Tooele 30x60 Field Review Discussion Outline

Day 1 (May 9)

Start ~7:15 am, Intro 30-45 min, Depart 7:45-8:00

1-0

Mapping Program Overview (Grant)

History

Mapping Scales

Now 2 primary scales 1:24K, 1:62K

Poster of 30x60 Status Progress Pre-Statemap and Statemap

Thanks (Don)

Thank you for your attendance today and support of mapping program

Wonderful to be part of the strong geologic community in Utah

Extend thanks to coauthors – Jack Oviatt, Dave Dinter

And to other speakers Eric C, Ken K., Jim P.

And UGS colleagues - Grant, Bob, Jon for their support

Basia and Kent for their work on the GIS and imagery

Geologic Overview of Map Area (Don)

Poster of N UT geomap, handouts

About 2 billion yrs geologic time (Precambrian to Present)

Total of 137 map units

Basement rocks – Antelope Island

Exposed cover rocks – few Neoprot, much Paleozoic (41,000 ft/7.8 mi/12.5 km), few Mesozoic

Tertiary sedimentary and volcanic rocks – covering and filling basins

Quaternary surficial deposits – blanket from several types of depositional environments, mostly alluvial and lacustrine (Lake Bonn, GSL)

Key Structural Features –

Uinta axis (intermittently active through time)

Wasatch hingeline (marks stable craton E and passive

margin/miogeocline W, related to PC rifting)

Oquirrh basin

Sevier fold-thrust belt – compressional tectonics (E. Cret to Eocene)

Basin and Range/E Great Basin – extensional tectonics (Miocene to Recent)

There are many geologic issues to wrestle with, we would appreciate your input along the way.

On this trip, trying to give a good overview of map. However, large group and limited time necessitate some overview/arm waving-type stops (less of that in Day 2). Will try to keep the discussion general enough for a wide audience, but don't hesitate to ask for clarification.

Safety (Grant/Don)

Collect consent forms (Non-UGS people)

Driving, traffic, poor road conditions, cattle, dust

Lightning

Remoteness

Hiking on uneven terrain

Stay well off roadways

Snakes, scorpions, bugs, allergies

Logistics (Don, Grant)

Day 1 schedule/Day 2 schedule

Stops/Coordinates/Timing

Driving directions

Restrooms

Gas up vehicle

Caravan vs. not

Coordinate vehicles (5 UGS vehicles, may be some room)

Trip Leaders and Tooele Hospital (see List of Stops)

Notify trip leaders if leaving, problems

1-1 Copperton/Bingham, Pz strat, Sevier Structure, Tertiary volc and sed rx, (Don), Petrogenesis (Eric), Resources (Ken), Tertiary and Q (Don and Jack?)

Mapping Methods:

30x60 Series, 1:62,500 scale/intermediate, more detailed than prior regional-scale (1:250K) maps of Stokes (1963), Moore and Sorenson (1979)

4-year project, Statemap funded, Mapping Poll highest # of 30x60 requests
Poster of Mapping Sources/year

Yr 1 – 12 E quads (Don/Jack contract, Dinter GSL fault zone mapping provided)

Yr 2 – 10 quads to W (Don/Jack)

Yr 3 – 8 quads to W (Don, no Jack)

Yr 4 – 2 quads, details and completion (Don)

Mapping compiled from several sources, will discuss at each stop

Key Point - This map is not just current authors work, but represents decades of geologic research! Every map is a progress report, and future generations will improve on our work.

Generally newer and more detailed maps on E, older and less detailed on W

We updated and revised geology where needed using field work in key areas,

using statewide stereo NAIP imagery (thanks to Kent)

we refit or redrew geology from older maps so our geospatial accuracy is much better than older 30x60 (1:100K) maps

We used select drill hole, water well, and publically available geophys data to map faults, delineate basins, draw cross sections

Compiled geologic data to an ArcGIS geodatabase (thanks to Basia M)

Mapping Sources:

Bingham Cyn quad - Swenson and Kennecott staff, 1991 guidebook, 1:24K

Pit Map – KUCC, 2009, 1:4800

Oquirrh Mtns map – Laes, Krahulec and others, 1997, 1:62K

Magna and Copperton 7.5s – Biek, Solomon, Smith, Keith

Thanks for Kennecott/Rio Tinto for access

Pz Bedrock:

Oquirrh Group (Penn, L Perm), overlying L-M Permian Fms (Pdk, Ppp)

Oquirrh Fm (Gilluly, 1932)

Per LFH "Formational nomenclature for Oquirrh Gp has been slow to become established.

Several attempts to subdivide

Thick, monotonous unit present across several thrust sheets in 2 sub-basins

State geomap

USGS (T&R) and Kennecott geologists worked together and sometimes at odds

Current scheme lithostratigraphic with aid of microfossils – fusulinids and condonts

Fossil poster, Lith column

Nomenclature:

figure 3 poster

Bingham sequence of T&R, includes some lower P fms per Kennecott

Do this to match Wasatch Range nomenclature package

Sevier belt structure – complexly folded and faulted

Poster Structural features

Uinta axis – Tooker and Roberts (several lines of evidence, not universally accepted idea)

Midas/Bear to S

N Oquirrh and Black Rock to N

1) PC suture
2) Tert uplift Bingham
3) Ig rocks to W
4) local uplifts
5) geophys evid

Assume that E directed sheets impinged upon the Uinta axis (T&R, 1971; Crittenden, 1976)

But also Champion and Congor thrusts near axis, not affected?

No detailed structural work here to confirm (as has been done by Yonkee and others to N)

Garfield and Arthur faults-

Strange, much vertical offset. Also folded, possibly some lateral movement to account for map relations.

Tertiary rx:

Tso – 3 patches, cgl and ss (siliceous) at Harkers Cyn

1 overlain by Tv, 1 intruded by Ti

DZ age of 40 Ma (Harkers Cyn)

Tertiary volcanic rx:

38-39 Ma Older extrusive and volcaniclastic rx (Tvfou, intermed lava flows, Tvlo, lahars, debris avalanches)

~37-39 Older intrusive rx (Tipqm, Tiqmp, Tim, Tilp, Tiqlp)

Ages: Younger Suite (to S) ~30-37 Ma

Older Suite ~37-39 Ma

Bingham mine xsections?

Eric C. will talk about volcanic rx petrogenesis

Ken K. will talk about associated resources

Tsl:

Overlying Tv along range front is what we call Salt Lake Fm in 2 lithosomes – gravel, fine-grained

Tslg- is unconsol gravel etc that looks like an older alluvial fan deposit (QTaf of Biek and Solomon, Harkers fanglomerate of Slentz), but contains tephra (volcanic ash), Blacktail Creek ash (6.6 Ma)

tephrochron work by Barb Nash UU- EMP, database

Tslf – To E of Tslg, marlstone, micrite, claystone, ss, tephra (Tsl, Jordan Narrows unit of B/S, Slentz)

Tephrochron BTC (6.6), Walcott (6.4 Ma), Wolverine Creek (5.6 Ma?)

No direct ages since no dateable material

Also sampled tephras at ATK, but no conclusive matches with UU database

Quaternary deposits-

Qafo, incised by BSL and Provo SL

Alluvial and lacustrine deposits, mixed deposits (Qla)

B&R normal faulting bounds the range

Harkers fault appears to bound Miocene deposits, not sure cuts any Q probably ends here on S according to Kennecott, could extend farther to N (fix bar/ball)

1-2 GSL State Park/Marina, Great Salt Lake fault zone (Jim P), GSL cores and chronology, Lake Bonneville (Jack), adjacent mapping, Transverse zone, Wasatch culmination (Don)

Q Mapping etc:

Q mapping and West Valley FZ work by Adam and Mike in Baileys Lake quad (2015 review)

Adam also mapped adjacent Q areas to W and N

Geophys data suggests the WVFZ continue to N (MRE is _____)

New prison site is slated in the Baileys Lake quad

Notable feature is the Kennecott Tailings Impoundment-

Active N part permitted to 247 ft ht; inactive S part ~215 ft ht

Sits on ground surface (~4215 ft)

GSL bathymetry – provided by Rob Baskin, includes 4200 ft shoreline and 1 ft contours

Tertiary basin, GSL-

Figure seismic line

GSL Amoco AI well 10,419 ft and seismic line 39 (Bortz)

This is the South Basin (BR ridge from Carrington to Fremont)

Palynology data indicated (Pleist ~3000 ft, Plio ~2000 ft, Mio~5000 ft) seds and rx

Also Amoco Sandbar and Carrington wells, but little info

Tertiary Basin, E Ant Isle- Exposures and geophys data suggest ½ graben config

Tsl, Tnf, Tw?, Tso is combined unit

Tephrochron ages ~8-11 Ma

K-Ar ages Tnf 42.9 bentonite, 39 and 49 on recycled vol clasts

Geophys data suggests the graben ends, but starts again to N

Ant Isle Rx – used Doelling and others map, and updated units of Yonkee

KXa – shearing within basement rx and at basement/cover rx

Ct

Zsd

Zmf

Xfc – granites, gneisses, ultramafic rx

Much debated age of Xfc, but Zr age from Nelson and others (2011) 1.6-1.7 Ga

Figure Basement Provinces

Note SLC near junction of several provinces

Basement rx continue to S in subsurface

DH3 – Whitlock-Morton

DH6 – MFS-Saltair 1

Then rather abruptly changes to Oquirrh rx in water wells and exposures

Discordance noted before - John Young suggested in MS thesis (1953), Don Mabey (1963) noted a probable fault here, Lawton etal (1994)

A substantial fault zone is indicated – called Transverse zone

Exact location, configuration, movement, timing poorly known

Most likely Sevier feature later reused in Cenozoic, no evidence of Quaternary movement

Thrust poster

Updated thrust map for N UT with Wyoming and Provo salient (updates prior of Tooker, Morris)

Tooele map straddling Fuzzy Area between 2 salients, which includes the Uinta axis and Transverse zone

Discuss E breaking sequence of thrust belt

Discuss linkages

Discuss Western and Eastern thrust systems

Wasatch anticlinorium: (Northern Utah Highland of Eardley)

North of Transverse zone is WA or WC

Figure Yonkee xsect of WA (no extension)

Poster also regional xsection from UGA 28 (with extension)

Santaquin culmination in Provo salient

Touch on Black Rock thrust in view

1-3 NW Oquirrh Mtns-Tooele Valley, Oquirrh fault zone, Pz stratigraphy, Sevier structure, Tooele Valley data

Mapping Sources etc.: we used first two with few modifications

Barry (1993) Q geomaps Tooele Valley and WDHIA (20 maps, 1:24K)

Barry (1996) Strip map of N Oquirrh FZ

Black et al (1999) Geology and Geohazards of TV and WDHIA

Olig et al (1996) Paleoseismic investigation Oquirrh FZ

UGS 2005 Wetlands Study

USGS 2009 Hydrologic study and GW flow model TV

Paleoseismic Study:

Photo of Scarp/Trenches

Big Canyon, 3 trenches, 3 scarp profiles

Pole Cyn, 1 trench 1 scarp profile

RC ages for youngest event 6320 yrs +/- 1600 yrs (Big Cyn)

Penultimate event 27,600 yrs +/- 3840 (Pole)

Older > 33,000 yrs (Pole)

Net vertical displacement 2.2-2.7 m

Mike Bunds UVU – Working on a recent drone, Structure for Motion study

Should we link GSLFZ and NOFZ?

BR mapping sources:

Tooker and Roberts (1971), Farns Peak quad, started here, is their best work

Nomenclature:

Rogers Canyon sequence on N Oquirrh thrust sheet

Different names per thrust sheet (discuss problems with this approach)

John Welsh, Kennecott consultant, argued against this nomenclature

Clark used Bingham sequence nomenclature, based on similar lithofacies and fossil ages, for consistency

Decending strat-

Park City, Grandeur (New units Ppp)

Kessler Cyn, Fm (Pu/Pdk, Pofp, Pocp? and IPobm)

Erda Fm (IPobp)

Lake Pt Ls (IPowc and Mmc using biostrat work of Davis and Webster), Mmc not typical

Green Ravine Fm (Mgb)

Structure:

N Oquirrh FZ provides nice cross sectional view of range

Fixed fault block near Kessler anticline

Added thrust on west side

Cross section C to C'

Discuss Transverse zone, Black Rock thrust, Kessler anticline, N Oquirrh thrust

Schurer's chaos zone, Uinta axis area, Midas thrust, Bingham stock

Subsurface data Tooele Valley:

Amazes me how little deep subsurface data is available for our populated valleys!

Shallow water wells

Some relatively shallow O/G wells (2 to rock DH 12, 4900 ft PIPo?, DH15, 4400 ft, Pz)

Gravity data map

Discuss lows, Adobe Rock bench, lack of signal for NOFZ except S end

1-4 Lunch – Grantsville City Park

1-5 E Stansbury Mtns, Davenport Canyon area, Glacial (Jack), Tertiary sed and volcanic rx, Pz stratigraphy, Stansbury uplift, Sevier structure (Don)

Mapping Sources:

Rigby (1958) 1:62K, Foose (1989) 1:24K, better than Sorenson (1982) 1:62K

Tertiary and Volcanic Rx:

Notice that Tert rx collected here

Decending:

QTaf/Tslc –

Conglomerate Tsl with Tv and qtz/carb clasts overlain by Qtz clast gravel

Gravel thickens Eward

Could not differentiate on photos or imagery

Tephrochron age S Willow 11 Ma (Cougar Pt Tuff XIII)

Volcanic rx along Uinta axis-

TAS plot?

Tsh- Shoshonitic lava flows, aphanitic, Mack Cyn

Previously called basalt

Rock to altered for Ar/Ar age per lab

Prior K-Ar age 12.7 Ma

Tvs (Davis, 1959)

Volcanic and volcaniclastics

Lava flows, ash-flow tuffs, lahars, debris avalanches, tuff ss

New geochem rhyolite, dacite, trachydacite, andesite

2 new Ar/Ar biotite 39.7 and 41.3 Ma (similar to prior K-Ar)

Also within Tvs is pod of lacustrine ls, previously called Mgb

Tirs –

Porphyritic rhyolite and trachydacite intrusions

Plugs, dikes, sills

K-Ar ages 30 and 40 Ma

Tso –

Davenport Cyn, 1 crop

Cgl, ls and dol, lesser ss/qtzite clasts

Underlies Eocene vol rx

Notice patchy deposits across map, some drainage system existed, discuss

Pz rocks:

Along E part of range

Cpm core overlain by thin to zero Cambrian rx and Miss rx

Poster Stansbury uplift, discuss Dev unconf/rocks missing

This is the Stansbury uplift (Rigby, 1959)

Centered on the Uinta axis

Upper-Middle Devonian uplift – hold off on Dst discussion until next stop

Rigby reports 6000 ft structural relief on central part of fold

Local uplift of most of Pz section, tilting up to 30 degrees

Enigmatic structure

Some attribute to Antler orogeny (Late Dev-Miss-E Penn) in NV, Roberts Mtn thrust emplacement

Foose reports unconformity has local evidence of shearing

Rx adjacent are brecciated, veined, silicified from local differential movement along unconformity during folding

Contact has localized mineralization (mines, Prospects)

Devonian structural disturbance here has been overprinted by Sevier

That may explain some complicated structural relations in S Stansbury Mtns, and along E front

Poster Tooele and RV geomap together along E front Stansbury Mtns

Part of Cross section A to A'

Part of RV xsection

Use Whiteboard as needed

Discuss fault-bend fold scenario for S part – develop fold pair, fault in Mmc decouples fold pair, syncline more tightly folded and faulted, relaxation forms Tertiary basin.

N part is backthrust (Broad Canyon fault), discuss at next stop

1-6 N Stansbury Mtns – Stansbury Fm., Pz strat, Sevier Structure, Resources (Don)

Mapping: Rigby and some Foose

Other Studies: Arnold (1956 MS) Stansbury Fm

UGS Mineral Lease funded project -

Trexler (1992) Stansbury Fm update

Cashman (1992) Structural geol

Sandberg and Gutschick (1979) Dev and Miss biostrat/conodonts

Dst – Enigmatic rock unit formed on flanks of Stansbury uplift

Wish I could put us on crops, not readily accessible

Unconformably overlying SOu here and overlain by Mdf (Deseret, Gardison, Fitchville?)

Type section at Flux, very localized unit

Photo of Dst

Cgl, lesser qtz ss, qtzite, dol, ls, shale

Distinctive conglomerate!

Dol clast type with dol matrix, matrix supported

Rare qtzite clasts, sourced from adjacent rx

Clasts to 1.5 m

Some dol and ls near lower and upper contacts

Conodont and other fossils data – Late Dev to Early Miss age

Contains 3 large slide blocks of SOu near Flux and Miners Cyn

Flux paleocurrent data: Cgl imbrication, transport to NE, Qtz ss cross strat mostly W (SW to NW)

Stans Isle section, next stop, is different lithofacies

Pz Strat – (Miss on C, Op, SOu, D)

We are on western thrust system (marked by Stansbury, Willard thrusts). Used W UT nomenclature. Serious update in strat nomenclature from Rigby's map.

Tooele arch is here, but discuss at later stop

Up section is Mdf, Mh, Mgb, Mmc (shaley decoll), IPobw

Structure – Reported on by Cashman

E-vergent Sevier folding/thrusting overprinting cryptic Dev deformation (folding, uplift, erosion)

I am not the only one who hammered T&R structural interpretations (3 W dipping thrust faults to 1 backthrust)

N end Stans Mtns series of folds:

Deseret anticline plunging and dying out, en echelon folds take up much of the shortening

Timpie Valley sync, Timpie Ridge anti, unnamed sync, Little Mtn sync

Note here and elsewhere Mmc and above is more tightly folded than below

Cashman talks about fold pair via fault propagation fold development (blind thrust), but then states that the major thrust must be to the east, TV thrust, this implies fault-bend fold development

Interesting observations:

(1) Macroscopic folds are curvilinear (convex to the west), related to interference with Uinta axis, or alternatively due to later uplift on Uinta axis
(2) Max overturning on Deseret anti and max relief is adjacent to South Mtn (Uinta axis)

Broad Canyon fault – An E dipping reverse fault (backthrust) that has been rotated more steeply (by tilting of range), post-dates major E-vergent thrusting

Look at field relations and discuss evidence (older over younger, anti in hanging wall)

I am not sure if there is just one fault along E side, or is different faults considering hanging/footwall relations, any suggestions?

Cashman states:

No major thrusts between Flux and Timpie Valley (Dst deposition issue)

No evidence for large structural boundary between Stans Mtns and Isle, but maybe some minor lateral offset (similar units and structural style). Does this have implications for Transverse zone?

If no major structures btwn them then lateral compositional variation in Dst needed

Resources:

Dolomite – Lhoist, was Chemical Lime, Ofh dolomitic lime, uses steel flux, water neutralization, mortar, glass making

Flux – Now Broken Arrow Salt, road salt?, Mgb quarries – High Ca Ls for sugar refining, metallurgical flux, mortar

Mineral resources – Free Coinage district (Ken, brief)

Geothermal Springs and Wells - Thermal (warm) >20 degrees C, Bonneville Seabase springs, few Tooele Valley wells

Water (Springs, wells)

Potential Prison site (W of Walmart)

Consider hike to outcrop, if extra time

1-7 S Stansbury Peninsula/Island, Lake Bonneville deposits and shorelines, Gilbert episode (Jack), Pz Strat, Sevier structure, Resources (Don)

Is technically peninsula, only island when GSL is high

Mapping Sources: Chapusa (1969), Palmer (1970) Discuss interesting tale of 2 maps

Clark used these maps, limited field work where accessible (thanks to Morton), photogeology elsewhere

Pz Strat:

We are on the western thrust system (Willard or Stansbury). Which strat nomenclature to use (W UT vs. NE UT)? For Cambrian, Chapusa used W UT and lumped upper nomenclature, Palmer used E Tintic nomenclature.

I struggled with with nomenclature to use. I used W UT nomenclature for Pz strata, but had to lump most Cambrian (Cum) because it is disarticulated by faulting and also poor access. Did not fully consider major structural zone between them when mapping. Some key exposures (Cum) on 6 mile ranch land.

Strat units (ascending) include Cpm, Cp, Cum, Cnp, Op, SOu, Dst, Mgf, Md, Mh (Day 2, talk about N end Z units, Cambrian)

Dst: Key point of Trexler, quite different from Stansbury Mtns, There is no congl and 4X as much qtz ss compared to Flux. Sedimentology and internal stratigraphy quite different

Light-colored band of primarily quartzite and qtz ss, also ls near base, thin shale at top that Trexler did not see here

SS cross beds paleocurrent data are bimodal (east and west), shallow submarine dep environ

Trexler says data suggest that Flux and SI cannot be in their original positions relative to each other.

Tooele arch:

First disruption of long lived sedimentation along passive continental margin

Middle Ordovician regional unconformity across structural high that coincides with the Uinta axis

Figure – Hintze's original cross sections (3 N-S) across arch

So in W UT terminology we are missing (ascending):

Upper part Pogonip Gp (including some Ls, Kanosh Sh, Lehman Fm), Watson Ranch Qtz, Crystal Peak Dol, Eureka Qtz

Nomenclatural issues N-S across arch and E-W across thrust sheets

Sevier Structure:

Tale of 2 parts, S part is Stansbury anticline, N part is torn apart by steep NW trending faults

Today discuss S Part -

Stansbury anticline, fairly isoclinal, gentle plunge NNE, east flank Miss rx are folded

Put inferred SI thrust off east side of island (Could this be the Stanbury thrust, or a different one?)

There is a smaller thrust to N in range

How does the SI thrust relate to the Willard? (note different hanging/footwall relations)

How do we cross the Transverse zone?

Could the Transverse zone splay S of, through, or N of Stans Isle?

Not sure if a thrust exists W of Stans Isle, btween Lakesides

Poster of thrusts

Geophysical map to show large basins on each side of Stansbury Island

Resources:

Sand and gravel pits

Dst Quarry – Si flux for Kennecott

Salt Evaporation (Cargill, Morton, Broken Arrow, US Mag)

Day 2 (May 10)

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2-0

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Remoteness

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Snakes, scorpions, bugs, allergies

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2-1 NW Stansbury Mtns – Lineaments, Stansbury fault zone, Tertiary basin, Pz strata, Structural features, Water resources

Mapping Sources: Rigby, Foose, Sack, (1993), Helm (1994) geomapping/scarp profiling

Faults: Barnhard and Dodge (1988), Geomatrix (1999)

Used Sack as guide and redrew and revised Q

Quat – Younger alluvium, Bonneville sand, gravel, fines; Pre-Bonneville fans incised by Bonneville, Provo, locally Stansbury shorelines

Convergence of Lineaments – related to Bonneville shorelines and Stansbury FZ

Ortho/topo image poster

Stansbury FZ – Along W range front from near Johnson Pass, mostly as a single fault,

to N near Broons Cyn steps W and splays, and several splays have been mapped to the N near stop

Age – No trenching, but cuts pre-Bonneville fans and does not cut younger alluvium

Helm found some interesting fault scarps near Q-BR contact

Other faults:

Springline fault of Rigby – not needed to explain springs, and gravity low farther W

Skull Valley faults (mid-valley) – East and West faults interpreted by Geomatrix as normal faults, but my interpretation is a thrust with later normal movement for their East fault (my Skull Valley fault).

We continue the Skull Valley fault to the north as a thrust fault with later normal movement, positioned based on gravity data and near MC subcrop. There is no surface evidence of thrusting, like there is to the south, and concealed normal.

Tertiary basin:

Interesting Tertiary half graben Broons-Salt Mtn area.

Basalt at base with conglomeratic Salt Lake Fm above.

No age control on Tb or Tsl (no tephras).

The graben has a low-angle normal fault along E side (cuts Cambrian) which is cut by the higher angle Stans FZ

We are doing better job recognizing and mapping Tert deposits now

Salt Mtn has some Tvs (Eocene) volcanic rx under the Tb/Tsl

Pz strata:

Section on west flank of Deseret anticline

Core is Cpm overlain by nice Cambrian section here (see lith column)

Clark and Kirby (UGA 2009) looked at Broons Cyn section.

Muskrat Cyn section is even better.

This is the western UT section based on lithologies, we have little fossil control

Note this section is similar, but noticeably different than S Lakesides

Overlain by Op (with some Kanosh to S), SOu, Dss, Dst, Mdf

Structural features:

Tooele arch

Stansbury uplift

Sevier fold-thrust belt

Cross section A-A' part

Water Resources:

Springs -

Horseshoe and Deseret Livestock are warm springs (>20 degrees C)

Wells – 3 well houses nearby, wells 300-500 ft (no logs), assume in Q

Water is piped N, apparently to industrial facilities

Sand and gravel resources - pits at N end range

2-2 W Cedar Mtns – Strat, Structure, Thrust timing, Hike to Cedar thrust, Cretaceous deposits

Road talk: (before hike to thrust)

Eolian qtz sand and silt blown in from GSL desert, piled on W and over

Older fans incised by BSL

New Quaternary fault to N. Cuts Qafo, somewhat obscured by Qes cover

Mapping Sources: Maurer (1970)

Strat:

Lith column

TRd, Pgp, Ppm, Ppg, Psl, Oquirrh Group, correlations to E

Wardlaw and others (1979) did strat/paleo work on Permian, but no real data to support

Structure:

This part of range anticlinal structure with thrusts on W (Cedar) and E (backthrusts) flanks

Skull Valley has some Oil/Gas exploration wells into Miss strata

(Thanks to Craig M for obtaining more data on these wells)

Cross section A-A'

Gravity data is off here, suggested deeper basin

Thrust timing:

Thrust poster

Some timing studies have been done in the UT part of Sevier belt

Wyoming salient (Yonkee, Eleogram)

Provo salient (Mitra estimates, Guenther)

Central UT (DeCelles)

Remember E breaking sequence older to W, some of older thrusts are folded (Canyon Range, Sheeprock)

Timing from a variety of methods – 40Ar/39Ar ages muscovite from syntectonic veins, palynology from synorogenic strata, Apatite fission track ages, U-Th/He zircon thermochronometer ages, U-Pb detrital zircon dating

Yonkee –

Time Scale Chart in handout

Willard (Neocomian to Turonian, 130 to 90 Ma), Wasatch anticlinorium and Crawford (K-Turonian to Campanian, 90 to ~ 80 Ma), Absaroka (K-Campanian to Paleocene, 80 to 60 Ma), Hogsback (Paleocene to Eocene, 60 to 50 Ma)

Eleogram/Wells –

Samples from Willard thrust sheet for zircon thermochrometry

Slow cooling/exhumation ~130 Ma to 90 Ma, slip rates roughly consistent with 60 km net slip

Mitra/Kwon –

Estimates - Sheeprock (K-Aptian? ~115 Ma), Midas (K-Albian?, 110-100 Ma), Nebo (K-Turonian-Santonian, 90-85 Ma), Charleston & Frontal blind thrusting (K-Campanian-Paleocene, 80-55 Ma).

Guenther/DeCelles–

Samples from Stansbury, Oquirrh, Wasatch for zircon He dating

Stansbury – inconclusive results (120 Ma??)

Oquirrh Mtns – exhumation starting at 110 or 100 Ma

Wasatch Range – exhumation at 100 Ma

DeCelles/Coogan -

Canyon Range (K-Neocomian to Albian, 145 to 110 Ma), Pavant system (K-Albian to Coniacian, ~110 to 88 Ma), Paxton (K-Coniacian to Campanian?, 88 to 75? Ma), Gunnison thrust (K-Campanian to Paleocene, 75 to 63 Ma), Frontal triangle zone (K-Coniacian to Paleocene, 88 to 63 Ma)

Hike:

Reason for stop is series of red beds on W side range. To S are sandwiched between the Cedar thrust and the Permian rx.

Let's hike to E, have a look at rocks, and reassemble to discuss

Lunch on hike, or short time back at vehicles

Outcrop talk:

Cedar thrust with IPo (no age control) thrust over Ks

Ks based on DZ sample here of 117 Ma (E Cret, Aptian) and land snails *Gyraulus* (E Cret to Recent)

Called North Horn? Fm by Maurer

DZ data

Ks lying on Permian Gerster-Plympton?

2-3 N Cedar Mtns – Lake Bonneville features, Oquirrh Group rx, structure, Tm unit, geophysical data, Puddle Valley

Lake Bonneville features:

Jack may/may not want to discuss Bonneville and Provo shorelines, tombolo, lower shoreline features. Stansbury barrier/lagoon farther E. Lower level gravels (Sack called Gilbert)

Old Map Example:

Maurer map - Prior map by Maurer, 1970

(Pick on him a bit, but shows how we build on prior work)

Original mapping of area on planimetric base, covered large area

Focused on bedrock, did a lot of paleo work, simple Q

Some outdated strat nomenclature and structural concepts

Issues with geospatial accuracy, cartography

So solid work, we went to key areas, used imagery, some new labwork, updated geology,

all new linework. This takes time and effort, W half of map required this

Oquirrh Group rx:

We are on Oquirrh rx, Permian part

On Day 1 we discussed strat nomenclature problems, biostrat

Mappers tended to devise their own scheme to subdivide or lumped

Maurer Units 1 to 5

Clark revised Maurer's Oquirrh on DPG map

Carried strat nomenclature from Bingham W across to Cedars,

Based on similar lithofacies succession, biostrat control

Fig 3 Poster

However, there is a substantial change from Cedars to Grassys in lithofacies sequence

Missourian strata missing

Doelling Units 1 to 6 (small part in NW corner)

I marked this change by thrust fault in Puddle Valley,

Could be on Skunk Ridge thrust, but no fossil control

Why do we care about subdividing the Oquirrh? Because has structure in it and couldn't be delineated otherwise

Tertiary:

Tm – small crops of olivine melanephelinite lava flows (ultrabasic rock)

Geochemically similar to melanephelinite/minette at Bingham district (per EHC)

Strange, as no other volcanic rx nearby, rare find

Hastings Cyn T basin -

E side, Tso with Tb cap

In canyon is Tsl and Tb

Also couple of aragonite/travertine quarries in faulted Oquirrh

Structure:

S Hastings thrust and backthrusts

Changes across T basin to graben

Skunk Ridge thrust suggested by folds and Low syncline

Geophys data:

Geophys map

Discuss gravity lows – Skull Valley, Lakeside Valley, looks off-set

Aeromag high at Stans Island, New study to N - Vicki L says data suggest source concealed in crystalline basement

Puddle Valley:

Lacustrine and alluvial deposits covered by eolian silt and sand

Puddle Valley FZ – Q fault, Barnhard and Dodge profiles, scarps 1.3 to 4.4 m

2-4 SW Lakeside Mtns – Resources, Pz strat, Lakeside fault and structure

Mapping Sources: Young (1953), Doelling (1964)

Resources:

Marblehead quarries/plant retired, was Chemical Lime

Dolomitic lime for steel flux, water neutralization, mortar, glass making

Quarried from Ofh (Oes) and Cnp, HD helped them site facilities

Holcim quarry – High Ca Ls for cement (now LaFarge Holcim) from Mgb

Pz Strat:

Lith column/handout

Doelling upgraded Young's strat nomenclature, but used a mixed one (NE and W UT)

I used the W UT nomenclature throughout

Cambrian section is similar, but notably different than Stansbury Mtns (suggesting different thrust sheet), Prospect Mtn up thru Notch Peak

Tooele arch is present, thin Eureka on Kanosh

No evidence of Stansbury uplift here

Up thru Dev, Miss, Oquirrh

Lakeside fault and Structure:

Interesting structural relations -

Lakeside block gentle syncline to S, heavily faulted to N

Lakeside fault rips through at MC interval on S and along W side

Oquirrh block is much folded (note folding discordance), presumably backthrusted, looks offset 4 miles W?

Lakeside fault has MC/ bits of IPo against Cnp, much throw (~9000 ft)

Is on Q fault/fold map, could just be erosional scarp

Doelling shows as a normal fault, refers to faults parallel to N UT Highland Dome (after Eardley)

Young refers to N Utah Highland (now Wasatch anticlinorium),

Shows left-lateral/SW down movement on fault, considered connection to E (and linked to left-lateral Transverse zone toward SLC), TZ may be joined by faults from Stans Isle

What are the possiblilities:

Normal (no, or minor later), strike-slip (possible), backthrust (probable)

Consider linkage to Transverse zone and to Miller's accommodation zone

Directions of movement may not work with Transverse zone?

Thrust poster

Cross section B-B'

2-5 S Lakeside Mtns *(Optional Stop)* – Mississippian strat, Resources,

Miss Strat:

Near type section of Delle Phosphatic Member of Woodman Fm

(Correlative to Deseret to E)

Woodman - Upper part is calcareous siltstone and sandstone

Lower 60 m is Delle Mbr – phosphatic and cherty siltstone and mudstone, lesser nodular limestone and cherty limestone; phosphorite (pelletal, pisolitic, oolitic)

Studies by Silberling and Nichols USGS, 1992; Sandberg and Gutschick, 1984

Interpreted as anoxic/phosphatic event similar to subsequent Phosphoria Fm (Permian)

Possible paleotectonic control of anoxic events

Carbonate shelf was flooded and modified by waters produced through upwelling in the Miss. Antler foredeep of central NV

Organic rich and possible hydrocarbon source rock

Resources:

US Magnesium – Extract Mg from lake water, byproduct chlorine

Ti plant next to USMag (inactive), process using Mg metal, Ti sponge

Salt Evaporators – Cargill, Morton, Broken Arrow

No food grade, industrial and road salt, several thousand tons/yr

Stansbury Fm quarry – Silica flux for Kennecott (Bolinder Resources)

2-6 N Stansbury Peninsula/Island – Lake Bonneville, Great Salt Lake, bedrock, structure

Lake Bonne/GSL (Jack)

Bedrock:

N half island different from S half (Stansbury anticline)

Here Cambrian section (Cum) is torn by NW trending steep faults

Small thrust fault – Middle C on SOu

N end - Large fault places Z rx against C

Chapusa and Palmer called Big Cottonwood Fm

Clark accessed and calls Mutual, Inkom, Caddy Canyon Fms in W dip panel

Note different dip domains

To N on Carrington Island is Zpc (middle part, slate and qtzite mbr) structurally deformed (Yonkee and student ongoing work)

Stans Isle block is relatively down and missing 3 Fms (Papoose Creek, Kelley Cyn, Maple Cyn) and upper Perry Cyn

Discussion about Willard thrust sheet extent and linkages to Transverse zone, Miller's Accommodation zone

Thrust poster

B-B'

See part of Carrington fault – Separate fault, possible splay off of GSL FZ, bounds NW side of structural high that separates GSL into N and S basins

Resources:

US Magnesium – Extract Mg from lake water, byproduct chlorine

Ti plant next to USMag (inactive), process using Mg metal, Ti from TN

Salt Evaporators – Cargill, Morton, Broken Arrow

No food grade, industrial and road salt, several thousand tons/yr

Stansbury Fm quarry – Silica flux for Kennecott (Bolinder Resources)

List of Posters/Figures

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30x60 Status poster

UT geomap

1-1

Mapboard

Mapping sources poster

UT geomap

Fossil poster

Fig 3 poster

Structural features poster

Bing mine xsections poster

1-2

Mapboard

Figure seismic line AI well

Figure basement provinces

Thrust poster

Yonkee figure xsects Wasatch anticlinor

Poster Yonkee E-W xsect

1-3

Mapboard

Fig photo of scarp/trenches

C-C' xsect

Gravity data map

1-5

Mapboard

??TAS plot

Structural features poster

Poster RV-Tooele geomap

A to A' xsect

RV xsect

Whiteboard?

1-6

Mapboard

Dst photo

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Mapboard

Fig Hintze's xsects Tooele arch

Thrust poster

Geophys map

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30x60 status poster

UT geomap

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Mapboard

Poster ortho/topo

A to A' xsect

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Mapboard

A to A'xsect

Thrust poster

DZ data

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Mapboard

Maurer map

Fig 3 poster

Geophys map

2-4

Mapboard

Thrust poster

B-B' xsect

2-5 (Opt) Mapboard

2-6

Mapboard

Thrust poster

B-B' xsect