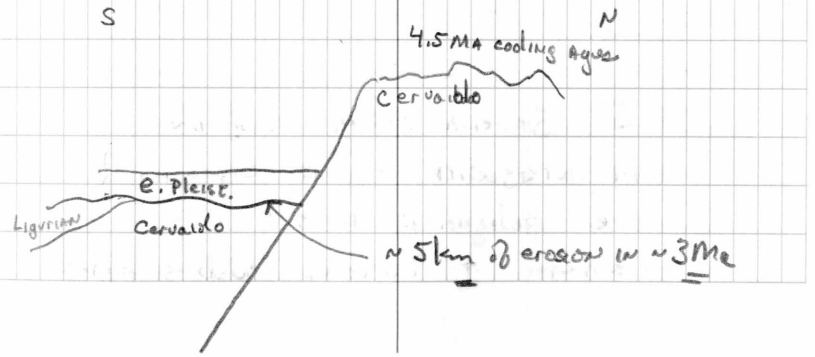
cool, clear, beautiful morning

Stayed at Barberino for the evening - Toscana Emiglia-Romana Apennines today

STOP 1 Mt. Altuzzo Section - Cervarolo unit overturned on an out of sequence fault
Classic complete turbidite section - classic Abyssal plain facies.

STOP 2 Across the drainage divide, up basin of Firenzuola. There are Q deposits in the valley bottom. Photo 5. Santerno River valley.

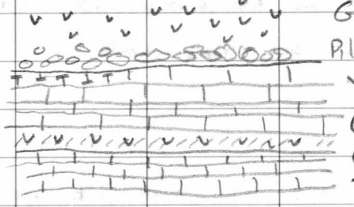
In the Modello valley, Ligurian + Cervarolo units have been downdropped + locally preserved



STOP 3 Sasso di Castro Quarry - on the saddle along the old Firenze - Bologna Rd, N of Fierenzuola.

Photo 6

Gabbros, pillow lavas, pelagic carbonates, all overturned.



* The valley west of Fierenzuola is linear - along strike ... looking alot like a normal-fault bounded basin.

STOP 4 - Looking at K-E flysch of Ligurian

Savena Valley - Loiano - good target for Terraces.

STOP 5 Savena valley N. of the Loiano intersection - great exposures of Eocene epiligurian rocks + br stream ± Terraces. Well-stratified

gravel ~ 15-20 m and then again ~ 35 m above the stream. They are well weathered more so than "equivalent" terraces along the Reno. Photo 10

STOP 6 Marzabotto. Mauro spoke well of trying to find the Savignano soil. Guardia River - some soil stuff done.
Savignano

→ GHIARDO RIVER → CREMASCHI M
→ STIRONE RIVER MILANO UNIV.

Day 3 Friday 02/16/01

clear, beautiful

STOP 1 Serchio Valley

Lopia tributary, S. of Barga

Plio-Pliestocene graben. Pliocene sequence begins at a meandering facies alluvial fill. Then there is an unconformity, tilting, then braided stream facies. Then seven inset Pleistocene terraces

[Provenance is dominated by Maccino in basal Pliocene, few metamorphics, braided facies is more dominated by metamorphics, Pleistocene terraces are again all Maccino (Appennines)

The interpretation is that there are no Pliocene faults ... all meandering stream no alluvial fans

Pliocene deposits have lignites w/ Liquidambar water climate - middle Pliocene

My Castelnuovo gravels are QT1.

Unconformity of Alpine Apuane?

STOP 2 BARGA - BARGA TERRACES Qf1-Qf5
INSET FAN SURFACES, SOME MANTLED w/ GRAVEL Qf1 ~ 200 ~ 300-400 KA

METTATO BRECCIA - APUANE PROVENANCE
+ some maechino clasts. These are upland gravels on the Apuane Tyrrhenian flank.

Photo 17 - CASTELNUOVO - BARGA divide - The gravels of BARTOLINI.

Photos ~12-17 Alpi Apuane

STOP 3 Alpi Apuane core - on ROAD that straddles the range west of CASTELNUOVO The drainages here are essentially vertical - no regolith or ~~deep-seated~~ landslide.

JAURAND EMILE PHYS. GEOGR. GEOL. DAN
glaciation in the Apennines - Late Glacial moraines are at 300m, There is no Bull Lake Moraines ↑ IN Alpi Apuane
are not preserved except
for ~~maybe~~ METTATO BRECCIA

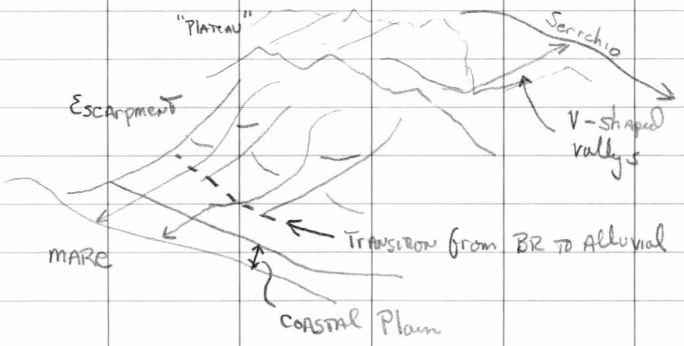
Trevesan → studied glaciation in Apuane.

Maps to get - Alpi Apuane by G. Sguazzoni
CNR Firenza
Geologic Map of N. Apennines
V. Bortolitti

STOP 4 crest of Alpi Apuane. Very impressive relief, very impressive slopes. Alpine in scale. Slopes have no regolith, no evidence for landsliding, no evidence for debris flows.

NE side - vertical walled canyons carved into a "plateau-like" feature, base level controlled by the Serrchio

SW side → wet side - A retreating escarpment, wide valleys, glaciated, U-shaped valleys



2002 Italian contacts, Papers, Notes

- Map of Bologna foothills - Pini
- Geodynamics of Apennines - Ingrid Kroon (dist.)
- Alps erosion rates - Mattias Hinderer
- Topo Maps of Bologna Foothills
  - Carta Escursionistica Emilia Romana 1:25,000
  - Itinerari Geologico-Ambientali nella Colline Bolognesi 1:50,000.
- Burrati + De Martini papers are in review now.
- Missy's Wells-Fargo bank account

2002

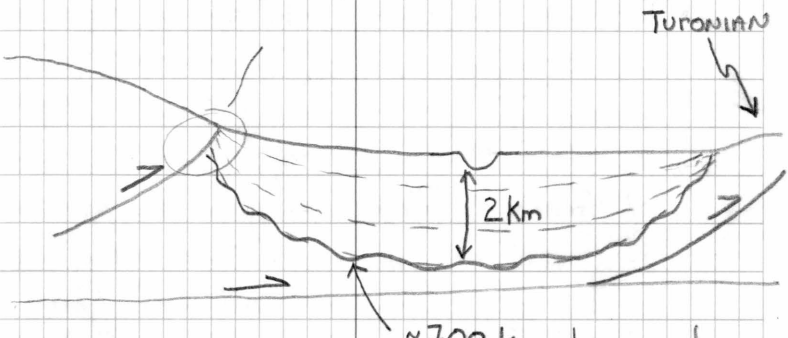
Nov 2-10, Retreat Meeting 1

IL Ciocco, Garfagnana, Toscana

3 field days following the meeting

Day 1, Nov. 7, 2002 cool, gray, breezy

Foothills of Bologna, Reno River. Meeting with Alessandro Amorosi and Paolo Severi

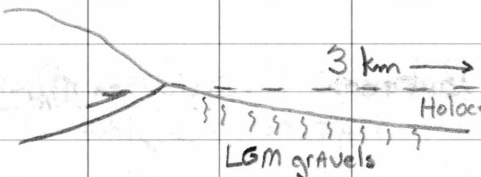


Piggy-back BASIN

Accommodation space is produced by subsidence in center of Po BASIN.

- Po deposits are gravels during glacials, silts during interglacials.

- Deposition in the Po plain is really strongly influenced by base level. Holocene silts bury a red soil developed in LGM deposits ~3 km from present m.f.



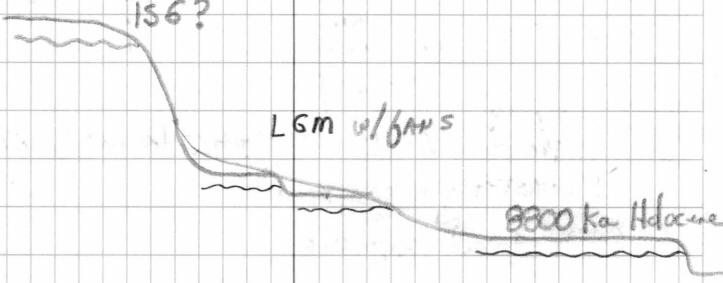
- Terraces in lower ~15 km of Reno valley are straths. All of them. It is really incredible. ~1-3 m of gravel w/ 1-3 m of fine-grained tops (loess?). All of Amorosi's dates are from the fines + they are all minima - there really are a lot of colluvium + alluvial fan material burying treads. (locally)

- I figure that for the Holocene there is a: Pleist-Holocene transition terrace
  - ~8500 yr terrace
  - ~3500 yr terrace
  - ~1000 yr terrace

) sound familiar?

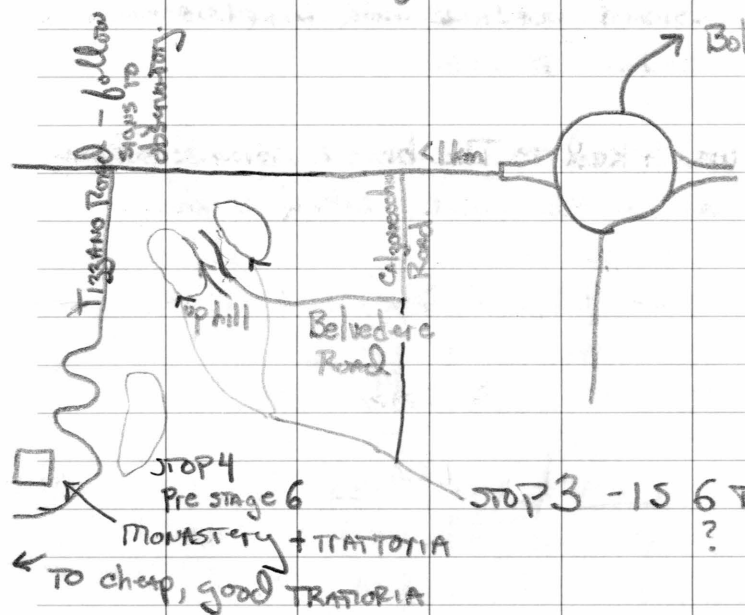
Incision rates are like 30 m in 8000 yrs, 3 m / 800 yrs, ~ 3-4 mm/yr! It is possible that climate + complex response both influence sediment supply + strath cutting.

STOP 1. Via Pontecchio, N of Sasso Marconi, at the church + elementary school Pontecchio Marconi — good Holocene, some l. Pleist, + good IS 6 (?) terrace.



STOP 2. Behind the Diesel debaucle gas-station + in front of it, towards the Reno (enter through narrow brick portal). V. nice Holocene + l. Pleist terraces.

STOP 3 - Toward Bologna, on main Rd (Rt. ____) big traffic circle North of Sasso Marconi



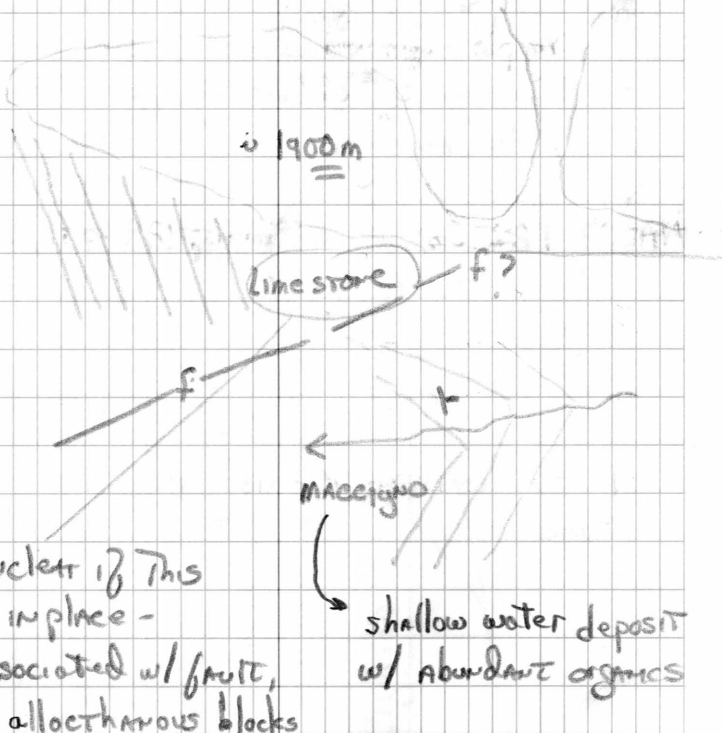
- Missy will be digging pits in these terraces.

Day 2 11/08/02

Trip to Mt. Cimone.

- Darryl is of the opinion that the upland surfaces are inverted glacial valley bottoms.

- we hiked to the broad upland surface on the SE flank of Mt. Cimone.



we took 2 samples -
sample Cimino 2 blasts on surface "pavement"
sample Cimino 3 bedrock outcropping of Maccigno.

NAD27 Cont.us. 0636331, 4893349, 1888 ±3.7m

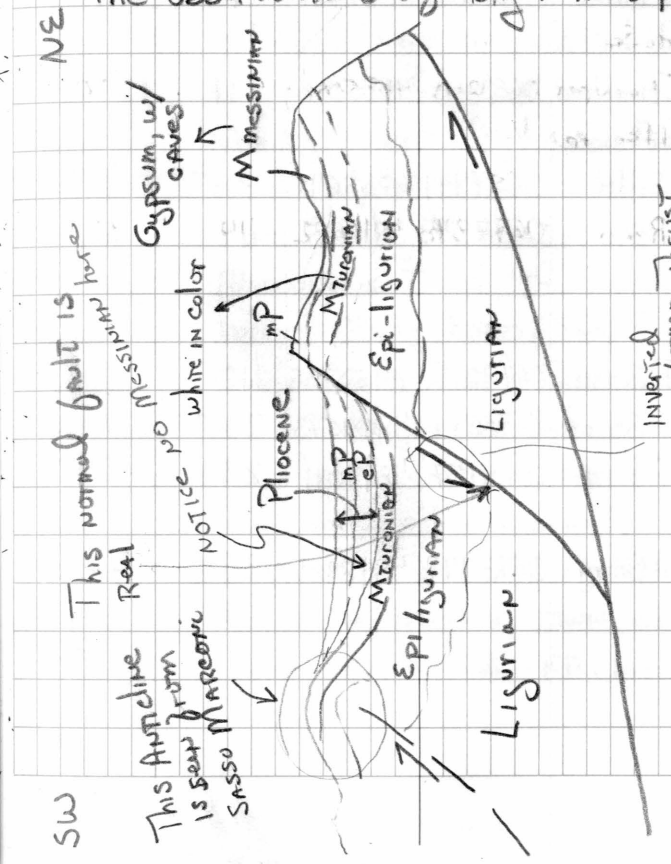
Sample Cimino 1 is a chunck of Macignio collected for AFT-U-Th/He analysis.

NAD27 T32 Cont US 0636148, 4894647, 1976 ±5m

Day 3 Nov. 09, 2002

Today was A River sediment sampling day.

We also met-up with Vincenzo Picotti at San Salvatore, A small town on the Zeno River (east of Pianoro). There are v. good relationships between The structure + strata here That help put The observations of Day 1 into perspective



Sand Samples - Reno drainage

UTM coordinates, Zone 32, NAD27 Conus

Sample	River	E (m)	N (m)	Z (m)	+/- (m)
1	Venola	0674207	4910975	140	–
2	Porrettana (?)	0658778	4887706	405	8.2
3	T. Limentra di Samb.	0659687	4887971	398	4.6
4	T. Limentra inferiore	0663800	4885098	491	5.0
5	Silla	0657949	4893695	315	5.7
6	Reno	0677878	4916092	114	5.1
7	T. Setta	0679212	4915545	110	5.4
8	T. Samba	0675594	4904573	235	5.4
9	T. Setta	0674157	4899041	299	6.1
10	T. Setta	0673947	4898991	292	7.8

EPE	COMMENTS
8	AT The small bridge - Piandi Venola, east of RR tracks
9	Rt. onto Rd to San Marcello, 100m - left to parking area, down to small house, down steps to river *Note* A qtz monzonite boulder was found in The stream here
5	Portretanna - into town (left off of main Rd.) to bridge next to small factory
6	N. of big reservoir, at bridge on small road to Stagno.
6	At Park, Adjacent to Road to Logano, Silla
6	Reno fishing (?) access, south of Sasso Marconi, south of "The diesel station", north of Marzabotto, South of A-1 entrance
6	River access @ Piccolo Paradisio entrance.
7	At The Rio Veggio City Park, east side of HW
7	Lagado (?), east into town, sample at bridge w/ splash dam beneath.
10	Lagado (?) West off of HW north of big bridge North of town, down to River, sample under RR. bridge

START, 2003 field season in Italy.

Day 1, Saturday, May 24, 2003 bello.

- Arrived OK on Friday. Short delay with the luggage. Great to be at Il Cerro again.

- ready to go with surveying. Today - learn
- Sunday - profile an area near Piano di Venola
- Monday - meet with Vincenzo @ Archivo Cartografico and profile near Palazzo dei Rossi

Instructions

- verify equipment vs packing list
- charge batteries each night; charge is good for 1.5-2 days; one of the big batteries is missing a nut (use receiver or battery charger / two separate cables)
- small batteries are for the rovers, charge these each night too
- be careful with cables, the connectors have small delicate pins. Do not wind too tight.
- record problems in log book

Base Station U15701 - Flash card # matches

- screw in brass knob of leveling mount to antenna
- place it in the leveling mount - level it
- connect yellow cable to antenna.
- use controller (lots of buttons) to set up receiver.

- check voltage with multimeter / redonred....
- connect black cable to battery. Keep battery in case - finish all lines through
- Controller ports
  1. Controller - receiver
  2. 9 pin serial port to computer
  GPS Antenna
  3. for power input (can also go on top)
  note collar connector; pull on cable to release.

battery recharge 2 hrs

- Green is on-off, may not have to use
  Blue button is configure - we will do this once, then just make sure light is on
  satellite light blinks when at least one satellite is in range.
- other black cord to controller.

Files (Enter)
job managment
New (F1)
<Enter name>
PC card
ok
No projection/No datum
Grid
NO
ok

ESC

Survey (ENTER)

5SECPPKIN (ENTER)

START BASE RECEIVER (ENTER)

ENTER OPTIONS including name

FOR ROVER

- BATTERIES INTO receiver
- ANTENNA ONTO backpack
- receiver + yellow cable - CONNECT TO ANTENNA, WRAP WIRE AROUND POST
- black cable INTO 1.
- hold CONTROLLER, ON - Survey, 5SECPPKIN
- 8-15 MINUTES TO change from FLOAT TO SATELLITE FIX
- PDOP = 2.1 = good, will stop collecting data @ 10; SAVE what you are doing if + when IT GETS TO 5
- SAVE if you are ABOUT TO lose signal - obstructions, < 5 SATELLITES
- START SURVEY <ENTER>
- NAME IT <ENTER>
- MEASURE POINTS
  - ANTENNA elev <ENTER>
  - POINT NAME <ENTER> (WAYPOINT)

STOP + GO survey

F1, measure point

ESC

End survey

No power down receiver.

DAY 2, SUNDAY MAY 25, 2003 :O: bello

General Procedure & file nomenclature

- BATTERY CHARGING previous evening - include recharging controller for ABOUT 2 HRS.
- BASE STATION
  - TERMINALS TO BATTERY before plugging into receiver
  - check THAT TERMINALS + CONNECTIONS are secure
  - ANTENNA + cables.
  - GREEN light (power) + logging button should be ON .... if NOT TURN THEM ON with buttons
  - MAKE SURE CARD IS IN.

    0307 + Julian Day
  - slow flashing of SATELLITE light, your ready to go

- ROVER
  - memory CARD IN controller
  - BATTERIES IN pouch UNTIL ready TO go; 4-5 hrs per charge; TWO SETS of BATTERIES + VOLT METER
  - controller CABLE TO PORT 1
  - yellow cable TO SATELLITE
  - MEASURING TAPE

① JOB - a new job per day
<RE 25MAY> PC-CARD
NO projection, NO datum
GRID and NO Geoid
ESC

② DATA File IN roving mode
C 25MAY1
↑
channel

③ POINT (waypoint)
C25MAY1 - BEG
edit
C25MAY1-1
-2 } auto increment
-3

STOP → GO,
do not preserve roving
C25MAY1-STOP1
C25MAY1 - FEATURE 1 ← whatever it is
GO → STOP
preserve roving
C25 MAY1-GO1
C25 MAY1-4
C25 MAY1-5
C25 MAY1-END

it is possible that instead of point features, I may want to actually preserve roving.... in this case, when you get to the feature enter it as a GO; when you've got the feature completed, enter it as a STOP

ESC
ENDSURVEY

Begin JOB for May 25th Pian di Venola Spillway
JOB = RE25MAY
- First two data files are good
- File 3 lost signal once.
- channel is awsome - bar/bedrock distribution like the middle Clearwater w/o deep pools.

STOP 1-525 Upstream edge of Margaboito Calanche. Possible active fault - lines up with major tributary that enters at upstream edge of Calanche. 148° strike.
- Nice knick zone w/ ~ 1-2 m of relief looks like a fold, no obvious offset or rock type change although bedded sed upstream turns into a shear zone

mudstone at crest of fold. - If I had to guess - fault bend fold verging NE.

~50cm across

elevated, cone-like structure on flat? bedding plane? surface in SMT zone

UTM 32 0676443 E, 4910935 N

Day 3 Monday, May 26, 2003

Survey RE26MAY

Castel dei Rossi Dam + suspension bridge
32T 0680950, 4920670

- late to the survey, we had to find a base station. - found one at a 64fm due north of Palazzo dei Rossi ... off of via Pila; industrial zone of Pontecchia. It is (base station) marked by a waypoint in my handheld.

- The section surveyed has alot of bedrock exposed in the channel ... many knickpoints, The BR is a sandstone, with local conglomerates. This gives way downstream to a mudstone where the channel is barely flowing.
- Alluvial, but only a thin mantle. - Nice mudstone channel strath + strath terrace ~ 2-3 m above channel. This low strath has no soil in it.

There is a strath terrace with ~1m of yellow soil weathering profile in the PDR dam area. It is approximately 10-15 m above the channel on "far" side. On near side

PDR side, there are several terraces that step down nicely to the river.

Day 4, Tuesday, May 27, 2003

Base station at San Cristofo farmhouse
START - Sapaba Dam 32T 0681813, 4922339
very gentle reaches w/ br exposed only at the dam. Rocks here are dipping steeply to east

- There is a road that trends N-S along the west side of the river - gravel pits to the left. Road stretches from Sapaba Quarry / Dam ~2 km north. The road is on a
San Cristofo
= [Terrace Tread - Very continuous - Terrace (Above what is exposed in channel) is exact same scale as QT5 in Clearwater It sits on a strath with very little relief (<0.5 m) consistently 0.8-1.3 m above the channel. There is no soil in this Terrace.

- we have sampled 900 m of channel. at the end point, there is ~1 km of unaccessable channel

- STOP 2 Casalecchio Dam at Lido di Casalecchio.
  FS2 at Damtop
  FS3 at Terrace of the Park/Lido

· STOP 3 PALAZZO dei ROSSI

- survey upstream from DAM
- flat + muddy ~500 m, Then an alluvial channel with local bedrock CUTBANKS.

1 Rovia segment ; 2 FASTSTADIC upstream F4 + F5

Day 5, Wednesday, May 28, 2003

Missy has arrived. We are spending the morning looking at her work.

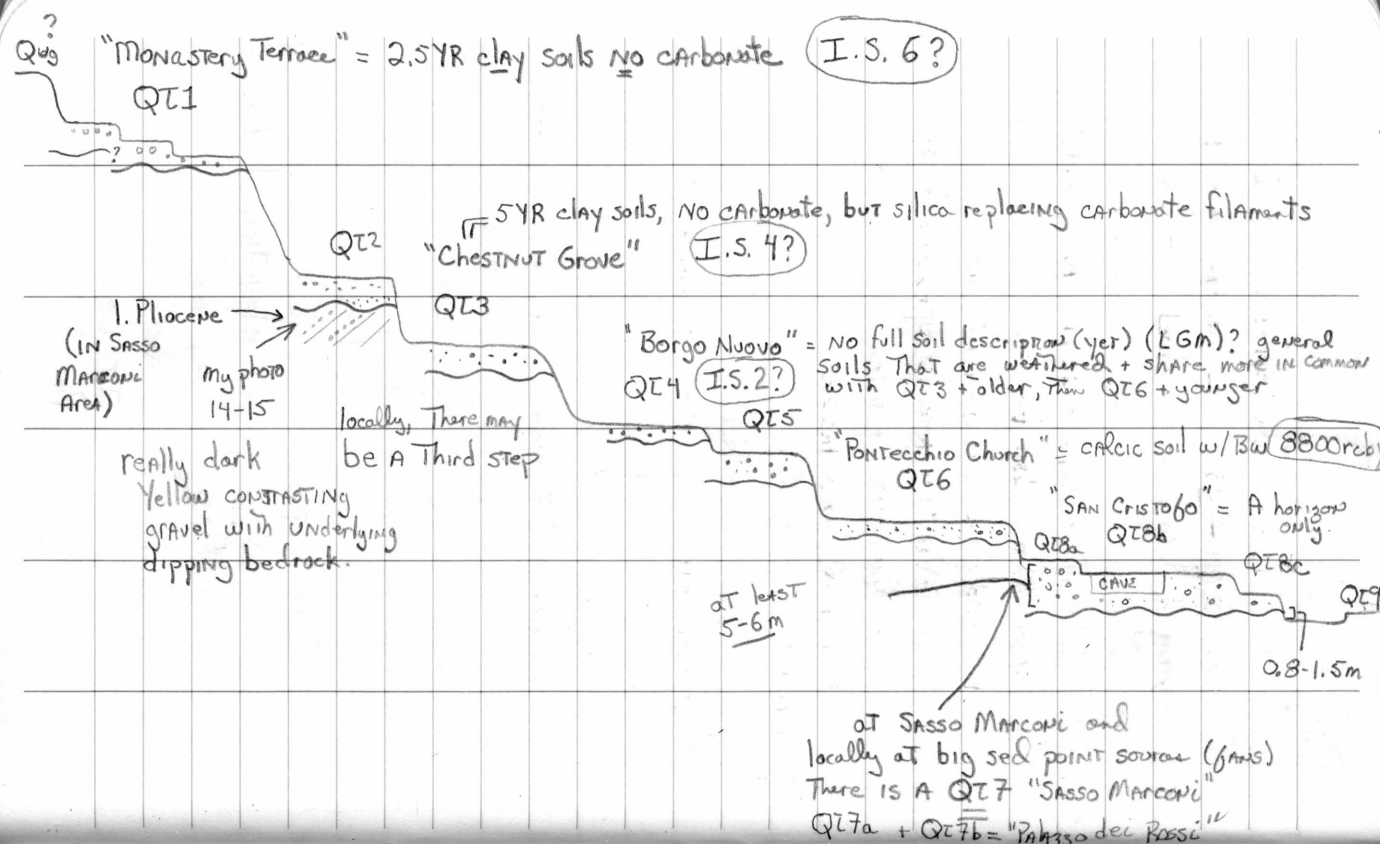
STOP 1 - Terrace sequence from old Sasso Marconi bridge to Sasso Marconi

STOP 2 Via Meggano up the hill to pink commune - Palazza Meggana
* Great Chestnut grove.
0679139, 4920633
Photos 14 + 15

STOP 3 - Montechiaro, via Montechiaro - intersection w/ via Pontecchio - Access to Monestary Terrace. IS 6 or greater

Some summary of terrace observations, based on Missy's work.

- we can get at least 3 cross-valley terrace profiles that can more or less be used to project elevation data
- 1 at Casalecchio, another at Sasso Marconi, and a third at Marga botto? It would be nice to get a 4th at Piani di Venola - Pioppe

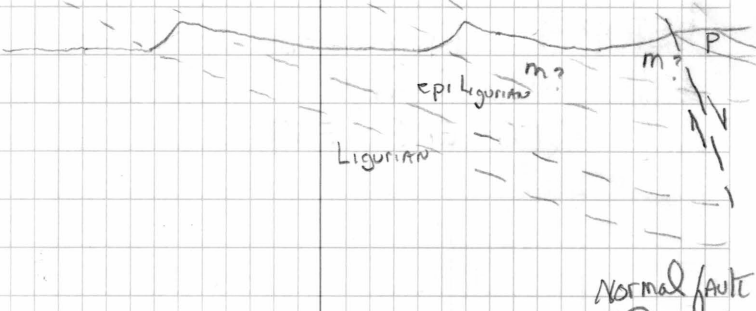

Qvg ?
"Monastery Terrace" = 2.5YR clay soils NO carbonate I.S. 6?
QT1
5YR clay soils, NO carbonate, but silica replacing carbonate filaments
QT2
"Chestnut Grove" I.S. 4?
QT3
1. Pliocene
(IN Sasso Marconi Area)
my photo 14-15
really dark Yellow contrasting gravel with underlying dipping bedrock.
locally, there may be a Third step
"Borgo Nuovo" = NO full soil description (yet) (LGM)? general soils that are weathered + share more in common with QT3 + older, than QT6 + younger
QT4 I.S. 2?
QT5
"Pontecchio Church" = calcic soil w/ Bw 8800rcb
QT6
"San Cristofo" = A horizon only
QT8a
QT8b
QT8c
CAVE
QT9
at least 5-6m
0.8-1.5m
at Sasso Marconi and locally at big sed point sources (fans) There is A QT7 "Sasso Marconi"
QT7a + QT7b = "Palazzo dei Rossi"

STOP 4 - Monastery Terrace - Qt1

Three FAST STATICS, The second one is IN front of church.... probably ~2m from highest point on Terrace (IN church courtyard). The Third FS is ON The highest Qt1.... which might also be Qvg.... This elevation is ABSOLUTELY CONCORDANT with The sub-summit surface projecting South from The SAN LUCA ridge. MANY POTATO STONES at This location.

PHOTO 19-24

★ GREAT PLACE TO START a field TRIP



STOP 5 Via Belvedere - END - QT2 + QT3
FS 4- BELV1 QT2] STRATH exposed IN ROAD CUTTING
FS 5- QT3

STOP 6 Via Rosa QT5 FS6
↳ QT5VR IN HANDHELD.
Via Michelangelo - Via S. Botticelli
QT4 VMICH FS 7

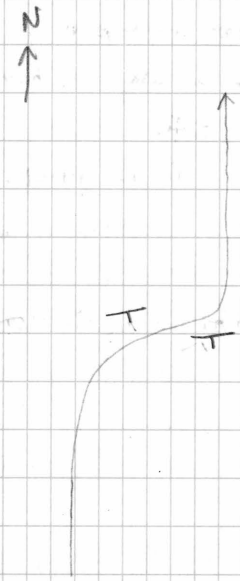
STOP 7 ERG GAS STATION EAST... down private Lane Through NARROW column gate
QT8a ERG - FS8
definite SCARP here distinguishing QT8a + QT8b; QT8b is 2m lower.

STOP 8 ERG STATION (careful to stay off alluvial fan)
QT6 ERG FS9

DAY 6 Thursday, May 29, 2003 calda

Missy + Chuck are doing a channel survey today in the vicinity of the Sasso Marconi bridge.
The "Public Park" at Vizzano has turned into a squatters settlement! No easy river access.

GPS reading here SASMARBRDG



DAY 7 Friday May 30th 2003

Morning spent in Bologna at the Universita Matematica Matteo did some GPS statics on Terraces in Sasso Marconi

Afternoon spent in the reach from Casalecchio to Sapaba Dam.
"Blue Bridge" (BLUEBRDG) is a notable landmark in the Casalecchio Park.
We are <1km from where we finished the Sapaba survey. Channel here is Alluvial - Almost completely looking in bedrock... it is pretty flat.

One more survey on the QT8 Terrace in the Casalecchio Park.... A long kinematic stretch... to see if it is Tilted.
END of this survey is CASA END

T30MAY-FS11 QT8b @ CASA END

30MAYT3 QT8b KINEMATIC

Terrace

TRIMBLE PT	UTM (32T)	(m)	(+rib)
30TFS1	0679079, 4924409,	160	Qt, MUT
30TFS2	0679794, 4924585,	143	Qt3b
30TFS3	0680092, 4924482,	110	Qt4
30TFS4	0680346, 4924240,	102	Qt5
30TFS5	0679093, 4923386,	285	Qt1
30TFS6	0679625, 4923305,	179	Qt3a
30TFS7	0680005, 4923273,	155	Qt3b
30TFS8	0680487, 4922837,	109	Qt6
" 9	0680317, 4922925,	114	Qt5
" 10	0680845, 4923035,	71	Qt8a
30CFS1	0681832, 4925907,	62	channel
30CFS2	0681895, 4925904,	60	"
30CMAY2-END	0681835, 4924910,	54	channel
30TFS11	0681867, 4924987,	56	Qt8b
30MAY3-BE1	0681643, 4926450	49	Qt8b

Day 8, Saturday, May 31st 2003

Martha will continue with soils today + tomorrow; Matteo and I will do the channel from Marzabotto down to ~ Lama di Reno

- Fault! @ the Marzabotto Terrace N10°E down to the west
- Data file 1 is the fault reach... almost all bedrock, many small knick zones.
- Data file 2 (C31May2) is mostly alluvial - mixed with Bedrock and stretches to the Marzabotto suspension bridge (MARZASBRDG)
- Data file 3 is all alluvial... at its end it is basically a delta dumping into a reservoir? I'm guessing a briglia downstream.
- At the end of survey 3, there is a good exposure, back in the trees... maybe a QT5 or QT6? Photo 1-28 of a stitch at this level.

STOP 2. Briglia @ Panaco Stone Bridge
→ FS-1 Dam top; FS-2 Dam base

STOP 3. RR Bridge. Dam top + Dam Bottom
Begin survey - some problems with connection

numbers of satellites. We will try to get a fix following a short kinematic. Then we will try two fast statics further down the channel.

- Little br knickpoints.... mostly a br channel through this reach. One more prominent knickpoint is "aligned" with the valley swale where the watermelons are sold at the roadside stop.

DAY 9, Sunday, June 1, 2003 hot

office day, laundry + dinner @ Vincenzo's

Day 10, Monday June 2, 2003

Maybe last day on the channel - Lama di Reno to Sasso Marconi

START, Lama di Reno Brighia - Park on West side of bridge - road adjacent to Levee. LDR DAM.

Oh... Oh.... Problems with the Controller Unit. It will not start-up. We have placed a call to Chuck Kurnick and UNAVCO support... we need to wait until 2-4 to know what our next move is.

In the meantime: A written record of all waypoints up to now

- UTM 32

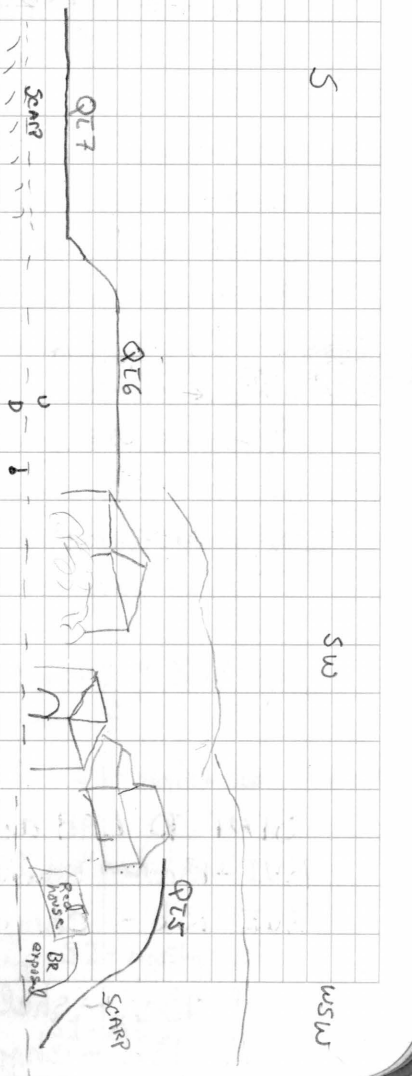
Lama di Reno Dam	LDRDAM	0676529	4914971	93m
Panico Dam	PANDAM	0676199	4914026	121m
Upstream RR bridge	RRBRDG1	0676064	4914072	109m
Suspension Bridge @ Margabotto	MARZASBRDG	0676037	4912488	107m
Calanche Fault	CALAN-FLT	0676438	4910936	118m
IL Cerro	CERRO	0673228	4912288	402m
Cerro Base Station	CBSTATION	0673260	4912218	412m
Sasso Marconi Bridge (NOT Highway entrance bridge)	SASMARBRDG	0679885	4918001	63m

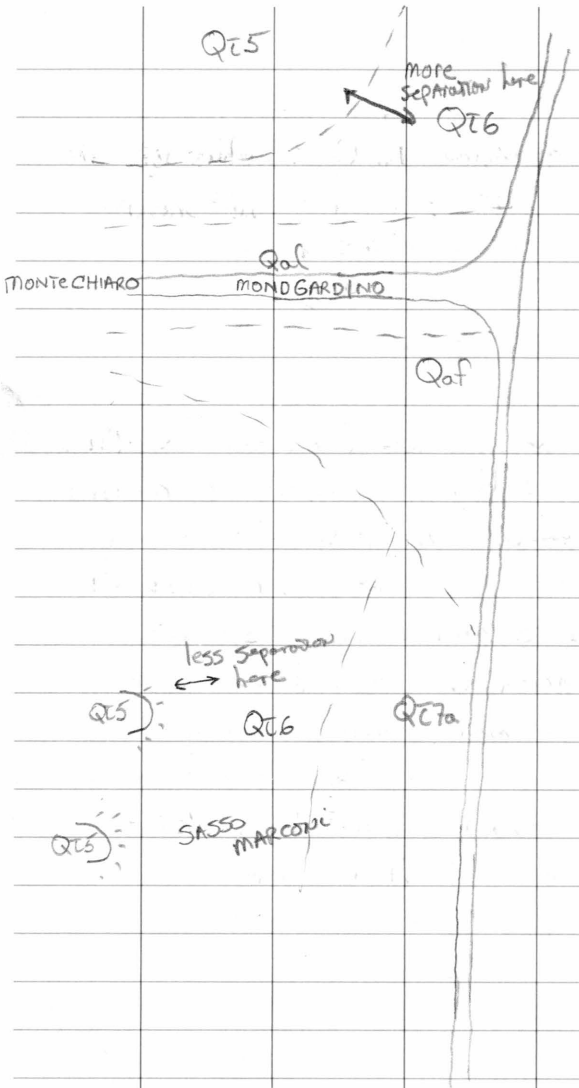
Pian Di Venola Dam	PDVENOLA	0674515	4910619	160
Pian Di Mazzano (QT3)	PMAZZANO	0679131	4920633	168
Palazzo dei Rossi Dam	PDRDAM	0680948	4920669	73
SAN Cristofo Base	SCBASE	0681348	4921682	15
SAPABA Bridge	SAPABRDG	0681849	4921780	40
Belvedere (QT2)	Belv1	0679966	4926618	164
BlueBridge (Casalecchio Park)	BLUEBRDG	0681881	4925713	66
Casalecchio Dam	CASALDAM	0681431	4926867	27
QT1 Monastary	QT1MONAST	0679333	4926351	224
QT4 Via Michelangelo	QT4VMich	0680370	4926148	79
QT5 Via Rosa	QT5VR	0680118	4925862	78
QT6 ERG Gas station South of Casalecchio	QT6ERG	0680709	4924646	80
QT8a opposite ERG on Private Lane	QT8AERG	0680991	4924674	62
QT8b Casalecchio Park	QT8CASAEND	0681872	4924972	55
SAPABA DAM	SAPABADAM	0681815	4922340	60

Afternoon spent looking at Terraces.
Flat Tire! at South Palazzo dei Rossi road -construction site... QT7b exposure..... we pulled gravel from here QT7b-S1.

- AT The RR crossing, North Palazzo dei Rossi road. View looking south + southwest

Photos 31-32-33





SENT TO LAB as

RVI-13a - "seeds"
RVI-13b - charcoal

RVI-13c - shells
RVI-13d - charcoal

Day 11, Tuesday, June 03, 2003

STOP 1. Construction site @ Casalecchio - via Bottechino off of Via Michelangelo - GPS location of Qt4 V. Mich.

Photos 1-34, 35, 36

In nearly all respects, this exposure illustrates how much colluvium has washed across the terrace treads. - At least 2 to 3 meters of colluvium. I believe this exposure shows 2-3 m of colluvium atop Qt5; Qt4 is up above... standby colluvium down. Colluvium is mostly a pebbly sandy silt, pedogenically altered to contain clay. There are lenses of sandy gravel. ... At least 2 buried soils marked by dark A horizons.

disturbed zone • All samples = RVI-13

UNIT5 Brownish-yellow sandy colluvium 5

→UNIT4 Brownish-yellow colluvium 4 S4 - snails + some charcoal

UNIT3 buried A horizon 3, S3 - not much... mix

UNIT2 Yellowish brn colluvium 2 S2 - mostly snails

→UNIT 1 buried A horizon 1 S1 - charcoal

UNIT 1 IS TRUELY A buried soil.... IT TRUELY IS red UNDER THE dark buried A. THIS IS probably THE TOP of QT5

UNIT 5 IS ALMOST CERTAINLY ANTHROPOGENIC - deposition IT CONTAINS pieces of brick....

STOP 2 TERRACE MAPPING from BORGO NUOVO TO SASSO MARCONI, INCLUDING both SIDES of THE NARROW SUSPENSION bridge at PALAZZO dei ROSSI

- definite? fault @ PALAZZO dei ROSSI
- down dropping of QT7b SEEMS across CONSTRUCTION SITE @ PALAZZO dei ROSSI South ENTRANCE ROAD
- TILTING of TERRACE TREADS.
- REMAPPING of QT5, QT4, QT6, QT7 IS very CONSISTENT with FAULT offset.

Day 12, Wednesday, June 04, 2003

In Bologna today to pick up, drop off stuff... got the DTM, talked to Vincenzo, we've planted the seed of an active fault. We will use the afternoon to do some fast-static points on terrace.

Antenna height = 1.86 m; set at 1.94 m rod height

- 04 Jun FS-1 QT8a Palazzo dei Rossi ← FIX This
- 04 Jun FS-2 QT7b Palazzo dei Rossi
- 04 Jun FS-3 QT4 back Via Montechiaro QT4T
- 04 Jun FS-4 QT4 strath " " QT4S
- 04 Jun FS-5 QT5 tread " " QT5T

This point, antenna height = QT5 is on a farm here... Trail is modified.

- 04 June FS-6 QT5 strath " " QT5S
- 04 June FS-7 QT6 tread Private dead-end east of SS64 Reg Ant. height < 0.5 km S of Via Montechiaro QT6T
- 04 June FS-8 QT6 strath Public entrance to bike trail, behind black gate, just S of N. Palazzo dei Rossi road - Tough call - out in a field, we set up @ a color change in the field / scarp. QT6S

There is a spring in this park.... likely QT5S.

- 04 June FS-9 QT3 strath (main body of deposit) we put it on Via Montechiano, at major break in slope... at the spring BR outcrop. QT3S - rod height at max. ~160m elev

· 04 JUN FS-10 QTI (highest) TRAIL QTIT
- green gate off of VIA MONTECHIARO.
No hope of A STRAIGHT.
Photos 2-2 to 2-9 from up here.
Rod at normal height.

higher ANTENNA = 2.42 m

Day 13, Thursday, June 5, 2003

Deja vu all over again
we will "FAST-STATIC The missing river reach.
START at Lama di Reno dam. Water is up
~ 15 cm... dam release upstream.
Antenna height = 90 cm
GPS Waypoint = LDRDAM

START

- 05 JUN FS1 Lama di Reno dam top
- 05 JUN FS2 Lama di Reno dam bottom.
- 05 JUN FS3 Btwn Lama di Reno dam + Highway curbbank
- 05 JUN FS4 Just upstream of RR bridge #2
  This is the pool elevation of RR bridge dam.
- 05 JUN FS5 RR Bridge 2 dam bottom...
  add a point at FS4 elev to make
  the step. RRBRD62
- 05 JUN FS6 @ big br escarpment, east bank,
  channel is in br here... There is a little knickpt,
  This point is at the top of the knickpt
  The map shows a fault here... and the
  escarpment top is a stain with gravel - QT6?,
  QT7?
- 05 JUN FS7 Knickpoint base
- 05 JUN FS8 Wow! great exposure QT7 probably...
  ↳ Knickpt top

More importantly ... A major knickzone. This pt is at the top. There is a QT8-like (or QT9) strath projecting to the top of the knickpoint.
Photos 2-11 to 2-14
Almost a certain fault cutting this terrace. Terrace is probably QT6 ... not 7. (3m thick)
The whole outcrop is a fault zone. Sense of motion really looks like thrust faults verging north.

- There is a travertine deposit + spring smack in the middle of the fault.
- The A-horizon is buried .... looks like QT6 - almost certainly charcoal in there if we could get to it.

- 05 Jun FS9 knickpt base - knickpt is a big alluvial bar ... top of which grades to QT8-9 strath. BR exposed downstream of the knickpt.
- 05 Jun FS10 Add 10 cm to antenna cannot get a fix .... bad satellites
- 05 Jun FS11 - try again, other side of strm GOT IT!

FAULTS - 3 KINDS - ① OBlique, up to w w/ gouge N 20° E
② N 20° E, 45° rake, up to west
③ E-w, 0° rake

- 05 JUN FS 12 LAST BR IN channel, knickpt end in direction of FONTANA Access point
- 05 JUN FS13 FONT ACC FONTANA Access - Alluvial.
- 05 JUN FS14 Riffles close downstream of FONT ACC kind of A mixed BR - Alluvial step-pool reach.
- 05 JUN FS15 Next set of riffles... Downstream from here it opens up to A broad Alluvial reach.
- 05 JUN FS16 mixed br - Alluvial reach w/ little steps
- 05 JUN FS17 Almost at The SETTA
- 05 JUN FS18 confluence w/ SETTA SETTA CONF
- 05 JUN FS19 beginning of pool behind SASSO MARCONI Brdg dam. END SURVEY

(★) There is AN easy ford + road Access point at
Add 1 more point - WAYPOINT for A1ORBRDG with The pool elev from The Missy - Chuck survey of last Wednesday.

Day 14 Friday June 6, 2003

Field trip day with Darrel + Vincenzo.

(1) Palazzo dei Rossi Fault is real, but it strikes N 40° W... The so called "Setta trend" This fault cuts obliquely across via Montechiaro and explains a lot regarding the mini-scarps at the cemetary + high level of QTG @ San Michele - the place w/ the black gates. Fault goes through the spring.

(2) Fontana Fault. Yes they agree it is there - Again, it is on the Setta trend. Fault dip is unknown - will do structural analysis.

(3) Margabotto fault. It's origin is unclear.. will need to do GPS to document tilting.

HOT!

Day 15, Saturday, June 7, 2003

- Finish up Terrace elevations for regions north of Sasso Marconi

→ • I've had to jury-rig the base antenna - I forgot the base... it is at 7cm elev to base of antenna.

→ • All rover elevations are 90cm unless indicated otherwise

ALL TREAD ELEV UNLESS INDICATED
Always as far downtread as possible.

- 07 Jun FS 1 Casalecchio Park QT5 tread edge.
- 07 Jun FS 2 Casalecchio Park QT4 tread edge
- 07 Jun FS 3 Palazzo dei Rossi QT8b
  fix point from 04 Jun FS 1 to QT8a
  QT8b still has a bat-swale morphology.
- 07 Jun FS 4 QT7b @ Villa Angeli
- 07 Jun FS 5 QT7b @ the Villa Angeli - Palazzo dei Rossi intersection
- 07 Jun FS 6 QT7b @ PDR bridge, west side.
- 07 Jun FS 7 QT7b on Via Chiu, this is end of QT7b terrace on down thrown side of fault.
- 07 Jun FS 8 QT8b Vizzano
- 07 Jun FS 9 QT7b Vizzano
- 07 Jun FS 10 QT7b Vizzano upstream... before the Vizzano fault - Note new fault I've put on the map strikes more or less N 70°W - offsets QT7 here (I think) next point is on supposed down dropped side

- 07 JUN FS11 Qt7b VIZZANO on upthrown side of VIZZANO FAULT.
- 07 JUN FS12 Qt6 at VIZZANO crossroads, upthrown side of fault
- 07 JUN FS13 Qt7b VIZZANO downstream, down-thrown side of fault
- 07 JUN FS14 Qt6 VIZZANO downstream, down-thrown side of fault.

"Definite" A second fault, on the SETTA trend, at about the site of the bridge - IT explains the scarps in Qt6 + Qt7b

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- 07 JUN FS15 Qt7b, west side of river, VIA Chiu' construction site. up thrown part of fault.
- 07 JUN FS16 Qt7b, west side of river at TERMINUS of VIA GAMBIERI ... at TREAD level directly over exposed bedrock, overlooking Qt8 + old gravel quarry, now a lake.

close to SETTA

- 07 JUN FS17 Qt6? SAN LORENZO - ASDP big scarp.

★ This still maybe Qt7a on the upthrown side of yet another fault

- 07 JUN FS18 CHESTNUT TERRACE. Qt3 - off of Private Rd
- 07 JUN FS19 Qt6? off of (W) SASSO MARCONI Bldg.
- 07 JUN FS20 Qt3 LA PALAZZINA, SASSO MARCONI

X → NOT able, or UNNECESSARY TO do

MAPS → Porta San Felice

220 in press Via

236 237

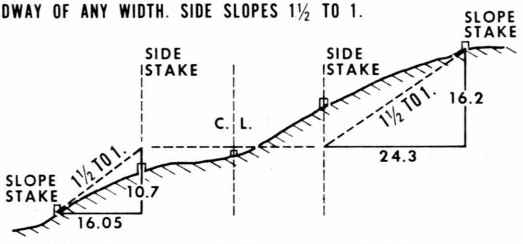
Porta Santa Cosima Park.

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	32 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	35 25	35 40	35.55	35.70	35 85	23
24	36 00	36 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

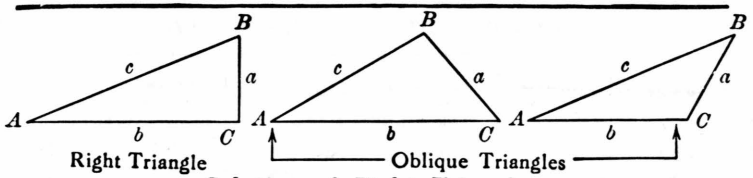
STADIA REDUCTIONS FOR READING 100

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

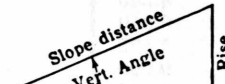
For Angle A. $\sin = \frac{a}{c}$, $\cos = \frac{b}{c}$, $\tan = \frac{a}{b}$, $\cot = \frac{b}{a}$, $\sec = \frac{c}{b}$, $\operatorname{cosec} = \frac{c}{a}$

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	$s = \frac{a+b+c}{2}, \sin \frac{1}{2}A = \sqrt{\frac{(s-b)(s-c)}{b\,c}}$, $\sin \frac{1}{2}B = \sqrt{\frac{(s-a)(s-c)}{a\,c}}, C = 180° - (A+B)$
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

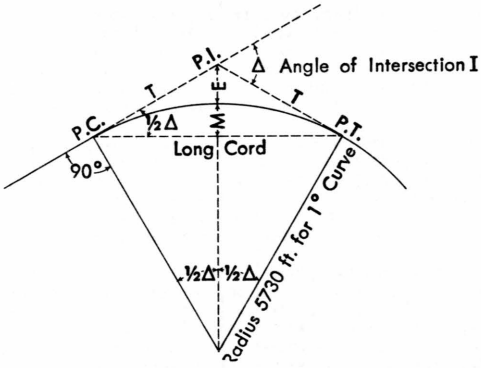
Angle	Sin.	Tan.	Sec.	Cosec.	Cotg.	Cosin.		Angle	Sin.	Tan.	Sec.	Cosec.	Cotg.	Cosin.	
° ′								° ′							
16	.2756	.2867	1.0403	3.628	3.487	.96126	**74**	**24**	.4067	.4452	1.0946	2.459	2.246	.91355	**66**
10	.2784	.2899	1.0412	3.592	3.450	.96046	50	10	.4094	.4487	1.0961	2.443	2.229	.91236	50
20	.2812	.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: $R = \dfrac{50}{\sin \frac{1}{2} D}$

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

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

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

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°
31°	1589.0	216.3	+
10′	1598.0	218.7	5° C.
20′	1606.9	221.1	T
30′	1615.9	223.5	.13
40′	1624.9	226.0	E
50′	1633.9	228.4	
32°	1643.0	230.9	.023
10′	1652.0	233.4	
20′	1661.0	235.9	
30′	1670.0	238.4	
40′	1679.1	241.0	
50′	1688.1	243.5	
33°	1697.2	246.1	10° C.
10′	1706.3	248.7	T
20′	1715.3	251.3	.26
30′	1724.4	253.9	E
40′	1733.5	256.5	.046
50′	1742.6	259.1	
34°	1751.7	261.8	
10′	1760.8	264.5	
20′	1770.0	267.2	
30′	1779.1	269.9	
40′	1788.2	272.6	
50′	1797.4	275.3	15° C.
35°	1806.6	278.1	T
10′	1815.7	280.8	.40
20′	1824.9	283.6	E
30′	1834.1	286.4	.070
40′	1843.3	289.2	
50′	1852.5	292.0	
36°	1861.7	294.9	
10′	1870.9	297.7	
20′	1880.1	300.6	
30′	1889.4	303.5	
40′	1898.6	306.4	20° C.
50′	1907.9	309.3	T
37°	1917.1	312.2	.53
10′	1926.4	315.2	E
20′	1935.7	318.1	.093
30′	1945.0	321.1	
40′	1954.3	324.1	
50′	1963.6	327.1	
38°	1972.9	330.2	
10′	1982.2	333.2	25° C.
20′	1991.5	336.3	T
30′	2000.9	339.3	.67
40′	2010.2	342.4	E
50′	2019.6	345.5	
39°	2029.0	348.6	.117
10′	2038.4	351.8	
20′	2047.8	354.9	
30′	2057.2	358.1	
40′	2066.6	361.3	
50′	2076.0	364.5	
40°	2085.4	367.7	30° C.
10′	2094.9	371.0	T
20′	2104.3	374.2	.80
30′	2113.8	377.5	E
40′	2123.3	380.8	.141
50′	2132.7	384.1	

I	T	E	I=50°
41°	2142.2	387.4	+
10′	2151.7	390.7	5° C.
20′	2161.2	394.1	T
30′	2170.8	397.4	.17
40′	2180.3	400.8	E
50′	2189.9	404.2	
42°	2199.4	407.6	.037
10′	2209.0	411.1	
20′	2218.6	414.5	
30′	2228.1	418.0	
40′	2237.7	421.4	
50′	2247.3	425.0	
43°	2257.0	428.5	10° C.
10′	2266.6	432.0	T
20′	2276.2	435.6	.34
30′	2285.9	439.2	E
40′	2295.6	442.8	.075
50′	2305.2	446.4	
44°	2314.9	450.0	
10′	2324.6	453.6	
20′	2334.3	457.3	
30′	2344.1	461.0	
40′	2353.8	464.6	
50′	2363.5	468.4	15° C.
45°	2373.3	472.1	T
10′	2383.1	475.8	.51
20′	2392.8	479.6	E
30′	2402.6	483.4	.116
40′	2412.4	487.2	
50′	2422.3	491.0	
46°	2432.1	494.8	
10′	2441.9	498.7	
20′	2451.8	502.5	
30′	2461.7	506.4	
40′	2471.5	510.3	20° C.
50′	2481.4	514.3	T
47°	2491.3	518.2	.68
10′	2501.2	522.2	E
20′	2511.2	526.1	.151
30′	2521.1	530.1	
40′	2531.1	534.2	
50′	2541.0	538.2	
48°	2551.0	542.2	
10′	2561.0	546.3	
20′	2571.0	550.4	25° C.
30′	2581.0	554.5	T
40′	2591.0	558.6	.85
50′	2601.1	562.8	E
49°	2611.2	566.9	.189
10′	2621.2	571.1	
20′	2631.3	575.3	
30′	2641.4	579.5	
40′	2651.5	583.8	
50′	2661.6	588.0	
50°	2671.8	592.3	30° C.
10′	2681.9	596.6	T
20′	2692.1	600.9	1.02
30′	2702.3	605.3	E
40′	2712.5	609.6	.227
50′	2722.7	614.0	

I	T	E	I=60°
51°	2732.9	618.4	+
10′	2743.1	622.8	5° C.
20′	2753.4	627.2	T
30′	2763.7	631.7	.21
40′	2773.9	636.2	E
50′	2784.2	640.7	
52°	2794.5	645.2	.056
10′	2804.9	649.7	
20′	2815.2	654.3	
30′	2825.6	658.8	
40′	2835.9	663.4	
50′	2846.3	668.0	
53°	2856.7	672.7	10° C.
10′	2867.1	677.3	T
20′	2877.5	682.0	.42
30′	2888.0	686.7	E
40′	2898.4	691.4	.112
50′	2908.9	696.1	
54°	2919.4	700.9	
10′	2929.9	705.7	
20′	2940.4	710.5	
30′	2951.0	715.3	
40′	2961.5	720.1	
50′	2972.1	725.0	15° C.
55°	2982.7	729.9	T
10′	2993.3	734.8	.63
20′	3003.9	739.7	E
30′	3014.5	744.6	.168
40′	3025.2	749.6	
50′	3035.8	754.6	
56°	3046.5	759.6	
10′	3057.2	764.6	
20′	3067.9	769.7	
30′	3078.7	774.7	20° C.
40′	3089.4	779.8	T
50′	3100.2	784.9	.84
57°	3110.9	790.1	E
10′	3121.7	795.2	.225
20′	3132.6	800.4	
30′	3143.4	805.6	
40′	3154.2	810.9	
50′	3165.1	816.1	
58°	3176.0	821.4	
10′	3186.9	826.7	
20′	3197.8	832.0	25° C.
30′	3208.8	837.3	T
40′	3219.7	842.7	1.05
50′	3230.7	848.1	E
59°	3241.7	853.5	.283
10′	3252.7	858.9	
20′	3263.7	864.3	
30′	3274.8	869.8	
40′	3285.8	875.3	
50′	3296.9	880.8	
60°	3308.0	886.4	30° C.
10′	3319.1	892.0	T
20′	3330.3	897.5	1.27
30′	3341.4	903.2	E
40′	3352.6	908.8	
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	20° C.	30′	4516.9	1566.3	20° C.	30′	5389.9	2136.7	20° C.
40′	3768.5	1128.2	T	40′	4530.4	1574.7	T	40′	5405.6	2147.5	T
50′	3780.4	1134.8	1.02	50′	4544.0	1583.1	1.22	50′	5421.4	2158.4	1.45
67°	3792.4	1141.4	E	77°	4557.6	1591.6	E	87°	5437.2	2169.2	E
10′	3804.4	1148.0	.321	10′	4571.2	1600.1	.445	10′	5453.1	2180.2	.603
20′	3816.4	1154.7		20′	4584.8	1608.6		20′	5469.0	2191.1	
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	25° C.	10′	4653.6	1651.7	25° C.	10′	5549.2	2246.7	25° C.
20′	3889.0	1195.2	T	20′	4667.4	1660.5	T	20′	5565.4	2258.0	T
30′	3901.2	1202.0	1.28	30′	4681.3	1669.2	1.53	30′	5581.6	2269.3	1.83
40′	3913.4	1208.9	E	40′	4695.2	1678.1	E	40′	5597.8	2280.6	E
50′	3925.6	1215.8	.403	50′	4709.2	1686.9	.558	50′	5614.2	2292.0	.756
69°	3937.9	1222.7		79°	4723.2	1695.8		89°	5630.5	2303.5	
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	I=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	
40′	6438.4	2889.0	20° C.
50′	6457.3	2903.1	T
97°	6476.2	2917.3	1.74
10′	6495.2	2931.6	E
20′	6514.3	2945.9	.809
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	
20′	6630.1	3033.1	25° C.
30′	6649.6	3047.9	T
40′	6669.2	3062.8	2.18
50′	6688.8	3077.7	E
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	1.22
50′	6930.1	3262.3	

I	T	E	I=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	
40′	7696.3	3865.2	20° C.
50′	7719.7	3884.0	T
107°	7743.2	3902.9	2.08
10′	7766.8	3921.9	E
20′	7790.5	3940.9	1.08
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	
20′	7934.6	4057.4	25° C.
30′	7959.0	4077.2	T
40′	7983.5	4097.1	2.61
50′	8008.0	4117.0	E
109°	8032.7	4137.1	1.36
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	I=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	
40′	9289.2	5184.5	20° C.
50′	9319.5	5210.3	T
117°	9349.9	5236.2	2.52
10′	9380.5	5262.3	E
20′	9411.3	5288.6	1.46
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	.3875	.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

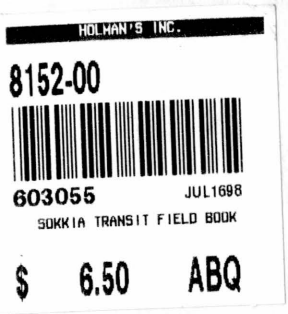
Rods	Feet	Rods	Feet	Rods	Feet	Rods	Feet	Rods	Feet
1	16.50	21	346.50	41	676.50	61	1006.50	81	1336.50
2	33.00	22	363.00	42	693.00	62	1023.00	82	1353.00
3	49.50	23	379.50	43	709.50	63	1039.50	83	1369.50
4	66.00	24	396.00	44	726.00	64	1056.00	84	1386.00
5	82.50	25	412.50	45	742.50	65	1072.50	85	1402.50
6	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

Sokkia Surveying Systems, Instruments, Equipment and Supplies

- *Total Stations*
- *Electronic Field Book*
- *Mapping Software*
- *EDM Systems*
- *Theodolites*
- *Levels*
- *Transits*
- *Tripods*
- *Rods*
- *Hand Levels*
- *Tapes*
- *Planimeters*
- *Accessories*



The paper in this book is a fine quality thick 50% rag ledger specially treated during the making to give "High Wet Strength." It retains is strength and writing surfaces when dried after having been subjected to extreme weather conditions.

Gallegos RR STATION Tuesday 11:00 AM

SOKKIA™

FIELD BOOKS

Rain-resistant fine quality ledger paper, bound in high-visibility durable yellow imitation leather. Printed in waterproof ink.

Stock No. 8152-00 Transit Field Book. Size 4 1/2 x 7 1/4 inches.

Stock No. 8152-05 Economy Field Book. Spiral bound, Paperback. Size 4 1/2 x 7 1/4 inches.

Stock No. 8152-10 Economy Field Book. Same as above except saddle stitched (stapled).

Left page blue horizontal lines; red vertical lines.
Right page 4 horizontal and 8 vertical blue lines; red vertical center line.

★★★★★

Stock No. 8152-20 Mining Transit Book. Size 4 1/2 x 7 1/4 inches.

Left page blue horizontal lines; red vertical center line.
Right page 8 x 8 blue lines; red vertical lines.

★★★★★

Stock No. 8152-30 Engineers Field Book. Size 4 1/2 x 7 1/4 inches.

Left page blue horizontal lines; red vertical lines.
Right page 10 x 10 blue lines; red vertical center line. Inch lines heavy.

★★★★★

Stock No. 8152-50 Level Book Size 4 x 6 1/2 inches.
Stock No. 8152-55 Level Book Size 4 1/2 x 7 1/4 inches.
Both pages blue horizontal lines; red vertical lines. 6 vertical columns.

★★★★★

Stock No. 8152-60 Field Book. Size 4 1/2 x 7 1/4 inches.
Left page blue horizontal lines; red vertical lines.
Right page 4 x 4 blue lines; red vertical center line.

★★★★★

Stock No. 8152-75 Cross Section Book. Size 6 1/2 x 8 1/2 inches.

Both pages 10 x 10 blue lines; inch lines slightly heavier.

★★★★★

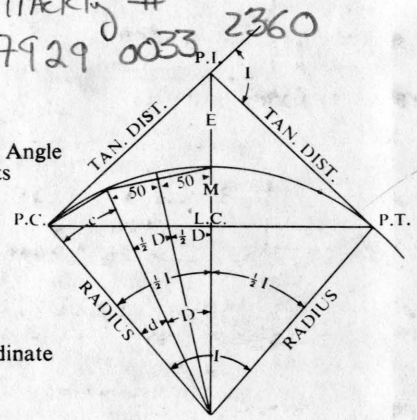
Stock No. 8152-80 Duplicating Transit Book. Size 4 1/2 x 7 1/4 inches.

Left page blue horizontal lines; red vertical lines.
Right page 4 horizontal and 8 vertical blue lines; red vertical center line. Pages numbered and perforated. Carbon paper.

CURVE FORMULAE

Tracking # 7929 0033 2360

D = Degree of Curve
1° = 1-Degree of Curve
2° = 2-Degree of Curve
P.C. = Point of Curve
P.T. = Point of Tangent
P.I. = Point of Intersection
I = Intersection of Angle, Angle between Two Tangents
L = Length of Curve, from P.C. to P.T.
T = Tangent Distance
E = External Distance
R = Radius
L.C. = Length of Chord
M = Length of Middle Ordinate
c = Length of Sub-Chord
d = Angle of Sub-Chord



$$R = \frac{L.C.}{2 \sin \frac{1}{2} I} \quad T = R \tan \tfrac{1}{2} I = \frac{L.C.}{2 \cos \frac{1}{2} I}$$

$$\frac{L.C.}{2} = R \sin \frac{I}{2}, \quad D\ 1° = R = 5730, \quad D\ 2° = \frac{5730}{2}, \quad D = \frac{5730}{R}$$

$$M = R (1 - \cos \tfrac{1}{2} I), = R - R \cos \frac{I}{2}$$

$$\frac{E + R}{R} = \sec \frac{I}{2}, \quad \frac{R - M}{R} = \cos \frac{I}{2}$$

$$c = 2 R \sin \tfrac{1}{2} d, \quad d = \frac{c}{2R}$$

$$L.C. = 2 R \sin \tfrac{1}{2} I, \quad E = R (\sec \tfrac{1}{2} I - 1), = R \sec \frac{I}{2} - R$$

Minutes in Decimals of a Degree

1′	·0167	11′	·1833	21′	·3500	31′	·5167	41′	·6833	51′	·8500
2	·0333	12	·2000	22	·3667	32	·5333	42	·7000	52	·8667
3	·0500	13	·2167	23	·3833	33	·5500	43	·7167	53	·8833
4	·0667	14	·2333	24	·4000	34	·5667	44	·7333	54	·9000
5	·0833	15	·2500	25	·4167	35	·5833	45	·7500	55	·9167
6	·1000	16	·2667	26	·4333	36	·6000	46	·7667	56	·9333
7	·1167	17	·2833	27	·4500	37	·6167	47	·7833	57	·9500
8	·1333	18	·3000	28	·4667	38	·6333	48	·8000	58	·9667
9	·1500	19	·3167	29	·4833	39	·6500	49	·8167	59	·9833
10	·1667	20	·3333	30	·5000	40	·6667	50	·8333	60	1·0000

Inches in Decimals of a Foot

$\frac{1}{16}$	$\frac{3}{32}$	$\frac{1}{8}$	$\frac{3}{16}$	$\frac{1}{4}$	$\frac{5}{16}$	$\frac{3}{8}$	$\frac{1}{2}$	$\frac{5}{8}$	$\frac{3}{4}$	$\frac{7}{8}$
·0052	·0078	·0104	·0156	·0208	·0260	·0313	·0417	·0521	·0625	·0729

1	2	3	4	5	6	7	8	9	10	11
·0833	·1667	·2500	·3333	·4167	·5000	·5833	·6667	·7500	·8333	·9167

SOKKIA™

MADE IN U.S.A.