Guidebook

Society of Economic Geologists Foundation, Inc. Student-Dedicated Field Trip Course – Ore Deposits of Utah and Colorado

September 25 – October 1, 2010

Erich U. Petersen[1]
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SEGF Student-dedicated Field Trip Course

Ore Deposits of Utah and Colorado

Welcome to the Society of Economic Geologists Foundation, Inc. Field Trip Course – Ore Deposits of Utah and Colorado, September 25 to October 1, 2010. This field trip course is the sixth in Society of Economic Geologists Foundations Series that was established as a response to a student petition to provide support for field trips to important mining districts at the 2005 SEG Conference in Keystone, Colorado.

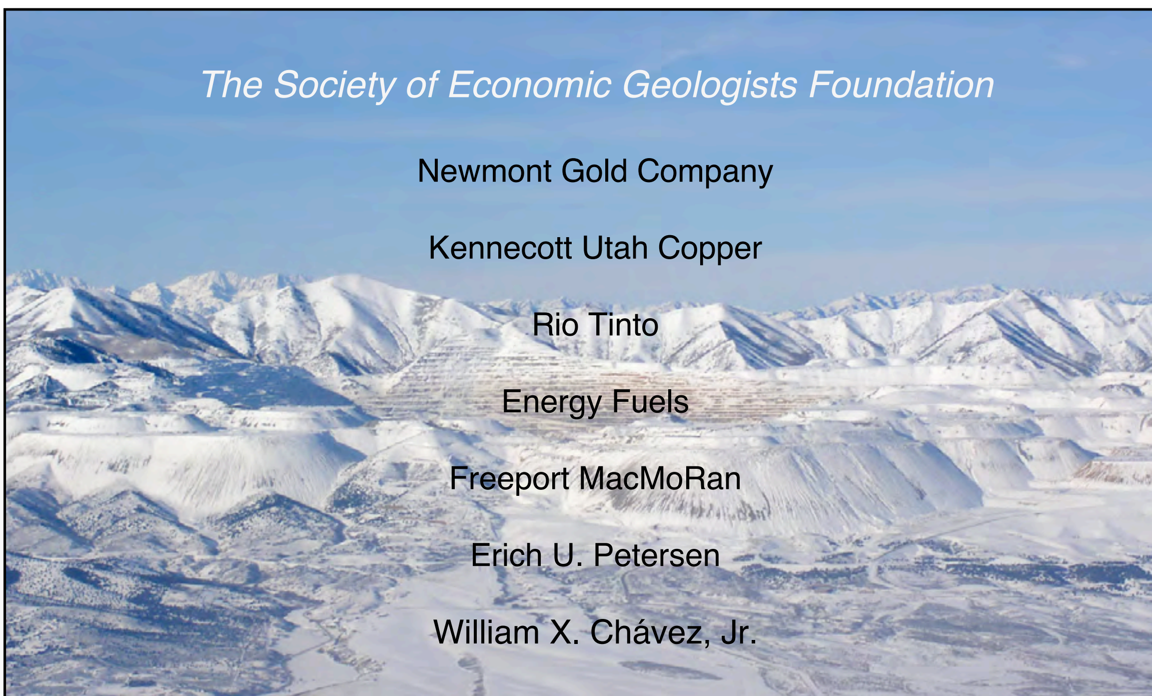
The course starts at 6:00 PM at the Hampton Inn (425 South 300 West, Salt Lake City, UT; 801-741-1110) with a safety, logistics and itinerary review meeting. On Sunday we travel in two vans to the Tintic District and return to Salt Lake City in the late afternoon. There will be a lecture on the geology of Utah – Colorado by Dr. Ronal L. Bruhn in the evening in the Department of Geology & Geophysics at the University of Utah. On Monday we visit the Bingham Canyon mine and continue on to Green River in east-central Utah. We visit uranium districts and mines in Utah and Colorado over the next three days and continue on our way to Grand Junction, Colorado. The field trip course ends at 6:00 pm on Saturday in Keystone at the student reception.

Entrance to the mine sites usually follows a specific protocol; please be patient. At the mines we will receive safety training and a geological/engineering presentation. Do not take any pictures of the presentations unless and until we clear this point with company personnel. We will ask, but in general, participants can take pictures and collect samples on company property. Participants are responsible for their own samples (be aware of weight limits if you plan to take samples back with you). Please be aware that last minute changes to the itinerary are possible.

We will have VERY LIMITED space for luggage, so you should bring clothing and field gear ONLY IN DUFFLE BAGS - NO HARD-SIDED LUGGAGE. See you in Salt Lake City.

Acknowledgements

*This field trip is generously supported through the Society of Economic Geologist Foundation through the **SEGF Student Field Trip Fund**. We also wish to thank the companies that provided access to their operations in Utah and Colorado and the many company representatives that gave generously of their time to make this trip a success. Special thanks are due to Kim Schroeder, Gary Austin, John Porter, Mike Schumway, Craig Barlow, Vicky Sternicki, Gordon Putnam and John Thoms.*



Front cover: Bingham Canyon mine in summer (ca. 2002); *This page*: Bingham Canyon mine in winter (ca. 2000); *Back cover*: Henderson Mine (2010). All photos by Erich U. Petersen

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SEG Foundation Student-Dedicated Field Trip
September 25 – October 1, 2010
Society of Economic Geologists Foundation, Inc.

Student-Dedicated Field Course:
Ore Deposits of the Colorado and Utah

25 September to 1 October, 2010

Field Course Leaders

Professor Erich U. Petersen
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Professor William X. Chávez, Jr.
New México School of Mines
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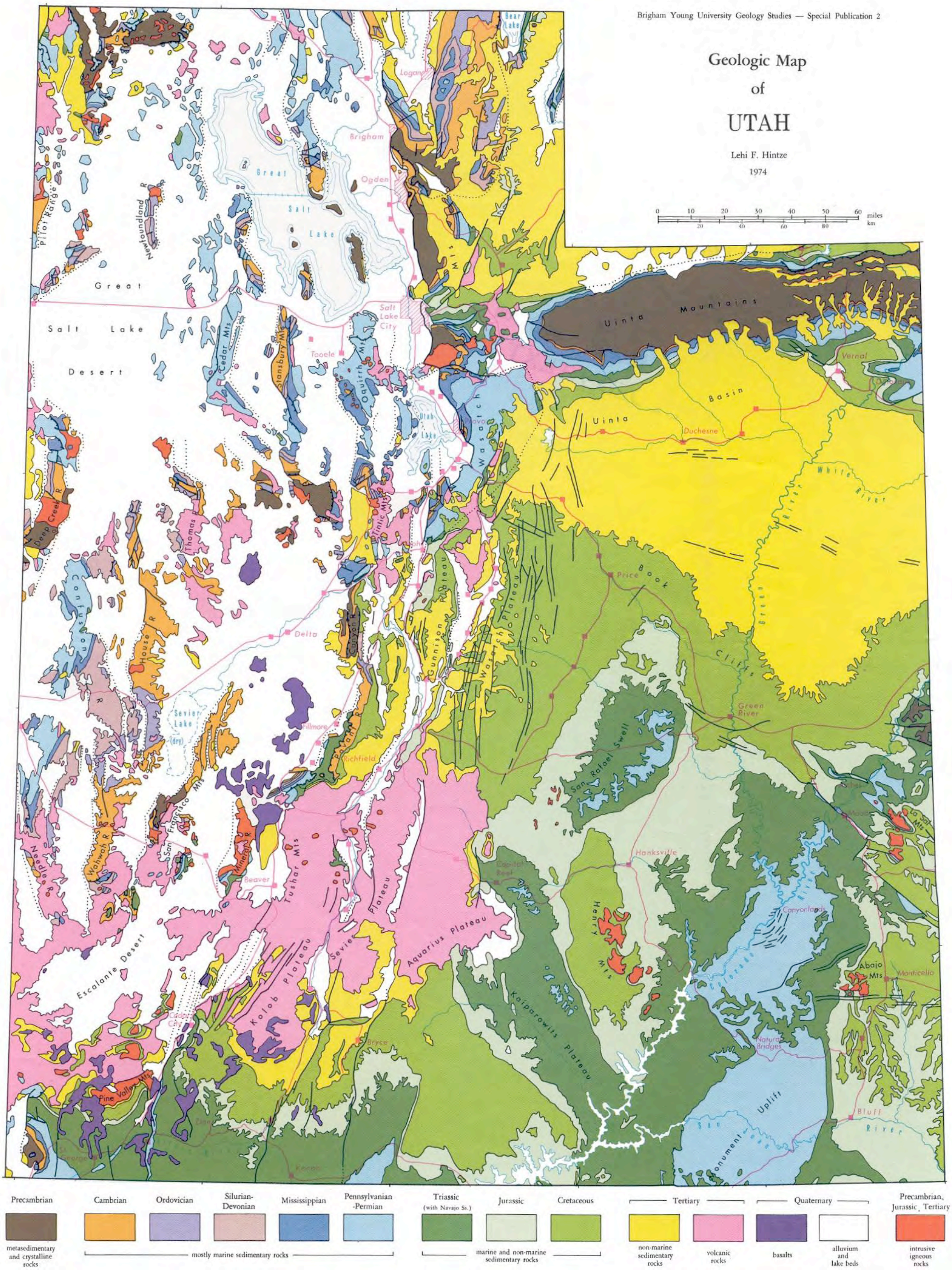
Date	Itinerary	Overnight
25 September Saturday	**6:00PM** Assemble at Little America Hotel Safety and logistics discussions, review itinerary	Hampton Inn Downtown 425 South 300 West Salt Lake City, Utah 801-741-1110
26 September Sunday	**7:00AM** Depart for **Tintic District**; review regional and local geologic settings of polymetallic mineral resources, district alteration patterns and metal zoning.	Hampton Inn Downtown Salt Lake City
27 September Monday	**7:00AM** Depart for **Bingham Canyon Cu-Mo-Au** porphyry system; review rock units and core, discuss porphyry system characteristics. Travel to Green River, Utah	Comfort Inn 1975 East Main St. Green River, Utah 435-564-3300
Contact:	**Kim Schroeder**: schroedk@kennecott.com	Phone: 801-569-7098
28 September Tuesday	**7:30AM** depart for **San Rafaél Swell** uranium districts; discuss Colorado Plateau stratigraphy, history of uranium production, and U-V-Cu deposits of the Colorado Plateau region.	Inn at the Canyons 33 North Main Street Monticello, Utah 435-587-2458
29 September Wednesday	**7:30AM** – Depart for **White Mesa uranium** mill (morning) and Dead Horse Point State Park (**Paradox Formation potash**). Discuss U-V geochemistry; Paradox Formation evaporite deposits.	Inn at the Canyons Monticello, Utah
30 September Thursday	**7:30AM** – Depart for Grand Junction, Colorado; review uranium-vanadium ore-bearing units as we cross Paradox Valley; review history of Ra-V-U production on the Colorado Plateau.	Best Western Sandman 708 Horizon Drive Grand Junction, Colo. P: 970-243-4150 Ref: Mike Pascale Reception: Norma
1 October Friday	**8:00AM** – Depart for **Keystone via Rifle**; Travel to Keystone, Colorado; arrive approximately 3:00PM. End of course at the **Student Reception, Keystone, 6:30 – 8:30PM.**	Keystone, Colorado

Brigham Young University Geology Studies — Special Publication 2

Geologic Map of UTAH

Lehi F. Hintze

1974



DEPARTMENT OF THE INTERIOR
UNITED STATES GEOLOGICAL SURVEY

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<u>Logistics and Field Gear Checklist</u>

- ♦ Participants should arrive at the Hampton Inn Hotel by 6:00 PM on the 25th for a safety and logistics meeting

- ♦ Participants must provide **proof of insurance coverage valid in the U.S.** prior to participation in the course.

- ♦ All participants must bring Personal Protective Equipment – hardhat, steel toe boots, reflective vest, gloves, and eye protection; these PPE are required by the mines- all participants must come prepared.

- ♦ Weather in Utah and Colorado in late September is quite variable, please bring:
  - Long pants and long-sleeve shirts (required for mine visits)
  - Jacket/windbreaker; rain/snow possible, as are sunny days
  - Cap or hat for sun protection
  - One nice set of clothing for company-sponsored dinners
  - Field / hiking boots for field days
  - Sunscreen and lip balm
  - Sunglasses

- ♦ For our field days:
  - rock hammer
  - hand lens
  - hardness tester (scratcher)

- ♦ We will be traveling in two vans, with **very limited space**; **use a <u>duffle bag or soft-sided luggage</u>** for your clothing and personal effects; **<u>no hard-sided luggage</u>**.

- ♦ Remember to bring any **prescription medicines** and your **insurance card/proof of insurance. You should also bring any medical information that would be important in case of an emergency.**

- ♦ Participants are expected to follow ALL safety regulations and rules required at mine sites. As a general rule, mine staff want us to stay together AT ALL TIMES during mine visits, and to be aware of safety issues associated with mines and the mining environment. The field trip leaders will ask about handouts, PowerPoint presentations, etc. Please do not ask our hosts for copies of materials presented before consulting with a field trip leader, as this can be a sensitive issue for the mines. Please note that we carry a first-aid kit with us at all times; please report ANY injury or incident to field course leaders immediately. Please be very careful with rock hammers and be aware of people around you.

- ♦ For underground mine tours – bring cool comfortable clothes to wear under coveralls.

- ♦ SEGF and our mine hosts will provide lodging and transport for students; students **should bring money for snacks/meals, incidental expenses, phone calls, and the like**.

- ♦ All participants must wear seat belts when vehicles are in motion.

Mi Vida Uranium Mine, Lisbon Valley, UT (ca. 2009)

Participants

PARTICIPANTS	UNIVERSITY	COUNTRY	EMAIL
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Bingham

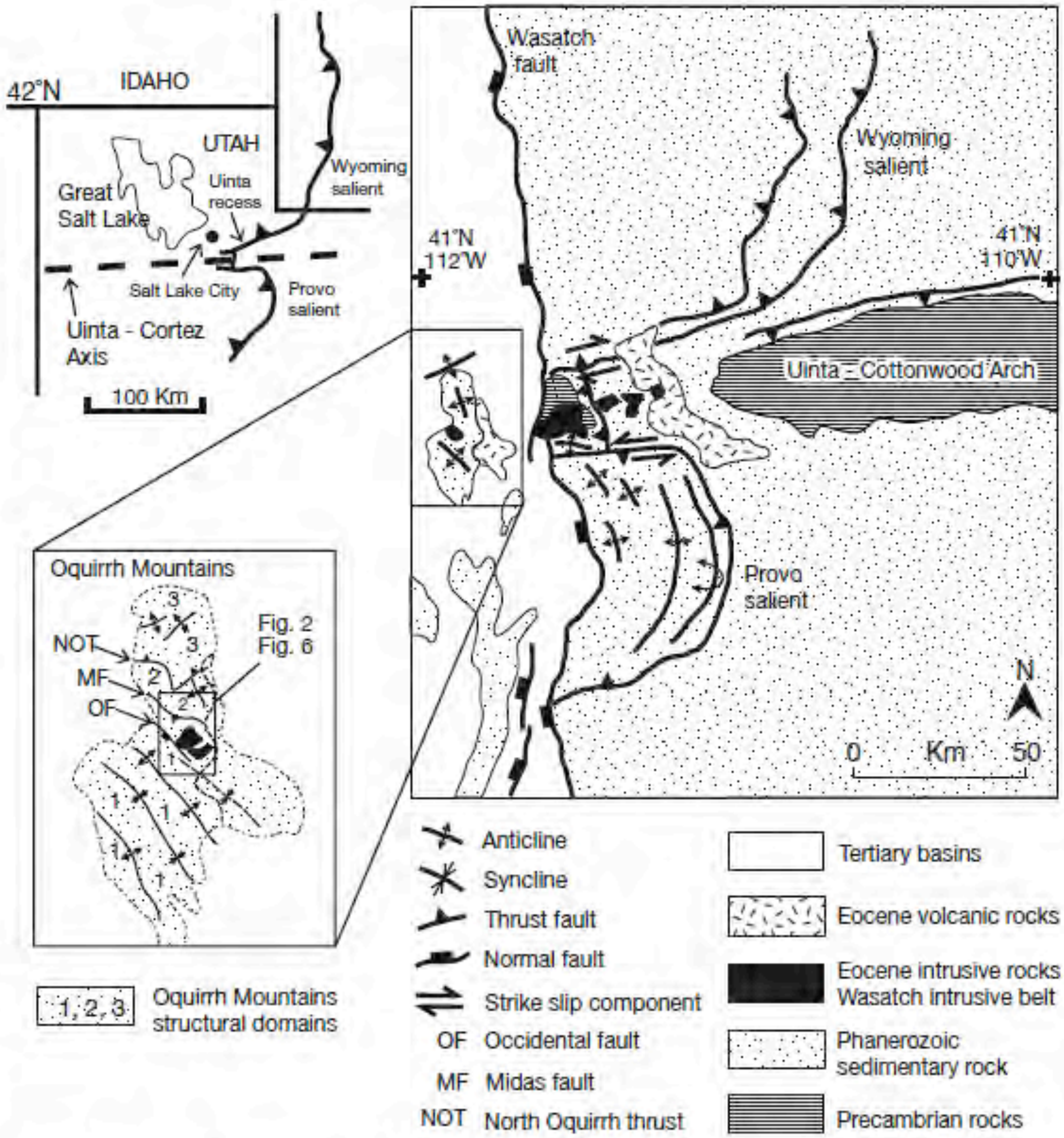


FIG. 1. Map of northeast and north-central Utah, showing major structures in the Sevier fold-thrust belt and in the Uinta recess. The inset map shows three Sevier structural domains in the Oquirrh Mountains and the location of Figures 2 and 6 (after Constenius, 1996; Paulsen and Marshak, 1998, 1999)

From: Kloppenburg *et al.*, 2010

Bingham

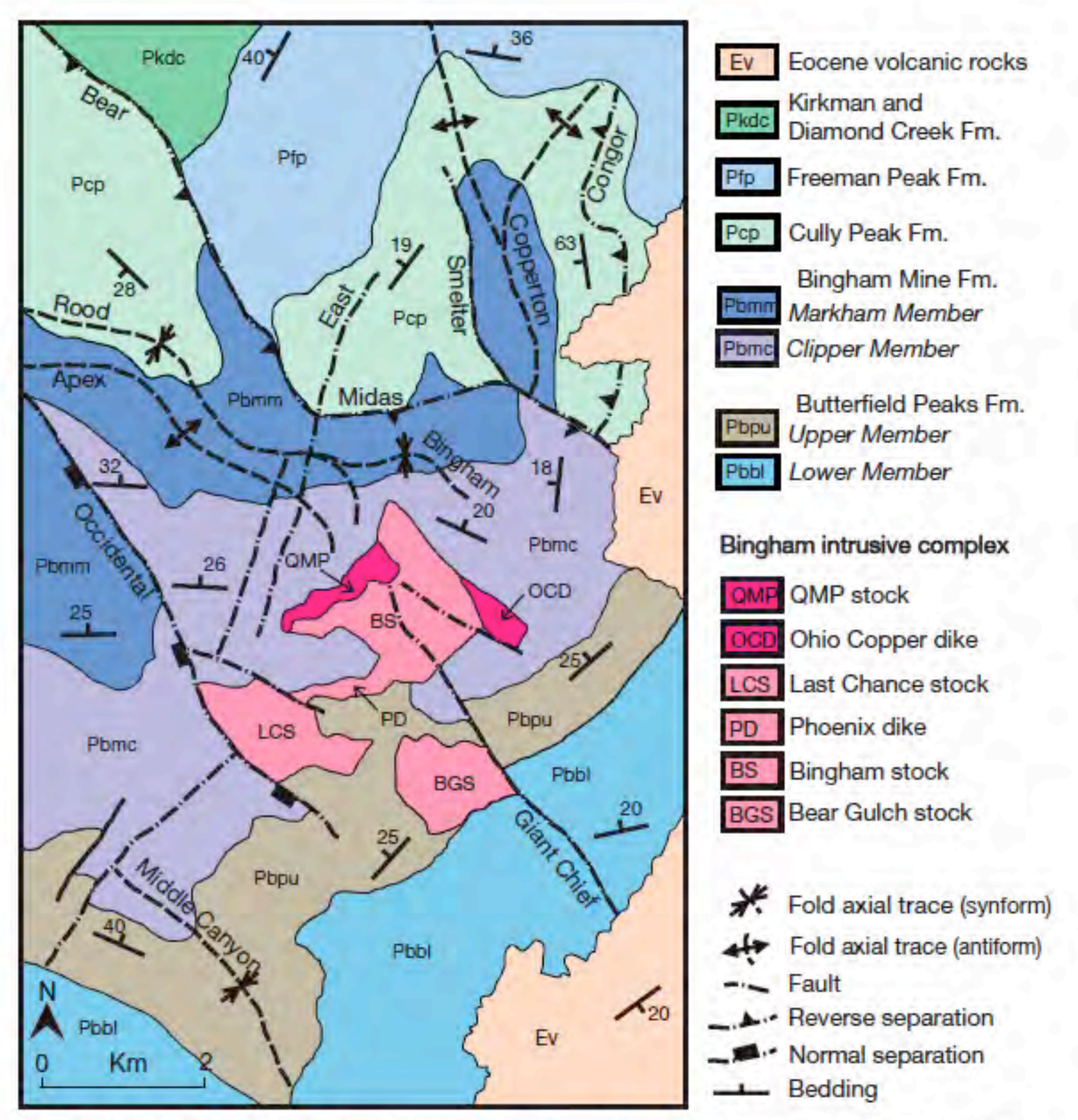
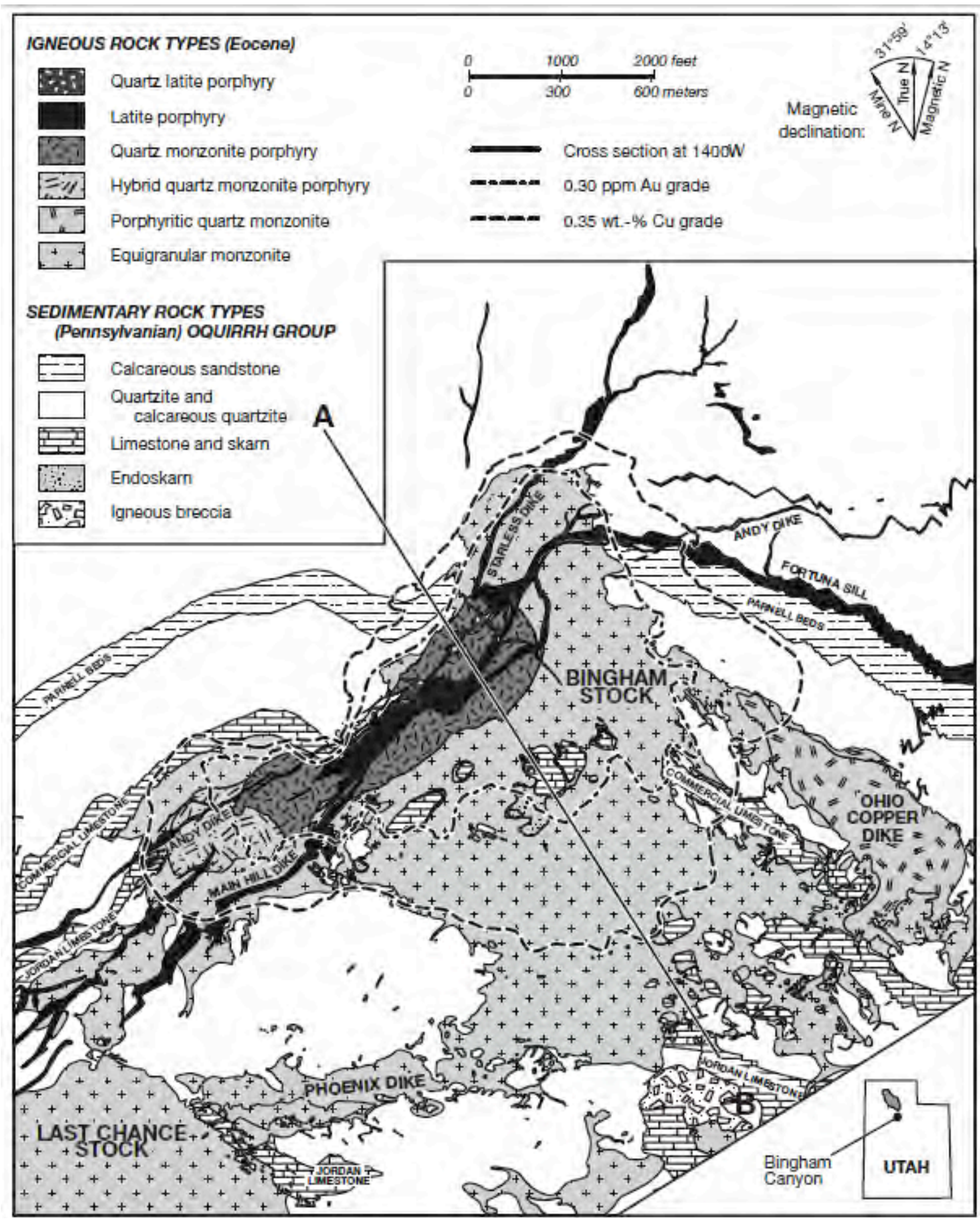


FIG. 2. Geologic map of the Bingham district, showing the major structures and intrusions (after Laes et al., 1997).

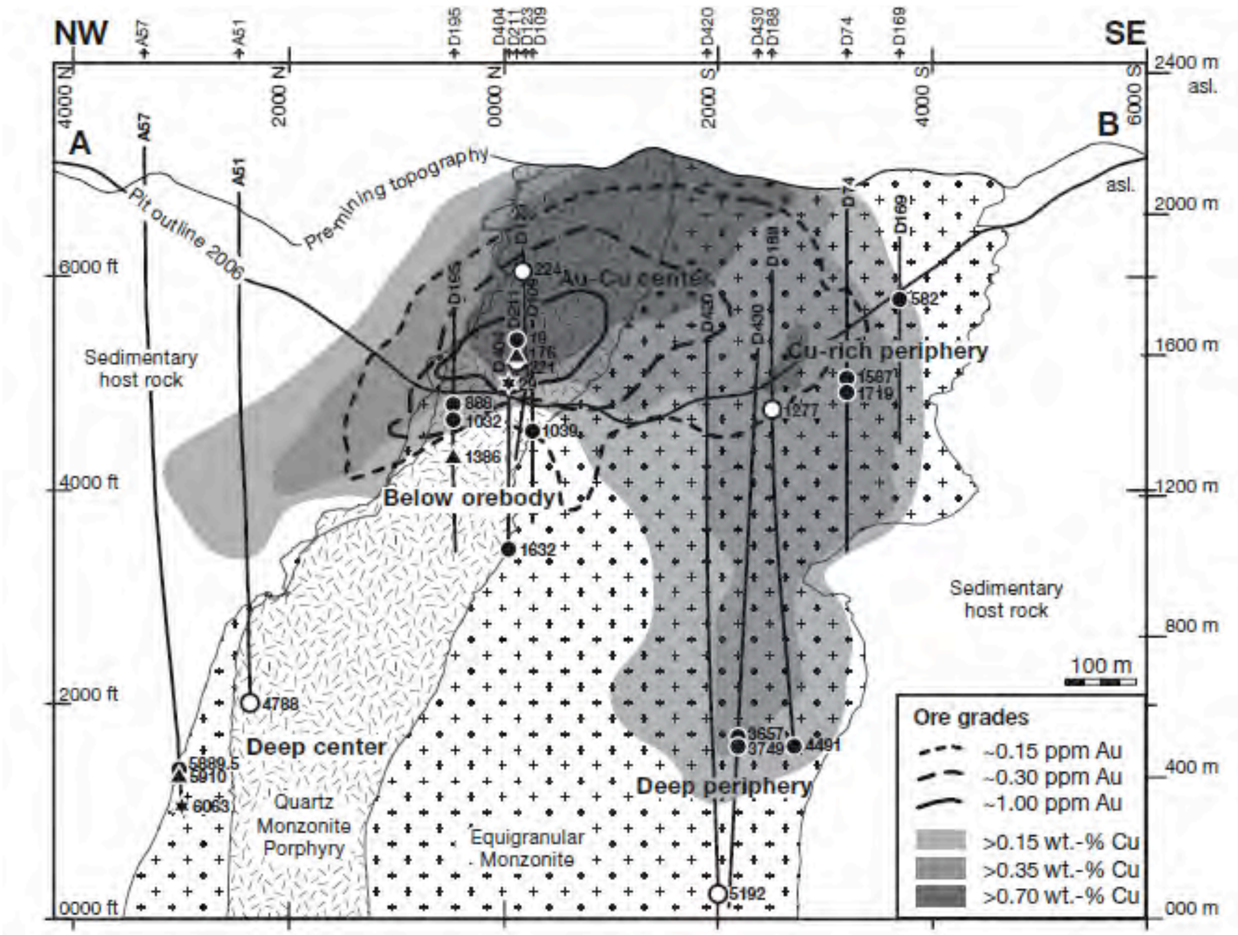
From: Kloppenburg *et al.*, 2010

Bingham



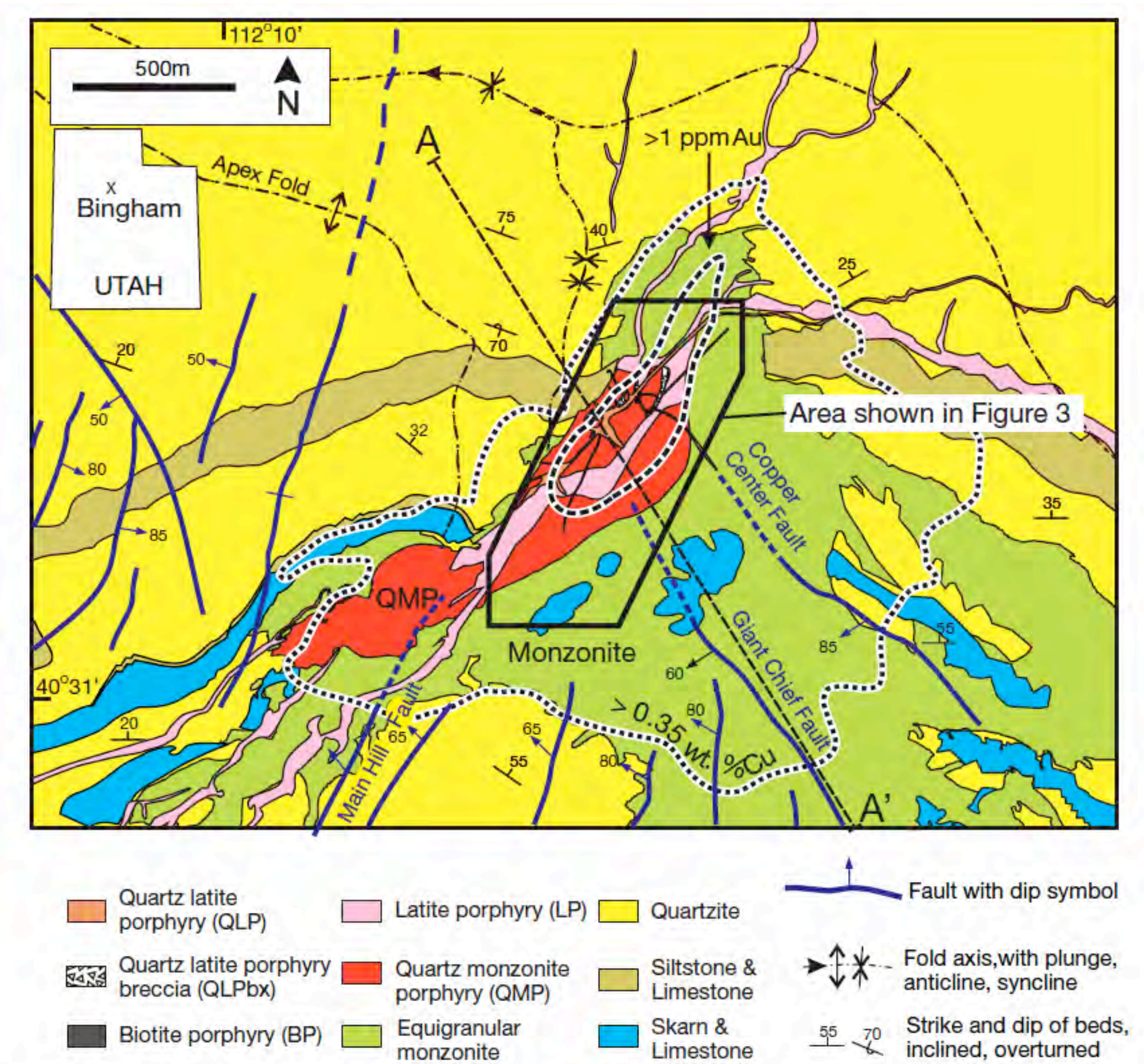
From: Landwing *et al*., 2010

Bingham



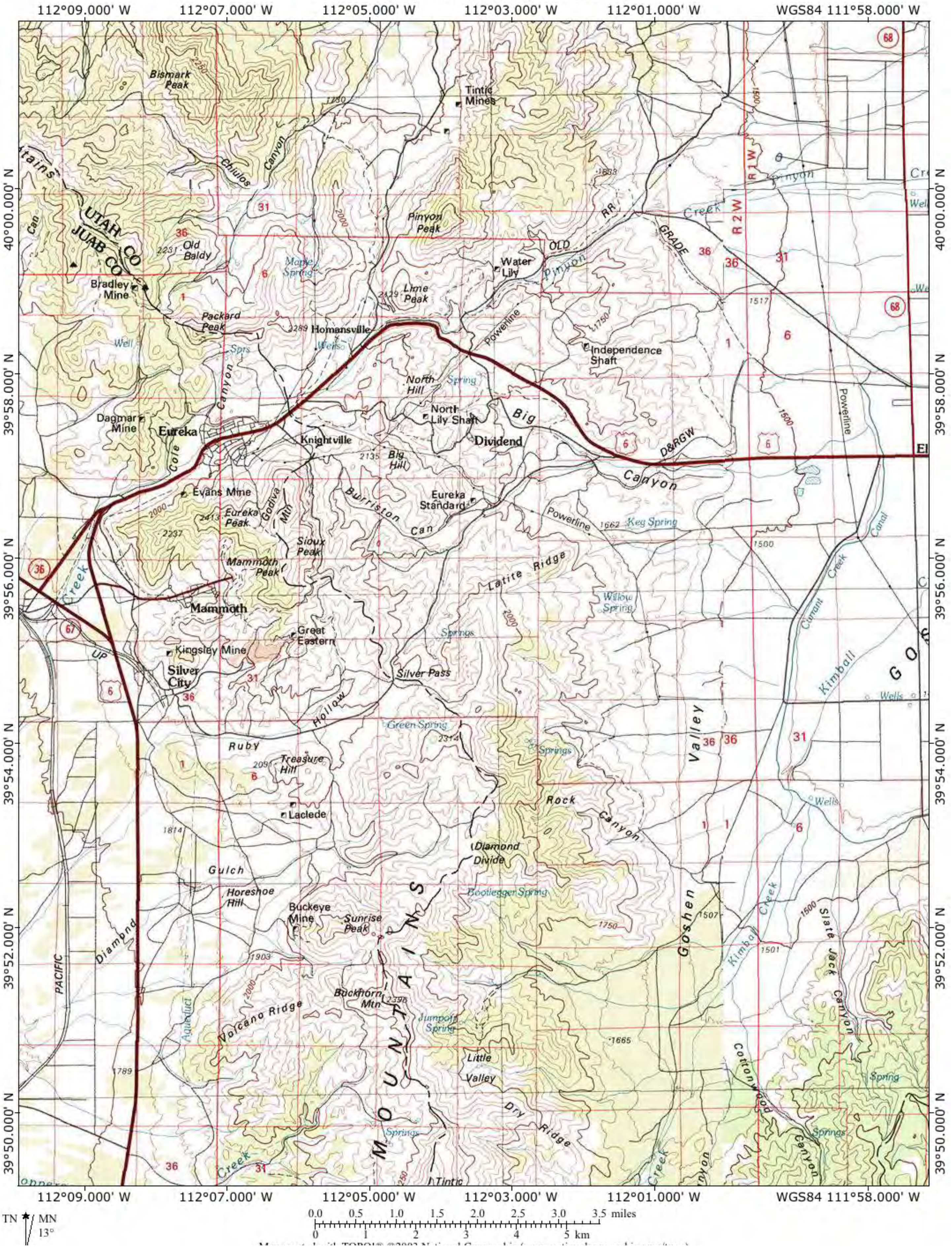
From: Landwing *et al*., 2010

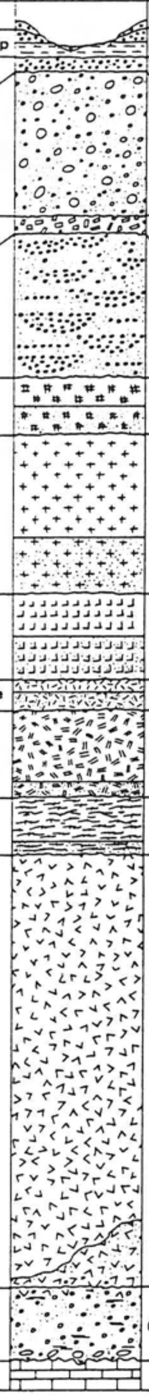
Bingham



From: Redmond & Einaudi, 2010

TOPO! map printed on 05/22/10 from "Untitled.tpo"





SERIES	GROUP, FORMATION, OR UNIT		LITHOLOGIC CHARACTER	THICKNESS (FEET)	DESCRIPTION
Holocene		Younger alluvium		0 - 50	Alluvium in most modern stream valleys
Pleistocene		Lake Bonneville Group		0 - 200	Lacustrine deposits of Alpine and Bonnevile Formations
Pleistocene		Terrace gravel		0 - 100	Gravel and sand in partly dissected benches
Pleistocene		Older alluvium		0-1,000+	Chiefly fanglomerate underlying thin alluvium and lacustrine deposits in Goshen Valley and the larger stream valleys that extend into the range
Miocene		Silver Shield Quartz Latite		0 - 125	Dark-gray coarse-grained quartz latite porphyry
Miocene		Pinyon Creek Conglomerate		0-1,000+	Poorly sorted moderately well stratified conglomerate consisting of boulders and cobbles of volcanic rock embedded in grit and sand; many channeled contacts
Oligocene	Laguna Springs Volcanic Group	Tintic Delmar Latite		0-400+	Flow member is gray to dark-reddish-brown medium-grained latite porphyry; tuff member is buff to white fine- to coarse-grained tuff
Oligocene	Laguna Springs Volcanic Group	Pinyon Queen Latite		0-1,100+	Flow member is dark-reddish-brown medium- to coarse-grained latite porphyry characterized by large white plagioclase phenocrysts; tuff member consists of intermixed fine-grained and boulder tuff, and agglomerate
Oligocene	Laguna Springs Volcanic Group	North Standard Latite		0-600	Flow member is purplish-gray medium-grained latite vitrophyre; tuff member is gray to white heterogeneous boulder tuff
Oligocene	Tintic Mountain Volcanic Group	Big Canyon Latite		0 - 200	Flow member is dark-gray fine-grained latite; tuff member is buff to white fine-grained tuff
Oligocene	Tintic Mountain Volcanic Group	Latite Ridge Latite		0 - 600	Welded tuff member is reddish-brown densely welded tuff and breccia; airfall tuff member is fine-grained white tuff
Oligocene	Tintic Mountain Volcanic Group	Copperopolis Latite		0-400+	Flow member is black to reddish-brown fine-grained latite; tuff member is white fine-grained vitric tuff
Oligocene		Packard Quartz Latite		0-3,000+	Chiefly pinkish- or lavender-gray medium-grained quartz latite porphyry. Generally divisible into an upper unit of dark-green to black vitrophyre and tuff as much as 500 feet thick; a middle unit of quartz latite porphyry locally more than 2,700 feet thick; a lower unit of dark-green to black vitrophyre as much as 200 feet thick; and a basal unit of fine-grained tuff as much 700 feet thick
Oligocene		Apex Conglomerate		0 - 500	Prelava soil and rubble, ranging from claystone to coarse conglomerate
Paleozoic rocks					Folded, faulted, and deeply eroded sedimentary strata

Figure 3. Columnar section of layered Cenozoic rocks, Tinitc districts (modified from Morris and Lovering, 1979).

SYSTEM or SERIES	FORMATION	LITHOLOGIC CHARACTER	THICKNESS (FEET)	DESCRIPTION
Upper Mississippian	Great Blue Formation		+100	Topliff Limestone Member: blue-gray limestone
	Humbug Formation		650	Interbedded blue-gray sparsely cherty limestone and persistent lenses of buff sandstone
	Deseret Limestone		1,000-1,100	Uncle Joe Member: light-gray massive cherty coquinoid limestone about 550 feet thick Tetro Member: medium-gray, cherty, sandy, and argillaceous limestone about 475 feet thick Phosphatic shale member: sooty black phosphatic shale and silty limestone 5 - 150 feet thick
Lower Mississippian	Gardison Limestone		500	Upper member, about 125 feet thick, is blue-gray massive cherty limestone; lower member, about 375 feet thick, is blue-gray medium-bedded fossiliferous limestone
Lower Mississippian and Upper Devonian	Fitchville Formation		300	Eight distinctive units of limestone and dolomite, some cherty. Stromatolitic limestone at top
Upper Devonian	Pinyon Peak Limestone		70–125	Blue-gray silt-streaked limestone
	Victoria Formation		250-300	Interbedded gray dolomite and buff quartzite; some lenses of penecontemporaneous breccia
Devonian, Silurian, and Upper Ordovician	Bluebell Dolomite		335-600	Dusky-gray massive dolomite; cherty near top. Prominent stromatolitic dolomite unit 275 - 300 feet above base
Upper Ordovician	Fish Haven Dolomite		200-345	Dusky-gray massive dolomite; mottled and cherty near top
Lower Ordovician	Opohonga Limestone		300-850	Light-blue-gray thin-bedded argillaceous limestone with many thin layers of flat-pebble conglomerate. Cherty and sandy at base
Upper Cambrian	Ajax Dolomite		650	Mostly dusky-blue-gray medium-bedded cherty dolomite. Emerald Member, a thin unit of grayish-white, mottled dolomite, 90 - 180 feet above base
	Opex Formation		145–245	Interbedded sandy limestone, shale, and sandstone
Middle Cambrian	Cole Canyon Dolomite		830-900	Interbedded dusky blue-gray dolomite like Bluebird Dolomite, and creamy white laminated dolomite like Dagmar Dolomite. Sparsely cherty
	Bluebird Dolomite		185	Dusky-gray dolomite with short white markings
	Herkimer Limestone		350-430	Blue-gray argillaceous limestone; zone of gray-green shale about 180 feet above base
	Dagmar Dolomite		65–100	Creamy-white laminated dolomite
	Teutonic Limestone		390-420	Blue-gray argillaceous limestone with pisolitic beds in lower part
	Ophir Formation		375-425	Upper shale member: gray-green shale Middle limestone member: limestone and shale Lower shale member: shale; sandy at base
Lower Cambrian	Tintic Quartzite		+1,200 (Base not exposed)	Buff, prominently bedded quartzite; gray-green phyllitic shale beds in upper 500 feet. Chloritized basalt flow 980 feet above base, and lower 500 feet or so conglomeratic in adjacent areas Total thickness in adjacent areas is 2,300 - 3,200 feet

Figure 2. Columnar section of Paleozoic rocks, Tintic districts (modified from Morris and Lovering, 1979).

Tintic Mining District

From: Krahulec & Briggs, 2003

Age	Formation	Member	Thickness (ft)
MISSISSIPPIAN	Great Blue From-ation	Poker Knoll Limestone Mbr	600
		Chiulos Member	900
		Paymaster Member	620
		Topliff Limestone Mbr	460
	Humbug Formation		650
	Deseret Limestone	Uncle Joe Member	550
		Tetro Member	475
		Delle Member	5-150
	Gardison Limestone		450-550
DEV	Fitchville Formation		300
	Pinyon Peak Limestone		270
	Victoria Formation		600
Sil	Bluebell Dolomite		300
ORD	Fish Haven Dolomite		200-350
	Opohonga Limestone		300-900
CAMBRIAN	Ajax Dolomite		550-660
	Opex Formation		140-350
	Cole Canyon Dolomite		830-1300
	Bluebird Dolomite		150-220
	Herkimer Limestone		350-430
	Dagmar Dolomite		65-200
	Teutonic Limetsone		390-420
	Ophir Formation		300-430
	Tintic Quartzite		2300-3200
PRO	Big Cottonwood Formation		2600+

After Morris, 1964a; Morris, 1964b; Morris, 1968; and Morris, 1975.

Tintic Mining District

From: Krahulec & Briggs, 2003

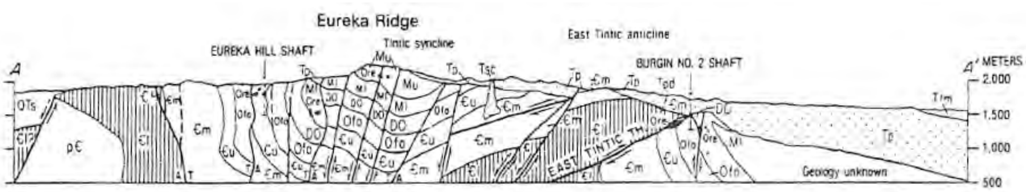


Figure 5 (cont.). Geologic map of the Tintic mining districts, central East Tintic Mountains, Utah (reproduced with permission from Morris, 1985).

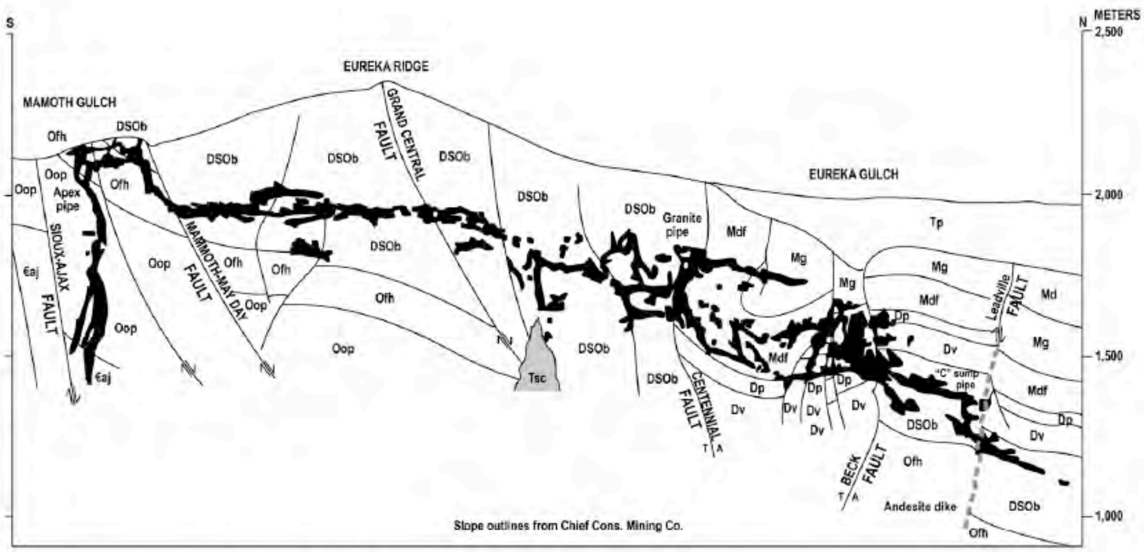


Figure 4. Longitudinal section of the Mammoth-Chief ore zone in the Main Tintic subdistrict showing ore bodies projected horizontally to the plane of the section. Section extends from Mammoth mine northward through Victoria mine and about 1 km beyond Chief No. 1 shaft. Caj, Cambrian Ajax Dolomite; Oop, Ordovician Opohonga Limestone; Ofh, Ordovician Fish Haven Dolomite; DSOb, Devonian, Silurian, and Ordovician Bluebell Dolomite; Dv, Devonain Victoria Formation; Dp, Devonian Pinyon Peak Limestone; MDf, Mississippian and Devonian Fitchville Formation; Mg, Mississippian Gardison Limestone; Md, Mississippian Desert Formation; Tp, Tertiary Packard Quartz Latite; Tsc, Tertiary Silver City monzonite porphyry stock. Ore bodies are in black. Based on stope outlines from Chief Consolidated Mining Co. as shown in Evans, 1957 and Morris, 1990.

Tintic Mining District

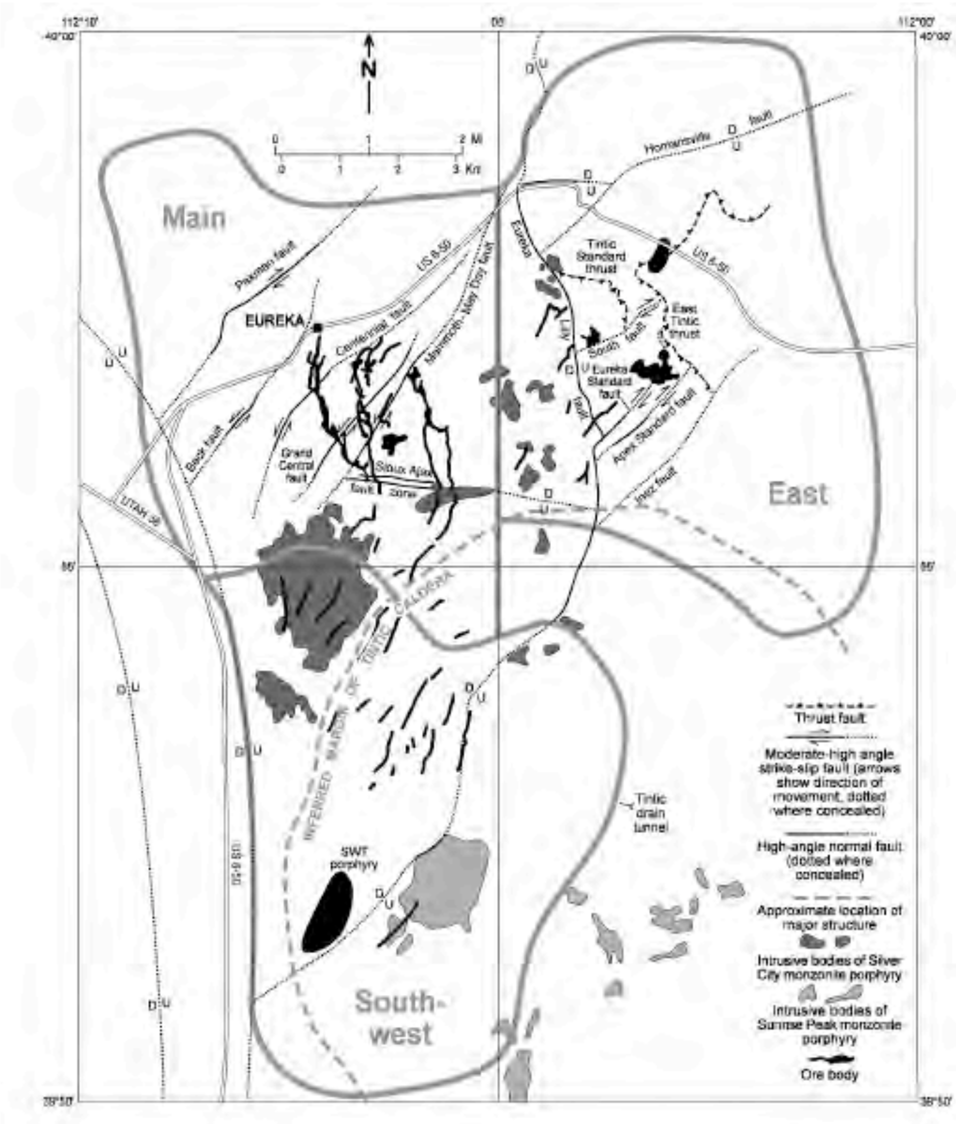
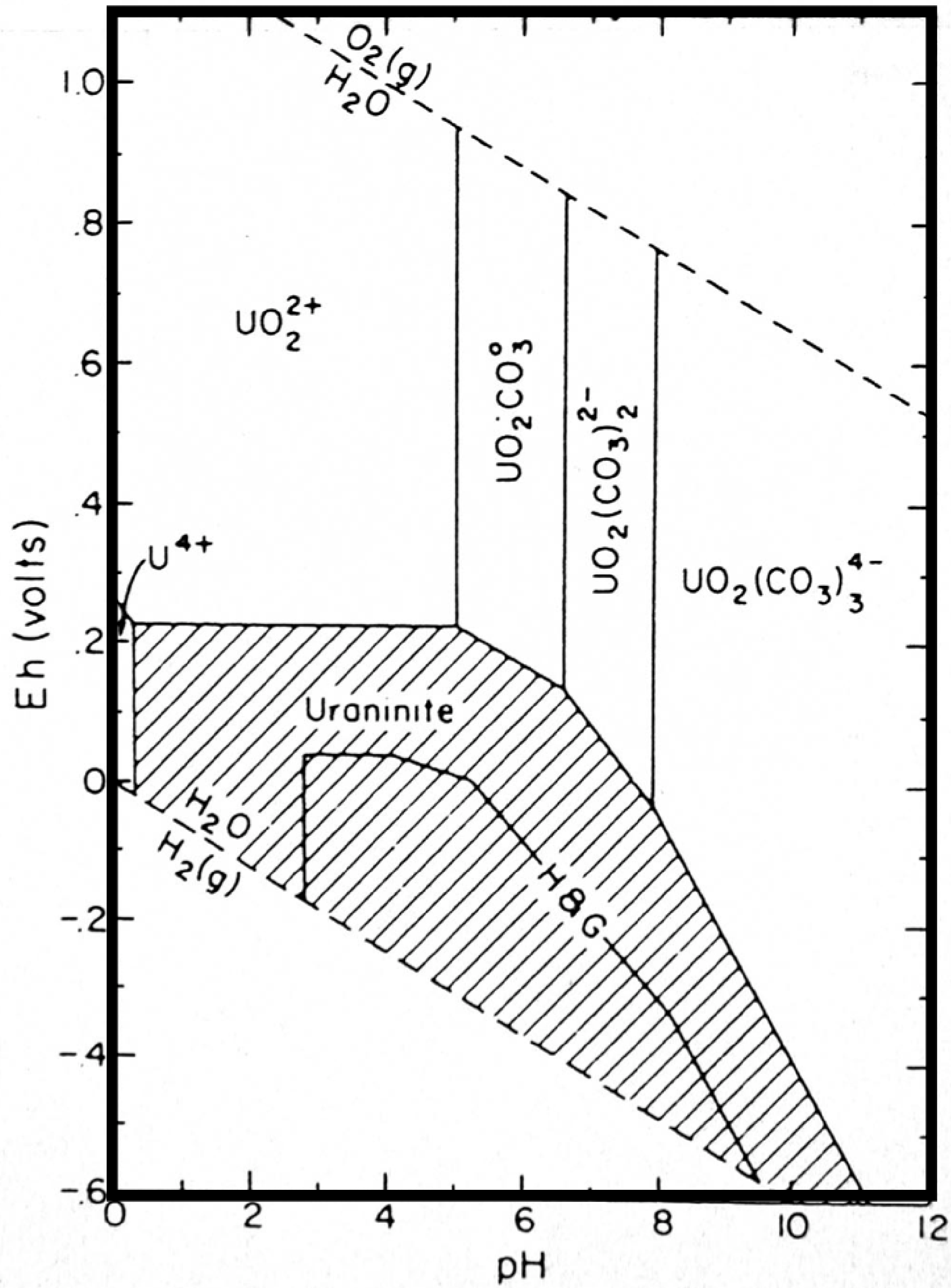


Figure 3. Generalized structure map of the Main, East, and Southwest Tintic sub-districts; modified from Morris and Mogensen (1978). The major highways and the town of Eureka are shown for geographic reference. The map also shows the larger intrusive bodies of the Silver City monzonite and Sunrise Peak monzonite as well as the approximate surface projections of the more important ore bodies.

From: Krahulec & Briggs, 2003



$O_2(g)$ / H_2O
UO_2^{2+}
$UO_2CO_3^{\circ}$
$UO_2(CO_3)_2^{2-}$
$UO_2(CO_3)_3^{4-}$
U^{4+}
Uraninite
H_2O / $H_2(g)$
H&G
Eh (volts)
pH
1.0
.8
.6
.4
.2
0
-.2
-.4
-.6
0
2
4
6
8
10
12

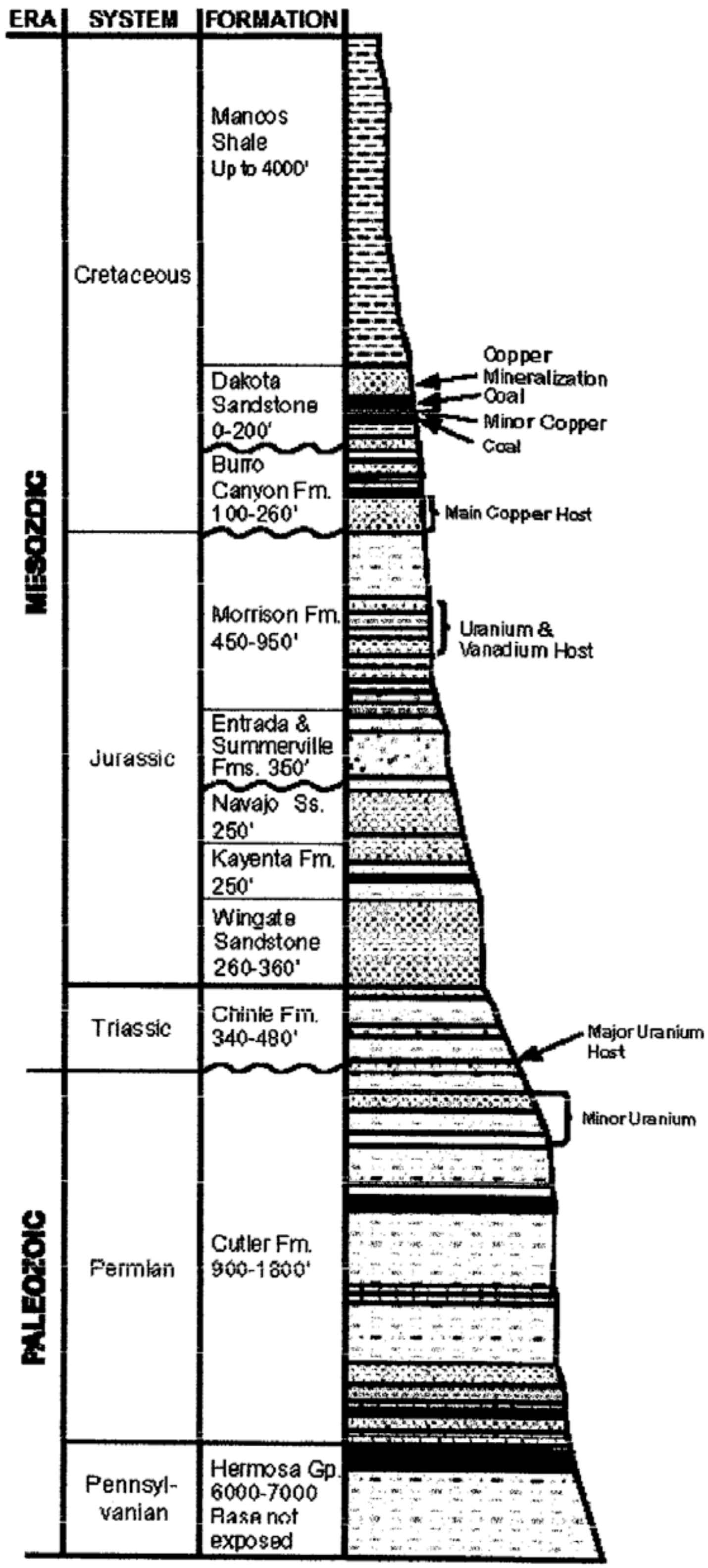
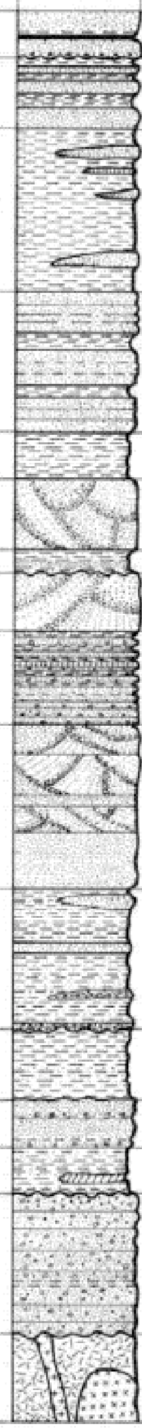


Figure 5. Stratigraphic column in the Lisbon Valley area; modified from Wood, 1968.

STRATIGRAPHIC SECTION
GATEWAY—URAVAN AREA
MESA AND MONTROSE COUNTIES, COLORADO



AGE	GROUP	FORMATION	MEMBER	LITHOLOGY	THICKNESS Feet	CHARACTER
Upper Cretaceous		Dakota Sandstone			100 +	Yellow, red, and brown lenticular sandstone and conglomerate with interbedded carbonaceous shale and impure coal. Top not exposed.
Lower Cretaceous		Burro Canyon Formation			100–210	White, gray, and red sandstone and conglomerate with interbedded green and purplish shale.
Upper Jurassic		Morrison Formation	Brushy Basin		300–500	Variegated bentonitic shale and mudstone, rusty-red and red sandstone and conglomerate; local thin limestone beds.
Upper Jurassic		Morrison Formation	Salt Wash		240–360	White, gray, buff, and rusty-red and red sandstone; red, reddish-brown, green and gray mudstone; scattered thin limestone beds.
Middle Jurassic		Summerville Formation			75–130	Red, gray, green, and brown, thin-bedded, sandy shale and mudstone.
Middle Jurassic	San Rafael	Entrada Sandstone	Slick Rock		80–200	Orange, buff, and white; fine-grained, massive and crossbedded sandstone.
Middle Jurassic	San Rafael	Entrada Sandstone	Dewey Bridge		5–90	Red, buff, and orange mudstone, siltstone, and sandstone.
Lower Jurassic	Glen Canyon	Navajo Sandstone			0–120	Buff and gray crossbedded, fine-grained sandstone. Contains 6-foot of limestone on Sewemup Mesa. Thickens to west.
Lower Jurassic	Glen Canyon	Kayenta Formation			90–300	Red, buff, gray, and lavender, irregularly bedded, fine- to coarse-grained sandstone, siltstone, and shale. Few lenses of conglomerate and limestones. Thins to northeast.
Lower Jurassic	Glen Canyon	Wingate Sandstone			275–400	Reddish-brown, fine-grained, thick-bedded, massive, and crossbedded, cliff-forming sandstone.
Upper Triassic		Chinle Formation			120–450	Red to orange-red siltstone, with interbedded lenses of red sandstone, shale, and limestone-pebble and clay-pebble conglomerate. Lenses of quartz-pebble conglomerate and grit at base. Thins to northeast.
Middle Triassic (?)		Moenkopi Formation	Upper Member		0–180	Chocolate-brown, thin- and ripple-bedded shale with interbedded sandstone. Thins to east.
Lower Triassic		Moenkopi Formation	Middle Member		0–200	Chocolate-brown ledge-forming beds of shale, sandstone, and arkosic conglomerate. Thins to east.
Triassic (?)		Moenkopi Formation	Lower Member		0–200	Reddish to yellowish-brown indistinctly bedded, poorly sorted, sandy mudstone. Local gypsum beds near base. Thins to east.
Lower Permian		Cutler Formation			0–7,800	Maroon, red, mottled light-red, and purple conglomerate, arkose, and arkosic sandstone. Thin beds of sandy mudstone. Thins to northeast.
Precambrian Complex					Base not exposed	Gray, medium-grained granite containing xenoliths of hornblende and biotite schists and gneisses. Intruded by pink granite, pegmatite and aplite dikes, and hornblende-rich dikes.

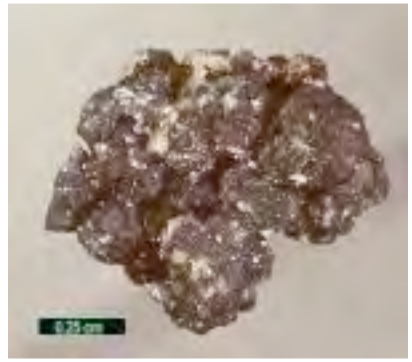
NOTE: The Summerville Formation is now considered to be the Wanakah Formation and the Tidwell Member of the Morrison Formation

(modified from Chenoweth 1980)

Coffinite

$USiO_4$

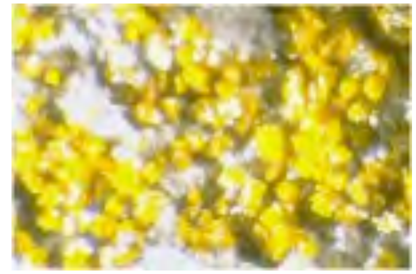
Black, interstitial coffinite cementing a sub-angular quartzose sandstone



Ningyoite

$CaU(PO_4)_2 \cdot H_2O$

Greenish-black fine grained masses



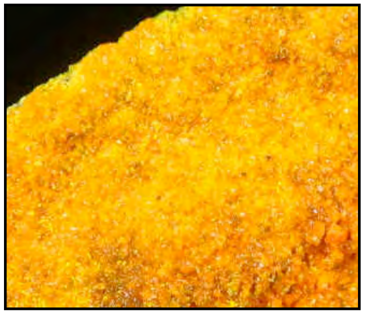
Carnotite

$K_2(UO_2)_2(VO_4)_2$

Tyuyamunite

$Ca(UO_2)_2(VO_4)_2$

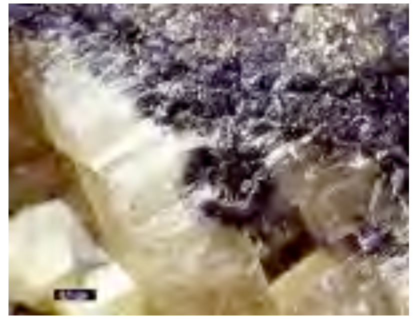
Bright yellow rosette crystals



Pascoite

$Ca_3V_{10}O_{28}\bullet 17(H_2O)$

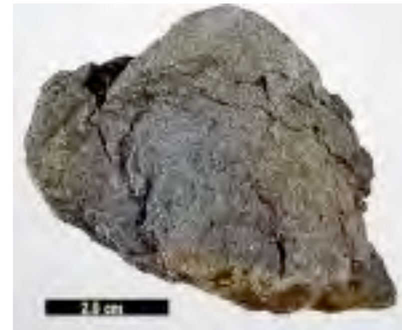
Bright orange sugary crusts of pascoite across sandstone matrix



Doloresite

$V_6O_{12}*4H_2O$

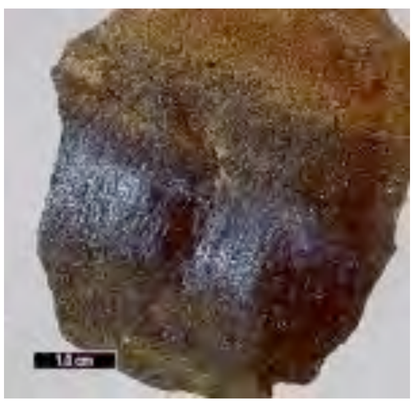
black radiating and crystalline doloresite with white calcite



corvusite

$(Na,Ca,K)V_8O_{20}\bullet 4(H_2O)$

ilky to dull brown corvusite in/on sandstone



Montroseite

$V^{3+}_{0.6}Fe^{2+}_{0.3}V^{5+}_{0.1}O(OH)$

Black silky fibrous montroseite on sandstone with tyuyamunite

Uranophane

$Ca(UO_2)_2(SiO_3)_2(OH)_2$

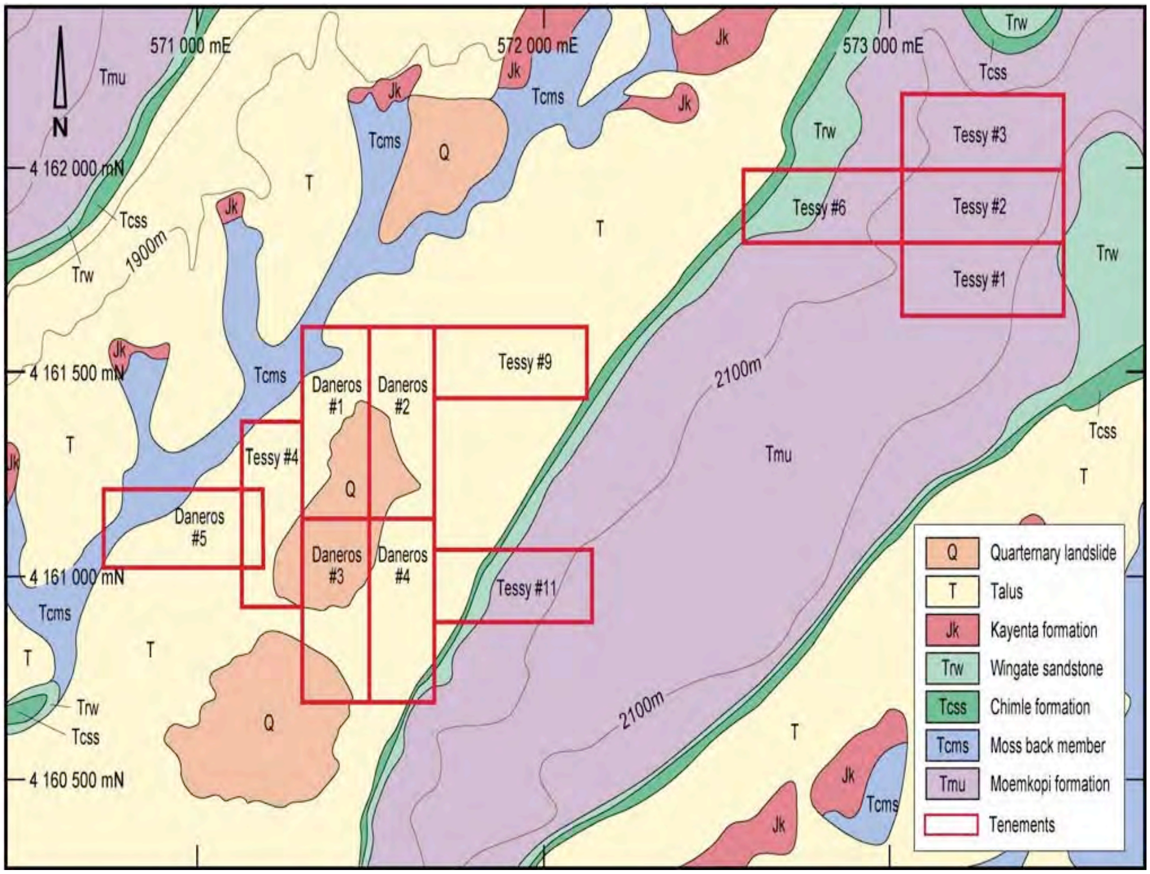
Yellow uranophane acicular crystal tufts

Autunite

$(H,Na,K)_2(UO_2)_2(PO_4)_2$

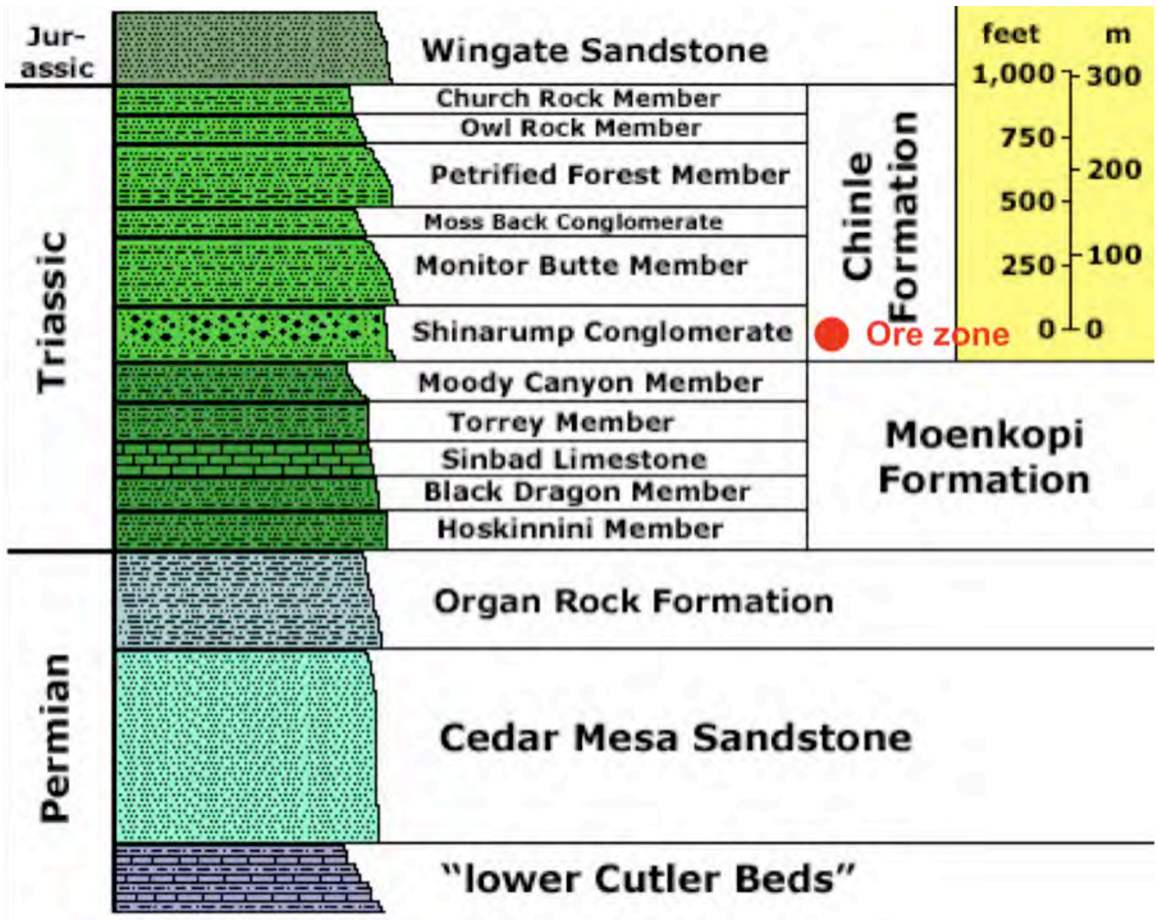
Fluorescent, tabular to platy, yellow green autunite crystal

Daneros Mine



White Canyon Uranium Limited, 2009

Daneros Mine



White Canyon Uranium Limited, 2009

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Many of the articles listed above are available in electronic format on the following website: http://www.mines.utah.edu/pyrite/SEGF2010/index.htm

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At the end of the trip, and as soon as possible, please send a brief e-mail to Gordon Putnam with a copy to John Thoms and Brian Hoal describing your experience on the trip and acknowledging the support of the Society of Economic Geologists. This is very important, as the feedback received by SEG is critical for the planning of future field course trips. You will also find that maintaining contact in this manner will greatly benefit your career what ever course you may follow. Your note may be in your native language.