Updating New Ventures exploration databases using ArcGIS data analysis techniques

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When we are looking for new oil & gas deals (like lease sales, bid rounds, farm-ins), we need to rapidly assimilate and evaluate geological datasets or "data packages". Obviously, ArcGIS has a quick GIS display engine, but the real power and benefits lies in the ability to standardize and quality-check the data. We want to standardize and normalize the data so we can quickly create an unbiased geological interpretation of the data.

Introduction to exploration

New Ventures exploration requires the rapid building of geological interpretation databases.

Data analysis techniques using ArcGIS during the data acquisition and preparation phases of a project greatly improve the data-quality of the interpretation databases and reduce cycle time.

Use ArcGIS to not just display your data, but to ANALYZE your data!

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Before forming a process to manage the interpretation databases, we should examine the needs of the specific projects.

What is our data management philosophy? / Internal drilling and production data? / Regional exploration interpretation team?Lease bid rounds, Other business drivers?

Data warehouses: stores of "clean" data with consistent quality, some data is missing

Interpretation database: all data is filled in with best-available or best-guess

Interaction between these two types of databases is becoming more critical to the future success of regional hydrocarbon exploration.

Interpretation databases will eventually go back into the data warehouse database.

Need to facilitate this handoff by developing corporate data management standards.

Organization is essential if we expect to quickly evaluate the upstream business opportunities presented to the corporation.

New Ventures exploration requires the rapid building of geological interpretation databases. Data analysis techniques using ArcGIS during the data acquisition and preparation phases of a project greatly improve the data-quality of the interpretation databases and reduce cycle time. So what we want to do is to use ArcGIS to not just display your data, but to ANALYZE your data!

Examples to be presented

- "Data room" assimilation (seismic line selection)
- Well location analysis (precision, geodetic datum)
- Well header updates (country, elevation, status, field, basin)
- Spatial analysis of stratigraphic picks (time-equivalent facies distribution)

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Some examples to be presented are:

- **Digitization / digestion / assimilation of large amounts of paper records. Seismic line selection by cross-referencing vendor and in-house navigation databases and overlays of prospect areas**
- **Well location precision analysis to separate out wells that can not be used for geodetic analysis**
- **Well location geodetic analysis of vendor and in-house databases to add datum metadata**
- **Using the ArcToolbox Intersection tool to update Well header country / elevation / water depth / basin name / field name / updates**
- **Spatial analysis of stratigraphic pick distribution to identify time-equivalent facies**

Seismic Interpretation

2D Seismic

3D Seismic

Grid

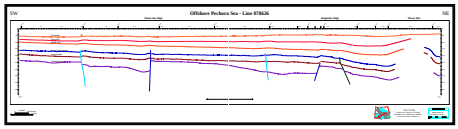
Contour

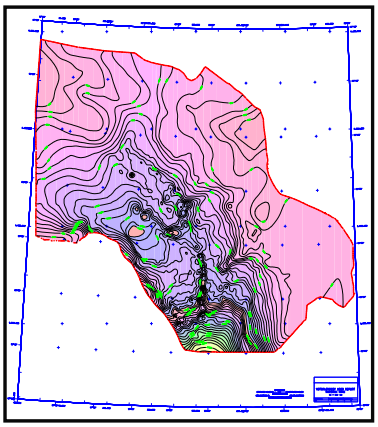
Cross sections

Regional

Prospect

Merged





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2D Seismic interpretation
3D Seismic interpretation
Contours
Digitize
Grids
<u>Semi-structured data!</u>

Regional-scale maps
Prospect-scale (small scale) maps
Merged regional and detail (prospect) maps

These teams need to interpret seismic data for structural geology.

Optimistic project timelines of earth science teams operating under tight project schedules often…

underestimate
data management time!

What is the importance of quality data?

Geological interpretation is one of the most important tasks in our corporation.

Quality data input to the interpretation computer programs is essential...

- ***These programs are very sensitive to outlier data points.***
- ***Bad data slows the interpretation process due to the time required to make corrections and the mental distraction from the interpretation process.***

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Geological interpretation is one of the most important tasks in our corporation. Quality data input to the interpretation computer programs is essential. These programs are very sensitive to outlier data points. Bad data slows the interpretation process due to the time required to make corrections and the mental distraction from the interpretation process.

Database quality management can be difficult in cases of ambiguous data. When problems with poor-quality data are compounded by the amount of data needed to evaluate regional areas for hydrocarbons, computer programming is the only method to increase the quality of the data.

The number of fields in the typical New Ventures project database that we need to quality-check is actually quite low. This talk will discuss short scripts, extensions and macros for ArcGIS to further increase our productivity. The programming needed to evaluate the database is quite simple; most of the calculations involve only arithmetic and logic.

New projects seismic line selection

- Need to quickly evaluate new opportunities
- How quickly can we "digest" the geologic information provided by the seller?
- Seismic line selection by cross-referencing vendor and in-house navigation databases

Fortunately, most New Ventures exploration projects do not required the topological rigor (precision) that development projects require!

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New projects seismic line selection

We need to quickly evaluate new opportunities and ordering seismic data is one of the most important early tasks. We need to quickly "digest" the existing "data package" of geologic information provided by the seller. The first job is to select new seismic lines by cross-referencing vendor/data package and our in-house seismic navigation databases.

I digitize or photograph the paper basemaps, georeference the raster images and digitize the seismic line shapefiles. Fortunately, for my digitizing, most New Ventures exploration projects do not required the topological rigor (precision) that development projects require!

"Data Room" Deliverables

- ✓ Detailed GGIS listings & basemap AOI polygons
- ✓ Georeferenced raster images of basemaps
- ✓ Seismic line navigation digitized (highlighted)
- ✓ Cross section lines digitized

Other info: seismic navigation, technical reports, well log database listings by well

dBase tables / Shapefiles / Raster images

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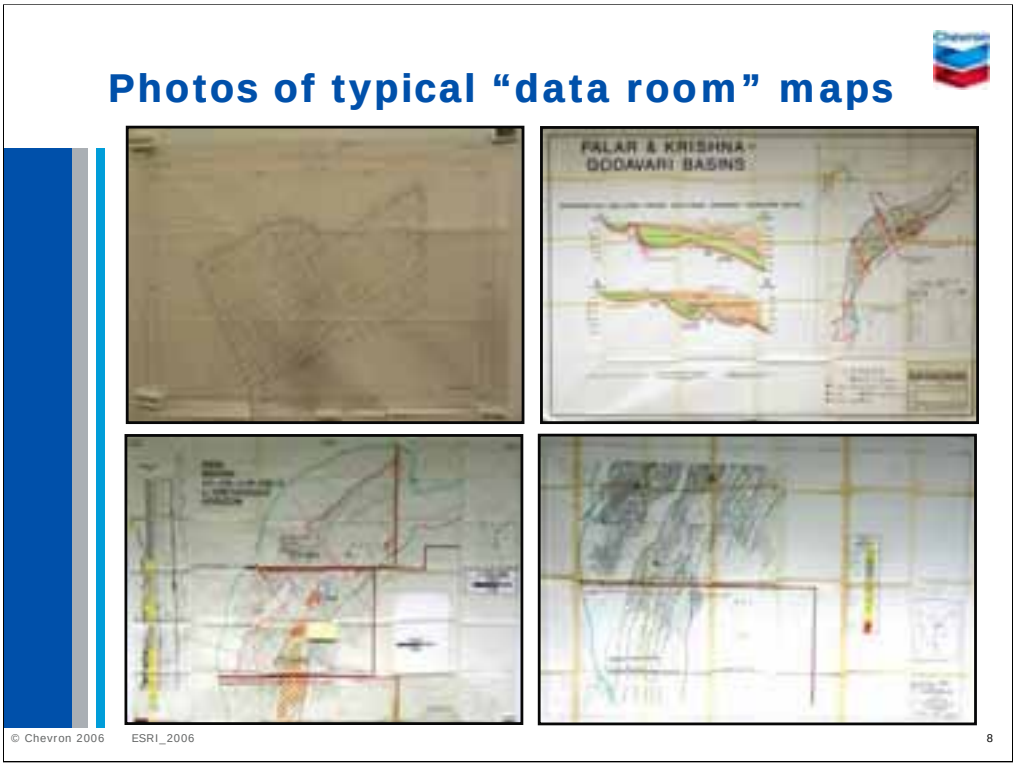
New ventures projects often require the rapid incorporation of paper records in a data room into the interpretation database.

Typically, we have only a day or two to examine the farm-in project records in the data room. How can we quickly "digest" this information and bring it back to our office and use it to evaluate the new project?

We need three sets of information to quickly import the paper records into ArcGIS: (1) a raster image of the item, (2) a table of the locations of the wells and corner reference points of the AOI polygons of the map images and (3) a tabular listing of descriptions of the data.

- ✓ Detailed GGIS listings & basemap AOI polygons
- ✓ Georeferenced raster images of basemaps
- ✓ Seismic line navigation digitized (highlighted)
- ✓ Cross section lines digitized
- ✓ *Other info: seismic navigation, technical reports, well log database listings by well*
- ✓ dBase tables / Shapefiles / Raster images

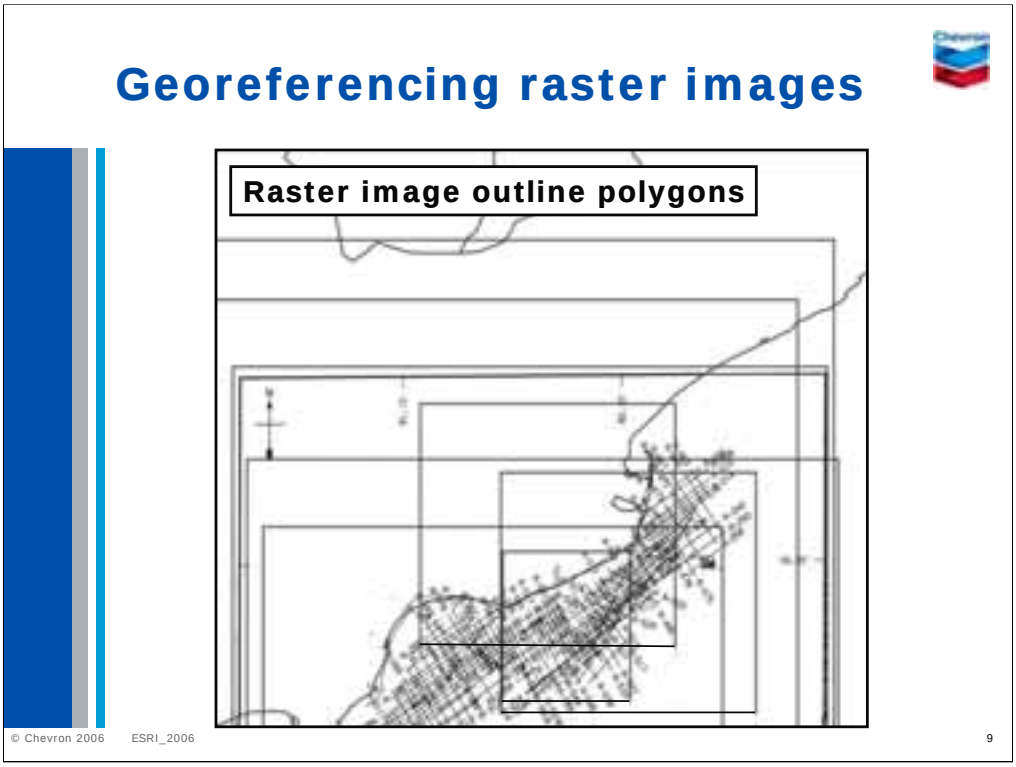


The quickest way to create image files from the paper records is to photograph the maps and cross sections on the wall. Although not nearly as accurate as large-format scanning, the text labels on the maps are legible. The photographs are much smaller images than large format scans and can be quickly georeferenced to regional interpretation standards. We can also use Layout View to line up the latitude and longitude corner points of the maps.

The main problem is renaming the raster image files. It is better to take the photo and immediately rename and copy to your ArcGIS project folder. Build pyramids, georeference and move to the project personal geodatabase.

After loading existing digital seismic nav data, remaining lines are digitized on-screen and linenames entered.

Join or relate any data tables to the seismic nav data so selections of data can be made.



Making a raster fit data from a known coordinate system.

ArcGIS may put georeference in AUX file

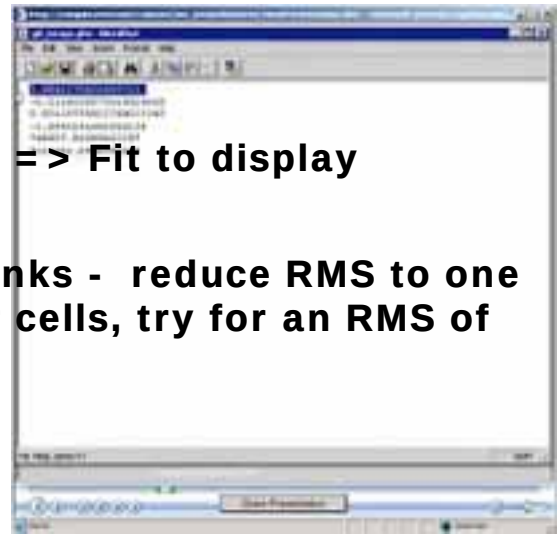
Gif image

Xml created by metadata

Rrd reduced pyramids

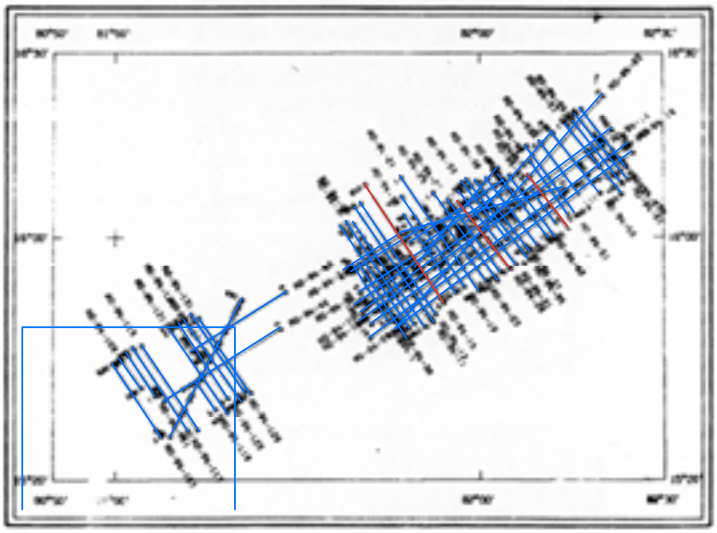
Aux georef stats coor sys

Gfw world file



1. **Add control and raster layers**
2. **Adjust raster display Georeferencing => Fit to display**
3. **Add links**
4. **Evaluate link errors and delete bad links - reduce RMS to one output cell size or less (For 10 meter cells, try for an RMS of 10)**
5. **Apply georeferencing, rectify image**

Seismic basemap



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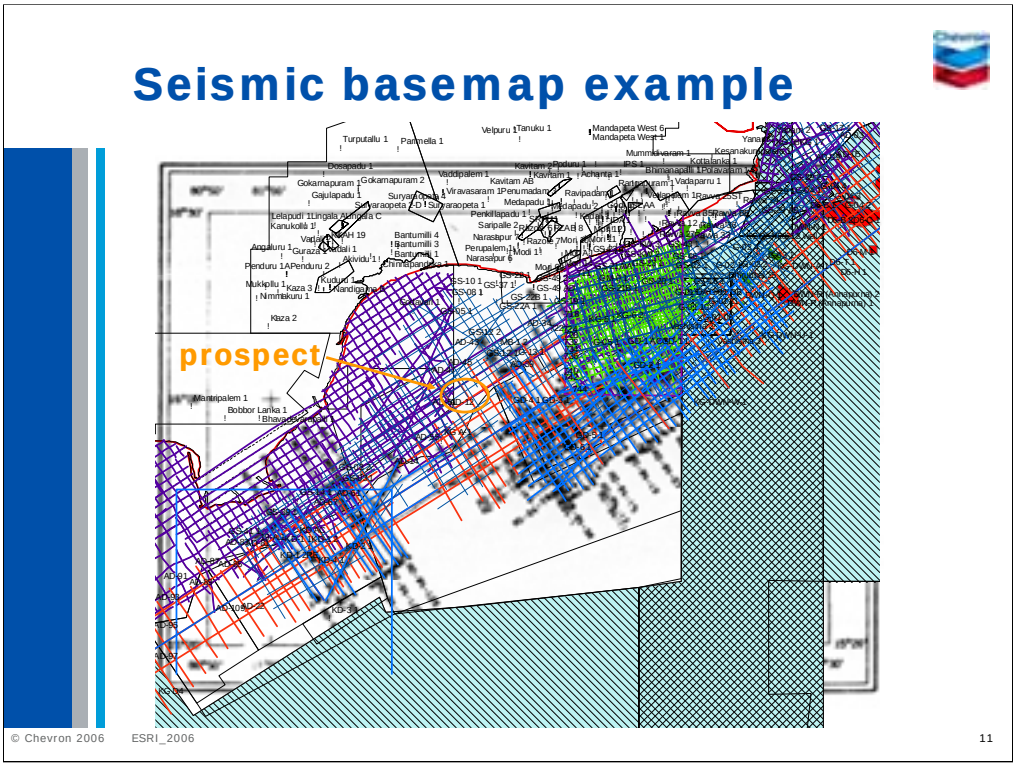
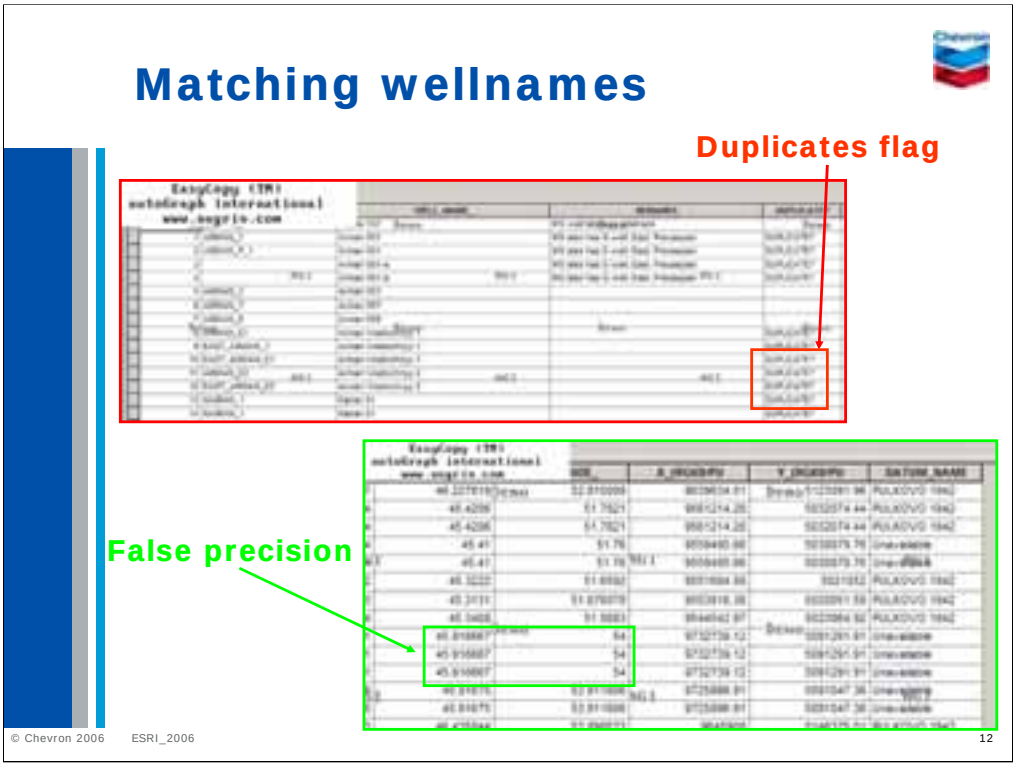
The quality of the photographed rasters is quite good. Create and edit a line shapefile and add use ArcToolbox to Add a "Linename" Field to the shapefile. Digitize the seismic line navigation and save. Now seismic lines in the data package can now be quickly located.

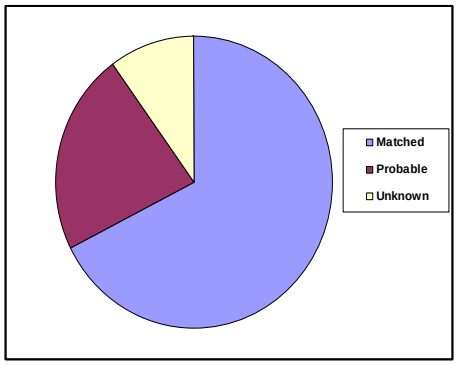


Overlaying additional layers aids in selecting additional seismic lines for purchase. An Access project seismic navigation database can manage the ordering of the seismic data. Symbology of the lines can be color-coded by those that are available, ordered, received and loaded. This prevents the purchase of duplicate lines.



1. Match the Chevron and IHS wellnames.
2. Create a table of Chevron UWI versus IHS WellID.
3. Edit IHS wellnames to match CVX wellnames.
4. Merge Chevron UWI and IHS WellID key fields.
5. Merge IHS data to CVX Project as needed.

IHS Well Matches



67% matched

Well location precision analysis

- Data-entry, reformatting and data storage conversion into a standard dataset
- Calculate distance and bearing between datasets
  - typographical errors
  - geodetic datum-shift errors
  - within tolerance "close-enough"
  - duplicates & exact matches (overposting)
- Data precision analysis
- Generate Comments/Remarks; generate Actions to perform on dataset to create load file

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- A study of 700+ well locations from Iraq show that *data rounding and truncation*, not geodetic datum shifts are the most likely source of well location errors.
- Select "best" well location from several well location datasets
- Eliminate duplicate well locations and resulting overposting of well picks
- Quantify area of uncertainty around well location for well correlation ties

- Data-entry, reformatting and data storage conversion into a standard dataset
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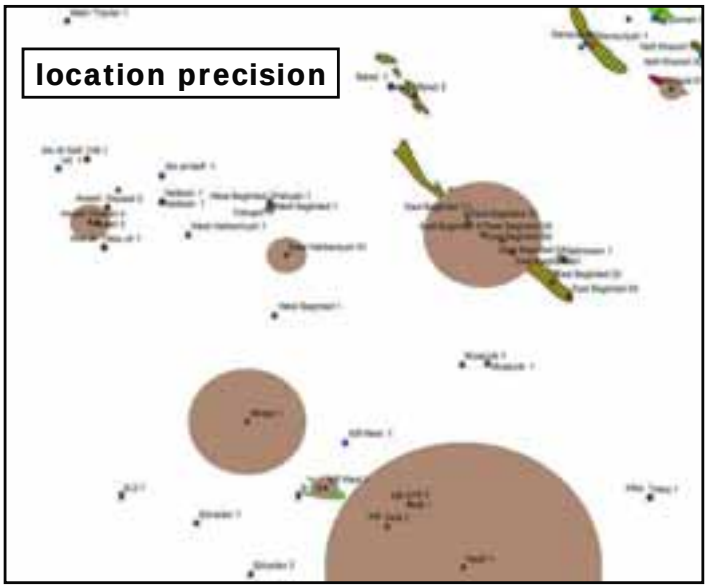
Quality-checking map displays



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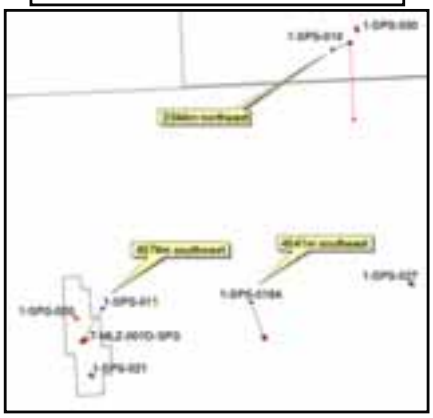
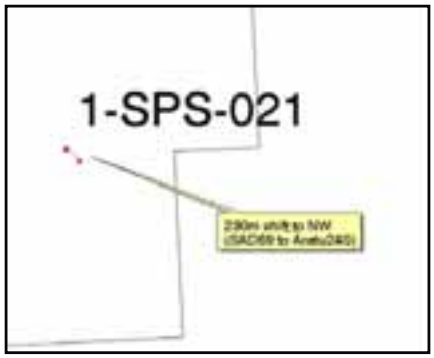
The creation of a buffer feature symbolizing the maximum possible error due to a lack of precision in the wel location coordinate aids in identifying the wells with a large possible error and allows more intelligent ties to other data such as seismic lines. Often the wells with large errors are older, outlying rank-wildcat wells needed for regional correlations.

Datum shift example – Brazil Offshore

Distance and bearing



Geodetic datum



Calculate distance and bearing between locations…
Look for consistent (known) values of datum shifts.

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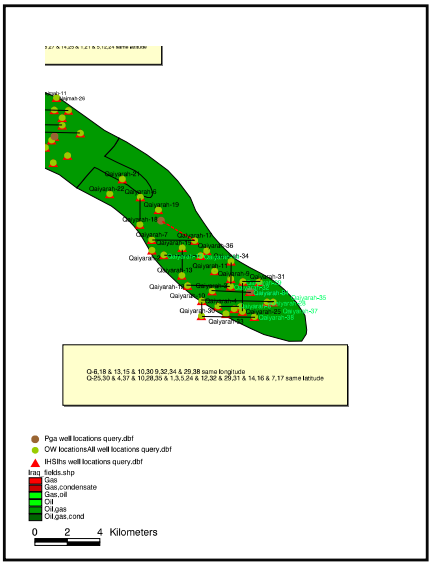
Calculate distance and bearing between locations… sort the table and look for consistent (known) values of datum shifts.

Drawing lines between locations for the same wellbore obtained from different vendor sources allows much easier viewing of the well location descrepancies.

Duplicate well locations



REFNO	Wellname	Lat	Lon	Notes
VB6361	Well-1	35.9	43.1375	LON SAME
VB6365	Well-5	35.90416667	43.12083333	LON SAME
VB6366	Well-7	35.88333333	43.1375	LON SAME
VB6367	Well-8	35.89166667	43.125	LON SAME
VB6368	Well-10	35.91944444	43.125	LON SAME
VB6370	Well-12	35.90416667	43.15277778	LON SAME
VB6371	Well-14	35.89583333	43.15833333	LON SAME
VB6372	Well-18	35.87916667	43.1625	LON SAME
VB6373	Well-20	35.875	43.15277778	LON SAME
VB6374	Well-21	35.9	43.15833333	LON SAME
VB6375	Well-22	35.88333333	43.14722222	LAT SAME
VB6377	Well-24	35.90416667	43.1625	LON SAME
VB6378	Well-25	35.89583333	43.10833333	LAT SAME
VB6380	Well-27	35.89166667	43.17083333	LAT SAME
VB6381	Well-28	35.88333333	43.125	LON SAME

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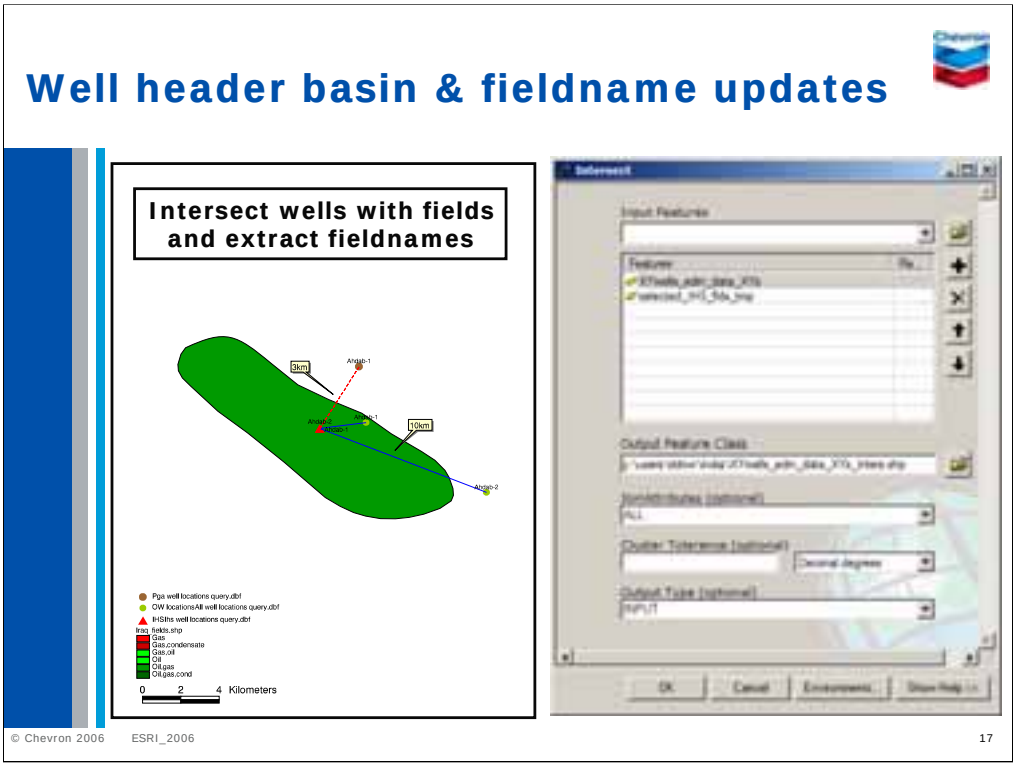
1. Sort the well location spreadsheet by latitude
2. Subtract one cell by the next cell to identify duplicates
3. Repeat process for longitude
4. Create a sub-table of duplicate well locations for a field
5. Display the map view and add annotation and lines tying each duplicate well location



Well header basin & field name updates using the ArcToolbox Intersection tool

Toolbox => Analysis Tools => Overlay => Intersect

Extract *field name* values from polygon layer and append to well location table

<u>Overlays to use</u>

Fieldname

Basin name

Bathymetry

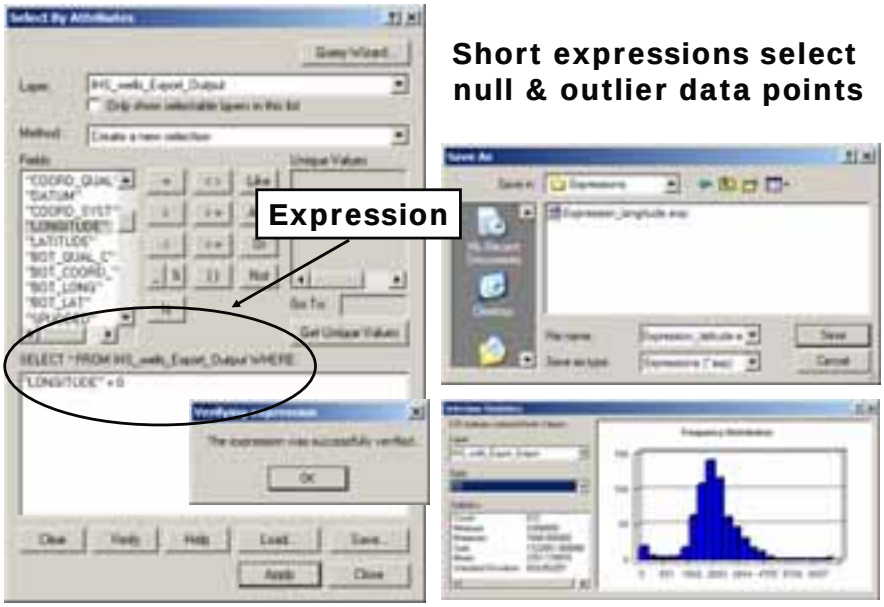
Ground elevation

Concession

Country

Raster cell values

QC data – Select by Attributes



Short expressions select null & outlier data points

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Well header basic QC

- blank common well names
- duplicate well names
- zero or null XY locations
- zero, null or too large latitude / longitude
- null geodetic or elevation datum
- zero or null total depth
- unknown status or status symbol
- picks greater than total depth
- picks with duplicate names

Lookup Table - Corrections

Create a "look-up" table with a list of common corrections to the database.

Apply this list of standardize naming conventions to your data by joining or relating the look-up table to your database.

Use for country, field, well status, log curve names, pick names…

Country Look-up

Burma => Myanmar
Ceylon => Sri Lanka
Dahomey => Benin
Ellice Islands => Tuvalu
Gold Coast => Ghana
Kazakstan => Kazakhstan
KAZAKSTAN => Kazakhstan
Liechtenstien => Liechtenstein
Luxemburg => Luxembourg
Rhodesia => Zimbabwe
Siam = > Thailand
South-West Africa => Namibia
Spanish Guinea => Equatorial Guinea

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Create a "look-up" table with a list of common corrections to the database.

Apply this list of standardize naming conventions to your data by joining or relating the look-up table to your database.

Use for country, field, well status, log curve names, pick names…

•Create look-up tables with lists of wells that you are working on.

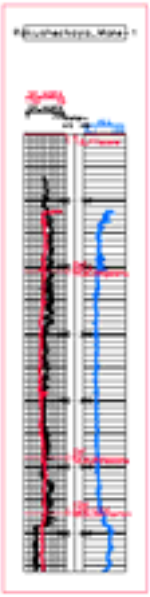
• Use these *Well lists* to SELECT only the subset of well data you need to access.

Well Name	Well Id
Dahanu B-12-2	100000368100
Geleki 286	100000368255
Geleki BA	100000368266
Lakwa 507	100000368267
Santhal 175	100000368273
Mewad 12	100000368330
Gandhar 470	100000368331
Ahmedabad 095	100000368332

Well log issues

- Run, version numbers of field logs
- Create log templates
  (need list of log names & types)
- FE Analysis done? (computed logs)

- log depth > well total depth
- decimal / percent issues
- possible duplication of logs
- suspicious min / max values
- unknown / null / mismatched units



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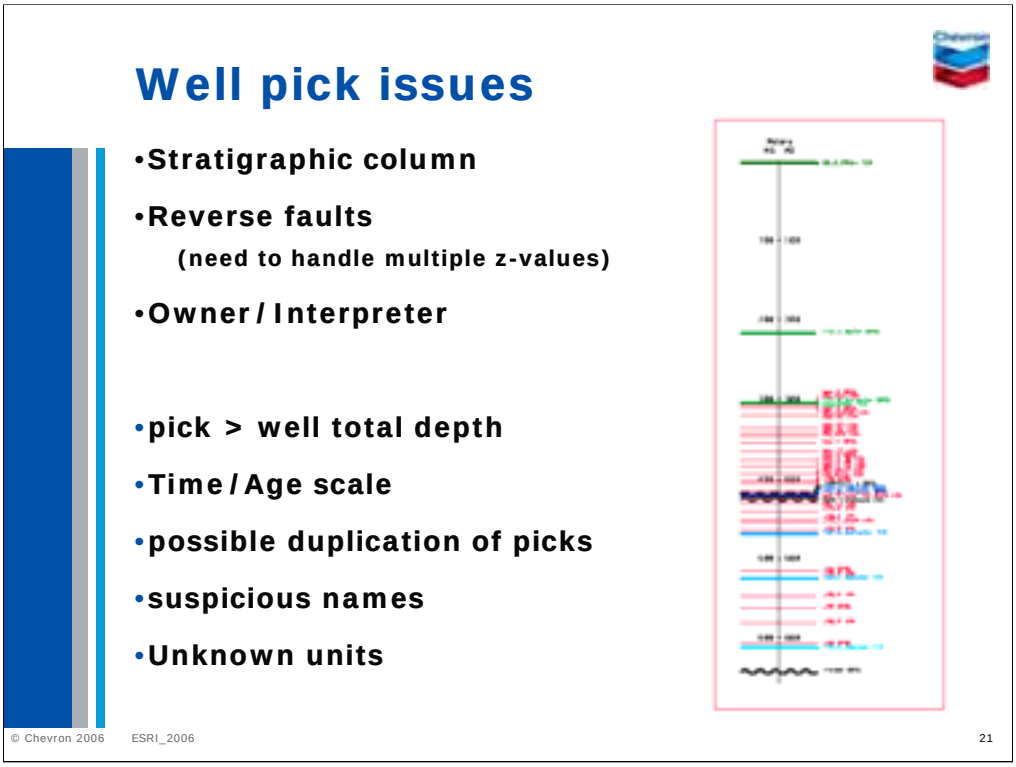
Items to QC for well logs

- Run, version numbers of field logs (Composite or processed logs get a different designation)
- Create log templates
  (We will need a list of log names, types and a count of the number of curves of each type)
- FE Analysis done? (computed or processed logs)

- Is the log depth greater than the well total depth?
- Are there decimal / percent issues especially with posrosity logs
- Are there possible duplicate copies of logs?
- Are there suspicious min / max values for the curves?
- Are there unknown / null / or mismatched units?



Common QC issues with stratigraphic well picks

- Need to make a Stratigraphic column from list of unique pick names
- Need to identify and handle multiple z-values for Reverse faults

- Who is the Owner / Interpreter of the data, is the data going to be copied to the corporate strat database?

- Is the pick depth greater than the well total depth?
- What is the Time or Age of the pick for the time scale?
- Are there possible duplication of picks? Picks with different names meaning the same horizon?
- Are there suspicious names?
- Are there Unknown units of depth / porosity / perm?

Stratigraphic nomenclature

- Making decisions early about stratigraphy "front-end" loads the process. This avoids changing pick names once the dataset has been loaded to OpenWorks.
- OpenWorks database naming for surfaces is consistent, so computer applications run much better.
- This technique can be used for both new and existing pick datasets regardless of the size of the datasets.
- A set of unique surface names is generated that can be transformed into a stratigraphic column.

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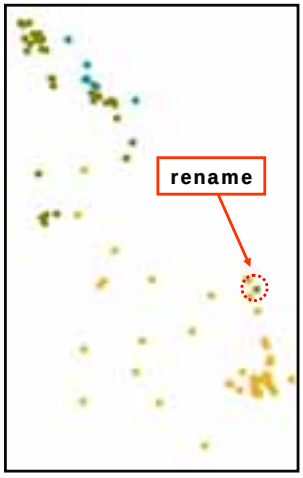
- Making decisions early about stratigraphy "front-end" loads the process. This avoids changing pick names once the dataset has been loaded to OpenWorks.
- This technique can be used for both new and existing pick datasets regardless of the size of the datasets.
- OpenWorks database naming for surfaces is consistent, so computer applications run much better.
- Using Microsoft Excel's PivotTable feature, you can quickly transform a column of data into a list of unique name or numbers with a count of the number of occurrences of each pickname.
- Display of OpenWorks picks in StratWorks is controlled by the surfaces in the Stratigraphic Column, the surface names are the key to pick data management.
- Use the pickname count to look for "one-off" picks that will create confusion in the database.
- A set of unique surface names is generated that can be transformed into a stratigraphic column.
- Use the pickname list to generate an StratWorks Stratigraphic Column ".sce" ASCII file.

Spatial analysis of stratigraphic picks

- When concatenating stratigraphic picks from several different interpreters, there are differences in stratigraphic terminology that need to be standardized
- Some picks have different names, but represent the same stratigraphic surface
- Check spatial distribution of picks for facies-equivalent picks



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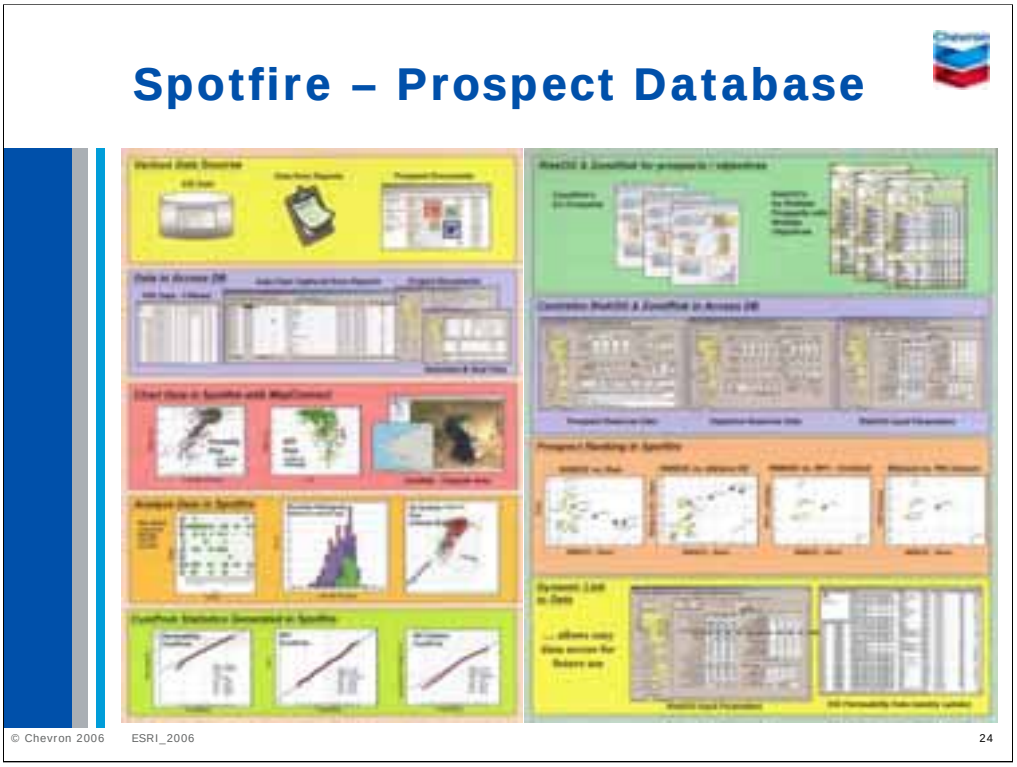
- Check spatial distribution of picks for facies-equivalent picks

This example from Iraq shows a shoreface facies in blue, a shallow-water faciesin green and a deep-water facies in yellow. Note the 1 shallow-water pick name in the deep-water facies area.



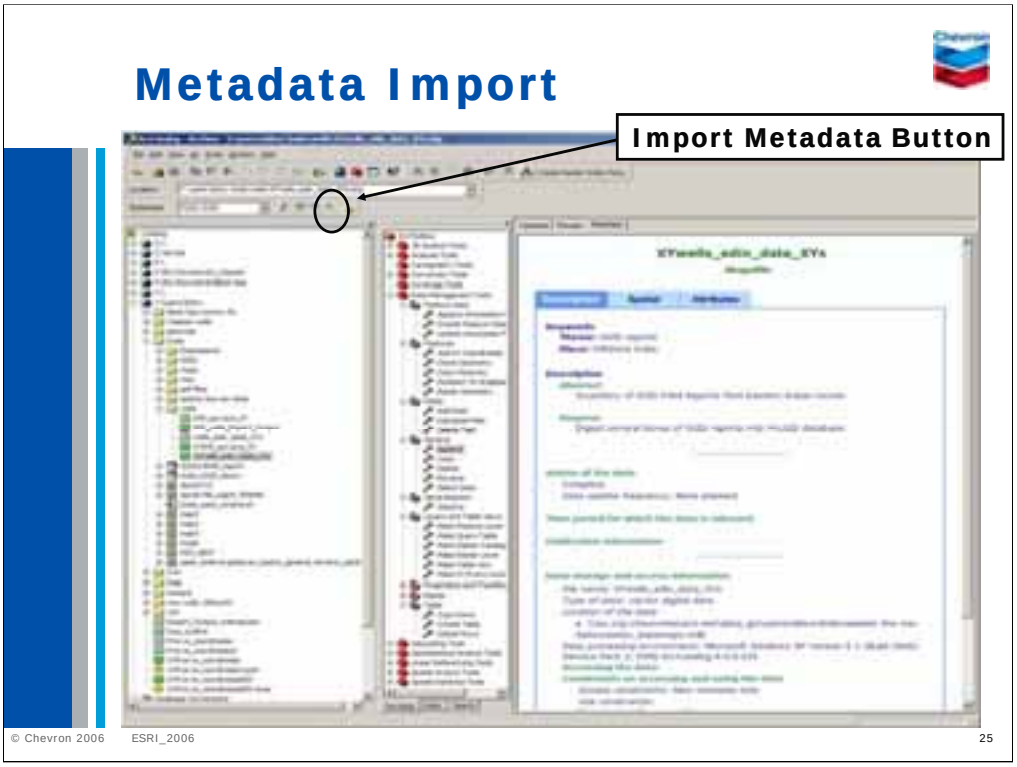
Example Spotfire Problem Overview

Use Spotfire DecisionSite to determine which of the 11 Oil Fields are the best candidates for the recovery of bypass oil.

View the Oil Production per Production Year for all 11 Oil Fields.

Find the Oil Fields that exhibit all of the three key characteristics of interest:

- **Decline in Active Well Rate > 5%**
- **Decline in Oil Production Rate > 20%**
- **Declines during the first 7 Production Years**



- Standard metadata template for your project. Fill in the basic information your company needs for these files.
- Metadata "template" as a html file and import into each project file
- .xml metadata files
- Thumbnail image of the file.
- Catalog files of the Windows/Adobe/Raster Image File Properties

Conclusions

Analyzing the datasets using basic math and logic algorithms grades the quality of the data, allowing adjustment of difficult interpretation problems to fit the real nature of the dataset.

Using ArcGIS to analyze the various geological datasets *before* loading the final update files to the exploration interpretation database results in a significant cost-savings compared to correcting duplicate or lower-quality data.

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Examples presented

- Seismic line selection by cross-referencing vendor and in-house navigation databases
- Well location precision analysis
- Well location geodetic analysis of vendor and in-house databases
- Well header basin and fieldname updates using the ArcToolbox Intersection tool
- Spatial analysis of stratigraphic pick distribution

Analyzing the datasets using basic math and logic algorithms grades the quality of the data, allowing adjustment of difficult interpretation problems to fit the real nature of the dataset.

Using ArcGIS to analyze the various geological datasets *before* loading the final update files to the exploration interpretation database results in a significant cost-savings compared to correcting duplicate or lower-quality data.

Contact Info

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Thanks!