DIGITAL MAPPING TECHNIQUES 2013

The following was presented at DMT '13
(June 2-5, 2013 - Colorado Geological Survey and Colorado School of Mines
Golden, CO)

The contents of this document are provisional

See Presentations and Proceedings
from the DMT Meetings (1997-2013)

http://ngmdb.usgs.gov/info/dmt/

U.S. GEOLOGICAL SURVEY
Alaska Science Center
Geology Office

Update on the Alaska state map compilation – towards completion but not closure

Frederic Wilson, Chad Hults, and Keith Labay

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Outline

Background

A new state map: The Geology of Alaska

Basic data structure

Spatial and attribute databases

Compilation issues and challenges

Map scales
Mapping style
Description variances
Age and geochronology

Tools we used, linking the databases

Checking the spatial databases
Creating a draft Correlation of Map units and all those colors

Preparation of the review draft

Here is where the rubber meets the road

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USGS participants and other collaborators

USGS Emeritus and former staff – George Plafker, Florence Weber, Gil Mull, Warren Coonrad, Hank Schmoll, Lynn Yehle, Dave Brew, Tom Hamilton, Bill Patton (deceased), Bill Brosgé (deceased), Don Richter (deceased), Joe Hoare (deceased), Hank Condon (deceased), and Bob Detterman (deceased) have been important.

In the Alaska Science Center, Solmaz Mohadjer and Chad Hults have been extremely valuable assistants and Alison Till and Julie Dumoulin are important participants for northern Alaska efforts and Sue Karl for southeast Alaska.

GIS help has come from Nora Shew, Keith Labay, and a large number of other staff over the more than a decade of this effort.

Alaska State agencies

Alaska Division of Oil and Gas (DOG)

Alaska Division of Geological and Geophysical Surveys (DGGS)

Regional Native Corporations

Such as Calista Corp. and Bristol Bay Native Corp.

National Park Service

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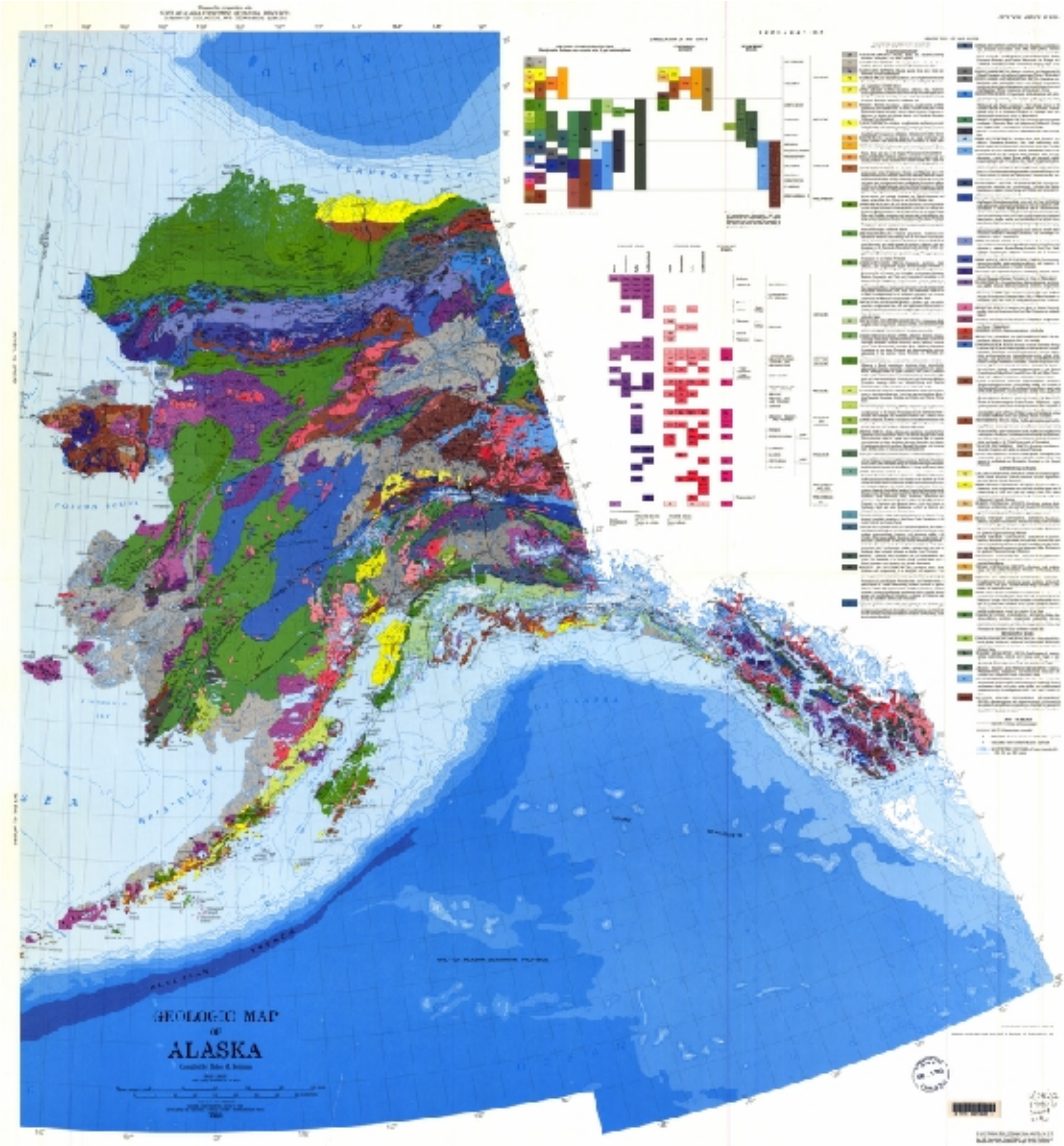

Beikman, 1980
1:2,500,000

A new Alaska Geologic map

Existing map published in 1980

- Compiled in the 1970's, it largely reflects pre-plate tectonic thinking.
- It is not digital and efforts to make so have yielded poor results.
- Since publication, an incredible amount of mapping in the state has been done.
- It depicts the state in something on the order of 60 to 70 map units

A new map was begun in 1998

- 100% digital
- Compiled from data sources of all vintages; seeking the best data.
- Released initially as a series of regional maps

Challenges and Goals for the new map

Nominal scale to be 1:500,000

- Acquire/Digitize maps suitable for this scale; actual data capture is at 1:250,000 or better

Integrate statewide (Nationwide)

Define standardized attributes and language:

- Description,
- Age,
- Lithology….

Build a searchable database that captures the data

So, what did this mean for Alaska?

Our spatial database presently contains:

- About 450,000 arcs or lines
- About 250,000 polygons
- Stored in 153 1:250,000-scale quadrangle datasets

The attribute database contains:

- Nearly 17,000 individual map unit descriptions
- More than 1,300 composite map units, with related age, lithologic, and geologic-setting databases
- More 6,000 radiometric age determinations

Additionally, 15 regional compilations reflect:

- More than 1,700 regional map unit descriptions

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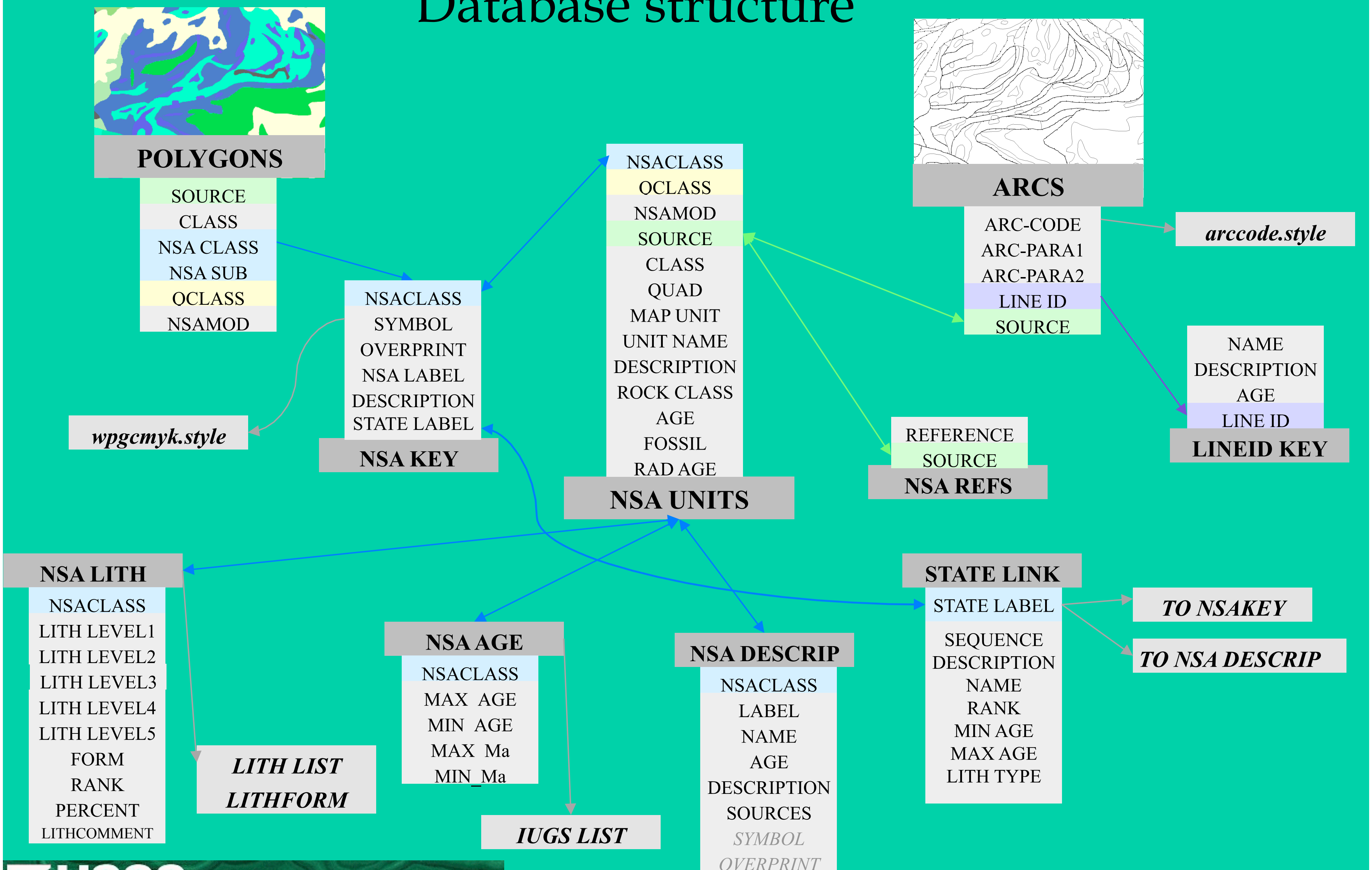
Database structure



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Units:

Source Map Fields

Assigned Fields

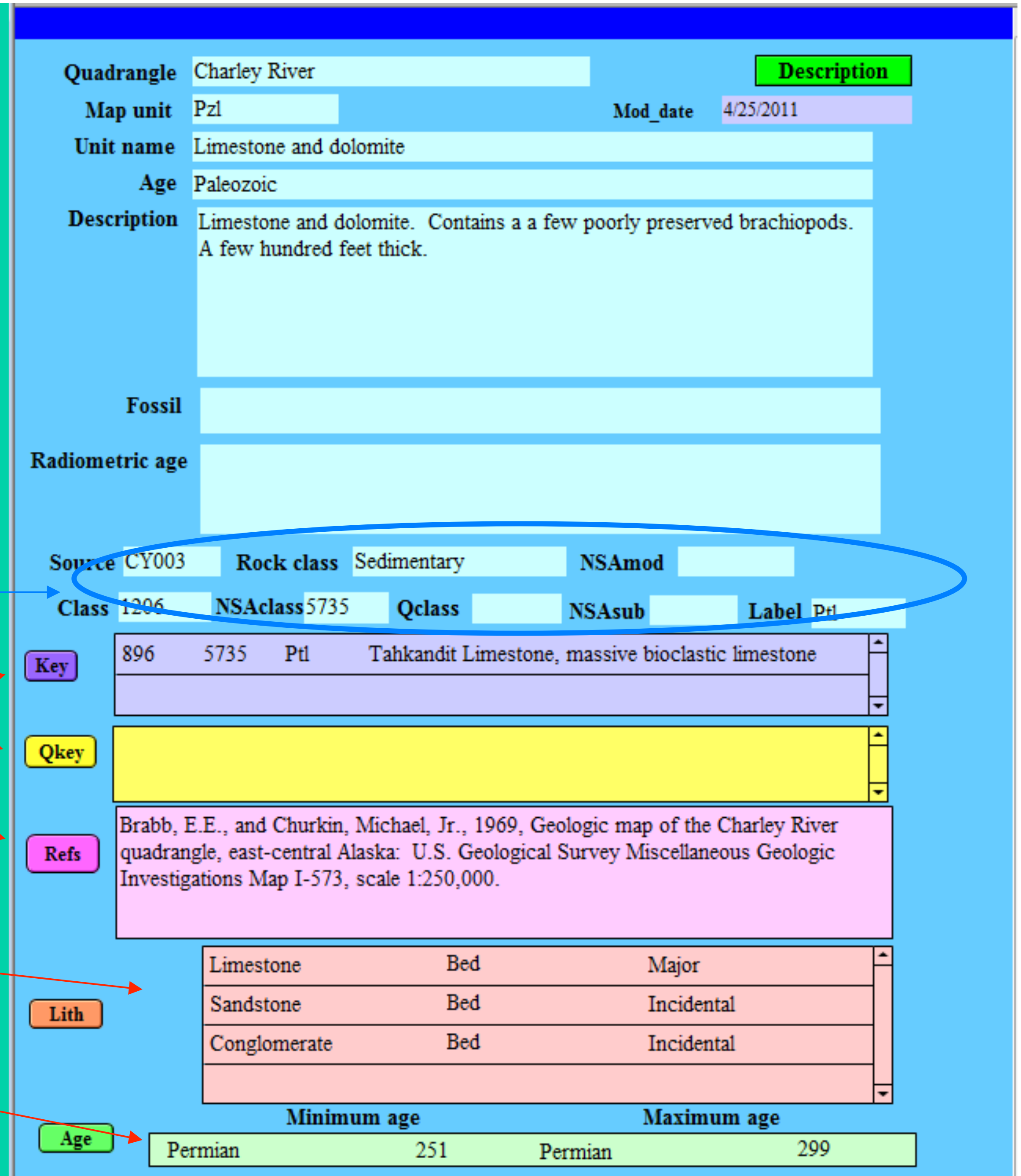
Links:

Keys

References

Lithology

Age



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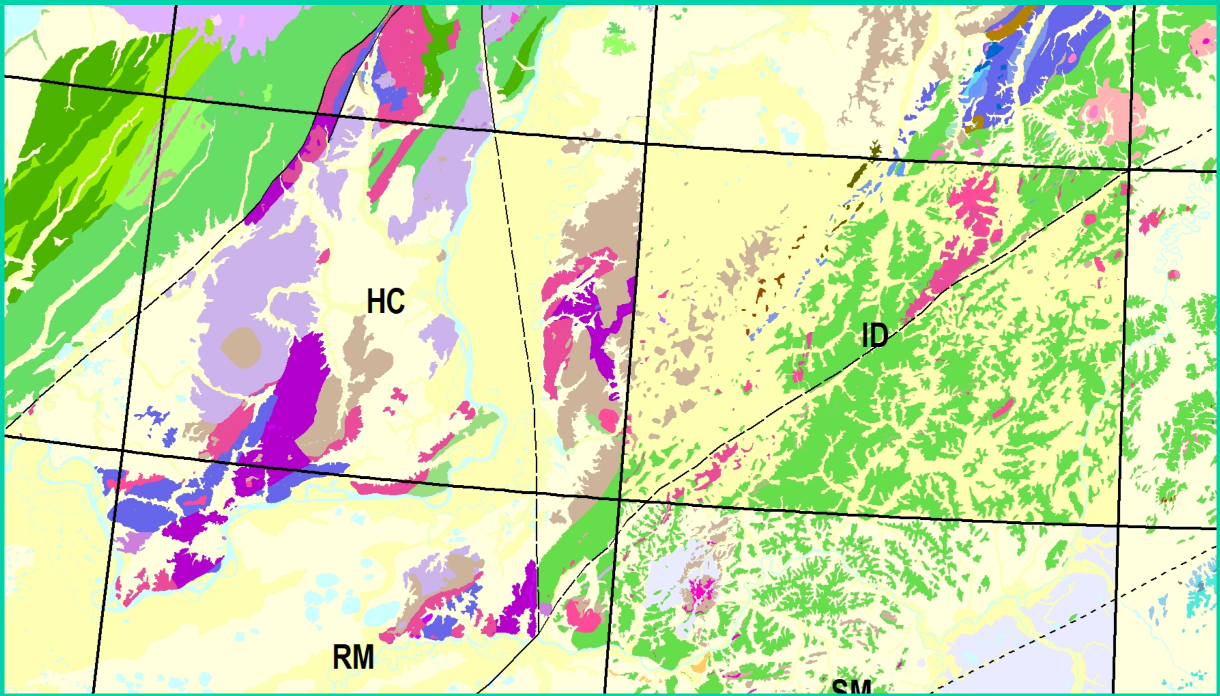
Map scale and mapping style

The adjacent Holy Cross and Iditarod quadrangles reflect distinctly different mapping styles and also reflect differing scales of data.

The Holy Cross (HC) map is at best a 1:500,000-scale recon-naissance map product, whereas the adjacent Iditarod (ID) map was compiled originally from 1:63,360-scale mapping.

The Holy Cross map also reflects the geologists inference of the extent bedrock, whereas the Iditarod map is more akin to an outcrop map.



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Unit description variances

Same unit, different maps:

Kss -- Shallow marine sandstone, siltstone, and shale -- Late Cretaceous -- Fine-to medium-grained, thinly cross-bedded, fossiliferous sandstone and poorly exposed dark siltstone and shale. Clasts composed of 40 to 45 percent quartz, 45 to 50 percent volcanic and sedimentary lithic fragments, and 5 to 15 percent feldspar, chiefly plagioclase. Clasts set in a finely divided calcareous and argillaceous matrix. Unit deposited in a nearshore marine environment. Unit contains abundant early Late Cretaceous (Cenomanian) species of Inoceramus.

Kkq -- Kuskokwim Group, quartzose sandstone and siltstone -- Late Cretaceous, (Paleocene?) Campanian to Turonian? -- Quartzose sublithic sandstone, conglomerate, siltstone, and siliceous shale. Finer-grained layers locally contain abundant coaly leaf and stem debris; thin coal seams are present locally. Coquina layers composed of brackish to fresh water bivalves are locally interbedded with sandstone and siltstone. Rocks are interpreted as shallow-marine to locally nonmarine. Dicotyedon leaf fragment of probable Turonian to Paleocene age but may be as old as Cenomanian. K-Ar age of 77 Ma on interbedded andesite tuff in upper part of section.

Age and geochronology

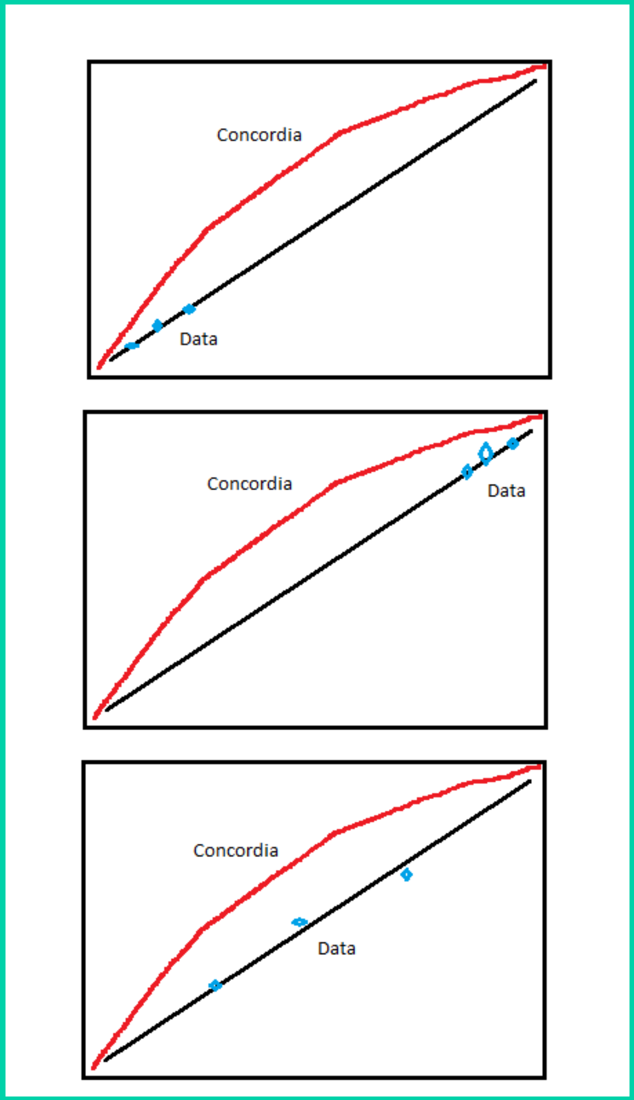
As the compilation came together, access to about 7,000 radiometric dates, ranging from generally discredited 1950's era Lead-alpha dates to conventional K/Ar, $^{40}Ar/^{39}Ar$, Rb/Sr, and U/Pb (both TIMS and SHRIMP analyses) required careful examination of the analytical data of many dates.

Key considerations emerged:

1. Ignore most Lead-alpha dates,
2. Look for discordant K/Ar or $^{40}Ar/^{39}Ar$ or disagreement between the two complementary methods,
3. U/Pb, TIMS multi-grain or SHRIMP single-grain? If multi-grain, concordant or discordant, upper or lower intercept and how close to the intercept?

Ultimately, we found most K/Ar dates are in pretty good agreement with good U/Pb dates, but many TIMS multi-grain dates are questionable and some quite dubious.

In the example to the right, the top sketch shows a reasonable interpretation of age for a lower intercept and a likely spurious upper intercept. The middle sketch is the converse, a reasonable upper intercept and spurious lower intercept. The lower sketch shows data that is most likely completely spurious. Yet many age reports simply indicate a single age and maybe if it is concordant or an upper or lower intercept.



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Lumping Map Units for the description (DMU)

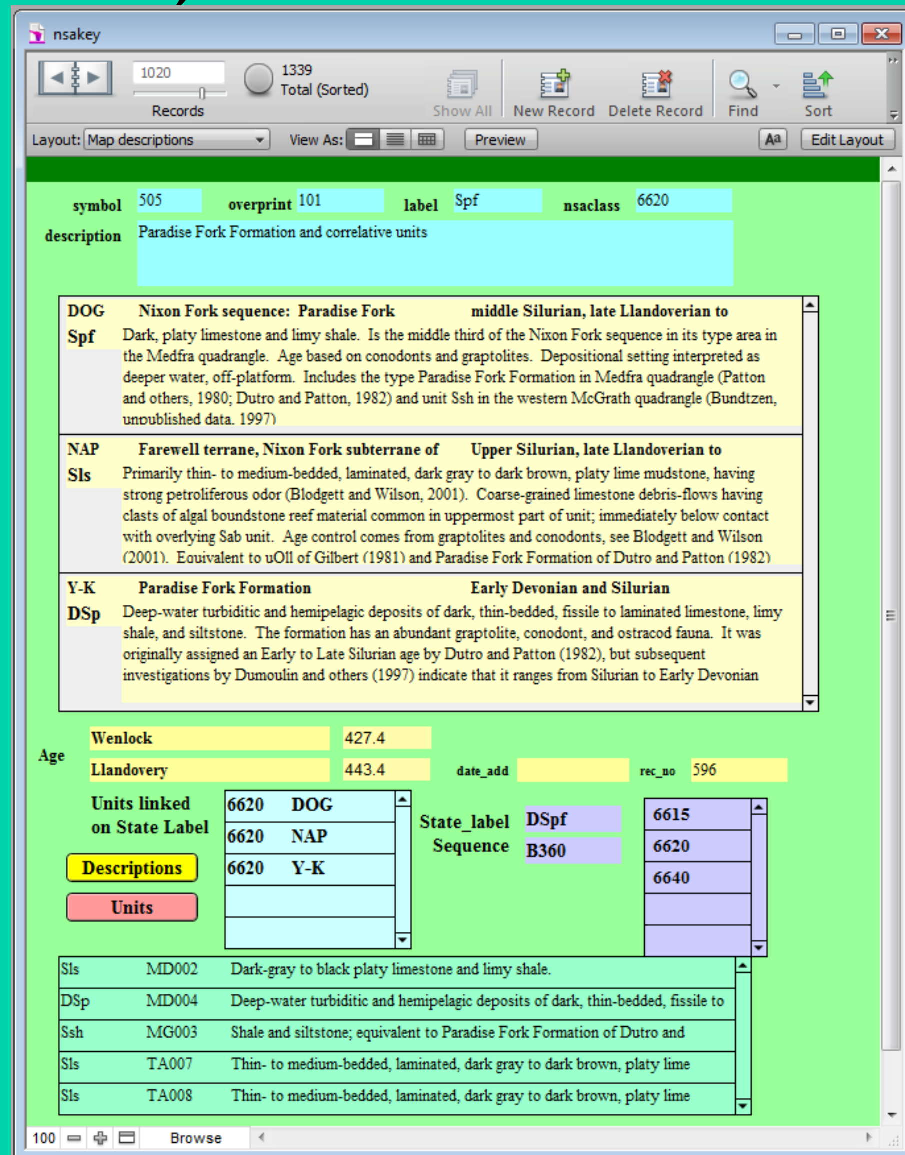
An important step was to see if the 1,300 composite units could be reduced for the new map.

Step 1 was to link a number of existing databases to a copy of the "NSAkey" file (The database that tracks each of the 1,300 composite units.)

Another link was to a database that contained the unit descriptions used on published regional maps for each composite unit. The display then showed each description. And another link showed the description from each source map for that unit.

Step 2 was to examine that database with the links in place and do a rudimentary lumping based on related information.

For example, could all early Tertiary sedimentary units be combined? Or can Cretaceous plutons be lumped?



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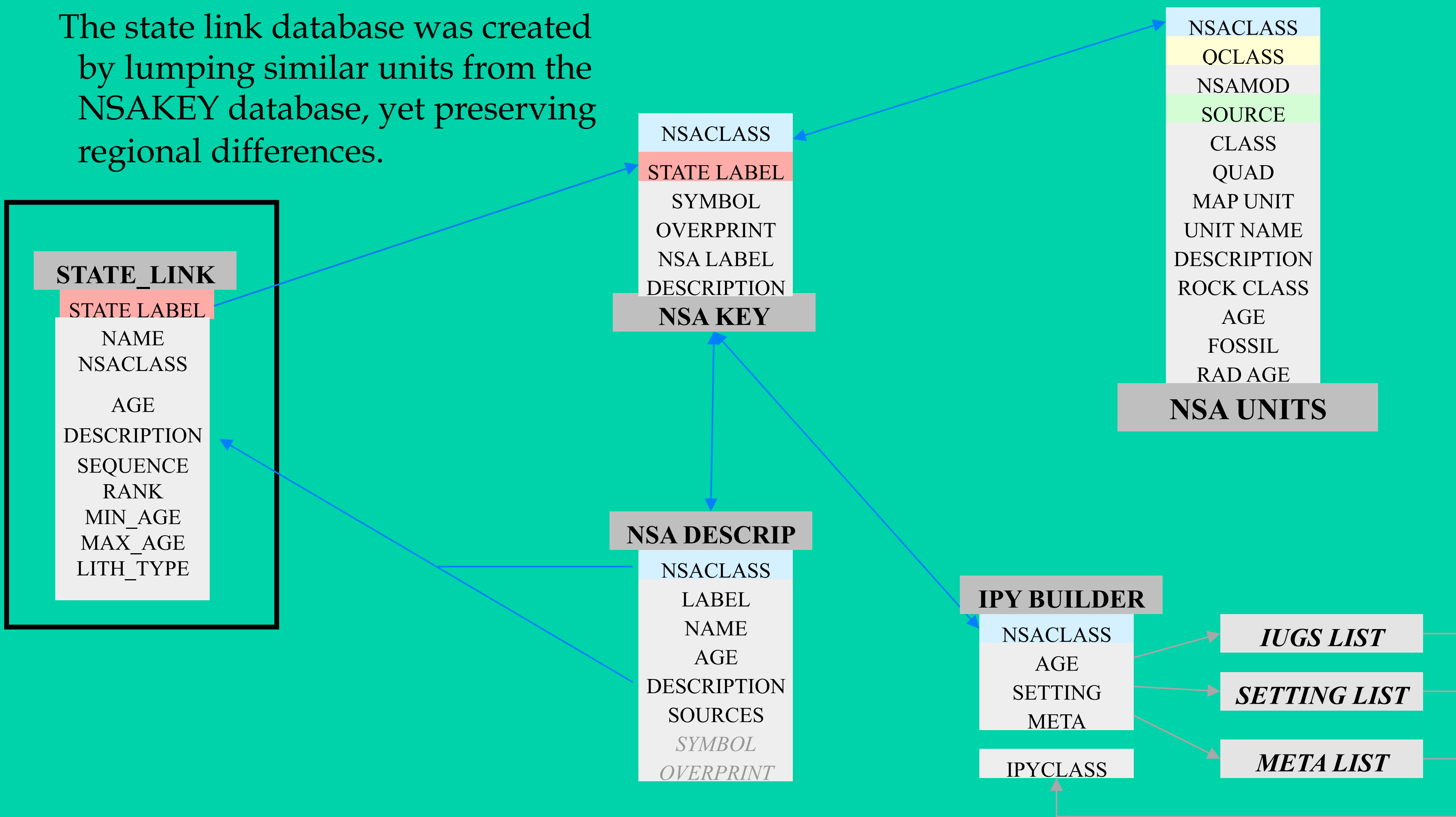
Linked files to create unit descriptions

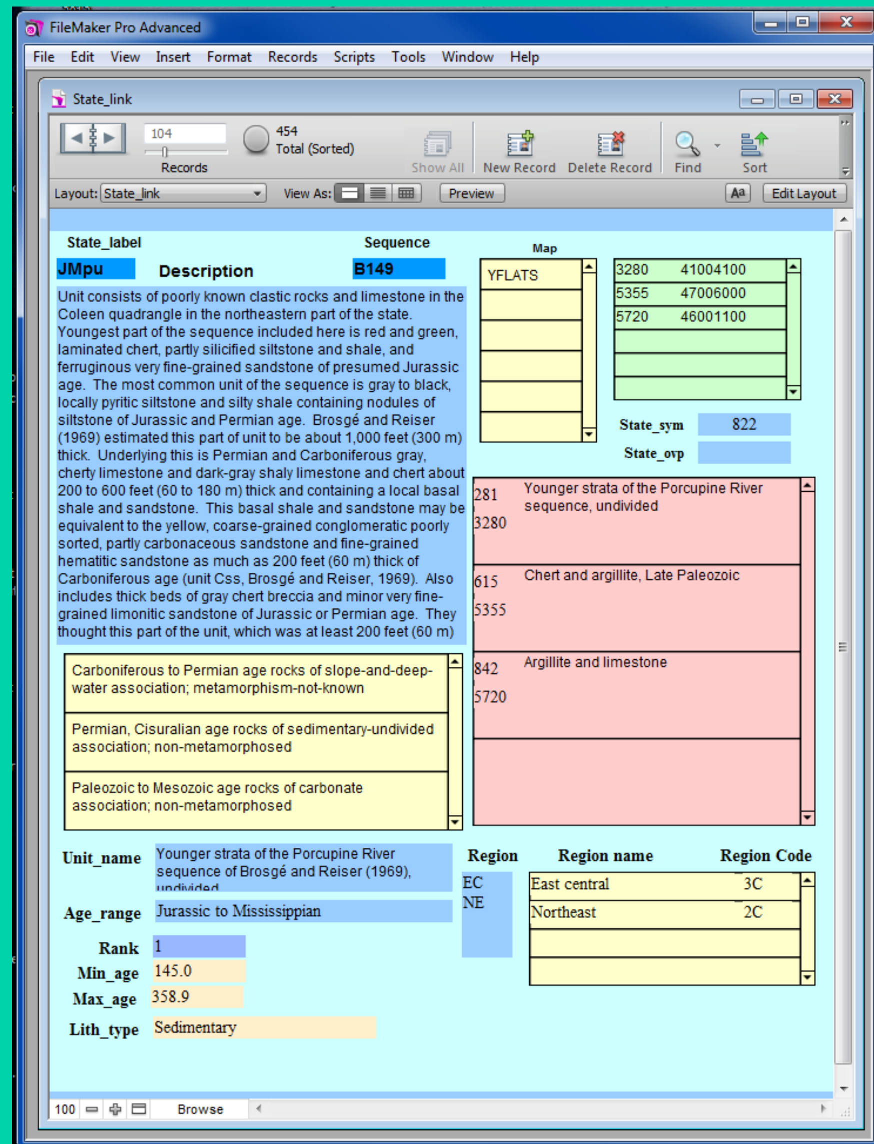
The state link database was created by lumping similar units from the NSAKEY database, yet preserving regional differences.



Winnowing the units down

This database was populated with the new lumped labels and also linked to a number of existing databases.

Map unit descriptions from either source maps or regional compilations that appeared to be useful were dragged into this database's description field for the regional map description database. Linked databases showed which regional maps were represented, which NSACLASS codes and related IPYCLASS codes were included, and abstracted descriptions from the key and IPY databases. Also added was a unit rank, numeric maximum and minimum age and lithology type.

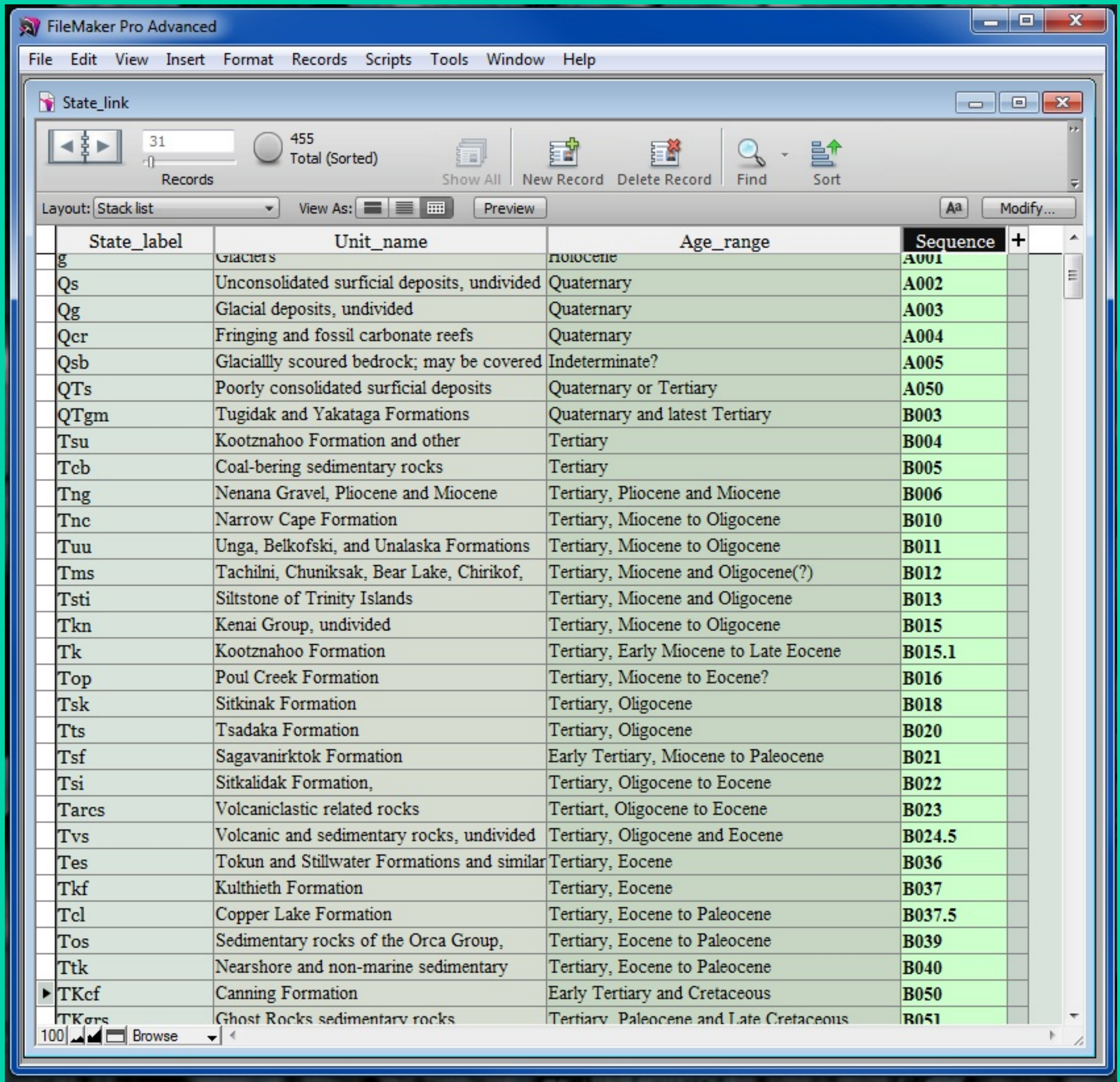


An initial sort and scan

The view of the data was switched to a table-like view and records were sorted by sequence number.

A quick scan of the table indicated any units that might be significantly out of sequence.

At the completion of this phase, the number of units had been reduced from a little more than 1,300 to about 450. Our desire was to reduce this further, without compromising the geologic or tectonic story, but it hasn't proved possible.



State_label	Unit_name	Age_range	Sequence
g	Glaciers	Holocene	A001
Qs	Unconsolidated surficial deposits, undivided	Quaternary	A002
Qg	Glacial deposits, undivided	Quaternary	A003
Qcr	Fringing and fossil carbonate reefs	Quaternary	A004
Qsb	Glaciallly scoured bedrock; may be covered	Indeterminate?	A005
QTs	Poorly consolidated surficial deposits	Quaternary or Tertiary	A050
QTgm	Tugidak and Yakataga Formations	Quaternary and latest Tertiary	B003
Tsu	Kootznahoo Formation and other	Tertiary	B004
Tcb	Coal-bering sedimentary rocks	Tertiary	B005
Tng	Nenana Gravel, Pliocene and Miocene	Tertiary, Pliocene and Miocene	B006
Tnc	Narrow Cape Formation	Tertiary, Miocene to Oligocene	B010
Tuu	Unga, Belkofski, and Unalaska Formations	Tertiary, Miocene to Oligocene	B011
Tms	Tachilni, Chuniksak, Bear Lake, Chirikof,	Tertiary, Miocene and Oligocene(?)	B012
Tsti	Siltstone of Trinity Islands	Tertiary, Miocene and Oligocene	B013
Tkn	Kenai Group, undivided	Tertiary, Miocene to Oligocene	B015
Tk	Kootznahoo Formation	Tertiary, Early Miocene to Late Eocene	B015.1
Top	Poul Creek Formation	Tertiary, Miocene to Eocene?	B016
Tsk	Sitkinak Formation	Tertiary, Oligocene	B018
Tts	Tsadaka Formation	Tertiary, Oligocene	B020
Tsf	Sagavanirktok Formation	Early Tertiary, Miocene to Paleocene	B021
Tsi	Sitkalidak Formation,	Tertiary, Oligocene to Eocene	B022
Tarcs	Volcaniclastic related rocks	Tertiart, Oligocene to Eocene	B023
Tvs	Volcanic and sedimentary rocks, undivided	Tertiary, Oligocene and Eocene	B024.5
Tes	Tokun and Stillwater Formations and similar	Tertiary, Eocene	B036
Tkf	Kulthieth Formation	Tertiary, Eocene	B037
Tcl	Copper Lake Formation	Tertiary, Eocene to Paleocene	B037.5
Tos	Sedimentary rocks of the Orca Group,	Tertiary, Eocene to Paleocene	B039
Ttk	Nearshore and non-marine sedimentary	Tertiary, Eocene to Paleocene	B040
TKcf	Canning Formation	Early Tertiary and Cretaceous	B050
TKgrs	Ghost Rocks sedimentary rocks	Tertiary, Paleocene and Late Cretaceous	B051

Creation of the draft document

Following the quick check, an export of the data was made.

The fields:
State_label,
Unit_name,
Age_range,
Description,
Sequence number,
and the applicable NSACLASS
values were exported as tab delimited text, for import into MS Word.

A template in Word, provided by our publications unit was then used to set the basic format.

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A unit description would come in looking like:

Tng Nenana Gravel Tertiary, Pliocene and Miocene Yellowish-gray to reddish-brown well-sorted, poorly to moderately consolidated conglomerate and coarse-grained sandstone having interbedded mudflow deposits, thin claystone layers, and local thin lignite beds widely distributed on the north side of the Alaska Range. Unit is more than 1,300-m-thick and moderately deformed (Csejtey and others, 1992; Bela Csejtey, written commun., 1993) B006 570, 571

And upon revision and editing (minimal in this case) would look like:

Tng **Nenana Gravel** (Tertiary, Pliocene and late Miocene)—Yellowish-gray to reddish-brown well-sorted, poorly to moderately consolidated conglomerate and coarse-grained sandstone having interbedded mudflow deposits, thin claystone layers, and local thin lignite beds widely distributed on the north side of the Alaska Range. Unit is more than 1,300-m-thick and moderately deformed (Csejtey and others, 1992; Bela Csejtey, USGS, written commun., 1993)

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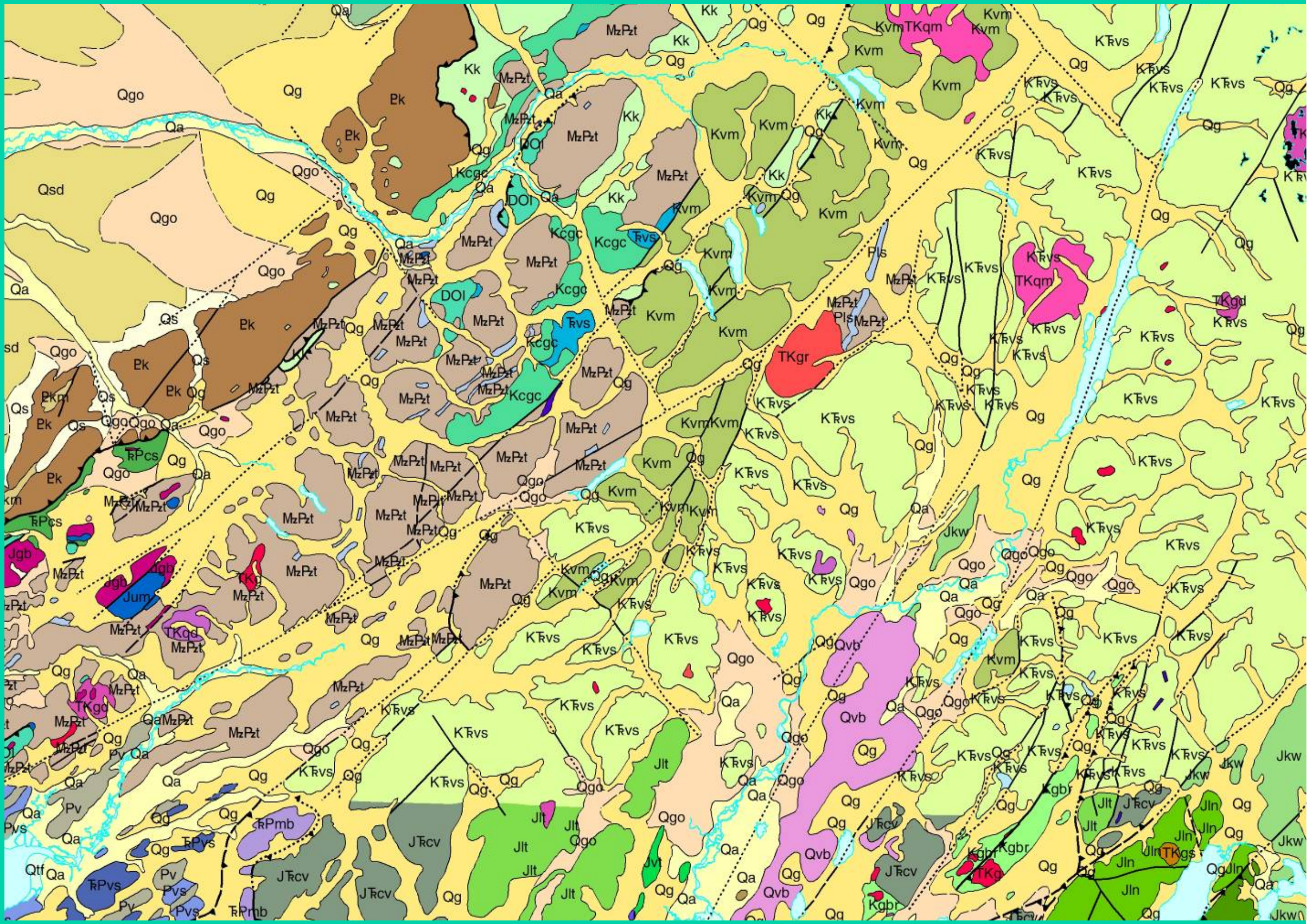
Check routines

As we use geo-databases as well as coverages, we have created Python or AML check routines which generate a report we use to insure consistent coding. Items checked include:

1) Topology issues,
2) That polygon and arc codes are within proper ranges,
3) That polygon codes used are consistent with the master units database.



Typical check output

Shown here is a typical output from a "check" run for a quadrangle database. These check runs help us to ensure our data is topologically correct, properly and completely attributed.

```
Coverage location: o:\nsa\bt\btgeol
Check run by: klabay
Date: 29 May 13 10:01:16 Wednesday
Arc look-up table used: O:\LUTS\GEOLINE.LUT
Polygon look-up table used: O:\LUTS\GFWPGKEY.LUT
Unit labels keyed to: NSACLASS

NSACLASS lut last updated:
05/01/2013
Filemaker lut last updated:
05/29/2013

Labelerrors:
Polygon          1 has     0 label points.
Total number of Polygons with No Labels:        1
Total number of Polygons with Multiple Labels:  0

Labels or arcs with non-LUT values:

Arcs that may need to be flipped.
Use O:\pantry\amls\direction.aml to flag the arcs
listed with TMP = 1:

Number of arcs with same CLASS code on each side: 0
Number of CONCEALED arcs separating different NSACLASS values: 0
Number of invalid arcs bounding GLACIERS: 0
Number of invalid arcs bounding WATER BODIES: 0
Number of invalid BOUNDARY arcs: 0
Number of ARC-CODE = 99 not defining the BOUNDARY: 0

ITEM STRUCTURE OF THE .PAT

COLUMN   ITEM NAME        WIDTH OUTPUT  TYPE N.DEC  ALTERNATE NAME     INDEXED?
    1  AREA                   8    18     F     5                          -
    9  PERIMETER              8    18     F     5                          -
   17  BTGEOL#                4     5     B     -                          -
   21  BTGEOL-ID              4     5     B     -    ID                    -
   25  CLASS                  4     5     B     -                          -
   29  QCLASS                 4     5     B     -    QC                    -
   33  SOURCE                 6     8     C     -                          -
   39  NSACLASS               4     5     B     -    NSA                   -
   43  NSAMOD                 8    10     C     -    MOD                   -
   51  NSASUB                 4     5     B     -    SUB                   -
   55  TMP                    4     5     B     -                          -

ITEM STRUCTURE OF THE .AAT

COLUMN   ITEM NAME        WIDTH OUTPUT  TYPE N.DEC  ALTERNATE NAME     INDEXED?
    1  FNODE#                 4     5     B     -                          -
    5  TNODE#                 4     5     B     -                          -
    9  LPOLY#                 4     5     B     -                          -
   13  RPOLY#                 4     5     B     -                          -
   17  LENGTH                 8    18     F     5                          -
   25  BTGEOL#                4     5     B     -                          -
   29  BTGEOL-ID              4     5     B     -    ID                    -
   33  ARC-CODE               3     3     I     -    AC                    -
   36  ARC-PARA1              3     3     I     -    AP1                   -
   39  ARC-PARA2              3     3     I     -    AP2                   -
   42  SOURCE                 6     8     C     -                          -
   48  LINEID                 8    10     C     -                          -
   56  TMP                    4     5     B     -                          -
```

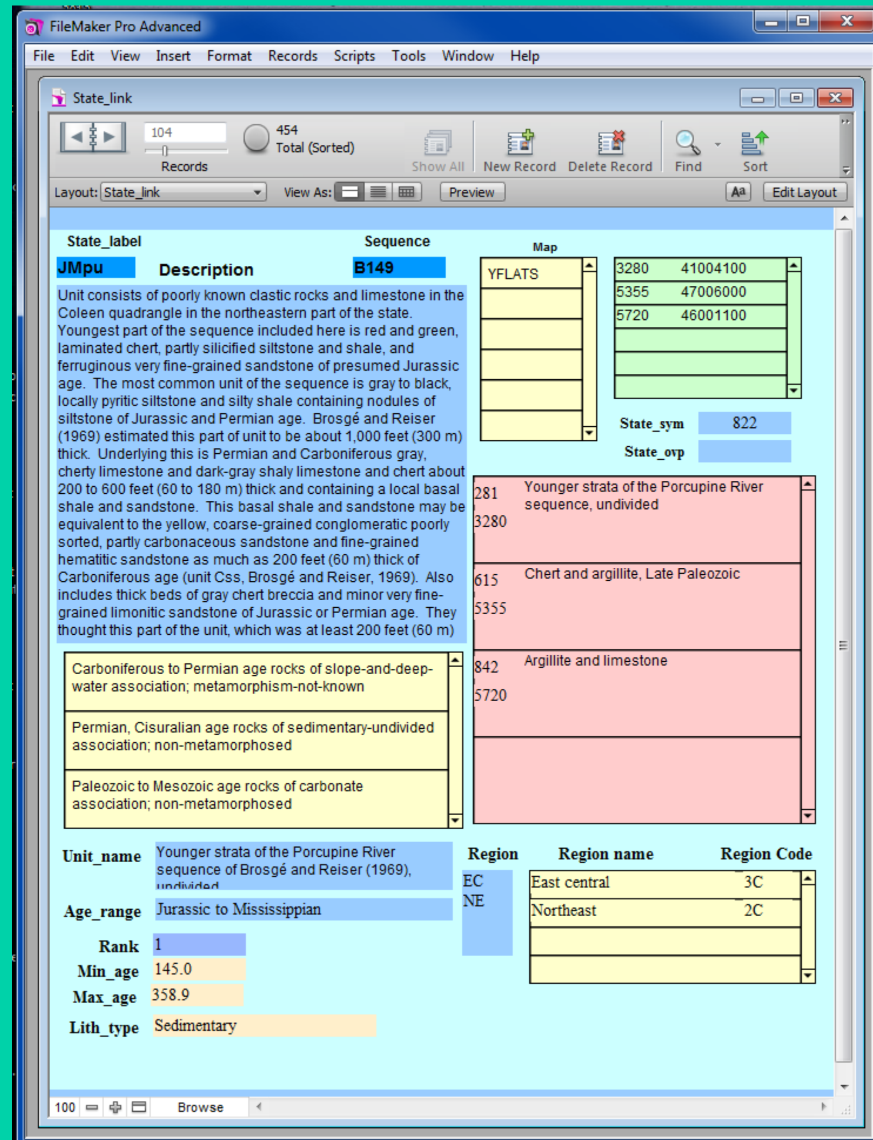
```
UNIQUE ATTRIBUTES IN THE .PAT

Record  FREQUENCY NSACLASS CLASS QCLASS NSAMOD     SOURCE   LABEL2   FILEMAKER
     1       1         0       0     0
     2      18       100     100  1000             BT003    Qs       X
     3     481       102     102   102             BT001
     4     126       105     109  1050             BT003    Qa       X
     5       6       120     112  1200             BT003    Qd       X
     6      48       190     111  1900             BT003    Qew      X
     7       1       285     127  2850             BT003    QTg      X
     8       2      1103     105     0             BT002    Tvab     X
     9       4      1160     110     0             BT002    Tfv      X
    10       1      1160     135     0             BT002    Tfv      X
    11       6      1602     129     0             BT003    TKgp     X
    12       3      1603     136     0             BT003    TKvr     X
    13      10      1990     115     0             BT002    Kqc      X
    14       1      1990     171     0             BT003    Kqc      X
    15       2      2030     116     0             BT003    Kipc     X
    16       7      2030     120     0             BT002    Kipc     X
    17      58      2180     125     0             BT002    Kvm      X
    18      22      2491     131     0             BT003    Kmqm     X
    19       1      2545     134     0             BT003    Ksy      X
    20      10      3498     118     0             BT003    Jtu      X
    21       1      3498     145     0             BT002    Jtu      X
    22       9      5130     132     0             BT003    JTrtmu   X
    23      24      5133     119     0             BT003    JMtu     X
    24       1      5133     140     0             BT002    JMtu     X
    25       3      5145     172     0             BT003    MzPzl    X
    26      11      5340     150     0             BT002    Pzrm     X
    27       1      5340     173     0             BT003    Pzrm     X
    28       8      5561     155     0             BT002    Pzp      X
    29       6      9325     122     0             BT003    PzZrqm   X
    30       6      9325     170     0             BT002    PzZrqm   X

UNIQUE ATTRIBUTES IN THE .AAT

Record  CASE# FREQUENCY ARC-CODE ARC-PARA1 ARC-PARA2 SOURCE
     1      1   283        2         0         0      BT002
     2      2   247        2         0         0      BT003
     3      3   707        7         0         0      BT001
     4      4     3       10         0         0      BT003
     5      5    22       11         0         0      BT002
     6      6    13       11         0         0      BT003
     7      7    19       19         0         0      BT003
     8      8     1       30         0         0      BT003
     9      9    28       31         0         0      BT002
    10     10    23       31         0         0      BT003
    11     11     1       51         0         0      BT003
    12     12    12       52         0         0      BT002
    13     13     1       53         0         0      BT003
    14     14    14       57         0         0      BT003
    15     15     6       88         0         0      BT003
    16     16   134       99         0         0      BT001
```


```
UNIQUE ATTRIBUTES IN THE .AAT

Record  CASE# FREQUENCY ARC-CODE ARC-PARA1 ARC-PARA2 SOURCE
     1      1   283        2         0         0      BT002
     2      2   247        2         0         0      BT003
     3      3   707        7         0         0      BT001
     4      4     3       10         0         0      BT003
     5      5    22       11         0         0      BT002
     6      6    13       11         0         0      BT003
     7      7    19       19         0         0      BT003
     8      8     1       30         0         0      BT003
     9      9    28       31         0         0      BT002
    10     10    23       31         0         0      BT003
    11     11     1       51         0         0      BT003
    12     12    12       52         0         0      BT002
    13     13     1       53         0         0      BT003
    14     14    14       57         0         0      BT003
    15     15     6       88         0         0      BT003
    16     16   134       99         0         0      BT001
```


```
          Description of DOUBLE precision coverage O:/nsa/bt/btgeol

                            FEATURE CLASSES

                                    Number of  Attribute     Spatial
Feature Class          Subclass     Features   data (bytes)  Index?   Topology?
-------------          --------     ---------  ------------  -------  ---------
ARCS                                     1514        60
POLYGONS                                  878        58                Yes
NODES                                    1229

                           SECONDARY FEATURES

Tics                                       92
Arc Segments                            75909
Polygon Labels                            877

                               TOLERANCES

Fuzzy   =              10.000 V        Dangle  =               50.000 N

                           COVERAGE BOUNDARY

Xmin =               500000.000        Xmax =              636123.794
Ymin =              7319720.173        Ymax =             7434345.982

                                 STATUS

The coverage has not been Edited since the last BUILD or CLEAN.

                      COORDINATE SYSTEM DESCRIPTION

Projection                  UTM
Zone                          5
Datum                     NAD27
Units                    METERS          Spheroid            CLARKE1866
Parameters:
```

Correlation of Map Units (CMU)

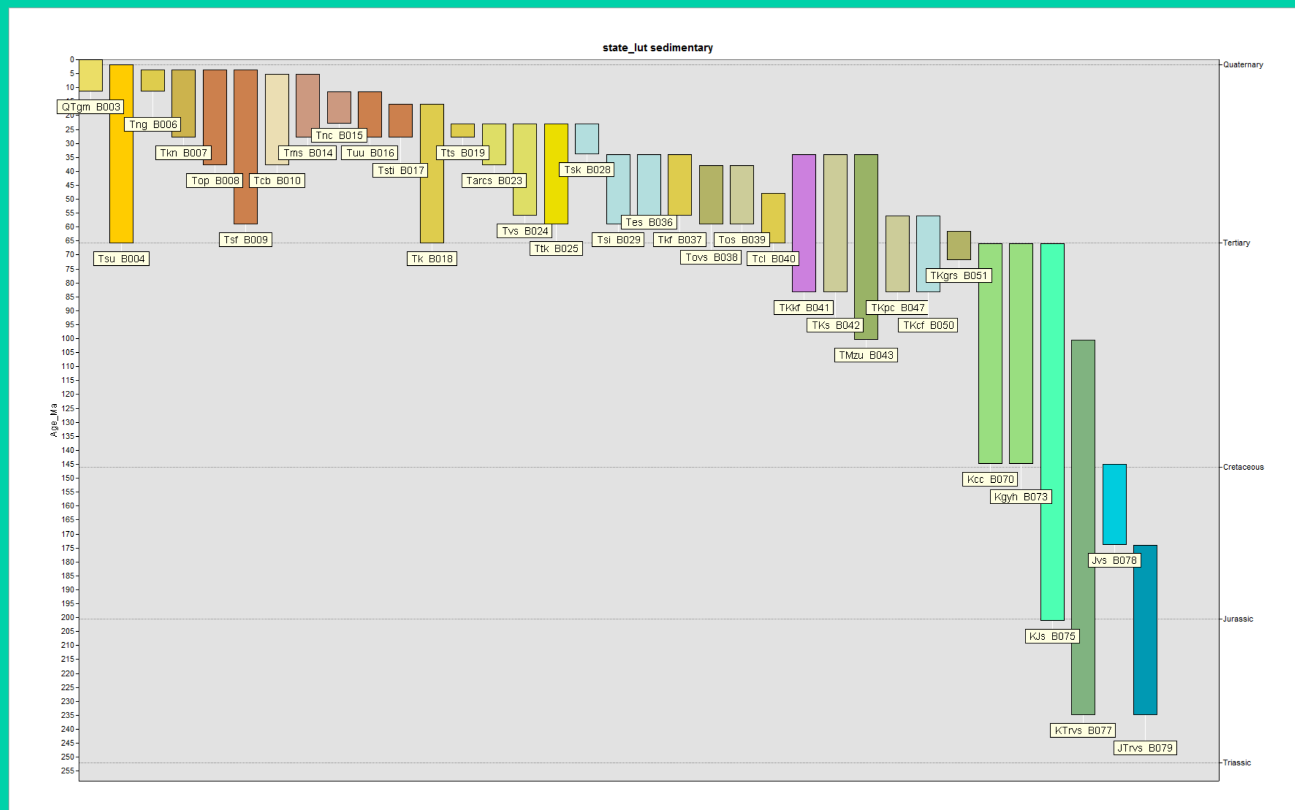
- Levering off of the "State_link" database, a graph tool was written using a Python script that reads the database, capturing State_label, sequence number, color symbol, and the numeric maximum and minimum age, and lithologic type.
- This Python script, run through ArcToolbox, is used to create the draft CMU graphic. The script uses the ArcMap graph tool to create a minimum-maximum age bar graph that shows the age relationships of units. Each bar on the graph is colored using the assigned color and identified by its unit label and sequence number. A numeric age scale-bar is drawn along the left side while the right side shows a geologic time scale.
- Input to the tool can be a feature dataset or standalone table.
- Graphs are created for each lithologic category selected when the tool is run. More than one category can be selected at once. For example, if just sedimentary rocks only one graph would created; if sedimentary and igneous rocks were selected, two separate graphs would be created.
- Output is a graphics file such as an image or eps file. There is also an option to output an ArcMap graph file that can be loaded into the ArcMap Graph Manager.
- The graph tool is intended to provide a quick way to view the age relationships between units within different lithologic categories and to assist with the creation of a correlation of map units chart, but it is not a substitute for the cartographic process of creating the published version of a correlation of map units chart.



Next – Correlation of Map Units

Shown is output from the Python script was created that read the State_link database and its newly added minimum and maximum age fields and generated a graphic of a draft Correlation of Map Units (CMU). As there are about 450 units, the images are sub-divided by lithologic type and apportioned to a reasonable units number per image.

Sample image



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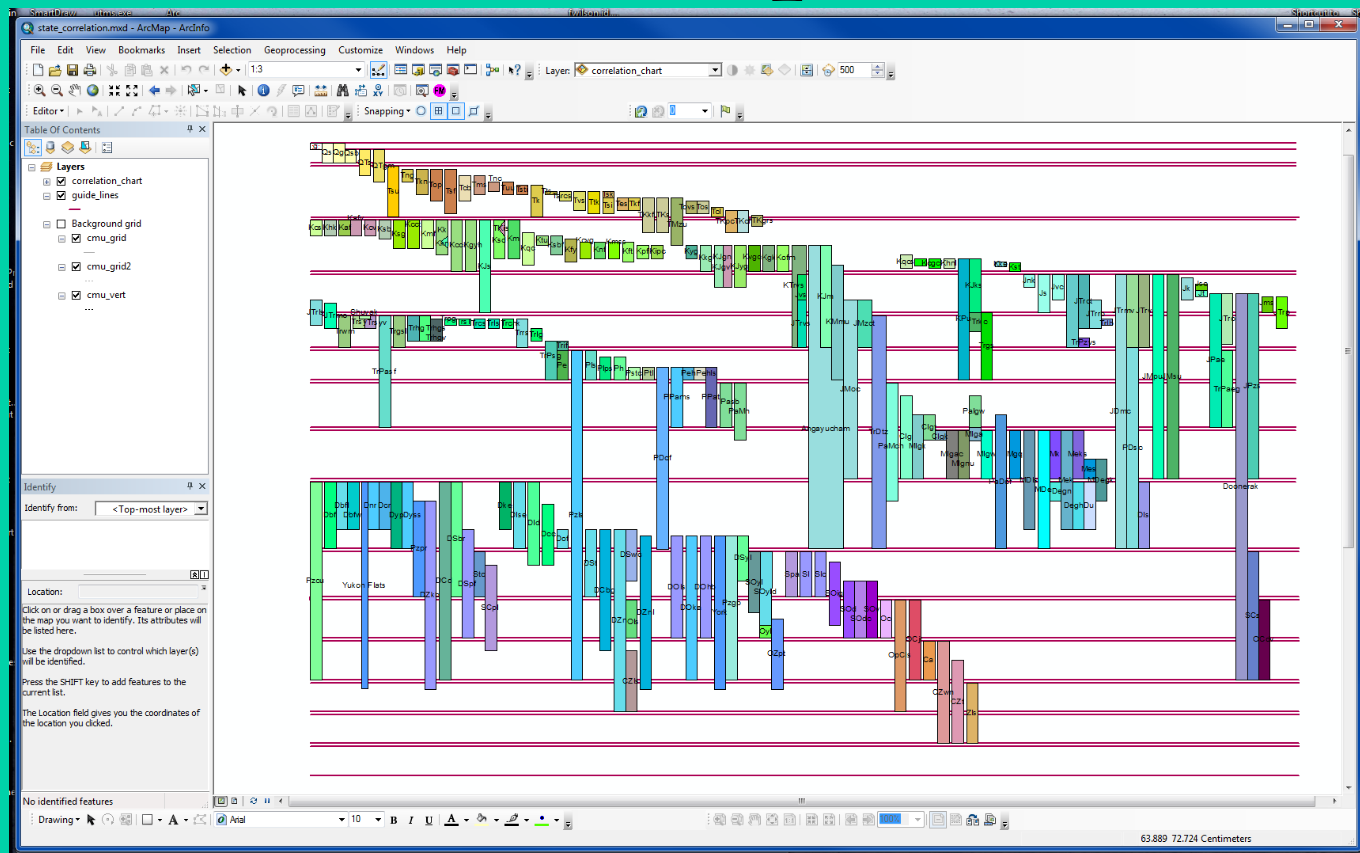
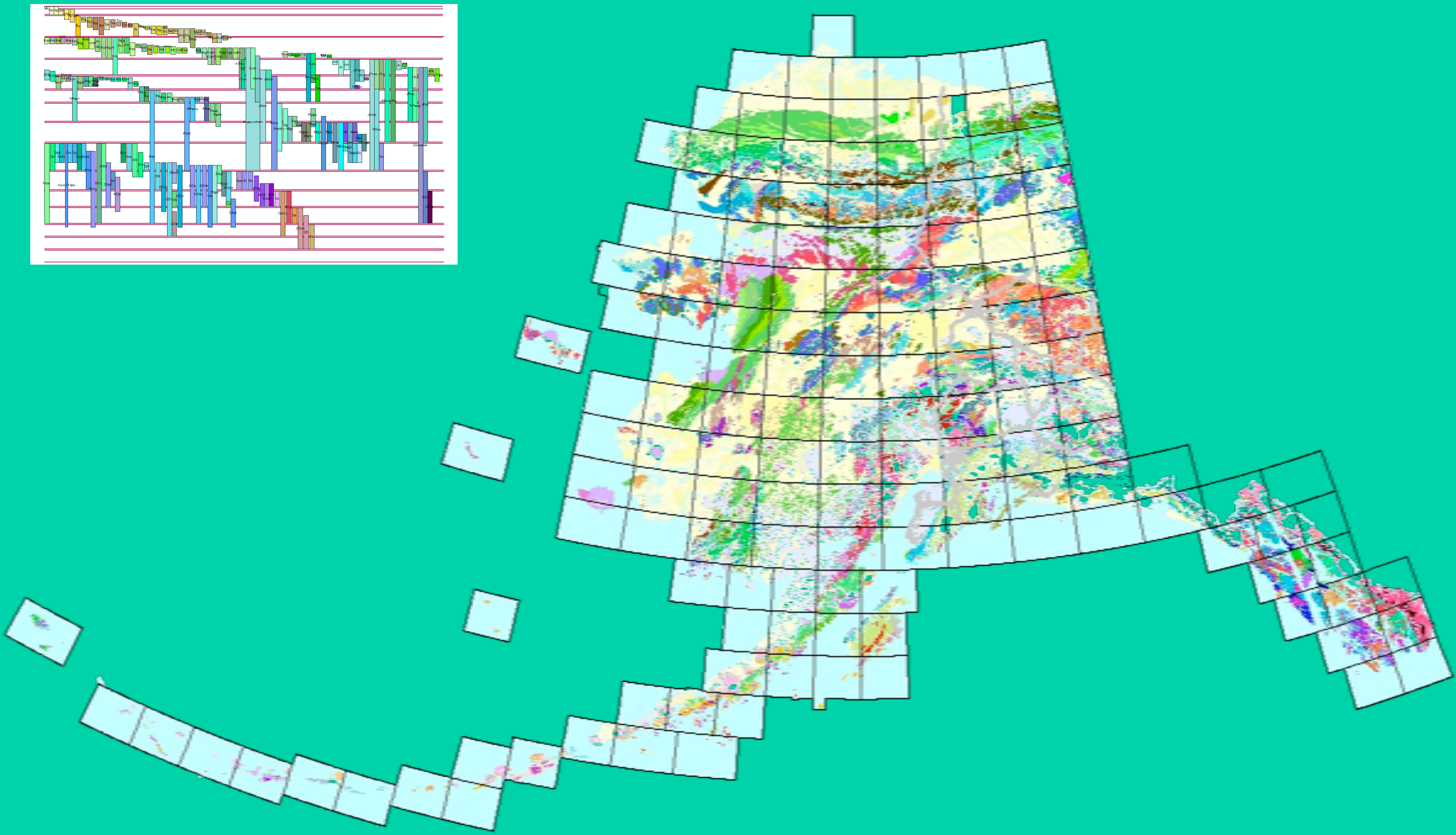
CMU next step

The draft CMU images were used as guides to create an ArcGIS MXD for the final CMU. The MXD is linked to the Filemaker Pro State_link database (using ODBC) such that once a box is drawn and attributed with a sequence number, the label and color symbol are automatically added. A hidden fishnet grid is used to snap vertices, ensuring proper alignment of boxes. If a label or color symbol is changed in the database, this change is reflected in the MXD by doing a refresh.



This draft version covers only the sedimentary rock units for the state map; additional charts will cover igneous and metamorphic rock units.

A mock-up of the new Alaska map



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END OF PRESENTATION

Following slide adds information regarding CMU python script.

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CMU tools

A python script, run through ArcToolbox is used to create the draft CMU graphic. The tool is written as a python script that is run through ArcToolbox.

The python script uses the ArcMap graph tool to create a min.-max. age bar graph that shows the age relationships of units for a particular lithology. Each bar on the graph is colored using the correct color from the map and identified by its unit label and sequence number. A numeric age scale-bar is shown along the left side while the right side shows a geologic time scale.

Input to the tool can be a feature dataset or standalone table.

The input data for the geologic units must include the unit label, lithologic category, numeric minimum and maximum ages, and the color symbol values to apply.

Graphs are created for each lithologic category selected when the tool is run. More than one category can be selected at once. For example, if just sedimentary only one graph would created; if sedimentary and igneous were selected, two separate graphs would be created.

Output from the tool are graphics files such as images or eps files. There is also an option to output an ArcMap graph file that can be loaded into the ArcMap Graph Manager.

The graph tool is intended to provide a quick way to view the age relationships between units within different lithologic categories and to assist with the creation of a correlation of map units chart, but it is not a substitute for the cartographic process of creating the published version of a correlation of map units chart.