CNWRA #42

Analogs

308 --- Q200312080003

Scientific Notebooks No. 042: Field work at the Nopal I Uranium Deposit, Pena Blanca, Mexico (08/18/1995 through 12/20/1996)

"Rite in the Rain"

ALL-WEATHER

TRANSIT BOOK

No. 300

JAMES D. PRIKRYL

Scientist

CENTER FOR NUCLEAR WASTE REGULATORY ANALYSES

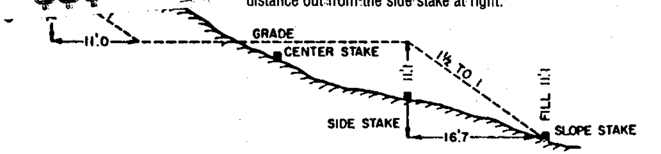
6220 Culebra Road
San Antonio, Texas 78228-0510
(512) 522-5446
FAX (512) 522-5155

SOUTHWEST RESEARCH INSTITUTE

[partly hidden] SIDE STAKES FOR CROSS-SECTIONING

Roadway of any Width. Side Slopes 1½ to 1.

In the figure below: opposite 7 under "Cut or Fill" and under .3 read 11.0, the distance out from the side stake at left. Also, opposite 11 under "Cut or Fill" and under .1 read 16.7, the distance out from the side stake at right.



Cut or Fill	0	.1	.2	.3	.4	.5	.6	.7	.8	.9	Cut or Fill
	Distance out from Side or Shoulder Stake										
0	0.0	0.2	0.3	0.5	0.6	0.8	0.9	1.1	1.2	1.4	0
1	1.5	1.7	1.8	2.0	2.1	2.3	2.4	2.6	2.7	2.9	1
2	3.0	3.2	3.3	3.5	3.6	3.8	3.9	4.1	4.2	4.4	2
3	4.5	4.7	4.8	5.0	5.1	5.3	5.4	5.6	5.7	5.9	3
4	6.0	6.2	6.3	6.5	6.6	6.8	6.9	7.1	7.2	7.4	4
5	7.5	7.7	7.8	8.0	8.1	8.3	8.4	8.6	8.7	8.9	5
6	9.0	9.2	9.3	9.5	9.6	9.8	9.9	10.1	10.2	10.4	6
7	10.5	10.7	10.8	11.0	11.1	11.3	11.4	11.6	11.7	11.9	7
8	12.0	12.2	12.3	12.5	12.6	12.8	12.9	13.1	13.2	13.4	8
9	13.5	13.7	13.8	14.0	14.1	14.3	14.4	14.6	14.7	14.9	9
10	15.0	15.2	15.3	15.5	15.6	15.8	15.9	16.1	16.2	16.4	10
11	16.5	16.7	16.8	17.0	17.1	17.3	17.4	17.6	17.7	17.9	11
12	18.0	18.2	18.3	18.5	18.6	18.8	18.9	19.1	19.2	19.4	12
13	19.5	19.7	19.8	20.0	20.1	20.3	20.4	20.6	20.7	20.9	13
14	21.0	21.2	21.3	21.5	21.6	21.8	21.9	22.1	22.2	22.4	14
15	22.5	22.7	22.8	23.0	23.1	23.3	23.4	23.6	23.7	23.9	15
16	24.0	24.2	24.3	24.5	24.6	24.8	24.9	25.1	25.2	25.4	16
17	25.5	25.7	25.8	26.0	26.1	26.3	26.4	26.6	26.7	26.9	17
18	27.0	27.2	27.3	27.5	27.6	27.8	27.9	28.1	28.2	28.4	18
19	28.5	28.7	28.8	29.0	29.1	29.3	29.4	29.6	29.7	29.9	19
20	30.0	30.2	30.3	30.5	30.6	30.8	30.9	31.1	31.2	31.4	20
21	31.5	31.7	31.8	32.0	32.1	32.3	32.4	32.6	32.7	32.9	21
22	33.0	33.2	33.3	33.5	33.6	33.8	33.9	34.1	34.2	34.4	22
23	34.5	34.7	34.8	35.0	35.1	35.3	35.4	35.6	35.7	35.9	23
24	36.0	36.2	36.3	36.5	36.6	36.8	36.9	37.1	37.2	37.4	24
25	37.5	37.7	37.8	38.0	38.1	38.3	38.4	38.6	38.7	38.9	25
26	39.0	39.2	39.3	39.5	39.6	39.8	39.9	40.1	40.2	40.4	26
27	40.5	40.7	40.8	41.0	41.1	41.3	41.4	41.6	41.7	41.9	27
28	42.0	42.2	42.3	42.5	42.6	42.8	42.9	43.1	43.2	43.4	28
29	43.5	43.7	43.8	44.0	44.1	44.3	44.4	44.6	44.7	44.9	29
30	45.0	45.2	45.3	45.5	45.6	45.8	45.9	46.1	46.2	46.4	30
31	46.5	46.7	46.8	47.0	47.1	47.3	47.4	47.6	47.7	47.9	31
32	48.0	48.2	48.3	48.5	48.6	48.8	48.9	49.1	49.2	49.4	32
33	49.5	49.7	49.8	50.0	50.1	50.3	50.4	50.6	50.7	50.9	33
34	51.0	51.2	51.3	51.5	51.6	51.8	51.9	52.1	52.2	52.4	34
35	52.5	52.7	52.8	53.0	53.1	53.3	53.4	53.6	53.7	53.9	35
36	54.0	54.2	54.3	54.5	54.6	54.8	54.9	55.1	55.2	55.4	36
37	55.5	55.7	55.8	56.0	56.1	56.3	56.4	56.6	56.7	56.9	37
38	57.0	57.2	57.3	57.5	57.6	57.8	57.9	58.1	58.2	58.4	38
39	58.5	58.7	58.8	59.0	59.1	59.3	59.4	59.6	59.7	59.9	39
40	60.0	60.2	60.3	60.5	60.6	60.8	60.9	61.1	61.2	61.4	40

CNWRA CONTROLLED COPY 042

"Rite in the Rain"
ALL-WEATHER WRITING PAPER ®

Required for each rock sample: (TOP-016)

- I.D. No

Name

- Loc. of site

Address

- Description of sample
- Name + age of Formation (if known)

Phone

- Date of collection

Project

- Name or initials of person making entry

Also - photo, if necessary
- location marked on map if necessary

◯ JP 8/5/94

CONTENTS

PAGE NO.	REFERENCE	DATE
Initial Entry		
Field work at the Nopal I uranium deposit, Pena Blanca, Mexico		
James D. Prikryl		
Obj: Collect rock + mineral samples for analysis of radionuclide transport.		
Equipment - rock hammer, chisels, ziploc bags.		

5/22/92 JP 1435 hrs

Sample traverse of +10 level of Nopal I uranium ore body

All samples will be taken from the Nopal Formation

Samples will be given IDs corresponding to the grid constructed on the structure map of the +10 level. Samples can then be easily located on the map

Traverse #1

North-South from uranium mineralized zone to unmineralized rock

Sample No.	Description
NOPI-ECP-22.5/10.4	kaolinitized tuff with U^{+6} silicates
NOPI-ECP-22.8/10.8	kaolinitized, very hematitic tuff with U^{+6} silicates
NOPI-ECP-22.25/11.45	kaolinitized tuff with U^{+6} silicates
NOPI-ECP-22.6/11.9	kaolinitized, very hematitic tuff
NOPI-ECP-22.5/12.4	Uraninite + U^{+6} minerals in brecciated kaolinitized host rock
NOPI-ECP-22.8/12.95	kaolinitized, hematitic tuff with U^{+6} minerals
NOPI-ECP-22.6/13.6	kaolinitized, oxidized (hematitic) tuff
NOPI-ECP-22.1/14.65	kaolinitized tuff, U^{+6} minerals
NOPI-ECP-22.35/15.3	kaolinitized, hematitic tuff
NOPI-ECP-22.6/15.85	kaolinitized, hematitic tuff with U^{+6} minerals

NOPI-ECP-22.5/16.55 kaolinitized, hematitic tuff with U[th] minerals

NOPI-ECP-22.25/17.15 kaolinitized tuff.

NOPI-ECP-22.85/17.85 kaolinitized slightly hematitic tuff.

NOPI-ECP-22.3/18.3 kaolinitized tuff

NOPI-ECP-22.65/18.85 kaolinitized hematitic tuff

NOPI-ECP-22.5/19.55 kaolinitized tuff

NOPI-ECP-22.85/20.1 kaolinitized, hematitic tuff

NOPI-ECP-22.85/20.85 kaolinitized tuff

NOPI-ECP-22.4/21.4 kaolinitized, limonitic tuff

NOPI-ECP-22.7/21.8 kaolinitized tuff

NOPI-ECP-22.6/22.4 kaolinitized tuff

NOPI-ECP-22.7/23.0 kaolinitized, hematitic tuff

NOPI-ECP-22.8/23.75 kaolinitized, hematitic tuff

NOPI-ECP-22.5/24.6 kaolinitized, hematitic tuff

NOPI-ECP-22.7/25.25 kaolinitized tuff

5/23/92 JP

0830 hrs Traverse #2

East-West across highly hematized zone to limonitic zone with higher uranium content to unmineralized rock

NOPI-ECP-20.65/7.55 kaolinitized, limonitic tuff

NOPI-ECP-20.1/7.7 kaolinitized, limonitic with little minerals

NOPI-ECP-19.65/7.55 kaolinitized, hematitic tuff

NOPI-ECP-19.0/7.8 hematitic tuff

NOPI-ECP-18.6/7.7 hematitic tuff

NOPI-ECP-18.35/7.9 hematitic tuff

NOPI-ECP-18.05/7.9 hematitic tuff

NOPI-ECP-17.4/7.85 hematitic tuff

NOPI-ECP-17.0/7.5 hematitic tuff

NOPI-ECP-16.4/~~7~~.9 hematitic tuff

NOPI-ECP-15.6/7.7 hematitic tuff

NOPI-ECP-15.0/7.6 hematitic/limonite tuff with U^{+6} minerals

NOPI-ECP-14.45/7.95 hematitic/limonite tuff

NOPI-ECP-13.95/8.0 hematitic/limonite tuff with U^{+6} minerals

NOPI-ECP-13.5/7.75 hematitic/limonite tuff

NOPI-ECP-12.95/7.9 hematite tuff with U^{+6} minerals

NOPI-ECP-12.5/7.75 limonitic tuff with U^{+6} minerals

NOPI-ECP-11.9/7.9 limonite tuff with U^{+6} minerals

NOPI-ECP-11.55/7.8 Kaolinite but less altered

NOPI-ECP-10.8/7.8 less altered tuff, some limonite staining

NOPI-ECP-10.3/7.7 less altered tuff, some limonite staining

NOPI-ECP-9.7/7.35 less altered tuff, hematite/limonite staining

NOPI-ECP-9.0/7.5 less altered tuff, some hematite/limonite staining

NOPI-ECP-8.15/8.0 slightly altered, some hematite/limonite staining

NOPI-ECP-7.45/7.9 slightly altered tuff.

NOPI-ECP-6.2/8.1 slightly altered tuff

NOPI-ECP-5.2/7.5 slightly altered tuff

NOPI-ECP-4.0/7.75 slightly altered tuff

NOPI-ECP-2.55/7.65 slightly altered tuff

5/23/92 1100hrs JP

Random samples taken on +10 level

NOPI-ECP-26.85/11.65 U minerals in mineralized breccia

NOPI-ECP-26.75/11.25 U minerals in mineralized breccia.

NOPI-ECP-24.0/10.5 U minerals in mineralized breccia

NOPI-ECP-25.2/9.5 U mineral coating fracture in limonite/hematite tuff

NOPI-ECP-23.3/9.8 U mineral coat limonite tuff JP

NOPI-ECP-19.6/14.5 hematite/limonite tuff with U minerals

NOPI-ECP-18.55/16.2 U mineral coat limonite tuff JP

NOPI-ECP-17.1/15.2 hematite tuff with U minerals JP

NOPI-ECP-16.0/14.4 U coating fracture in limonite tuff JP

5/29/92 JP

XRD analyses were performed on samples collected at the Nopal I deposit. XRD analyses were done on the Siemens D-500 x-ray diffractometer in Div 06. Procedures set forth in "TOP-004-02" were followed.

NOPI-ECP-26.85/11.65-XRD1
Yellow acicular uranium crystals; appear to line late fractures

NOPI-ECP-26.85/11.65-XRD2
Black to violet acicular crystals surrounded by yellow acicular crystals

Raw XRD patterns are kept in a folder entitled "Pena Blanca Ore Samples - XRD PATTERNS".

XRD data (2θ angles) are entered into a spreadsheet database (REFLEX) which calculates d-spacings. This data is then saved. The saved filename is recorded on ~~the~~ XRD pattern for later reference if needed.

All XRD files are written to a floppy disk entitled "Pena Blanca XRD Data".

JP 6/1/92 XRD analysis
Revisit Sample
NOPI-ECP-28.65/11.65-XRD2

6/4/92 1030 hrs
JP

Sample descriptions under low magnification (10x-70x) using Bausch and Lomb binocular scope.

These descriptions are intended as a guide for future subsampling. For instance - x-ray diffraction analysis and petrography.

N-S traverse

NOPI-ECP-22.5/10.4

Tuff that has undergone kaolinitic & oxidative (iron oxide) a~~lteration~~. Matrix has been kaolinitized along with feldspar phenocrysts. Quartz phenocrysts appear to be unaltered. Iron oxidation products

are ubiquitous (orange-brown, red-brown material associated with kaolinite). Kaolinite is white to orange-brown where it is associated with iron oxides.

Yellow uranium minerals - probably uranyl silicates are common. They are either fine grained and intergrown with clay (kaolinite) which fills fractures or coarser where they appear to replace feldspar? Uranium minerals seen to mostly fill small fractures with kaolinite. Some coarser acicular to tabular yellow uranyl silicate crystals are observed.

XRD-analysis
NOPI-ECP-22.5/10.4-XRD1 (illegible initials) 4/11/98
Bulk sample

NOPI-ECP-22.8/10.8

Altered Tuff. Extremely kaolinitized; both matrix and phenocrysts altered to kaolinite; no observed unaltered quartz phenocrysts. Highly oxidized with abundant iron oxides; orange; orange-brown; red-brown; and black iron oxides present.
Fronts of oxidation are present with sharp contact between oxidized tuff (orange to red to brown colored tuff) and un- or less oxidized tuff (pinkish or tan colored tuff).

Only traces of yellow uranium minerals are observed. These are generally fine-grained and intergrown or associated with kaolinite.

NOPI-ECP-22.25/11.45

Some kaolinitation but no obvious oxidation is observed. Kaolinite replaces some feldspar phenocrysts and appears to be replacing feldspar in matrix. Matrix maintains shardy texture indicating that rock may have not undergone extensive devitrification. Glass shards may be preserved in matrix. Yellow uranium minerals are common but not abundant. Yellow uranium minerals are generally fine-grained and associated with kaolinite that replaced feldspars or fills small fractures and cavities.

6/5/92 JP

XRD analysis

NOPI-ECP-22.8/10.8-XRD1
Bulk sample

NOPI-ECP-22.25/11.45-XRD1
Bulk sample

6/8/92 JP

NOPI-ECP-22.6/11.9

Breccia, highly oxidized (hematite, limonite is very abundant). Breccia fragments are silicified. Kaolinite (white) occurs in open space between fragments. Hematite and goethite appear to be replacing the kaolinite - oxidation fronts observed where kaolinite preserved

some yellow uranium minerals
are present and intergrown
with kaolinite
Iron minerals display variety
of colors (black, red, orange etc..)
and texture (fibrous, botryoidal, etc)
Coarse tabular yellow uranium
mineral occupies open spaces
and appears to be final
phase.
An orange colored mineral
is also present and
appears to be coating the
yellow tabular uranium
mineral. Fe-coating perhaps?

XRD Analysis

NOP1-ECP-22.6/11.9-XRD1
Bulk sample

NOP1-ECP-22.6/11.9-XRD2
Yellow tabular mineral

NOP1-ECP-22.6/11.9-XRD3
Orange + yellow minerals

NOP1-ECP-22.5/12.4
Hot stuff!
Classic uraninite bearing-ore.
Brecciated - silicified
breccia fragments with
kaolinite intergrown with
uranyl silicates in fractures
Uraninite occurs as isolated
pockets. Iron oxides are
abundant and are associated
with kaolinite in late
fractures.

NOP1-ECP-22.5/12.4-XRD1
Bulk sample.

6/9/92 JP

N OPI-ECP-22.8/12.95

Hematized tuff. No obvious brecciation. In many areas the tuff has been altered but not hematized as yet. In these areas the matrix still maintains a glassy (shardy) texture although phenocrysts have been replaced by kaolinite. Yellow uranyl silicates are associated with kaolinite in fractures & replaced phenocrysts.
Iron oxidation is irregular but very intense in many instances. Iron oxides are red to orange in color.
One instance was observed where it appeared that acicular uranophane was overgrowing opal in a vug?

XRD Analysis

NOPI-ECP-22.8/12.95-XRD1
Bulk sample

NOPI-ECP-22.6/13.6

Altered tuff. Fractures & phenocrysts initially filled or replaced by kaolinite. Breccia fragments are observed that have been extensively hematized (dark-red color).
Iron oxidation is irregular - areas that look non-oxidized by iron (pinkish tinge)

Yellow uranium minerals are scarce.

XRD analysis

NOPI-ECP-22.6/13.6-XRD1
Bulk sample.

NOPI-ECP-22.1/14.65

Brecciated tuff that has undergone kaolinization followed by iron oxidation. Kaolinite fills fractures and replaces phenocrysts. Some breccia fragments appear to be silicified.
Iron oxidation is irregular with areas relatively free of iron oxides adjacent to abundant iron oxides.
Opal is quite abundant in this sample - milky amorphous material in fractures.
Light yellow-green uranyl silicates that occur in acicular sprays are present in oxidized areas.
XRD analysis
NOPI-ECP-22.1/14.65-XRD1
Bulk sample

6/10/92 JJP

NOPI-ECP-22.35/15.3

Kaolinitized tuff followed by iron oxidation. No obvious brecciation. Kaolinite replaces phenocrysts and fills open spaces. Predominantly oxidized to ~~an~~ an JJP orange-yellow color (limonite mostly). Some quartz phenocrysts have survived ~~the alteration~~.
Yellow uranyl silicates are common. Mostly fine-grained + intergrown with kaolinite. Minor coarse acicular clusters.

JJP Most kaolinization + oxidation along fractures. Where fluids have not penetrated tuff is relatively unaltered.

XRD analysis
NOPI-ECP-22.35/15.3-XRD1
Bulk sample

NOPI-ECP-22.6/15.85

Fracture containing hematized breccia adjacent to relatively unoxidized tuff. Breccia is predominantly dark red. Kaolinite is present in fractures + as phenocryst replacements.

Yellow uranyl silicates are common and generally occur as delicate needle clusters growing from hematized substrates.

Unoxidized tuff still has glassy texture. Some phenocrysts have been kaolinitized but others are relatively unaltered. A late fracture possibly containing opal was observed.

NOPI-ECP-22.6/15.85-XRD1

Hematized fracture

NOPI-ECP-22.5/16.55

Kaolinitized tuff with hematized fractures. Tuff still has a somewhat glassy texture in places with unaltered quartz + biotite phenocrysts. Other areas are more altered with kaolinite replacing phenocrysts + filling fractures. Yellow fine-grained uranium silicates are intergrown with the kaolinite.

Iron oxidation occurs along fractures. Red to orange mineral coatings. Coarse uranyl silicates in fractures are associated with the iron oxidation.

NOPI-ECP-22.5/16.55-XRD1

Bulk Sample

NOPI-ECP-22.25/17.15

Tuff - matrix still has glassy texture but some phenocrysts have been replaced by kaolinite. Kaolinite also present along fractures. Quartz and biotite phenocrysts appear unaltered. Iron oxidation is present along some fractures (orange looking limonite) but is not pervasive.

No visible uranium minerals were observed.

XRD analysis
NOPI-ECP-22.25/17.15-XRD1
Bulk sample

NOPI-ECP-22.85/17.85

Tuff - matrix still has glassy texture. Feldspar phenocrysts are totally or partially replaced by kaolinite & kaolinite is present in fractures. Quartz and biotite phenocrysts appear fresh.
Iron oxidation is present along fractures but is not pervasive. Yellow-orange limonitic iron material predominates.

Some trace uranyl silicate minerals may be present with iron material but difficult to tell for sure.

XRD analysis
NOPI-ECP-22.85/17.85-XRD1
Bulk sample

6/11/92 JP

NOPI-ECP-22.3/18.3

Tuff - matrix has glassy texture. Feldspar phenocrysts replaced by kaolinite. Kaolinite also present along fractures. Unaltered quartz phenocrysts present. Iron oxidation predominantly as limonite (orange yellow staining). Some hematite? Nodules (small) present. Oxidation most pronounced with abundant kaolinite along fractures.

Uranium minerals not observed but may be present associated with iron oxidation (yellow material).

NOPI-ECP-22.3/18.3-XRD1
Bulk analysis

NOPI-ECP-22.65/18.85

Tuff with lot of iron oxidation mostly along fractures. Yellow orange-red-black iron minerals present.
Tuff has been kaolinized with kaolinite filling fractures + replacing phenocrysts but matrix still has glassy texture in many instances.

No visible uranium minerals were observed.

NOPI-ECP-22.65/18.85-XRD1
Bulk sample

NOPI-ECP-22.5/19.55

Tuff - Kaolinitized along fractures and kaolinite replacement of feldspar phenocrysts. Other phenocrysts (qtz, biotite, etc) appear relatively fresh and matrix is still glassy.
Iron oxidation occurs along fractures and weathered surface.

No uranium minerals observed

NOPI-ECP-22.5/19.55-XRD1

Bulk sample

NOPI-ECP-22.85/20.1

Tuff - as described in previous sample (p 34) with iron oxide rich fracture.
Iron oxide rich fracture in highly kaolinitized and contains abundant iron oxide materials (yellow orange - red - black material). Some flaky - wavy textured iron oxides along with amorphous material.

No visible uranium minerals.

NOPI-ECP-22.85/20.1-XRD1

Iron oxide rich fracture zone.

NOPI-ECP-22.85/20.85
Tuff with glassy matrix. Kaolinite replaces feldspar phenocrysts and occurs along fractures. Fresh quartz + biotite phenocrysts observed.
Iron oxidation (limonitic) occurs with kaolinite along fractures + on weathered surfaces.

No uranium minerals observed.

NOPI-ECP-22.85/20.85-XRD1
Bulk sample

NOPI-ECP-22.4/21.4
Tuff as described before (p 34, 36) with abundant iron oxide material along fractures. Limonite (yellow/orange) and hematite material are present. Kaolinite is more abundant along fractures associated with iron oxide material.

No uranium minerals observed.

NOPI-ECP-22.4/21.4-XRD1
Bulk sample

NOPI-ECP-22.7/21.8

Tuff with glassy texture. Kaolinite replaced feldspar phenocrysts. Kaolinite along fractures.
Limonite (orange-yellow) material is abundant predominantly on weathered surfaces and along fractures.
Pyrites appear altered to iron oxides in zones of limonitization.

No uranium minerals visible.

NOPI-ECP-22.7/21.8-XRD1

Bulk sample

NOPI-ECP-22.6/22.4

Same as previous sample (P38).

NOPI-ECP-22.7/23.0

Very iron oxide rich altered tuff. Probably a fracture zone. Phenocrysts altered to kaolinite. Kaolinite is pinkish red color due to presence of iron oxides.

Possible some uranium minerals present.

NOPI-ECP-22.7/23.0-XRD1

Bulk sample

NOPI-ECP-22.8/23.75

Tuff with glassy matrix but matrix is pinkish red probably due to iron staining. Phenocrysts are kaolinitized and limonite is also present in altered phenocrysts.
Iron oxides present throughout rock but more abundant along fractures.

No uranium minerals observed.

NOPI-ECP-22.8/23.75-XRD1
Bulk sample

NOPI-ECP-22.5/24.6

Tuff - glassy matrix but feldspar phenocrysts altered to kaolinite and kaolinite in fractures.
Limonite is pervasive - appears to occur in matrix as well as along fractures + weathered surfaces. Hematite (red) occurs only along fractures is the much less abundant.

No uranium minerals observed.

NOPI-ECP-22.5/24.6-XRD1
Bulk sample.

NOPI-ECP-22.7/25.25

Kaolinitized tuff - glassy texture in matrix. Limonite appears to occur throughout matrix. Some quartz + biotite phenocrysts remain unaltered.

No uranium minerals present.

NOPI-ECP-22.7/25.25-XRD1

Bulk sample

6/12/92

E-W traverse

NOPI-ECP-20.65/7.55

Limonitic tuff - matrix still has a glassy texture but has a light orange color indicating that limonite has formed. Sample has a weathered texture. Minor hematite (red) along fractures and at weathered surfaces. Feldspar phenocrysts altered to kaolinite but quartz and biotite phenocrysts appear fresh.

Minor yellow uranyl silicates occur as delicate needle clusters in vugs + fractures.

NOPI-ECP-20.65/7.55-XRD1

Bulk sample

NOPI-ECP-20.1/7.7

Limonitic-hematitic weathered tuff. Matrix has somewhat glassy texture ~~but~~ and appears to contain limonite (orange color). Hematitic zones occur along fractures. Fractures are also filled by quartz (opal) in some instances. Rock is very weathered - breaks up easily. Kaolinite replaces feldspar phenocrysts. Some quartz & biotite phenocrysts ~~remain~~ remain fresh.

Trace yellow uranium minerals present. Appear to precipitate in open space & have equigranular texture.

NOPI-ECP-20.1/7.7-XRD1
Bulk sample

NOPI-ECP-19.65/7.55

Hematitic-Kaolinitized tuff - Rock has undergone severe Kaolinitization - most phenocrysts & matrix has been replaced by kaolinite. Rock is weathered. Fractures have abundant iron oxide minerals in a variety of colors & textures. Opal is common and fills late fractures. Opal appears to form before iron oxide minerals.

A yellow fine-crystalline mineral (either a uranyl silicate or possibly jarosite) is common in fractures with iron oxide minerals. In some cases it coats iron oxides & in others it appears to form before iron oxides.

NOPI-ECP-19.65/7.55-XRD1
Bulk sample

NOPI-ECP-19.0/7.8

Kaolinitized-hematitic tuff. Matrix still has glassy texture but phenocrysts & feldspar in matrix replaced by kaolinite. Very competent rock. Quartz (opal) is present - may be undergoing silicification. Hematite throughout matrix and very abundant hematite on weathered surface & in fractures. Fractures cutting matrix are filled with quartz.

Minor yellow mineral was observed - either a uranyl silicate or jarosite. Appeared associated with kaolinite ~~but~~ and looked like open space filling.

NOPI-ECP-19.0/7.8-XRD1
Bulk sample.

NOPI-ECP-18.6/7.7

Kaolinitized-hematized tuff. Matrix still appears to have glassy texture but matrix and feldspar phenocrysts replaced by kaolinite. Very weathered - rock breaks apart easily. Hematite occurs ~~throughout~~ in matrix and along fractures & weathered surfaces. Fractures also filled by kaolinite. Some quartz & biotite phenocrysts were observed.

No visible uranium minerals present.

JP 6/12/92

NOPI-ECP-18.6/7.7-XRD1
Bulk sample

Some small fractures (generally in hematized areas) filled by quartz (opal)

NOPI-ECP-18.35/7.9

Hematyzed-kaolinitized tuff. Feldspar phenocrysts + feldspar in matrix replaced by kaolinite. Rock is ~~hematyzed throughout~~. Rich hematitic areas (dark red) occur along fractures. Weathered rock breaks apart easily. Some quartz phenocrysts.

No visible uranium minerals.

NOPI-ECP-18.35/7.9-XRD1

Bulk sample.

NOPI-ECP-18.05/7.9

Hematyzed-kaolinitized ~~tuff~~ as previous samples. Fractures are very hematyzed (dark red) and appear to contain other iron oxides especially a black fine-grained material ~~that~~ appears to be magnetite.

No uranium minerals observed.

NOPI-ECP-18.05/7.9-XRD1

Hematyzed fracture with black fine material.

NOPI-ECP-17.4/7.85
Hematized tuff. Matrix somewhat glassy. Feldspar phenocrysts & feldspars in matrix replaced by kaolinite. Kaolinite also occurs in fractures. Hematite occurs throughout matrix.

A fine grained crystalline yellow mineral - probably a uranyl silicate occurs throughout the rock - in matrix; with kaolinite in fractures & that has replaced feldspars.

NOPI-ECP-17.4/7.85-XRD1
Bulk sample

6/16/92 JP

NOPI-ECP-17.0/7.5
Hematized tuff. Matrix & even phenocrysts have been hematized. Fairly completely. Appears to be some quartz filling fractures. Phenocrysts that are not replaced by hematite are replaced by kaolinite.

No visible uranium minerals are present.

NOPI-ECP-17.0/7.5-XRD1
Bulk sample.

NOPI-ECP-16.4/7.9
Hematized tuff as in previously described sample. Quartz phenocrysts are still present in hematized matrix. Fractures filled by kaolinite and quartz (opal).

No visible uranium minerals observed.

NOPI-ECP-16.4/7.9-XRD1
Bulk sample.

6/17/92 [initials]

NOPI-ECP-15.6/7.7
Hematized tuff. Kaolinite replaces phenocrysts and fills fractures + cavities. Weathered. Hematized ~~throughout~~ matrix and along fractures. Various iron oxides present. (red, black and orange minerals).

A fine crystalline yellow (as in 17.4/7.85) mineral - probably a uranyl silicate - occurs ~~throughout~~ and seems to be associated with the kaolinite but difficult to determine

NOPI-ECP-15.6/7.7-XRD1
Bulk sample.

NOPI-ECP-15.0/7.6

Hematized tuff. Variety of iron oxides present mostly along fractures - black botryoidal, dark red amorphous, orange, orange red.

Kaolinite has replaced phenocrysts & precipitated in fractures. Some quartz filled veins appear to be associated with iron oxidation.

Acicular needle sprays of uranyl silicates are associated with heavy iron oxidation in late fractures. Also occurs along weathered surfaces.

NOPI-ECP-15.0/7.6-XRD1

Bulk sample.

NOPI-ECP-14.45/7.55

Limonitic-hematitic tuff. Kaolinite occurs along fractures and replaces feldspar phenocrysts. Matrix is mostly limonitic (orange color) with some hematite. Fractures are more hematitic (red). Possibly some quartz in late fractures.

No visible uranium minerals observed.

NOPI-ECP-14.45/7.55-XRD1

Bulk sample.

NOPI-ECP-13.95/8.0
Hematized tuff. Iron oxides throughout in various colors + textures. Mostly dark red. Kaolinite replaces phenocrysts + fills fractures. Quartz also appear to fill fractures + open space.

Weathered surfaces have abundant uranyl silicates which form needle clusters. No uranium minerals were observed in matrix or fractures

NOPI-ECP-13.95/8.0-XRD1
Uranyl silicate on surface with bulls.

6/18/92 JP

NOPI-ECP-13.5/7.75
Hematized tuff. Hematization varies from pinkish red to dark red. Matrix still has somewhat of a glassy texture where rock is pinkish red but matrix is hematized. Weathered surfaces of dark red iron oxidation contain yellow uranyl silicate minerals. Feldspar phenocrysts replaced by kaolinite + kaolinite occurs in fractures. Quartz + biotite phenocrysts were observed.

Yellow uranium minerals only occur in strongly hematized zones on weathered surfaces.

NOPI-ECP-13.5/7.75-XRD1
Strongly hematized area (dark red) with uranyl silicates.

NOPI-ECP-12.95/7.9

Hematized tuff. Dark red in color. Some of rock is weathered - breaks apart easily while other parts are very competent. Kaolinite replaces feldspar phenocrysts + occurs in fractures.

Yellow uranyl silicates are abundant and occur mostly in weathered tuff. Uranium minerals appear to form in open spaces along fractures. Have acicular habit but also appear to occur as fine-grained masses.

NOPI-ECP-12.95/7.9-XRD1

Weathered tuff with uranyl silicates

NOPI-ECP-12.5/7.75

Hematized tuff (pinkish in color). Limonite occurs along late fractures (orange in color). Phenocrysts (feldspars) replaced by Kaolinite + Kaolinite fills fractures.

Yellow uranyl silicates occur throughout as fine-grained masses in fractures associated with kaolinite + limonite in some instances.

Uranyl silicates seem to be concentrated along fractures and weathered surfaces.

NOPI-ECP-12.5/7.75-XRD1

Bulk sample

NOPI-ECP-11.9/7.9.

Hematite to limonitic tuff. Pinkish red in color. Kaolinite replaces feldspar phenocrysts + fills fractures. Fairly competent rock.

Yellow uranyl silicates occur in fractures, open spaces, and as a crust on weathered surfaces. Uranyl silicates occur as either fine-grained crystal masses that seem to be associated with kaolinite or as acicular crystal masses. Uranyl silicates are most abundant as crusts in fractures + weathered surfaces.

NOPI-ECP-11.9/7.9-XRD1
Bulk sample

6/19/~~80~~ JP

NOPI-ECP-11.55/7.8

Pinkish tuff. Glassy matrix. Very competent. Kaolinite replaces feldspar phenocrysts + occurs along fractures. Matrix appears to be limonitic in some areas - along fractures + weathered surfaces. Hematite also occurs along fractures but appears less abundant than limonite.
Dendritic black material or mineral occurs along with iron oxides.

No visible uranium minerals present.

NOPI-ECP-11.55/7.8-XRD1
Bulk sample.

NOPI-ECP-10.8/7.8

Pinkish tuff. Competent. Glassy groundmass. Kaolinite replaces feldspar phenocrysts & fills fractures. Limonitic on weathered surface and fractures. Hematite occurs with limonite but less abundant.

No visible uranium minerals present.

NOPI-ECP-10.8/7.8-XRD1

Bulk sample.

NOPI-ECP-10.3/7.7

Pinkish tuff. Devitrified matrix. Kaolinite replaces feldspar phenocrysts + fills fractures. Hematite + limonite occur along fractures + sometimes in matrix. A black iron oxide mineral also occurs throughout sample.

No uranium minerals present.

NOPI-ECP-10.3/7.7-XRD1

Bulk sample.

NOPI-ECP-9.7/7.35

Silicified ~~Hematized~~ tuff. Devitrified, 6/19/92 ~~hematized~~ matrix. Very competent rock. Silicified groundmass. Feldspar phenocrysts replaced by kaolinite. Hematite in open spaces + fractures. Quartz + biotite phenocrysts are relatively unaltered.

No visible uranium minerals.

NOPI-ECP-9.7/7.35-XRD1
Bulk sample

NOPI-ECP-9.0/7.5

Silicified to glassy tuff. Some parts of tuff are highly silicified whereas other parts still have somewhat of a glassy matrix. Feldspars replaced by kaolinite. Glassy parts of tuff are hematitic & limonitic. Also weathered surfaces are hematitic & limonitic.

No uranium minerals observed.

NOPI-ECP-9.0/7.5-XRD1
Bulk sample

NOPI-ECP-8.15/8.0
Silicified tuff. Very competent. Matrix of fine crystalline quartz. Feldspar phenocrysts replaced by kaolinite. Weathered surfaces are limonitic and clayey. Also hematitic along weathered surfaces. Quartz + biotite phenocrysts observed.

No ore minerals present.

NOPI-ECP-8.15/8.0-XRD1
Bulk sample

NOPI-ECP-7.45/7.9
Silicified tuff. Same as previous sample.

NOPI-ECP-7.45/7.9-XRD1
Bulk sample

NOPI-ECP-6.2/8.1
Silicified tuff as in previous sample.

NOPI-ECP-5.2/7.5
Silicified tuff as in previous samples. Limonite and altered along fractures + weathered surfaces.

NOPI-ECP-5.2/7.5-XRD1
Bulk sample.

NOPI-ECP-4.0/7.75

Silicified tuff - same as previous samples.

NOPI-ECP-2.55/7.65

Silicified tuff - same as previous samples. Limonite + hematite along weathered surfaces + fractures.

NOPI-ECP-2.55/7.65-XRD1

Bulk sample

6/19/92 JJ

Random samples of +10 level

NOPI-ECP-16.0/14.4

Tuff - still has glassy matrix. Feldspars replaced by kaolinite. Quartz + biotite phenocrysts relatively unaltered.
Matrix may be somewhat limonitic (light orange color).
Fractures are lined with limonite and uranyl silicates.
Weathered surfaces also have limonite + uranyl silicates.

Uranyl silicates are either acicular open space filling clusters or fine grained masses associated with kaolinite

NOPI-ECP-16.0/14.4-XRD1

Uranyl silicates in fracture.

NOPI-ECP-23.3/9.8

Tuff- glassy texture in matrix. Feldspars replaced by kaolinite but quartz, biotite and other phenocrysts are relatively unaltered. Very competent. Limonite and hematite in fractures. Iron oxides have various texture + colors.

Yellow uranyl silicates associated with iron oxides in fractures and on weathered surfaces. Uranyl silicates are either acicular crystals or fine grained masses.

NOPI-ECP-23.3/9.8-XRD1

Bulk with yellow uranyl minerals

6/23/92 JP

NOPI-ECP-26.75/11.25

Breccia zone contains abundant U mineralization. Original tuff has been brecciated + kaolinitized. Some U minerals are intergrown with kaolinite and have a fine grained ~~texture~~.

A black material coats + fills some fractures - originally looks like uraninite but may be some other mineral or material. Black material is either fine-grained masses or acicular type blades growing from a black fine-grained substrate. Black may be some type of iron oxide mineral rather than uraninite. Iron oxides - hematite + limonite occur ~~throughout~~ rock.

(over)

Yellow uranium minerals are abundant. In addition to fine-grained uranyl minerals intergrown with kaolinite abundant coarse acicular uranyl silicates fill open spaces + fractures.

Brecciated fragments are silicified

Yellow acicular uranyl minerals grow from black masses which coat fractures.

NOPI-ECP-26.75/11.25-XRD1

Black material - contains flaky to bladed black material, yellow uranyl minerals (acicular), and red orange iron oxides

NOPI-ECP-26.75/11.25-XRD2

Bulk sample - black material, iron oxides yellow uranyl silicates, + silicified tuff.

NOPI-ECP-24.0/10.5

Breccia zone uranium ore. Similar to NOPI-ECP-2A samples. Silicified breccia fragments. Tuff has been kaolinitized. Kaolinite replaces feldspars + fills fractures. Rock is iron oxide rich - hematite-red and limonite-orange stains throughout especially associated with kaolinite.

Yellow to yellow green uranyl minerals occur in fractures. Most is fine grained + intergrown with the kaolinite. Some uranyl minerals are coarser and have acicular habit + tend to precipitate in open spaces.

NOPI-ECP-24.0/10.5-XRD1

Bulk sample - high grade fracture fill

NOPI-ECP-25.2/9.5
Limonitic tuff with abundant uranyl silicates present. Tuff has been kaolinized. Kaolinite replaces feldspars + fill fractures. Tuff does not appear to be extensively brecciated as previous sample, however fractures are very common.
Dark red hematite coats some fractures + weathered surfaces.

Uranyl minerals generally occur as fine grained masses intergrown with kaolinite in fractures. In addition coarse acicular uranyl minerals fill open spaces.

NOPI-ECP-25.2/9.5-XRD1
Bulk sample.

NOPI-ECP-18.55/16.2
Uranyl silicates & iron oxides (black fine material) filling vugs + fractures in kaolinized tuff

Iron oxides (black) appear to coat fractures + vugs. Yellow uranyl minerals occur as fine grained masses intergrown with kaolinite or as later tabular to acicular fracture filling minerals. The later tabular uranyl silicates appear to postdate the iron oxides.

NOPI-ECP-18.55/16.2-XRD1
Bulk sample - tuff, yellow fracture fill + black iron oxide.

NOPI-ECP-17.1/15.2
Hematized tuff with uranyl silicates in fractures + on weathered surfaces.
Tuff is red-orange.
Kaolinite replaces feldspar + occurs in fractures but matrix is very hematitic.
Late fractures contain iron oxides that are coated by uranyl silicates.
Uranyl silicates generally occur as acicular crystals that grow in open space.
A lime green uranyl mineral was observed - it has a botryoidal type texture + grows from iron oxides.

NOPI-ECP-17.1/15.2-XRD1
Bulk sample - tried to include lime green mineral.

NOPI-ECP-19.6/14.5
Brecciated hot uranium ore.
Silicified breccia fragments with uranyl silicates generally filling fractures.
Kaolinitized + hematized.
Very similar to NOPI-ECP-2A sample.

Uranium minerals generally occur as fine grained intergrown with kaolinite in fractures.
Rock is iron oxide rich.
Coarse acicular uranium minerals occur in some vugs + late fractures.

NOPI-ECP-19.6/14.5-XRD1
Bulk sample.

NOPI-ECP-~~22.65~~ 26.85/11.65

Breccia zone ore - very hot. Silicified and often hematized breccia fragments with uranyl silicates + iron oxides in fractures. Kaolinite replaces feldspar in fragments + fills some fractures.
Uranyl silicates appear to coat some iron oxides

Uranyl silicates either have fine grained textures intergrown with kaolinite or occur as acicular crystals filling late fractures.

NOPI-ECP-26.85/11.65-XRD3
Bulk sample

This rock similar to NOPI-ECP-2A.

8/29/92 JP

Goals of Peña Blanca Trip -

Peña Blanca Trip August 30- September 3, 1992

Goals:

- review Level +10 geologic map
- review 2 x 2 km geologic map
- review high wall maps (discuss fracture pattern interpretation with I.R.)
- co-register Level 0 adit map with Level +10 map
- discuss with I.R. additional clearing of Level +10
- discuss with I.R. a topographic map of Level +10
- use gamma scintillometer to better define boundary of the ore zone (take more closely spaced measurements)
- take samples across and along selected fractures on cleared area
- take samples across western margin of ore body
- make detailed observations of fracture density and patterns in selected areas, try to relate to deposit-scale U distribution pattern
- take additional samples for fluid inclusion work of altered Tn near to but outside the ore body; also of "vapor phase quartz"

8/31/92 JP

Photos - slides ①

1 Fracture pattern on +10;
② shows 3 sets
2 Same as #1 but with scale
3 Group on +10 overlooking
4 valley, looking east
5 +10 level on arrival showing grid
6 Group on +10, looking south
7 Same as #6.
8-10 ECP photos of samples across hematite fracture
11-24 Photos to to level and adit.

9/1/92 JP
1000 hrs

Performed a gamma survey on the +10 level of 2 adjacent 1X1 meter areas or blocks.
On the grid system of the +10 level, the blocks were between 9 and 10 m N and 11 to 13 m E.
This area was chosen for more detailed work because of a sharp drop in uranium content over about a 1 meter area.
Gamma readings were taken at 20 cm intervals and recorded directly on a grid constructed on a piece of graph paper in the field.
A model 14C Geiger counter (Ludlum #83561) with a model 44-6 gamma probe was used to take readings

9/1/92 1500hrs JJP

Performed more detailed gamma survey of North excursion on level +10. Gamma readings taken every 0.5m for more resolution. Readings were recorded directly onto a gridded map of the +10 level.

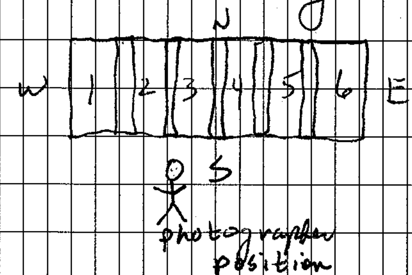
9/2/92 1000hr JJP

Photographs of the 2 adjacent 1 meter square areas selected for detailed work & sampling

Print film (100)

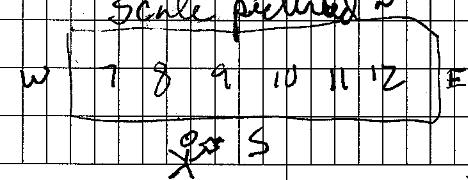
Photos 1-6

West to east standing on south boundary



Photos 7-12

Same as 1-6 but with scale pictured ~



Photos 13, 14, 15, 16

Views of entire 2 meter area

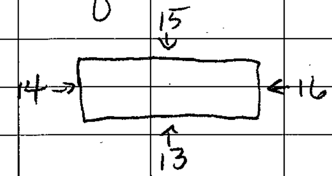
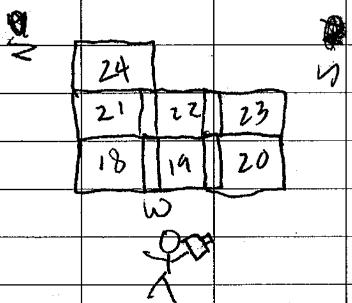


Photo 17 ?

Photos 18-24

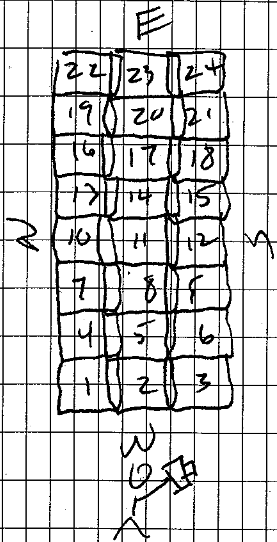
Closeups (350x) of 2 meter area

w



~~8/~~9/2/92

Restart of previous closeups ~~but at new scale~~ at 350x



9/2/92 1145hrs JP

Took closely spaced samples along an approximate E-W line in the 2 adjacent 1 square meter blocks on +10

Below is a list of the samples taken showing their grid coordinates for location purposes. A brief description is also included.

Sample	Description
OPI-ECP-13.0/9.2	Hematized, very competent, red, some uranyl silicates along fractures.
OPI-ECP-12.87/9.10	Hematitic, pink-red, competent, some uranyl silicates along fractures

NOPI-ECP-12.65/9.13	Orange colored, limonitic, hematitic fractures, uranyl silicates along some fractures
NOPI-ECP-12.42/9.14	Orange colored, limonitic, hematitic + uranyl silicate along fractures
NOPI-ECP-12.18/9.1	Very broken up rock, hematitic, some uranyl silicates present
NOPI-ECP-12.0/9.09	Broken rock, hematitic
NOPI-ECP-11.78/9.17	Broken rock, hematitic + limonitic

NOPI-ECP-11.6/9.12 Very broken rock, hematite, kaolinites

NOPI-ECP-11.4/9.13 Pinkish tuff with hematite along fractures

NOPI-ECP-11.22/9.07 Pinkish tuff with iron oxides along fractures

NOPI-ECP-11.0/9.15 Pink-white tuff with iron oxides along fractures.

9/2/92

Sampling of vertical walls for minerals that may be useful for fluid inclusion work.
Samples will be labeled and located with respect to numbering on walls placed by I. Reyes during his survey of the area.

+10 level vertical wall

Sample
NOPI-10-14/0
Calcite cemented breccia along a horizontal fracture ~ 8 ft from +10 surface

NOPI-10-14/0.5
Calcite cemented breccia very friable, in a vertical fracture ~ 8 ft from +10 surface

NOPI-10-16/3.5
Pieces of calcite/quartz? concretions removed with rock hammer + chisel. Appear to be forming in friable hematite vug. ~2.5 ft from +10 level

NOPI-10-16/4.0
Fracture containing breccia cemented by calcite ~10 ft from +10 level.

9/2/92 1620hrs JP

Took sample traverse along North extension. E-W from background over higher readings (0.5 mrem/hr) to background.

Samples are labeled below with respect to +10 level grid

NOPI-ECP-17.1/26.5 relatively fresh tuff

NOPI-ECP-15.9/26.7 limonite tuff

NOPI-ECP-14.95/26.55 limonite

NOPI-ECP-14.0/26.4 limonite

NOPI-ECP-12.7/26.45 hematite/limonite

Continuation to +10 level vertical wall

NOP1-10-25/2A
Fault gouge, red colored
plastic material

NOP1-10-25/2B
Fault gouge, red & black
material

NOP1-10-25/2C   off 9/2/97
County rock ~~adjacent~~ lining
fault

NOP1-10-19/2
Dark calcite infilling
both vertical & horizontal
fractures.

NOP1-1~~0~~-18/2A
County rock lining a fracture.

NOP1-10-18/2B
Broken county rock (gouge) in
fracture (limonite).

NOP1-10-18/2C
Limonite broken county rock
with black iron oxide in
some surfaces.

NOP1-10-18/2D
Limonite/hematite gouge

NOP1-10-18/2E
Black material from
fracture

Sampling on +20 level

NOP1-20-19/3A
Fault gorge, red colored

NOP1-20-19/3B
County rock long fracture

NOP1-20-20/0
Unaltered Nopal tuff

NOP1-20-26/1
Calcite veins in cutting fresh Nopal Tuff

NOP1-20-28/1
Quartz in vug.

3/23/93 [initials]

+10 level Nopal I

Took additional samples along Northern anomaly. (see p 91)

Samples trend E-W and are taken between 26 and 27 on North

Samples are labelled below with respect to +10 level grid.

393-10.7/26.5	Hematite Tuff
393-11.2/26.6	Limonitic
393-12.0/26.35	Limonitic
393-13.4/26.4	Limonitic
393-14.5/26.4	Limonitic

393 - 15.4/26.6	Limonitic
393 - 16.5/26.6	Hematitic
393 - 17.6/26.7	Limonite stain
393 - 18.2/26.5	"
393 - ~~19.14~~ 19.2/26.5	"

3/23/93

Sampled a calcite/caliche crust in area with slickensided sides on +10 level. Sample was on the side of a depression that may have been used for a sump by the miners.

Sample was labelled:

393 - 7.5/33.8 - calcite

3/23/93 Took traverse along an iron oxide rich fracture between 42 and 43 m North.

Samples consist of iron oxides from fracture that is about 1.5 cm thick at its widest point.

Samples were labelled as follows:

393 - 11.2/42.3 - Iron oxides

393 - 12.1/42.5 - "

393 - 13.9/42.4 - "

393 - 15.0/42.3 - "

393 - 17.1/42.5 - "

3/23/93 JP

Took samples of Nopal Tuff for hydrology experiments.

Samples labelled as follows:

NOP1-~~AG~~-1 - extremely altered Nopal Tuff. Collected on slope between level +10 and 0 of Nopal I. Slope on ~~north~~ east side of deposit. Sample was piece of float and was altered probably by hydrothermal activity associated with mineralization.

~~NONP~~ JP 3/23/93

NOP1-RG-2 partially altered Nopal rhyolite. Collected from tailings pile along to access road to southwest of orebody.

NOP1-RG-3 fresh Nopal rhyolite. Collected from tailings pile between +10 and +20 levels to west of orebody.

3/24/93 JP

Took sample from iron oxide rich fracture that splits from previously sampled iron oxide rich fracture between 42 + 43 m North (p 98).

Sample consists of iron oxides in fracture & is labelled:

393 - 8.1/43.2

3/24/93 JP

Sample of iron oxides taken from a vertical fracture on the +10 level wall between 28 and 29. This fracture appears to be extension of the iron oxide fracture sampled between 42 + 43 m North. (see p 98).

Sample labeled

393-10-28/5

3/24/93 JP

Sample of iron oxides taken from a fracture on the +10 level wall between 14 and 15. This fracture is hypothetically the extension of ~~the~~ iron oxide rich fracture sampled between 42 + 43 m North. (See p 98).

Sample labelled

393-10-14/6

3/24/93 JP

Iron oxides from a vertical fracture on the +10 level vertical wall. Fracture may be extension of the iron oxide rich fracture between 14 + 15 m North

Sample labelled.

393-10-7/0

3/24/93 JP

Sampled iron oxides from a vertical fracture on ~~the~~ +10 level wall. This fracture does not appear as yet to be associated with any iron-bearing fracture on the cleared +10 level.

Sample label:

393-10-25/3

Sampled calcite vein running N-S. near area with prominent slickensides.

Sample labelled

393-5.5/32.7

3/24/93

Took samples of uranophane filling fractures on +10 level at 26.85/11.3.

Sample labeled
393-26.85/11.3.

3/24/93

Vertical fracture at 7 on +10 level wall revisited

Took sample of country rock directly adjacent to fracture sampled previously for iron oxides. Vertical fracture runs approximately E-W.

Country rock on both sides of fracture was sampled S = south + N = north
Samples labeled

393-10-7/0/S

393-10-7/0/N

arrow on rock points toward fracture
→

3/24/93 JP

Sampling of E-W vein
at ~ 14N, extension

Sample of vein material -
Iron oxides
NOPI-ECP-(-) 9.6/14.67

Samples perpendicular ⊥
to vein.

NOPI-ECP-(-)9.6/14.65
immediately south of vein +
including vein wall

Moving to south

NOPI-ECP-(-)9.6/14.62

NOPI-ECP-(-)9.6/14.60

NOPI-ECP-(-9.6)/14.58

NOPI-ECP-(-9.6)/14.56

Samples to north of vein

NOPI-ECP-(-)9.6/14.70
North of vein and
including vein wall

Moving to north

NOPI-ECP-(-)9.6/14.72

NOPI-ECP-(-) 9.6/14.74

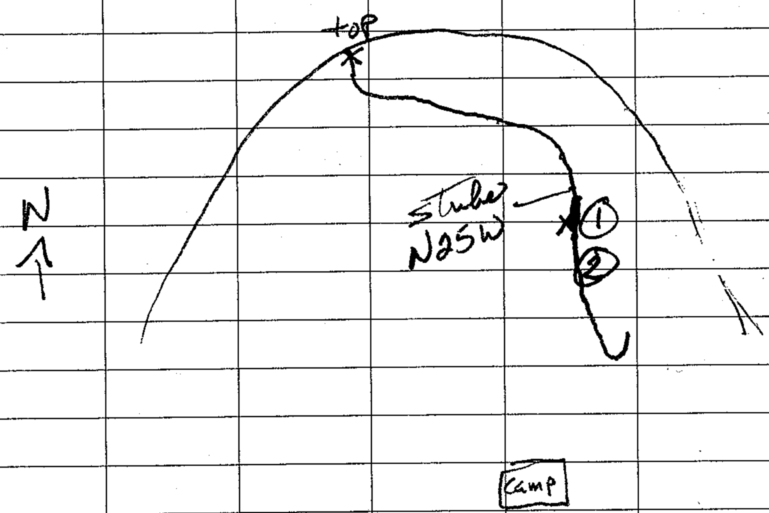
NOPI-ECP-(-) 9.6/14.76

NOPI-ECP-(-)9.6 /14.78

3/26/93 JP
* Note Prefix of above
samples (NOPI-ECP) have
been changed to 393.

3/24/93 JP

Caliche collecting on Nopal cuesta



Collected caliche at points 1 and 2 along road cut. Caliche appears to form as layered nodules in some cases

Sample local #1

NOP1-ECP-CAL1-T
Top layers of nodule

NOP1-ECP-CAL1-M
Middle layers of nodule

NOP1-ECP-CAL1-B
Bottom layers of nodule

Sample local #2

NOP1-ECP-CAL2-T
Top layers

NOP1-ECP-CAL2-M
Middle layers

NOP1-ECP-CAL2-B
Bottom layers

Bottom does not mean bottom of caliche. Means below middle layer.

3/26/93 JP

* Prefix of samples on previous page (NOP1-ECP) has been changed to 393.

3/31/93 Bret Leslie

According to English Pearcy the sample 393-10 7/0 was determined to be 28.1 meters from -10, 14 on the X·Y grid of the +10m level

7/28/93 JP

Sampling on +0 level at Nopal I

A gamma survey on +0 level was conducted on 7/27/93 (see Pearcy field notebook). From the gamma value it was decided to take a traverse of samples between 2 and 3 ~~[illegible]~~ east 7/28/93

Samples taken are listed below:

24.3/2.75/0	light gray altered tuff with many silicates (uranophane)
24.9/2.8/0	Reddish brown altered tuff with uranophane

25.6/2.7/0	reddish brown altered tuff with neozylose along fractures
26.4/2.6/0	Light gray limonite tuff
27.0/2.6/0	Light gray limonite tuff
27.65/2.65/0	Brownish limonite Tuff
28.3/2.8/0	Broken limonite/hematite altered tuff

28.75/2.7/0	Hematite altered tuff
29.25/2.9/0	Hematite altered tuff
29.7/2.8/0	altered limonite tuff
30.2/2.9/0	Very hematite + iron oxide rich broken altered tuff
30.75/2.95/0	Very iron oxide rich broken altered tuff
31.25/2.9/0	Very iron oxide rich broken altered Tuff

31.8/2.8/0 Iron oxide rich broken altered tuff

32.15/2.8/0 Iron oxide rich broken altered tuff

NW-SE diagonal traverse from about 28/-3.0 to 33/-8 across an area with slickened sides - probably a boundary fault for the orebody.

28.15/-3.15/0 limonite/hematite broken altered tuff

28.7/-3.5/0 Hematite tuff

28.9/-4.0/0 Broken tuff - black, maybe UO_2 uranium mineral & Iron rich. Broken.

29.5/-4.5/0 Broken altered tuff limonite/hematite

29.9/-5.0/0 Broken altered tuff limonite/hematite

30.2/-5.2/0 limonite tuff - slickened sides.

30.9/-5.9/0 limonite/hematite altered tuff

31.3/-6.4/0 limonite/hematite altered tuff

32.0/-6.9/0 Hematite/limonite altered broken tuff

32.5/-7.5/0 limonite altered tuff

33.3/-8.0/0 Iron rich altered tuff -

Random samples taken on +0 cleared area

21.9/-5.8/0 Iron rich tuff with yellow minerals on fractures

21.6/-6.6/0 Iron rich tuff with yellow minerals lining fractures

22.0/-7.0/0 Iron rich tuff with black + yellow minerals lining fractures

22.5/-8.0/0 Iron rich tuff with yellow minerals lining fractures

23.1/-8.2/0 Iron rich tuff with yellow minerals lining fractures

23.7/-1.8/0 Broken altered tuff with abundant uranium minerals

24.2/-0.6/0 Broken altered tuff with yellow uranium minerals

31.55/4.65/0 Iron rich altered tuff. Very broken

31.5/4.9/0 Iron rich altered tuff very broken

31.35/5.2/0 Kaolinized tuff Very altered

31.55/5.4/0 Kaolinized tuff.

Samples from vertical wall on +0 level.

9/0.4/1.1/0 — +0 level

No on wall placed by I. Reyes

Distance (m) from No. on wall

Vertical distance from existing ground surface

9/0.4/1.1/0 Broken altered tuff with uranium minerals

9/0.7/2.3/0 Altered tuff with yellow U minerals lining fractures.

9/1.5/0.7/0 Altered tuff with uranium minerals.

3/2/94 JP

Level O:

Traverse that runs ~SE from highly fractured Fe-rich tuff to weathered tuff. The weathered tuff is altered to clay (probably smectite).

NOPI-308 (26.3/~~-6.25~~ -7.25/0) JP 3/2/94
Broken fractured tuff
Kaolinitized-feldspars
Bleached Fe-oxide line fractures.

NOPI-309 (26.55/~~-6.7~~ -7.7/0) JP 3/2/94
Broken fractured tuff.
Very Fe-rich. Fractures lined + filled with Fe-rich material.

NOPI-310 (27.0/-8.25/0)
Broken, altered tuff.
Fe-oxide rich, Fe material lining fractures

NOPI-311 (27.8/-8.5/0)
Very Fe-rich broken altered tuff

NOPI-312 (28.5/-9.05/0)
Kaolinitized/Fe rich tuff
Fe-oxides occur in fractures

NOPI-313 (28.7/-9.7/0)
Very Fe-rich broken altered tuff

NOPI-314 (29.1/-10.2/0)
Very Fe-rich broken altered tuff. Bright orange material.

NOPI-315 (29.55/-10.5/0)
Very Fe-rich broken altered tuff.

NOPI-316 (30.0/-10.9/0)
Very Fe-rich broken altered tuff. Across fault that may separate more weathered tuff. Appears to contain much clay. Moderately weathered.

NOPI-317 (30.4/-11.35/0)
Very Fe-rich broken/altered tuff. Fairly competent.

NOPI-318 (30.8/-11.7/0)
Fe-rich altered tuff. Fairly weathered (clay rich) but still fairly competent.

NOPI-319 (31.1/-12.0/0)
Clay altered (weathered) tuff. Fe-rich material common throughout. Fairly competent.

NOPI-320 (31.45/-12.4/0)
Weathered (clay altered) tuff. Fe-oxides common. Friable (not very competent).

NOPI-321 (31.8/-12.75/0)
Weathered (clay altered) tuff. Less Fe-oxides. Very friable and unconsolidated.

NOPI-322 (32.15/-13.1/0)
Weathered (clay altered) tuff. Some Fe-oxides present. Fairly competent.

NOPI-323 (32.5/-13.4/0)
Very weathered (clay altered tuff) Some Fe-oxides present.
Friable/unconsolidated

NOPI-324 (32.9/-13.85/0)
Weathered friable (clay altered) tuff. Some Fe-oxides present

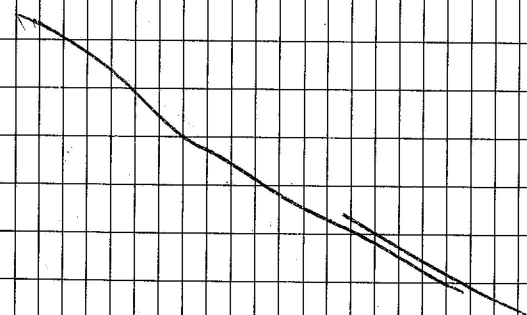
NOPI-325 (33.3/-14.0/0)
Weathered friable (clay altered tuff.) Some black Fe-oxide? mineral present.

NOPI-326 (33.8/-14.4/0)
Weathered friable (clay altered) tuff. Some black Fe/Mn oxide mineral is abundant.

NOPI-327 (34.1/-15.0/0)
Weathered friable (clay altered) tuff. Some black Fe/Mn oxide mineral is common

NOPI-328 (34.4/-15.4/0)
Weathered friable (clay altered) tuff. Some black Fe/Mn oxide mineral is common.

NOPI-329 (34.8/-15.7/0)
Weathered (clay altered) tuff. Black oxide mineral is common.



3/2/94 O level Nopal I

Continuation of E-W traverse from p. 113 (7/28/93).

NOPI-338 (32.4/2.85/0)
Broken tuff, Fe-oxide abundant. May be fault zone.

NOPI-339 (32.9/2.85/0)
Broken tuff, Fe-oxides present. May be fault zone.

NOPI-340 (33.3/2.85/0)
Broken tuff, Fe-oxide preset. May be fault zone material.

NOPI-341 (33.8/2.75/0)
Broken tuff. Fe oxide present. May be fault zone material.

NOPI-342 (34.1/2.8/0)
Contact with vitrophyre. Tuff fragments and red/white vitrophyre.

NOPI-343 (34.4/2.75/0)
Vitrophyre with tuff fragments. Vitrophyre is mostly red.

NOPI-344 (34.85/2.7/0)
Vitrophyre - red/unwelded tuff material with white clay material.

NOPI-345 (35.55/2.8/0)
Very friable/unconsolidated red/white vitrophyre.

NOPI-346 (36.25/2.8/0)
Very friable/unconsolidated red/white vitrophyre

NOPI-347 (37.1/2.8/0)
Very friable unconsolidated
red/white vitrophyre

NOPI-348 (37.9/2.8/0)
Red/white vitrophyre
More consolidated
than previous sample.

NOPI-349 (38.65/2.8/0)
Fairly consolidated
red/white vitrophyre.

NOPI-350 (39.5/2.8/0)
Fairly consolidated
mostly red vitrophyre

NOPI-351 (40.2/2.75/0)
Consolidated mostly
red vitrophyre

NOPI-352 (40.9/2.8/0)
Consolidated red
vitrophyre.

3/2/94 Continuation of NW/SE
Transverse on level 0
MP 3/2/94

NOPI-~~353~~ 354 (33.6/-8.3/0)
Altered broken Tuff
Fe oxides (limonite)
present.

NOPI-~~354~~ 355 (33.8/-8.40/0)
Contact between altered
Tuff + clay (smectite)
Clay very friable (white)
may be vitrophyre

NOPI-356 (34.2/-8.6/0)
Very friable clay,
Fe-oxides present.
Appears like weathered
tuff.

NOPI-357 (34.8/-9.1/0)
Very friable white
clay material.

NOPI-358 (35.2/-9.6/0)
Red/white/vitrophyre
Moderately consolidated.

NOPI-359 (35.8/-10.0/0)
Mostly red, moderately
consolidated vitrophyre.

NOPI-360 (36.35/-10.3/0)
Moderately consolidated
mostly red vitrophyre.

NOPI-361 (37.2/-10.9/0)
Loosely consolidated
red vitrophyre.

3/2/94 JP

NOPI-362 (28.9/4.0/0)
Black UO_2 bearing
ore.

3/2/94 JP N/S traverse on +10 level
across orebody boundary

NOPI-372 16.95/14.1/10
Broken tuff, Fe-oxide
rich

NOPI-373 17.15/14.1/10
Broken kaolinized tuff,
Fe-oxide rich

NOPI-374 17.4/14.15/10
Broken kaolinized tuff,
Fe-oxide rich

NOPI-375 (17.65/14.15/10)
Broken tuff, Fe-oxide rich

NOPI-376 (17.95/14.05/10)
Broken tuff Fe-oxide
/lomonite rich

NOPI-377 (18.15/14.00/10)
Broken tuff Fe-oxide
(limonite) + Kaolite
rich

NOPI-378 (18.45/14.0/10)
Broken, kaolinized, lomonite,
tuff.

NOPI-379 (18.65/14.05/10)
Covered area, broken
kaolinized tuff.

NOPI-380 (18.9/14.0/10)
Covered area(?), broken
kaolinized tuff

NOPI-381 (19.2/14.1/10)
Broken kaolinized Fe-
rich tuff.

NOPI-382 (19.5 [redacted] 13.95/10)
Broken (kaolinized) Fe-
oxide rich tuff.

NOPI-383 (19.65/13.95/10)
Broken kaolinized, Fe-oxide
rich tuff.

NOPI-384 (19.85/13.95/10)
Broken kaolinized, Fe-oxide
rich tuff

NOPI-385 (20.0/13.95/10)
Covered area kaolinized, Fe-oxide rich tuff.

NOPI-386 (20.2/13.95/10)
Broken kaolinized Fe-oxide rich tuff

NOPI-387 (20.45/13.95/10)
Broken kaolinized Fe-oxide bearing tuff.

NOPI-388 (20.75/13.9/10)
Broken, kaolinized, Fe-oxide bearing tuff.

NOPI-389 (20.95/13.9/10)
Broken, kaolinized, tuff. Kaolinized

NOPI-390 (21.25/13.9/10)
Broken kaolinized Fe-oxide (limonite) bearing tuff.

NOPI-391 (21.6/13.9/10)
Broken kaolinized Fe-oxide bearing tuff

3/3/94 [initials]

+10 level - samples taken along a NS traverse of a fault / fracture along the NE side of the cleared area.

→ NOPI-307 (23.8/25.4/10) Fe-oxide rich material with tuff fragments.

NOPI-397 (25.7/24.5/10)
Fe-oxide material fracture fill. Most is coating on host tuff fragments.

NOPI-398 (26.8/24.2/10)
Unconsolidated Fe-fracture fill material. Tuff fragments coated with Fe-oxide

NOPI-399 (28.6/23.75/10)
Fe-oxide fracture fill material coating host tuff fragments.

NOPI-400 (29.5/23.4/10)
Tuff fragments coated with Fe oxide material

NOPI-401 (31.3/22.6/10)
Fe-oxide rich fracture fill material with some tuff fragments

NOPI-402 (32.7/21.8/10)
Mostly tuff fragments coated by Fe-oxide

NOPI-403 (33.9/~~20.~~ 21.2/10)
Fe-oxide fracture fill material

NOPI-404 (35.4/20.5/10)
Fe-oxide fracture fill material.

NOPI-405 (36.4/20.1/10
Fe-oxide fracture fill material. Some tuff fragments.

NOPI-406 (38.4/19.5/10)
Fragments of tuff coated with Fe oxide fill material

NOPI-407 (41.1/18.8/10)
Fe-oxide fracture fill material, Tuff fragments.

NOPI-408 (43.5/18.1/10)
Mostly tuff fragments coated with Fe-oxide

NOPI-409 (48.3/17.0/10)
Outside cleaned area. Tuff fragments coated with Fe-oxide.

ON +10 Vertical wall

NOPI-410 (~~22.~~ JJ 3/13/94
Between 22 & 23
Fe-oxide altered fracture fill material.

NOPI-411
Between 22+23
Fe-oxide altered fracture fill material

NOPI-412
Relatively fresh Nopal tuff adjacent to fracture. On west side.

NOPI-413
Relatively fresh Nopal tuff adjacent to fracture. On east side.

3/3/94 +10 Level Nopal I

Samples taken along E-W fracture at ~13m N. Fracture fill material for thin sections.

NOPI-417 (13.7 / 15.85 / 10)

NOPI-418 (13.3 / 11.7 / 10)

NOPI-419 (13.8 / 9.0 / 10)

NOPI-420 (13.95 / 6.2 / 10)

NOPI-421 (13.6 / 3.2 / 10)

NOPI-422 (13.55 / 1.1 / 10)

NOPI-423 (14.1 / -2.1 / 10)

NOPI-424 (13.95 / -6.1 / 10)

NOPI-425 (14.6 / -9.8 / 10)

3/3/94

NOPI-426
Relatively fresh Nopal tuff collected on road leading to +10 level (SW of orebody) (for N. Snider) Probably excavated from +20 level.

3/3/94 NOPI-427 -
Nopal tuff, altered, cream colored, float
Collected for hydrologic tests.

NOPI-428
Nopal tuff, relatively fresh (unaltered), fractured.
Collected for hydrologic tests.

NOPI-429
Nopal tuff, altered, cream colored, fractured, float.
Collected for hydrologic tests.

NOPI-430
Nopal tuff, slightly altered, pink color, fractured, float
Collected for hydrologic tests.

NOPI-431
Nopal tuff, altered, orange color, fractured.
Collected for hydrologic test.

NOPI-432
Nopal tuff (float) relatively fresh, pink-purple, fractured.
Collected for hydrologic test.

NOPI-433
Nopal tuff, relatively fresh, pink-purple, fractured. float.
Collected for hydrologic tests.

3/3/94 The following two samples were collected from the vitrophyre on +0 level slope by Kristi Meyer.

NOPI*VIT*1 - highly friable, iron-rich clay / kaolinite
2 bags

NOPI*VIT*2 - highly friable, iron-rich clay / kaolinite.
3 bags.

8/5/94
Pages 1-146 of this notebook were reviewed for compliance to QAP-001 in response to CAR 94-02.
Corrections were made as appropriate. For some cases the date of the change will ~~not~~ 8/5/94 reflect the date of this review rather than the date of the original entry.
Randy Folk Institute QA

5/19/95 JP

Starting sample no of materials collected from Nopal I site on trip starting on 5/22/95 is NOPI-450.

5/24/95 JP

Continuation of sampling along an E-W line between 9 + 10 m N.
Initial sampling was conducted on 9/2/92 (see p. 86).
These samples are closely spaced; taken at about 20 cm intervals. These samples cross the western margin of the orebody. The rock is very fractured + broken.

Below is a list of samples taken + their grid coordinates. A brief description is also included:

Sample	Description
NOPI-459	
8.63/9.12/10	Nopal tuff, some kaolinitization, fractured, iron oxides in fractures,

NOPI-460 8.85/9.2/10	Nopal tuff, kaolinite replaces feldspars, Fe-oxides in fractures. Matrix dark-red
NOPI-461 9.08/9.2/10	Nopal, kaolinite replaces feldspar, Kaolinite + Fe-oxides in fractures. Matrix dark red.
NOPI-462 9.27/9.22/10	Nopal - dark red, kaolinite replaces feldspars, kaolinite + Fe-oxides in fracture.
NOPI-463 9.48/9.25/10	Nopal - dark red. kaolinite replaces feldspar, kaolinite + Fe oxides in fractures.

NOPI-464 9.7/9.25/10	Broken Nopal tuff. Fe-oxides + kaolinite in fractures
NOPI-465 9.9/9.1/10	Broken Nopal tuff Fe-oxides + kaolinite in fractures
NOPI-466 10.1/9.07/10	Very broken Nopal tuff, Fe-oxides + kaolinite in fractures.
NOPI-467 10.28/9.05/10	Broken Nopal tuff. Fe-oxides & kaolinite in fractures
NOPI-468 10.42/9.05/10	Broken pinkish tuff. Feldspars replaced by kaolinite. Fe-oxides in fractures.

NOPI-469 10.7/9.1/10	Altered kaolinitized Nopal tuff, Fe-oxides in fractures
NOPI-470 10.9/9.13/10	Brownish colored altered Nopal tuff. Kaolinite replaces feldspar. Fe-oxides in fractures.
NOPI-471 13.2/9.07/10	Altered, hematized Nopal tuff, Fe-oxides in fractures.
NOPI-472 13.35/9.15/10	Hematized tuff. Fe-oxides in fractures.
NOPI-473 13.57/9.1/10	Hematized tuff. Fe-oxides + yellow U-silicates in fractures.

NOPI-474 13.8/9.08/10	Hematized, kaolinitized tuff. Fe-oxides in fractures.
NOPI-475 14.02/9.08/10	Limonite gp 5/24/95 ~~Hematized~~, kaolinitized tuff. Fe-oxides in fractures
NOPI-476 14.2/9.1/10	Limonite, kaolinized tuff. Fe-oxides in fractures.
NOPI-477 14.45/9.13/10	Limonite, kaolinitized tuff. Massive Fe-oxides + U-silicates in fractures
NOPI-478 14.65/9.14/10	Hematite/limonite tuff. Kaolinized. Fe-oxides in fractures.

NOPI-479 14.86/9.1/10	Limonitic/hematitic altered tuff. Fe-oxides in fractures.
NOPI-480 15.1/9.07/10	Limonitic tuff Fe-oxides in fractures.
NOPI-481 15.34/9.1/10	Limonitic/hematitic tuff. Fe-oxides in fractures.
NOPI-482 15.55/9.13/10	Hematitic/limonitic altered tuff. Fe-oxides in fractures.
NOPI-483 15.8/9.1/10	Very hematitic altered tuff. Fe-oxides + U-silicate in fractures.

NOPI-484 16.02/9.15/10	Very hematitic tuff. Massive Fe-oxides in fractures.
NOPI-485 16.23/9.08/10	Hematitic tuff. Fe-oxides + Kaolinite in fractures.
NOPI-486 16.5/9.1/10	Hematitic altered tuff Fe-oxides + Kaolinite in fractures
NOPI-487 16.68/9.17/10	Hematitic altered tuff Fe-oxides + kaolinite in fractures.
NOPI-488 16.87/9.15/10	Hematitic to nolum altered tuff. Fe-oxides + Kaolinite in fractures

NOPI-489
17.03/9.02/10
Hematite/limonite altered Tuff. Kaolinite in fracture

NOPI-490
17.22/9.03/10
Hematite/limonite altered Tuff. Fe-oxide & Kaolinite in fracture

NOPI-491
17.46/9.04/10
limonite/hematite altered Tuff. Fe-oxide + kaolinite in fracture

NOPI-492
17.67/9.05/10
Hematite/limonite Tuff. Kaolinite + Fe-oxides in fractures.

NOPI-493
17.85/9.15/10
Hematite/limonite altered Tuff. Fe-oxides + Kaolinite in fractures.

5/24/95 gp

Uranophane was collected on the +10 Level. Its location is approximately 22/12/10.

NOPI-494
Relatively coarse grained needle like crystals collected from a fracture.

In several bags.

This project was ended due to US government budget cut.

James D. [signature]
12/20/96

CURVE TABLES

HOW TO USE CURVE TABLES

Table I. contains Tangents and Externals to a 1° curve. Tan. and Ext. to any other radius may be found nearly enough, by dividing the Tan. or Ext. opposite the given Central Angle by the given degree of curve.

To find Deg. of Curve, having the Central Angle and Tangent: Divide Tan. opposite the given Central Angle by the given Tangent.

To find Deg. of Curve, having the Central Angle and External: Divide Ext. opposite the given Central Angle by the given External.

To find Nat. Tan. and Nat. Ex. Sec. for any angle by Table I.: Tan. or Ext. of twice the given angle divided by the radius of a 1° curve will be the Nat. Tan. or Nat. Ex. Sec.

EXAMPLE

Wanted a Curve with an Ext. of about 12 ft. Angle of Intersection or I. P. = 23° 20′ to the R. at Station 542+72.

Ext. in Tab. I opposite 23° 20′ = 120.87
120.87 ÷ 12 = 10.07. Say a 10° Curve.

Tan. in Tab. I opp. 23° 20′ = 1183.1
1183.1 ÷ 10 = 118.31.

Correction for A. 23° 20′ for a 10° Cur. = 0.16
118.31+0.16 = 118.47 = corrected Tangent.

(If corrected Ext. is required find in same way)
Ang. 23° 20′ = 23.33° ÷ 10 = 2.3333 = L. C.

2° 19½′ = def. for sta.	542	I. P. = sta.	542+72
4° 49½′ = " " "	+50	Tan. =	1 .18.47
7° 19½′ = " " "	543	B. C. = sta.	541+53.53
9° 49½′ = " " "	+50	L. C. =	2 .33.33
11° 40′ = " " "	543+ 86.86	E. C. = Sta.	543+86.86

100 − 53.53 = 46.47 × 3′(def. for 1 ft. of 10° Cur.) = 139.41′ =
2° 19½′ = def. for sta. 542.
Def. for 50 ft. = 2° 30′ for a 10° Curve.
Def. for 36.86 ft. = 1° 50½′ for a 10° Curve.

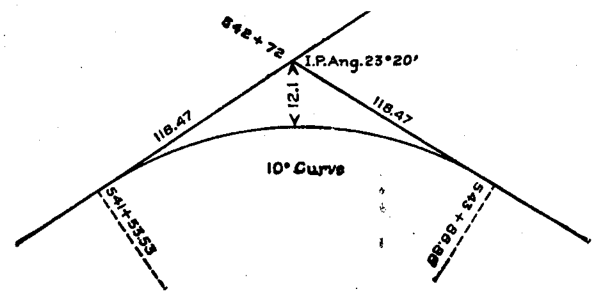


Table I.—Tangents and Externals to a 1° Curve. Chord = 100 ft.

Int. Angle	Tangent	External	Int. Angle	Tangent	External	Int. Angle	Tangent	External
1°	50.00	.22	8°	400.66	13.99	15°	754.32	49.44
10′	58.34	.30	10′	409.03	14.58	10′	762.80	50.55
20	66.67	.39	20	417.41	15.18	20	771.29	51.68
30	75.01	.49	30	425.79	15.80	30	779.77	52.82
40	83.34	.61	40	434.17	16.43	40	788.26	53.97
50	91.68	.73	50	442.55	17.07	50	796.75	55.13
2	100.01	.87	9	450.93	17.72	16	805.25	56.31
10	108.35	1.02	10	459.32	18.38	10	813.75	57.50
20	116.68	1.19	20	467.71	19.06	20	822.25	58.70
30	125.02	1.36	30	476.10	19.75	30	830.76	59.91
40	133.36	1.55	40	484.49	20.45	40	839.27	61.14
50	141.70	1.75	50	492.88	21.16	50	847.78	62.38
3	150.04	1.96	10	501.28	21.89	17	856.30	63.63
10	158.38	2.19	10	509.68	22.62	10	864.82	64.90
20	166.72	2.43	20	518.08	23.38	20	873.35	66.18
30	175.06	2.67	30	526.48	24.14	30	881.88	67.47
40	183.40	2.93	40	534.89	24.91	40	890.41	68.77
50	191.74	3.21	50	543.29	25.70	50	898.95	70.09
4	200.08	3.49	11	551.70	26.50	18	907.49	71.42
10	208.43	3.79	10	560.11	27.31	10	916.03	72.76
20	216.77	4.10	20	568.53	28.14	20	924.58	74.12
30	225.12	4.42	30	576.95	28.97	30	933.13	75.49
40	233.47	4.76	40	585.36	29.82	40	941.69	76.86
50	241.81	5.10	50	593.79	30.68	50	950.25	78.26
5	250.16	5.46	12	602.21	31.56	19	958.81	79.67
10	258.51	5.83	10	610.64	32.45	10	967.38	81.09
20	266.86	6.21	20	619.07	33.35	20	975.96	82.53
30	275.21	6.61	30	627.50	34.26	30	984.53	83.97
40	283.57	7.01	40	635.93	35.18	40	993.12	85.43
50	291.92	7.43	50	644.37	36.12	50	1001.7	86.90
6	300.28	7.86	13	652.81	37.07	20	1010.3	88.39
10	308.64	8.31	10	661.25	38.03	10	1018.9	89.89
20	316.99	8.76	20	669.70	39.01	20	1027.5	91.40
30	325.35	9.23	30	678.15	39.99	30	1036.1	92.92
40	333.71	9.71	40	686.60	40.99	40	1044.7	94.46
50	342.08	10.20	50	695.06	42.00	50	1053.3	96.01
7	350.44	10.71	14	703.51	43.03	21	1061.9	97.57
10	358.81	11.22	10	711.97	44.07	10	1070.6	99.16
20	367.17	11.75	20	720.44	45.12	20	1079.2	100.75
30	375.54	12.29	30	728.90	46.18	30	1087.8	102.35
40	383.91	12.85	40	737.37	47.25	40	1096.4	103.97
50	392.28	13.41	50	745.85	48.34	50	1105.1	105.60

Corrections to be Added (T = Tangent. E = External.)

Int. Angle	Curve 5°	10°	15°	20°	25°	30°	35°	40°	45°	50°	55°	60°	65°	70°
5°	T=.02 E=.000	.03 .000	.05 .001	.06 .001	.08 .002	.10 .002	.11 .002	.13 .003	.15 .003	.16 .004	.18 .004	.20 .004	.21 .005	.23 .005
10°	T=.03 E=.001	.06 .003	.09 .004	.13 .006	.16 .007	.19 .008	.22 .009	.25 .011	.28 .012	.31 .014	.34 .015	.38 .017	.42 .018	.46 .020
15°	T=.04 E=.003	.10 .007	.14 .010	.19 .014	.24 .018	.29 .023	.34 .027	.39 .029	.45 .032	.51 .035	.53 .039	.58 .043	.63 .047	.68 .051
20°	T=.06 E=.006	.13 .011	.19 .017	.26 .022	.32 .028	.39 .034	.45 .038	.51 .045	.58 .051	.65 .057	.72 .063	.79 .070	.84 .076	.90 .083
25°	T=.08 E=.009	.16 .018	.24 .027	.33 .036	.40 .046	.49 .056	.58 .065	.67 .074	.75 .083	.83 .093	.90 .106	.99 .120	1.06 .127	1.14 .135

Table I.—Tangents and Externals to a 1° Curve. Chord = 100 ft.

Int. Angle	Tangent	External	Int. Angle	Tangent	External	Int. Angle	Tangent	External
22°	1113.7	107.24	29°	1481.8	188.51	36°	1861.7	294.9
10′	1122.4	108.90	10′	1490.7	190.74	10′	1870.9	297.7
20	1131.0	110.57	20	1499.6	192.99	20	1880.1	300.6
30	1139.7	112.25	30	1508.5	195.25	30	1889.4	303.5
40	1148.4	113.95	40	1517.4	197.53	40	1898.6	306.4
50	1157.0	115.66	50	1526.3	199.82	50	1907.9	309.3
23	1165.7	117.38	30	1535.3	202.12	37	1917.1	312.2
10	1174.4	119.12	10	1544.2	204.44	10	1926.4	315.2
20	1183.1	120.87	20	1553.1	206.77	20	1935.7	318.1
30	1191.8	122.63	30	1562.1	209.12	30	1945.0	321.1
40	1200.5	124.41	40	1571.0	211.48	40	1954.3	324.1
50	1209.2	126.20	50	1580.0	213.86	50	1963.6	327.1
24	1217.9	128.00	31	1589.0	216.3	38	1972.9	330.2
10	1226.6	129.82	10	1598.0	218.7	10	1982.2	333.2
20	1235.3	131.65	20	1606.9	221.1	20	1991.5	336.3
30	1244.0	133.50	30	1615.9	223.5	30	2000.9	339.3
40	1252.8	135.35	40	1624.9	226.0	40	2010.2	342.4
50	1261.5	137.23	50	1633.9	228.4	50	2019.6	345.5
25	1270.2	139.11	32	1643.0	230.9	39	2029.0	348.6
10	1279.0	141.01	10	1652.0	233.4	10	2038.4	351.8
20	1287.7	142.93	20	1661.0	235.9	20	2047.8	354.9
30	1296.5	144.85	30	1670.0	238.4	30	2057.2	358.1
40	1305.3	146.79	40	1679.1	241.0	40	2066.6	361.3
50	1314.0	148.75	50	1688.1	243.5	50	2076.0	364.5
26	1322.8	150.71	33	1697.2	246.1	40	2085.4	367.7
10	1331.6	152.69	10	1706.3	248.7	10	2094.9	371.0
20	1340.4	154.69	20	1715.3	251.3	20	2104.3	374.2
30	1349.2	156.70	30	1724.4	253.9	30	2113.8	377.5
40	1358.0	158.72	40	1733.5	256.5	40	2123.3	380.8
50	1366.8	160.76	50	1742.6	259.1	50	2132.7	384.1
27	1375.6	162.81	34	1751.7	261.8	41	2142.2	387.4
10	1384.4	164.86	10	1760.8	264.5	10	2151.7	390.7
20	1393.2	166.95	20	1770.0	267.2	20	2161.2	394.1
30	1402.0	169.04	30	1779.1	269.9	30	2170.8	397.4
40	1410.9	171.15	40	1788.2	272.6	40	2180.3	400.8
50	1419.7	173.27	50	1797.4	275.3	50	2189.9	404.2
28	1428.6	175.41	35	1806.6	278.1	42	2199.4	407.6
10	1437.4	177.55	10	1815.7	280.8	10	2209.0	411.1
20	1446.3	179.72	20	1824.9	283.6	20	2218.6	414.5
30	1455.1	181.89	30	1834.1	286.4	30	2228.1	418.0
40	1464.0	184.08	40	1843.3	289.2	40	2237.7	421.4
50	1472.9	186.29	50	1852.5	292.0	50	2247.3	425.0

Corrections to be Added (T = Tangent. E = External.)

Int. Angle	Curve 5°	10°	15°	20°	25°	30°	35°	40°	45°	50°	55°	60°	65°	70°
20°	T=.06 E=.006	.13 .011	.19 .017	.26 .022	.32 .028	.39 .034	.45 .038	.51 .045	.58 .051	.65 .057	.72 .063	.79 .070	.84 .076	.90 .083
25°	T=.08 E=.009	.16 .018	.24 .027	.33 .036	.40 .046	.49 .056	.58 .065	.67 .074	.75 .083	.83 .093	.90 .106	.99 .120	1.06 .127	1.14 .135
30°	T=.10 E=.013	.10 .025	.29 .038	.39 .051	.49 .065	.59 .078	.69 .090	.79 .103	.89 .116	.99 .129	1.09 .149	1.20 .170	1.29 .179	1.39 .188
35°	T=.11 E=.018	.22 .035	.34 .054	.47 .072	.58 .086	.69 .109	.80 .131	.93 .153	1.05 .175	1.17 .197	1.29 .213	1.42 .230	1.54 .247	1.66 .264
40°	T=.13 E=.023	.26 .046	.40 .070	.53 .093	.67 .117	.80 .141	.93 .172	1.06 .203	1.20 .234	1.34 .265	1.49 .277	1.64 .290	1.79 .315	1.94 .341
45°	T=.15 E=.030	.30 .060	.44 .093	.60 .119	.76 .153	.91 .184	1.06 .216	1.21 .254	1.37 .289	1.52 .325	1.70 .351	1.87 .378	2.04 .411	2.21 .445

TABLE I.—Tangents and Externals to a 1° Curve. Chord = 100 ft.

Int. Angle	Tangent	External	Int. Angle	Tangent	External	Int. Angle	Tangent	External
43°	2257.0	428.5	50°	2671.8	592.3	57°	3110.9	790.1
10′	2266.6	432.0	10′	2681.9	596.6	10′	3121.7	795.2
20	2276.2	435.6	20	2692.1	600.9	20	3132.6	800.4
30	2285.9	439.2	30	2702.3	605.3	30	3143.4	805.6
40	2295.6	442.8	40	2712.5	609.6	40	3154.2	810.9
50	2305.2	446.4	50	2722.7	614.0	50	3165.1	816.1
44	2314.9	450.0	51	2732.9	618.4	58	3176.0	821.4
10	2324.6	453.6	10	2743.1	622.8	10	3186.9	826.7
20	2334.3	457.3	20	2753.4	627.2	20	3197.8	832.0
30	2344.1	461.0	30	2763.7	631.7	30	3208.8	837.3
40	2353.8	464.6	40	2773.9	636.2	40	3219.7	842.7
50	2363.5	468.4	50	2784.2	640.7	50	3230.7	848.1
45	2373.3	472.1	52	2794.5	645.2	59	3241.7	853.5
10	2383.1	475.8	10	2804.9	649.7	10	3252.7	858.9
20	2392.8	479.6	20	2815.2	654.3	20	3263.7	864.3
30	2402.6	483.4	30	2825.6	658.8	30	3274.8	869.8
40	2412.4	487.2	40	2835.9	663.4	40	3285.8	875.3
50	2422.3	491.0	50	2846.3	668.0	50	3296.9	880.8
46	2432.1	494.8	53	2856.7	672.7	60	3308.0	886.4
10	2441.9	498.7	10	2867.1	677.3	10	3319.1	892.0
20	2451.8	502.5	20	2877.5	682.0	20	3330.3	897.5
30	2461.7	506.4	30	2888.0	686.7	30	3341.4	903.2
40	2471.5	510.3	40	2898.4	691.4	40	3352.6	908.8
50	2481.4	514.3	50	2908.9	696.1	50	3363.8	914.5
47	2491.3	518.2	54	2919.4	700.9	61	3375.0	920.2
10	2501.2	522.2	10	2929.9	705.7	10	3386.3	925.9
20	2511.2	526.1	20	2940.4	710.5	20	3397.5	931.6
30	2521.1	530.1	30	2951.0	715.3	30	3408.8	937.3
40	2531.1	534.2	40	2961.5	720.1	40	3420.1	943.1
50	2541.0	538.2	50	2972.1	725.0	50	3431.4	948.9
48	2551.0	542.2	55	2982.7	729.9	62	3442.7	954.8
10	2561.0	546.3	10	2993.3	734.8	10	3454.1	960.6
20	2571.0	550.4	20	3003.9	739.7	20	3465.4	966.5
30	2581.0	554.5	30	3014.5	744.6	30	3476.8	972.4
40	2591.0	558.6	40	3025.2	749.6	40	3488.3	978.3
50	2601.1	562.8	50	3035.8	754.6	50	3499.7	984.3
49	2611.2	566.9	56	3046.5	759.6	63	3511.1	990.2
10	2621.2	571.1	10	3057.2	764.6	10	3522.6	996.2
20	2631.3	575.3	20	3067.9	769.7	20	3534.1	1002.3
30	2641.4	579.5	30	3078.7	774.7	30	3545.6	1008.3
40	2651.5	583.8	40	3089.4	779.8	40	3557.2	1014.4
50	2661.6	588.0	50	3100.2	784.9	50	3568.7	1020.5

Corrections to be Added (T = Tangent. E = External.)

Int. Angle	Curve 5°	10°	15°	20°	25°	30°	35°	40°	45°	50°	55°	60°	65°	70°
40°	T=.13 E=.023	.26 .046	.40 .070	.53 .093	.67 .117	.80 .141	.93 .172	.106 .203	1.20 .234	1.34 .265	1.49 .277	1.64 .290	1.79 .315	1.94 .341
45°	T=.15 E=.030	.30 .060	.44 .093	.60 .119	.76 .153	.91 .184	1.06 .216	1.21 .254	1.37 .289	1.52 .325	1.70 .351	1.87 .378	2.04 .411	2.21 .445
50°	T=.17 E=.037	.34 .075	.51 .116	.68 .151	.85 .189	1.02 .227	1.19 .266	1.36 .305	1.54 .345	1.72 .384	1.91 .425	2.10 .467	2.29 .508	2.48 .550
55°	T=.19 E=.046	.38 .093	.57 .142	.76 .188	.95 .236	1.14 .283	1.32 .332	1.52 .381	1.72 .420	1.92 .479	2.14 .530	2.35 .582	2.56 .641	2.77 .700
60°	T=.21 E=.056	.42 .112	.63 .168	.84 .225	1.05 .283	1.27 .340	1.49 .398	1.71 .457	1.94 .516	2.17 .575	2.38 .636	2.60 .697	2.83 .774	3.07 .851
65°	T=.23 E=.067	.46 .135	.69 .204	.93 .273	1.16 .343	1.40 .412	1.64 .483	1.88 .554	2.13 .625	2.38 .697	2.63 .711	2.88 .845	3.13 .922	3.39 1.01

TABLE I.—Tangents and Externals to a 1° Curve. Chord = 100 ft.

Int. Angle	Tangent	External	Int. Angle	Tangent	External	Int. Angle	Tangent	External
64°	3580.3	1026.6	71°	4086.9	1308.2	78°	4639.8	1643.0
10′	3591.9	1032.8	10′	4099.5	1315.6	10′	4653.6	1651.7
20	3603.5	1039.0	20	4112.1	1322.9	20	4667.4	1660.5
30	3615.1	1045.2	30	4124.8	1330.3	30	4681.3	1669.2
40	3626.8	1051.4	40	4137.4	1337.7	40	4695.2	1678.1
50	3638.5	1057.7	50	4150.1	1345.1	50	4709.2	1686.9
65	3650.2	1063.9	72	4162.8	1352.6	79	4723.2	1695.8
10	3661.9	1070.2	10	4175.6	1360.1	10	4737.2	1704.7
20	3673.7	1076.6	20	4188.5	1367.6	20	4751.2	1713.7
30	3685.4	1082.9	30	4201.2	1375.2	30	4765.3	1722.7
40	3697.2	1089.3	40	4214.0	1382.8	40	4779.4	1731.7
50	3709.0	1095.7	50	4226.8	1390.4	50	4793.6	1740.8
66	3720.9	1102.2	73	4239.7	1398.0	80	4807.7	1749.9
10	3732.7	1108.6	10	4252.6	1405.7	10	4822.0	1759.0
20	3744.6	1115.1	20	4265.6	1413.5	20	4836.2	1768.2
30	3756.5	1121.7	30	4278.5	1421.2	30	4850.5	1777.4
40	3768.5	1128.2	40	4291.5	1429.0	40	4864.8	1786.7
50	3780.4	1134.8	50	4304.6	1436.8	50	4879.2	1796.0
67	3792.4	1141.4	74	4317.6	1444.6	81	4893.6	1805.3
10	3804.4	1148.0	10	4330.7	1452.5	10	4908.0	1814.7
20	3816.4	1154.7	20	4343.8	1460.4	20	4922.5	1824.1
30	3828.4	1161.3	30	4356.9	1468.4	30	4937.0	1833.6
40	3840.5	1168.1	40	4370.1	1476.4	40	4951.5	1843.1
50	3852.6	1174.8	50	4383.3	1484.4	50	4966.1	1852.6
68	3864.7	1181.6	75	4396.5	1492.4	82	4980.7	1862.2
10	3876.8	1188.4	10	4409.8	1500.5	10	4995.4	1871.8
20	3889.0	1195.2	20	4423.1	1508.6	20	5010.0	1881.5
30	3901.2	1202.0	30	4436.4	1516.7	30	5024.8	1891.2
40	3913.4	1208.9	40	4449.7	1524.9	40	5039.5	1900.9
50	3925.6	1215.8	50	4463.1	1533.1	50	5054.3	1910.7
69	3937.9	1222.7	76	4476.5	1541.4	83	5069.2	1920.5
10	3950.2	1229.7	10	4489.9	1549.7	10	5084.0	1930.4
20	3962.5	1236.7	20	4503.4	1558.0	20	5099.0	1940.3
30	3974.8	1243.7	30	4516.9	1566.3	30	5113.9	1950.3
40	3987.2	1250.8	40	4530.4	1574.7	40	5128.9	1960.2
50	3999.5	1257.9	50	4544.0	1583.1	50	5143.9	1970.3
70	4011.9	1265.0	77	4557.6	1591.6	84	5159.0	1980.4
10	4024.4	1272.1	10	4571.2	1600.1	10	5174.1	1990.5
20	4036.8	1279.3	20	4584.8	1608.6	20	5189.3	2000.6
30	4049.3	1286.5	30	4598.5	1617.1	30	5204.4	2010.8
40	4061.8	1293.6	40	4612.2	1625.7	40	5219.7	2021.1
50	4074.4	1300.9	50	4626.0	1634.4	50	5234.9	2031.4

Corrections to be Added (T = Tangent. E = External.)

Int. Angle	Curve 5°	10°	15°	20°	25°	30°	35°	40°	45°	50°	55°	60°	65°	70°
60°	T=.21 E=.056	.42 .112	.63 .168	.84 .225	1.05 .283	1.27 .340	1.49 .398	1.71 .457	1.94 .516	2.17 .575	2.38 .636	2.60 .697	2.83 .774	3.07 .851
65°	T=.23 E=.067	.46 .135	.69 .204	.93 .273	1.16 .343	1.40 .412	1.64 .483	1.88 .554	2.13 .625	2.38 .697	2.63 .711	2.88 .845	3.13 .922	3.39 1.01
70°	T=.25 E=.080	.51 .159	.76 .240	1.02 .321	1.28 .403	1.54 .485	1.80 .568	2.06 .652	2.33 .735	2.60 .819	2.88 .906	3.16 .994	3.44 1.08	3.72 1.17
75°	T=.27 E=.095	.56 .182	.83 .286	1.12 .383	1.40 .480	1.69 .578	1.98 .678	2.27 .777	2.57 .877	2.87 .977	3.16 1.07	3.47 1.18	3.78 1.29	4.09 1.39
80°	T=.30 E=.110	.61 .220	.91 .332	1.22 .445	1.53 .558	1.84 .671	2.15 .787	2.46 .903	2.78 1.02	3.10 1.13	3.44 1.25	3.78 1.38	4.12 1.50	4.46 1.62
85°	T=.33 E=.128	.66 .259	1.00 .391	1.33 .524	1.68 .657	2.02 .790	2.36 .926	2.70 1.06	3.05 1.20	3.40 1.34	3.77 1.47	4.14 1.62	4.55 1.76	4.89 1.91

Table I.—Tangents and Externals to a 1° Curve. Chord = 100 ft.

Int. Angle	Tangent	External	Int. Angle	Tangent	External	Int. Angle	Tangent	External
85°	5250.3	2041.7	92°	5933.2	2518.5	99°	6708.6	3092.7
10′	5265.6	2052.1	10′	5950.5	2531.0	10′	6728.4	3107.7
20	5281.0	2062.5	20	5967.9	2543.5	20	6748.2	3122.9
30	5296.4	2073.0	30	5985.3	2556.0	30	6768.1	3138.1
40	5311.9	2083.5	40	6002.7	2568.6	40	6788.1	3153.3
50	5327.4	2094.1	50	6020.2	2581.3	50	6808.2	3168.7
86	5343.0	2104.7	93	6037.8	2594.0	100	6828.3	3184.1
10	5358.6	2115.3	10	6055.4	2606.8	10	6848.5	3199.6
20	5374.2	2126.0	20	6073.1	2619.7	20	6868.8	3215.1
30	5389.9	2136.7	30	6090.8	2632.6	30	6889.2	3230.8
40	5405.6	2147.5	40	6108.6	2645.5	40	6909.6	3246.5
50	5421.4	2158.4	50	6126.4	2658.5	50	6930.1	3262.3
87	5437.2	2169.2	94	6144.3	2671.6	101	6950.6	3278.1
10	5453.1	2180.2	10	6162.6	2684.7	10	6971.3	3294.1
20	5469.0	2191.1	20	6180.2	2697.9	20	6992.0	3310.1
30	5484.9	2202.2	30	6198.3	2711.2	30	7012.7	3326.1
40	5500.9	2213.2	40	6216.4	2724.5	40	7033.6	3342.3
50	5517.0	2224.3	50	6234.6	2737.9	50	7054.5	3358.5
88	5533.1	2235.5	95	6252.8	2751.3	102	7075.5	3374.9
10	5549.2	2246.7	10	6271.1	2764.8	10	7096.6	3391.2
20	5565.4	2258.0	20	6289.4	2778.3	20	7117.8	3407.7
30	5581.6	2269.3	30	6307.9	2792.0	30	7139.0	3424.3
40	5597.8	2280.6	40	6326.3	2805.6	40	7160.3	3440.9
50	5614.2	2292.0	50	6344.8	2819.4	50	7181.7	3457.6
89	5630.5	2303.5	96	6363.4	2833.2	103	7203.2	3474.4
10	5646.9	2315.0	10	6382.1	2847.0	10	7224.7	3491.3
20	5663.4	2326.6	20	6400.8	2861.0	20	7246.3	3503.2
30	5679.9	2338.2	30	6419.5	2875.0	30	7268.0	3525.2
40	5696.4	2349.8	40	6438.4	2889.0	40	7289.8	3542.4
50	5713.0	2361.5	50	6457.3	2903.1	50	7311.7	3559.6
90	5729.7	2373.3	97	6476.2	2917.3	104	7333.6	3576.8
10	5746.3	2385.1	10	6495.2	2931.6	10	7355.6	3594.2
20	5763.1	2397.0	20	6514.3	2945.9	20	7377.8	3611.7
30	5779.9	2408.9	30	6533.4	2960.3	30	7399.9	3629.2
40	5796.7	2420.9	40	6552.6	2974.7	40	7422.2	3646.8
50	5813.6	2432.9	50	6571.9	2989.2	50	7444.6	3664.5
91	5830.5	2444.9	98	6591.2	3003.8	105	7467.0	3682.3
10	5847.5	2457.1	10	6610.6	3018.4	10	7489.6	3700.2
20	5864.6	2469.3	20	6630.1	3033.1	20	7512.2	3718.2
30	5881.7	2481.5	30	6649.6	3047.9	30	7534.9	3736.2
40	5898.8	2493.8	40	6669.2	3062.8	40	7557.7	3754.4
50	5916.0	2506.1	50	6688.8	3077.7	50	7580.5	3772.6

Corrections to be Added (T = Tangent. E = External.)

Int. Angle	Curve 5°	10°	15°	20°	25°	30°	35°	40°	45°	50°	55°	60°	65°	70°
85°	T=.33 E=.128	.66 .259	1.00 .391	1.33 .524	1.68 .657	2.02 .790	2.36 .926	2.70 1.06	3.05 1.20	3.40 1.34	3.77 1.47	4.14 1.62	4.55 1.76	4.89 1.91
90°	T=.36 E=.149	.72 .299	1.09 .450	1.45 .603	1.83 .756	2.20 .910	2.57 1.07	2.94 1.22	3.32 1.38	3.70 1.54	4.10 1.70	4.50 1.87	4.91 2.03	5.32 2.20
95°	T=.39 E=.174	.79 .350	1.19 .522	1.55 .706	2.00 .985	2.40 1.06	2.80 1.25	3.20 1.43	3.61 1.62	4.02 1.80	4.49 1.99	4.98 2.18	5.38 2.38	5.83 2.58
100°	T=.43 E=.200	.86 .401	1.30 .604	1.74 .809	2.18 1.01	2.62 1.22	3.06 1.43	3.50 1.64	3.95 1.85	4.40 2.06	4.88 2.28	5.37 2.50	5.85 2.73	6.34 2.96
105°	T=.46 E=.230	.94 .470	1.42 .700	1.90 .938	2.38 1.17	2.87 1.42	3.34 1.65	3.84 1.90	4.35 2.14	4.84 2.39	5.35 2.64	5.87 2.90	6.40 3.16	6.93 3.41

Table I.—Tangents and Externals to a 1° Curve. Chord = 100 ft.

Int. Angle	Tangent	External	Int. Angle	Tangent	External	Int. Angle	Tangent	External
106°	7603.5	3791.0	111°	8336.7	4386.1	116°	9169.4	5082.7
10′	7626.6	3809.4	10′	8362.7	4407.6	10′	9199.1	5107.9
20	7649.7	3827.9	20	8388.9	4429.2	20	9229.0	5133.3
30	7672.9	3846.5	30	8415.1	4450.9	30	9259.0	5158.8
40	7696.3	3865.2	40	8441.5	4472.7	40	9289.2	5184.5
50	7719.7	3884.0	50	8468.0	4494.6	50	9319.5	5210.3
107	7743.2	3902.9	112	8494.6	4516.6	117	9349.9	5236.2
10	7766.8	3921.9	10	8521.3	4538.8	10	9380.5	5262.3
20	7790.5	3940.9	20	8548.1	4561.1	20	9411.3	5288.6
30	7814.3	3960.1	30	8575.0	4583.4	30	9442.2	5315.0
40	7838.1	3979.4	40	8602.1	4606.0	40	9473.2	5341.5
50	7862.1	3998.7	50	8629.3	4628.6	50	9504.4	5368.2
108	7886.2	4018.2	113	8656.6	4651.3	118	9535.7	5395.1
10	7910.4	4037.8	10	8684.0	4674.2	10	9567.2	5422.1
20	7934.6	4057.4	20	8711.5	4697.2	20	9598.9	5449.2
30	7959.0	4077.2	30	8739.2	4720.3	30	9630.7	5476.5
40	7983.5	4097.1	40	8767.0	4743.6	40	9662.6	5504.0
50	8008.0	4117.0	50	8794.9	4766.9	50	9694.7	5531.7
109	8032.7	4137.1	114	8822.9	4790.4	119	9727.0	5559.4
10	8057.4	4157.3	10	8851.0	4814.1	10	9759.4	5587.4
20	8082.3	4177.5	20	8879.3	4837.8	20	9792.0	5615.5
30	8107.3	4197.9	30	8907.7	4861.7	30	9824.8	5643.8
40	8132.3	4218.4	40	8936.3	4885.7	40	9857.7	5672.3
50	8157.5	4239.0	50	8965.0	4909.9	50	9890.8	5700.9
110	8182.8	4259.7	115	8993.8	4934.1	120	9924.0	5729.7
10	8208.2	4280.5	10	9022.7	4958.6	10	9957.5	5758.6
20	8233.7	4301.4	20	9051.7	4983.1	20	9991.0	5787.7
30	8259.3	4322.4	30	9080.9	5007.8	30	10025.0	5817.0
40	8285.0	4343.6	40	9110.3	5032.6	40	10059.0	5846.5
50	8310.8	4364.8	50	9139.8	5057.6	50	10093.0	5876.1

Corrections to be Added (T = Tangent. E = External.)

Int. Angle	Curve 5°	10°	15°	20°	25°	30°	35°	40°	45°	50°	55°	60°	65°	70°
100°	T=.43 E=.200	.86 .401	1.30 .604	1.74 .809	2.18 1.01	2.62 1.22	3.06 1.43	3.50 1.64	3.95 1.85	4.40 2.06	4.88 2.28	5.37 2.50	5.85 2.73	6.34 2.96
105°	T=.46 E=.230	.94 .470	1.42 .700	1.90 .938	2.38 1.17	2.87 1.42	3.34 1.65	3.84 1.90	4.35 2.14	4.84 2.39	5.35 2.64	5.87 2.90	6.40 3.16	6.93 3.41
110°	T=.50 E=.260	1.03 .535	1.55 .808	2.08 1.08	2.60 1.36	3.14 1.63	3.66 1.91	4.21 2.19	4.76 2.49	5.31 2.61	5.86 3.05	6.43 3.35	7.01 3.65	7.59 3.95
115°	T=.54 E=.307	1.13 .624	1.70 .939	2.29 1.26	2.86 1.57	3.45 1.89	4.03 2.21	4.63 2.54	5.23 2.87	5.83 3.20	6.44 3.53	7.07 3.88	7.70 4.23	8.35 4.58
120°	T=.61 E=.339	1.25 .720	1.89 1.08	2.52 1.45	3.16 1.82	3.81 2.20	4.44 2.56	5.11 2.95	5.78 3.33	6.44 3.72	7.11 4.10	7.80 4.50	8.51 4.91	9.21 5.32

Table II.—Radii, Ordinates and Deflections. Chord = 100 ft.

Deg.	Radius	Mid. Ord.	Tan. Dist.	Def. Dist.	Def. for 1 Ft.	Deg.	Radius	Mid. Ord.	Tan. Dist.	Def. Dist.	Def. for 1 Ft.
	ft.	ft.	ft.	ft.			ft.	ft.	ft.	ft.	
0°10′	34377.	.036	.145	.291	0.05	7°	819.0	1.528	6.105	12.21	2.10
20	17189.	.073	.291	.582	0.10	20′	781.8	1.600	6.395	12.79	2.20
30	11459.	.109	.436	.873	0.15	30	764.5	1.637	6.540	13.08	2.25
40	8594.4	.145	.582	1.164	0.20	40	747.9	1.673	6.685	13.37	2.30
50	6875.5	.182	.727	1.454	0.25	**8**	716.8	1.746	6.976	13.95	2.40
1	5729.6	.218	.873	1.745	0.30	20	688.2	1.819	7.266	14.53	2.50
10	4911.2	.255	1.018	2.036	0.35	30	674.7	1.855	7.411	14.82	2.55
20	4297.3	.291	1.164	2.327	0.40	40	661.7	1.892	7.556	15.11	2.60
30	3819.8	.327	1.309	2.618	0.45	**9**	637.3	1.965	7.846	15.69	2.70
40	3437.9	.364	1.454	2.909	0.50	20	614.6	2.037	8.136	16.27	2.80
50	3125.4	.400	1.600	3.200	0.55	30	603.8	2.074	8.281	16.56	2.85
2	2864.9	.436	1.745	3.490	0.60	40	593.4	2.110	8.426	16.85	2.90
10	2644.6	.473	1.891	3.781	0.65	**10**	573.7	2.183	8.716	17.43	3.00
20	2455.7	.509	2.036	4.072	0.70	30	546.4	2.292	9.150	18.30	3.15
30	2292.0	.545	2.181	4.363	0.75	**11**	521.7	2.402	9.585	19.16	3.30
40	2148.8	.582	2.327	4.654	0.80	30	499.1	2.511	10.02	20.04	3.45
50	2022.4	.618	2.472	4.945	0.85	**12**	478.3	2.620	10.45	20.91	3.60
3	1910.1	.655	2.618	5.235	0.90	30	459.3	2.730	10.89	21.77	3.75
10	1809.6	.691	2.763	5.526	0.95	**13**	441.7	2.839	11.32	22.64	3.90
20	1719.1	.727	2.908	5.817	1.00	30	425.4	2.949	11.75	23.51	4.05
30	1637.3	.764	3.054	6.108	1.05	**14**	410.3	3.058	12.18	24.37	4.20
40	1562.9	.800	3.199	6.398	1.10	30	396.2	3.168	12.62	25.24	4.35
50	1495.0	.836	3.345	6.689	1.15	**15**	383.1	3.277	13.05	26.11	4.50
4	1432.7	.873	3.490	6.980	1.20	30	370.8	3.387	13.49	26.97	4.65
10	1375.4	.909	3.635	7.271	1.25	**16**	359.3	3.496	13.92	27.84	4.80
20	1322.5	.945	3.718	7.561	1.30	30	348.5	3.606	14.35	28.70	4.95
30	1273.6	.982	3.926	7.852	1.35	**17**	338.3	3.716	14.78	29.56	5.10
40	1228.1	1.018	4.071	8.143	1.40	**18**	319.6	3.935	15.64	31.29	5.40
50	1185.8	1.055	4.217	8.433	1.45	**19**	302.9	4.155	16.51	33.01	5.70
5	1146.3	1.091	4.362	8.724	1.50	**20**	287.9	4.374	17.37	34.73	6.00
10	1109.3	1.127	4.507	9.014	1.55	**21**	274.4	4.594	18.22	36.44	6.30
20	1074.7	1.164	4.653	9.305	1.60	**22**	262.0	4.814	19.08	38.16	6.60
30	1042.1	1.200	4.798	9.596	1.65	**23**	250.8	5.035	19.94	39.87	6.90
40	1011.5	1.237	4.943	9.886	1.70	**24**	240.5	5.255	20.79	41.58	7.20
50	982.6	1.273	5.088	10.18	1.75	**25**	231.0	5.476	21.64	43.28	7.50
6	955.4	1.309	5.234	10.47	1.80	**26**	222.3	5.697	22.50	44.99	7.80
10	929.6	1.346	5.379	10.76	1.85	**27**	214.2	5.918	23.35	46.69	8.10
20	905.1	1.382	5.524	11.05	1.90	**28**	206.7	6.139	24.19	48.38	8.40
30	881.9	1.418	5.669	11.34	1.95	**29**	199.7	6.360	25.04	50.07	8.70
40	859.9	1.455	5.814	11.63	2.00	**30**	193.2	6.583	25.88	51.76	9.00

The middle ordinate in inches for any cord of length (C) is equal to .0012 C^2 multiplied by the middle ordinate taken from the above table. Thus, if it desired to bend a 30 ft. rail to fit a 10 degree curve, its middle ordinate should be .0012 × 900 × 2.183 or 2.36 inches.

Table III.—Deflections for Sub Chords for Short Radius Curves.

Degree of Curve	Radius = 50 / sin. ½ def. ang.	½ sub chord / R = sin of ½ def. angle				Length of arc for **100** ft.
		12.5 Ft.	**15** Ft.	**20** Ft.	**25** Ft.	
30°	193.18	1° 51′	2° 17′	2° 58′	3° 43′	101.15
32°	181.39	1° 59′	2° 25′	3° 10′	3° 58′	101.33
34°	171.01	2° 06′	2° 33′	3° 21′	4° 12′	101.48
36°	161.80	2° 13′	2° 41′	3° 33′	4° 26′	101.66
38°	153.58	2° 20′	2° 49′	3° 44′	4° 40′	101.85
40°	146.19	2° 27′	2° 57′	3° 55′	4° 54′	102.06
42°	139.52	2° 34′	3° 05′	4° 07′	5° 08′	102.29
44°	133.47	2° 41′	3° 13′	4° 18′	5° 22′	102.53
46°	127.97	2° 48′	3° 21′	4° 29′	5° 36′	102.76
48°	122.92	2° 55′	3° 29′	4° 40′	5° 50′	103.00
50°	118.31	3° 02′	3° 38′	4° 51′	6° 04′	103.24
52°	114.06	3° 09′	3° 46′	5° 02′	6° 17′	103.54
54°	110.11	3° 16′	3° 54′	5° 13′	6° 31′	103.84
56°	106.50	3° 22′	4° 02′	5° 23′	6° 44′	104.14
58°	103.14	3° 29′	4° 10′	5° 34′	6° 57′	104.43
60°	100.00	3° 35′	4° 18′	5° 44′	7° 11′	104.72

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

$T = \dfrac{50 \tan \frac{1}{2} I}{\text{Sin. } \frac{1}{2} D}$

$\text{Sin. } \frac{1}{2} D = \dfrac{50}{R}$

$\text{Sin. } \frac{1}{2} D = \dfrac{50 \tan \frac{1}{2} I}{T}$

$R = T \cot. \frac{1}{2} I$

$R = \dfrac{50}{\text{Sin. } \frac{1}{2} D}$

$E = R \text{ ex. sec } \frac{1}{2} I$

$E = T \tan \frac{1}{4} I$

$\text{Chord def.} = \dfrac{\text{chord}^2}{R}$

$\text{No. chords} = \dfrac{I}{D}$

$\text{Tan. def.} = \frac{1}{2} \text{ chord def.}$

The square of any distance, divided by twice the radius, will equal the distance from tangent to curve, very nearly.

To find angle for a given distance and deflection.

Rule 1. Multiply the given distance by .01745 (def. for 1° for 1 ft. see Table II.), and divide given deflection by the product.

Rule 2. Multiply given deflection by 57.3, and divide the product by the given distance.

To find deflection for a given angle and distance. Multiply the angle by .01745, and the product by the distance.

GENERAL DATA

Right Angle Triangles. Square the altitude, divide by twice the base. Add quotient to base for hypotenuse.

Given Base 100, Alt. 10. $10^2 \div 200 = .5$. $100 + .5 = 100.5$ hyp.

Given Hyp. 100, Alt. 25. $25^2 \div 200 = 3.125$. $100 - 3.125 = 96.875$ = Base.

Error in first sample, .002; in last, .045.

To find Tons of Rail in one mile of track: multiply weight per yard by 11, and divide by 7.

Leveling. The correction for curvature and refraction, in feet and decimals of feet is equal to $0.574d^2$, where d is the distance in miles. The correction for curvature alone is closely, $\frac{2}{3}d^2$. The combined correction is negative.

Probable Error. If d_1, d_2, d_3, etc. are the discrepancies of various results from the mean, and if Σd^2 = the sum of the squares of these differences and n = the number of observations, then the probable error of the mean =

$$\pm 0.6745 \sqrt{\frac{\Sigma d^2}{n(n-1)}}$$

Table IV.—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**	.333	**30**	.5000	**40**	.6667	**50**	.8333	**60**	1.0000

Table V.—Inches in Decimals of a Foot.

1–16	3–32	⅛	3–16	¼	5–16	⅜	½	⅝	¾	⅞
.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

Angle	Sin.	Tan.	Sec.	Cosec.	Cotg.	Cosin.	
° ′							
0	0	0	1.	∞	∞	1.	**90**
10	.0029	.0029		343.8	343.8	1.	50
20	.0058	.0058		171.9	171.9	.99998	40
30	.0087	.0087		114.6	114.6	.99996	30
40	.0116	.0116	1.0001	85.94	85.94	.99993	20
50	.0145	.0145	1.0001	68.76	68.75	.99989	10
1	.0175	.0175	1.0002	57.30	57.29	.99985	**89**
10	.0204	.0204	1.0002	49.11	49.10	.99979	50
20	.0233	.0233	1.0003	42.98	42.96	.99973	40
30	.0262	.0262	1.0003	38.20	38.19	.99966	30
40	.0291	.0291	1.0004	34.38	34.37	.99958	20
50	.0320	.0320	1.0005	31.26	31.24	.99949	10
2	.0349	.0349	1.0006	28.65	28.64	.99939	**88**
10	.0378	.0378	1.0007	26.45	26.43	.99929	50
20	.0407	.0407	1.0008	24.56	24.54	.99917	40
30	.0436	.0437	1.0010	22.93	22.90	.99905	30
40	.0465	.0466	1.0011	21.49	21.47	.99892	20
50	.0494	.0495	1.0012	20.23	20.21	.99878	10
3	.0523	.0524	1.0014	19.11	19.08	.99863	**87**
10	.0552	.0553	1.0015	18.10	18.07	.99847	50
20	.0581	.0582	1.0017	17.20	17.17	.99831	40
30	.0610	.0612	1.0019	16.38	16.35	.99813	30
40	.0640	.0641	1.0020	15.64	15.60	.99795	20
50	.0669	.0670	1.0022	14.96	14.92	.99776	10
4	.0698	.0699	1.0024	14.34	14.30	.99756	**86**
10	.0727	.0729	1.0027	13.76	13.73	.99736	50
20	.0756	.0758	1.0029	13.23	13.20	.99714	40
30	.0785	.0787	1.0031	12.75	12.71	.99692	30
40	.0814	.0816	1.0033	12.29	12.25	.99668	20
50	.0843	.0846	1.0036	11.87	11.83	.99644	10
5	.0872	.0875	1.0038	11.47	11.43	.99619	**85**
10	.0901	.0904	1.0041	11.10	11.06	.99594	50
20	.0929	.0934	1.0043	10.76	10.71	.99567	40
30	.0958	.0963	1.0046	10.43	10.39	.99540	30
40	.0987	.0992	1.0049	10.13	10.08	.99511	20
50	.1016	.1022	1.0052	9.839	9.788	.99482	10
6	.1045	.1051	1.0055	9.567	9.514	.99452	**84**
10	.1074	.1080	1.0058	9.309	9.255	.99421	50
20	.1103	.1110	1.0061	9.065	9.010	.99390	40
30	.1132	.1139	1.0065	8.834	8.777	.99357	30
40	.1161	.1169	1.0068	8.614	8.556	.99324	20
50	.1190	.1198	1.0072	8.405	8.345	.99290	10
7	.1219	.1228	1.0075	8.206	8.144	.99255	**83**
10	.1248	.1257	1.0079	8.016	7.953	.99219	50
20	.1276	.1287	1.0082	7.834	7.770	.99182	40
30	.1305	.1317	1.0086	7.661	7.596	.99144	30
40	.1334	.1346	1.0090	7.496	7.429	.99106	20
50	.1363	.1376	1.0094	7.337	7.269	.99067	10
							82
							° ′
	Cosin.	Cotg.	Cosec.	Sec.	Tan.	Sin.	Angle

Angle	Sin.	Tan.	Sec.	Cose.	Cotg.	Cosin.	
° ′							
8	.1392	.1405	1.0098	7.185	7.115	.99027	**82**
10	.1421	.1435	1.0102	7.040	6.968	.98986	50
20	.1449	.1465	1.0107	6.900	6.827	.98944	40
30	.1478	.1495	1.0111	6.766	6.691	.98902	30
40	.1507	.1524	1.0115	6.636	6.561	.98858	20
50	.1536	.1554	1.0120	6.512	6.435	.98814	10
9	.1564	.1584	1.0125	6.394	6.314	.98769	**81**
10	.1593	.1614	1.0129	6.277	6.197	.98723	50
20	.1622	.1644	1.0134	6.166	6.084	.98676	40
30	.1650	.1673	1.0139	6.059	5.976	.98629	30
40	.1679	.1703	1.0144	5.955	5.871	.98580	20
50	.1708	.1733	1.0149	5.855	5.769	.98531	10
10	.1736	.1763	1.0154	5.759	5.671	.98481	**80**
10	.1765	.1793	1.0160	5.665	5.576	.98430	50
20	.1794	.1823	1.0165	5.575	5.485	.98378	40
30	.1822	.1853	1.0170	5.488	5.396	.98325	30
40	.1851	.1883	1.0176	5.403	5.309	.98272	20
50	.1880	.1914	1.0181	5.320	5.226	.98218	10
11	.1908	.1944	1.0187	5.241	5.145	.98163	**79**
10	.1937	.1974	1.0193	5.164	5.066	.98107	50
20	.1965	.2004	1.0199	5.089	4.989	.98050	40
30	.1994	.2035	1.0205	5.016	4.915	.97992	30
40	.2022	.2065	1.0211	4.945	4.843	.97934	20
50	.2051	.2095	1.0217	4.877	4.773	.97875	10
12	.2079	.2126	1.0223	4.810	4.705	.97815	**78**
10	.2108	.2156	1.0230	4.745	4.638	.97754	50
20	.2136	.2186	1.0236	4.682	4.574	.97692	40
30	.2164	.2217	1.0243	4.620	4.511	.97630	30
40	.2193	.2247	1.0249	4.560	4.449	.97566	20
50	.2221	.2278	1.0256	4.502	4.390	.97502	10
13	.2250	.2309	1.0263	4.445	4.331	.97437	**77**
10	.2278	.2339	1.0270	4.390	4.275	.97371	50
20	.2306	.2370	1.0277	4.336	4.219	.97304	40
30	.2334	.2401	1.0284	4.284	4.165	.97237	30
40	.2363	.2432	1.0291	4.232	4.113	.97169	20
50	.2391	.2462	1.0299	4.182	4.061	.97100	10
14	.2419	.2493	1.0306	4.133	4.011	.97030	**76**
10	.2447	.2524	1.0314	4.086	3.962	.96959	50
20	.2476	.2555	1.0321	4.039	3.914	.96887	40
30	.2504	.2586	1.0329	3.994	3.867	.96815	30
40	.2532	.2617	1.0337	3.949	3.821	.96742	20
50	.2560	.2648	1.0345	3.906	3.776	.96667	10
15	.2588	.2679	1.0353	3.864	3.732	.96593	**75**
10	.2616	.2711	1.0361	3.822	3.689	.96517	50
20	.2644	.2742	1.0369	3.782	3.647	.96440	40
30	.2672	.2773	1.0377	3.742	3.606	.96363	30
40	.2700	.2805	1.0386	3.703	3.566	.96285	20
50	.2728	.2836	1.0394	3.665	3.526	.96206	10
							74
							° ′
	Cosin.	Cotg.	Cosec.	Sec.	Tan.	Sin.	Angle

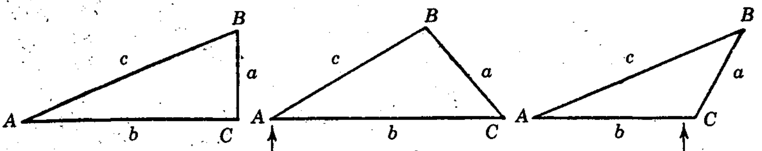
Angle	Sin.	Tan.	Sec.	Cosec.	Cotg.	Cosin.	
° ′							
16	.2756	.2867	1.0403	3.628	3.487	.96126	**74**
10	.2784	.2899	1.0412	3.592	3.450	.96046	50
20	.2812	.2931	1.0423	3.556	3.412	.95964	40
30	.2840	.2962	1.0429	3.521	3.376	.95882	30
40	.2868	.2994	1.0438	3.487	3.340	.95799	20
50	.2896	.3026	1.0448	3.453	3.305	.95715	10
17	.2924	.3057	1.0457	3.420	3.271	.95630	**73**
10	.2952	.3089	1.0466	3.388	3.237	.95545	50
20	.2979	.3121	1.0476	3.357	3.204	.95459	40
30	.3007	.3153	1.0485	3.326	3.172	.95372	30
40	.3035	.3185	1.0495	3.295	3.140	.95284	20
50	.3062	.3217	1.0505	3.265	3.108	.95195	10
18	.3090	.3249	1.0515	3.236	3.078	.95106	**72**
10	.3118	.3281	1.0525	3.207	3.048	.95015	50
20	.3145	.3314	1.0535	3.179	3.018	.94924	40
30	.3173	.3346	1.0545	3.152	2.989	.94832	30
40	.3201	.3378	1.0555	3.124	2.960	.94740	20
50	.3228	.3411	1.0566	3.098	2.932	.94646	10
19	.3256	.3443	1.0576	3.072	2.904	.94552	**71**
10	.3283	.3476	1.0587	3.046	2.877	.94457	50
20	.3311	.3508	1.0598	3.020	2.850	.94361	40
30	.3338	.3541	1.0608	2.996	2.824	.94264	30
40	.3365	.3574	1.0619	2.971	2.798	.94167	20
50	.3393	.3607	1.0631	2.947	2.773	.94068	10
20	.3420	.3640	1.0642	2.924	2.747	.93969	**70**
10	.3448	.3673	1.0653	2.900	2.723	.93869	50
20	.3475	.3706	1.0665	2.878	2.699	.93769	40
30	.3502	.3739	1.0676	2.856	2.675	.93667	30
40	.3529	.3772	1.0688	2.833	2.651	.93565	20
50	.3557	.3805	1.0700	2.811	2.628	.93462	10
21	.3584	.3839	1.0711	2.790	2.605	.93358	**69**
10	.3611	.3872	1.0723	2.769	2.583	.93253	50
20	.3638	.3906	1.0736	2.749	2.560	.93148	40
30	.3665	.3939	1.0748	2.729	2.539	.93042	30
40	.3692	.3973	1.0760	2.709	2.517	.92935	20
50	.3719	.4006	1.0773	2.689	2.496	.92827	10
22	.3746	.4040	1.0785	2.670	2.475	.92718	**68**
10	.3773	.4074	1.0798	2.650	2.455	.92609	50
20	.3800	.4108	1.0811	2.632	2.434	.92499	40
30	.3827	.4142	1.0824	2.613	2.414	.92388	30
40	.3854	.4176	1.0837	2.595	2.394	.92276	20
50	.3881	.4210	1.0850	2.577	2.375	.92164	10
23	.3907	.4245	1.0864	2.559	2.356	.92050	**67**
10	.3934	.4279	1.0877	2.542	2.337	.91936	50
20	.3961	.4314	1.0891	2.525	2.318	.91822	40
30	.3987	.4348	1.0904	2.508	2.300	.91706	30
40	.4014	.4383	1.0918	2.491	2.282	.91590	20
50	.4041	.4417	1.0932	2.475	2.264	.91472	10
							66
							° ′
	Cosin.	Cotg.	Cosec.	Sec.	Tan.	Sin.	Angle

Angle	Sin.	Tan.	Sec.	Cose.	Cotg.	Cosin.	
° ′							
24	.4067	.4452	1.0946	2.459	2.246	.91355	**66**
10	.4094	.4487	1.0961	2.443	2.229	.91236	50
20	.4120	.4522	1.0975	2.427	2.211	.91116	40
30	.4147	.4557	1.0989	2.411	2.194	.90996	30
40	.4173	.4592	1.1004	2.396	2.177	.90875	20
50	.4200	.4628	1.1019	2.381	2.161	.90753	10
25	.4226	.4663	1.1034	2.366	2.145	.90631	**65**
10	.4253	.4699	1.1049	2.351	2.128	.90507	50
20	.4279	.4734	1.1064	2.337	2.112	.90383	40
30	.4305	.4770	1.1079	2.323	2.097	.90259	30
40	.4331	.4806	1.1095	2.309	2.081	.90133	20
50	.4358	.4841	1.1110	2.295	2.066	.90007	10
26	.4384	.4877	1.1126	2.281	2.050	.89879	**64**
10	.4410	.4913	1.1142	2.268	2.035	.89752	50
20	.4436	.4950	1.1158	2.254	2.020	.89623	40
30	.4462	.4986	1.1174	2.241	2.006	.89493	30
40	.4488	.5022	1.1190	2.228	1.991	.89363	20
50	.4514	.5059	1.1207	2.215	1.977	.89232	10
27	.4540	.5095	1.1223	2.203	1.963	.89101	**63**
10	.4566	.5132	1.1240	2.190	1.949	.88968	50
20	.4592	.5169	1.1257	2.178	1.935	.88835	40
30	.4617	.5206	1.1274	2.166	1.921	.88701	30
40	.4643	.5243	1.1291	2.154	1.907	.88566	20
50	.4669	.5280	1.1308	2.142	1.894	.88431	10
28	.4695	.5317	1.1326	2.130	1.881	.88295	**62**
10	.4720	.5354	1.1343	2.119	1.868	.88158	50
20	.4746	.5392	1.1361	2.107	1.855	.88020	40
30	.4772	.5430	1.1379	2.096	1.842	.87882	30
40	.4797	.5467	1.1397	2.085	1.829	.87743	20
50	.4823	.5505	1.1415	2.073	1.816	.87603	10
29	.4848	.5543	1.1434	2.063	1.804	.87462	**61**
10	.4874	.5581	1.1452	2.052	1.792	.87321	50
20	.4899	.5619	1.1471	2.041	1.780	.87178	40
30	.4924	.5658	1.1490	2.031	1.767	.87036	30
40	.4950	.5696	1.1509	2.020	1.756	.86892	20
50	.4975	.5735	1.1528	2.010	1.744	.86748	10
30	.5000	.5774	1.1547	2.000	1.732	.86603	**60**
10	.5025	.5812	1.1566	1.990	1.720	.86457	50
20	.5050	.5851	1.1586	1.980	1.709	.86310	40
30	.5075	.5890	1.1606	1.970	1.698	.86163	30
40	.5100	.5930	1.1626	1.961	1.686	.86015	20
50	.5125	.5969	1.1646	1.951	1.675	.85866	10
31	.5150	.6009	1.1666	1.942	1.664	.85717	**59**
10	.5175	.6048	1.1687	1.932	1.653	.85567	50
20	.5200	.6088	1.1707	1.923	1.643	.85416	40
30	.5225	.6128	1.1728	1.914	1.632	.85264	30
40	.5250	.6168	1.1749	1.905	1.621	.85112	20
50	.5275	.6208	1.1770	1.896	1.611	.84959	10
							58
							° ′
	Cosin.	Cotg.	Cosec.	Sec.	Tan.	Sin.	Angle

Angle	Sin.	Tan.	Sec.	Cosec.	Cotg.	Cosin.	
° ′							
32	.5299	.6249	1.1792	1.887	1.600	.84805	**58**
10	.5324	.6289	1.1813	1.878	1.590	.84650	50
20	.5348	.6330	1.1835	1.870	1.580	.84495	40
30	.5373	.6371	1.1857	1.861	1.570	.84339	30
40	.5398	.6412	1.1879	1.853	1.560	.84182	20
50	.5422	.6453	1.1901	1.844	1.550	.84025	10
33	.5446	.6494	1.1924	1.836	1.540	.83867	**57**
10	.5471	.6536	1.1946	1.828	1.530	.83708	50
20	.5495	.6577	1.1969	1.820	1.520	.83549	40
30	.5519	.6619	1.1992	1.812	1.511	.83389	30
40	.5544	.6661	1.2015	1.804	1.501	.83228	20
50	.5568	.6703	1.2039	1.796	1.492	.83066	10
34	.5592	.6745	1.2062	1.788	1.483	.82904	**56**
10	.5616	.6787	1.2086	1.781	1.473	.82741	50
20	.5640	.6830	1.2110	1.773	1.464	.82577	40
30	.5664	.6873	1.2134	1.766	1.455	.82413	30
40	.5688	.6916	1.2158	1.758	1.446	.82248	20
50	.5712	.6959	1.2183	1.751	1.437	.82082	10
35	.5736	.7002	1.2208	1.743	1.428	.81915	**55**
10	.5760	.7046	1.2233	1.736	1.419	.81748	50
20	.5783	.7089	1.2258	1.729	1.411	.81580	40
30	.5807	.7133	1.2283	1.722	1.402	.81412	30
40	.5831	.7177	1.2309	1.715	1.393	.81242	20
50	.5854	.7221	1.2335	1.708	1.385	.81072	10
36	.5878	.7265	1.2361	1.701	1.376	.80902	**54**
10	.5901	.7310	1.2387	1.695	1.368	.80730	50
20	.5925	.7355	1.2413	1.688	1.360	.80558	40
30	.5948	.7400	1.2440	1.681	1.351	.80386	30
40	.5972	.7445	1.2466	1.675	1.343	.80212	20
50	.5995	.7490	1.2494	1.668	1.335	.80038	10
37	.6018	.7536	1.2521	1.662	1.327	.79864	**53**
10	.6041	.7581	1.2549	1.655	1.319	.79688	50
20	.6065	.7627	1.2577	1.649	1.311	.79512	40
30	.6088	.7673	1.2605	1.643	1.303	.79335	30
40	.6111	.7720	1.2633	1.636	1.295	.79158	20
50	.6134	.7766	1.2661	1.630	1.288	.78980	10
38	.6157	.7813	1.2690	1.624	1.280	.78801	**52**
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

Angle	Sin.	Tan.	Sec.	Cose.	Cotg.	Cosin.	
° ′							
39	.6293	.8098	1.2868	1.589	1.235	.77715	**51**
10	.6316	.8146	1.2898	1.583	1.228	.77531	50
20	.6338	.8195	1.2929	1.578	1.220	.77347	40
30	.6361	.8243	1.2959	1.572	1.213	.77162	30
40	.6383	.8292	1.2991	1.567	1.206	.76977	20
50	.6406	.8342	1.3022	1.561	1.199	.76791	10
40	.6428	.8391	1.3054	1.556	1.192	.76604	**50**
10	.6450	.8441	1.3086	1.550	1.185	.76417	50
20	.6472	.8491	1.3118	1.545	1.178	.76229	40
30	.6494	.8541	1.3151	1.540	1.171	.76041	30
40	.6517	.8591	1.3184	1.535	1.164	.75851	20
50	.6539	.8642	1.3217	1.529	1.157	.75661	10
41	.6561	.8693	1.3251	1.524	1.150	.75471	**49**
10	.6583	.8744	1.3284	1.519	1.144	.75280	50
20	.6604	.8796	1.3318	1.514	1.137	.75088	40
30	.6626	.8847	1.3352	1.509	1.130	.74896	30
40	.6648	.8899	1.3386	1.504	1.124	.74703	20
50	.6670	.8952	1.3421	1.499	1.117	.74509	10
42	.6691	.9004	1.3456	1.494	1.111	.74314	**48**
10	.6713	.9057	1.3492	1.490	1.104	.74120	50
20	.6734	.9110	1.3527	1.485	1.098	.73924	40
30	.6756	.9163	1.3563	1.480	1.091	.73728	30
40	.6777	.9217	1.3600	1.476	1.085	.73531	20
50	.6799	.9271	1.3636	1.471	1.079	.73333	10
43	.6820	.9325	1.3673	1.466	1.072	.73135	**47**
10	.6841	.9380	1.3711	1.462	1.066	.72937	50
20	.6862	.9435	1.3748	1.457	1.060	.72737	40
30	.6884	.9490	1.3786	1.453	1.054	.72537	30
40	.6905	.9545	1.3824	1.448	1.048	.72337	20
50	.6926	.9601	1.3863	1.444	1.042	.72136	10
44	.6947	.9657	1.3902	1.440	1.036	.71934	**46**
10	.6967	.9713	1.3941	1.435	1.030	.71732	50
20	.6988	.9770	1.3980	1.431	1.024	.71529	40
30	.7009	.9827	1.4020	1.427	1.018	.71325	30
40	.7030	.9884	1.4061	1.422	1.012	.71121	20
50	.7050	.9942	1.4101	1.418	1.006	.70916	10
	.7071	1.	1.414	1.414	1.	.70711	**45**
							° ′
	Cosin.	Cotg.	Cosec.	Sec.	Tan.	Sin.	Angle

TRIGONOMETRIC FORMULÆ



Right Triangle — Oblique Triangles

Solution of Right Triangles

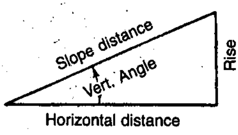
For Angle A. $\sin = \frac{a}{c}$, $\cos = \frac{b}{c}$, $\tan = \frac{a}{b}$, $\cot = \frac{b}{a}$, $\sec = \frac{c}{b}$, $\text{cosec} = \frac{c}{a}$

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

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, Page IX. 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.