Industry Contributed Fault Map of Oklahoma

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Introduction

The Oklahoma Geological Survey has recently assembled a statewide fault database in order to gain a better understanding of potential seismic hazards and subsurface geology. This database includes a compilation of surface and subsurface faults in Oklahoma based on available data contributed in voluntary cooperation with members of the Oklahoma Independent Petroleum Association (OIPA). The objectives of this database are to:

1. Identify significant subsurface and surface faults within Oklahoma. Particularly of interest in this effort was the contribution of faults in lower stratigraphic units, because most of the seismicity within Oklahoma is occurring below sedimentary units in crystalline basement (Darold et al., 2015).
2. Compile previously unreleased, proprietary industry contributions with a focus on metadata and quality of the fault location and other important information.
3. Enhance the Oklahoma Fault Database and maps that can be used for research, and by the public, industry, and state agencies.
4. Encourage future high quality contributions from the oil and gas industry and others.

The Oklahoma Fault Database is not intended to be a map of faults within Oklahoma, although such products can be derived from this effort (Holland, 2015; Marsh and Holland, 2016). Instead, the Oklahoma Fault Database is a GIS-enabled database that may provide several representations of the same fault. This has the advantage of providing assessments of where geologist agree and faults can be considered to have low spatial uncertainty and areas where there is little or no agreement; these faults would be considered to have high spatial uncertainty. In addition, the source of the fault and other key information such as the formation or formations the fault can be seen to offset. Each fault is assigned a quality rating, which is based on how the fault was constrained, which can dramatically help in assessing faulting structure within an area. The Oklahoma Fault Database is designed to be available to all stakeholders through the OGS.

Application

The compilation of data voluntarily contributed by industry presented a number of challenges, including:

- Each contributor may have a different the definition of what is a "significant" fault. The choice of what was a significant fault and the method of interpretation was left to each contributor.
- Differences in interpretation of subsurface data can and does occur throughout individual organizations as well as between organizations.
- The faults contributed to this effort become public record. Faults are already being used in the permitting and evaluation of existing wells by the Oklahoma Corporation Commission (Holland et al., 2014). This means that voluntary data contributions could potentially inhibit an organizations ability to operate within an area.
- It is often the case that individuals submitting data for an organization my not be familiar with the data enough to accurately provide the requested metadata.
- Oil and gas companies have many different software systems and methods of representing faults that may or may not be easily compatible or represented in the requested format.

Capturing relevant metadata was a major goal of the Oklahoma Fault Database effort. Metadata regarding faults is especially important, as a fault is a 3-dimensional structure with a wide variety of properties that are both potentially known and unknown. The OGS developed a framework for metadata that was provided to contributors that described the type of metadata requested (Table 1). Metadata takes time and effort to fill out correctly and fully capture. To encourage more data contributions, we attempted to establish a balance between forcing a rigid metadata requirement and making the process of contributing valuable data as easy as possible.

The metadata and geospatial information for the industry contributions is stored in a geospatially enabled relational database. The data contributions are provided in a number of geospatial formats derived directly from the database. The geospatial data and metadata can be downloaded from the OGS website's Oklahoma Fault Database page. The data can then be explored by standard GIS applications both spatially and from the metadata.

To further ease the contribution process, we created a secure online submission file server and communicated with the various industry contributors to ensure the integrity of the data. Contributors were given a login and password to the secure file server and provided with a list of instructions, a list of defined fault attributes, a shapefile of preliminary statewide faults from prior publications, and an example database. OGS staff are available for technical assistance.

Table 1. Metadata and definitions requested from contributors.

OBJECTID
Unique identification number assigned automatically when a feature is added in ArcGIS.

SHAPE
Default feature type is polyline z. Assigned automatically when a feature is added in ArcGIS.

SHAPE_LENGTH
Length of the polyline in decimal degrees. Calculated automatically in ArcGIS.

NAME
Name of the fault (if known).

TOPFORMATION
Name of geologic formation intersected by the top of fault (if known).

BOTFORMATION
Name of geologic formation intersected by the bottom of fault (if known). Also indicate basement or other information if known.

TOPZ
Depth in meters to top of fault (if known).

BOTZ
Depth in meters to bottom of fault (if known).

DIPDIRECTION
Dip direction for the entire fault or section, not the individual arc. Allowable values: C = center, E = east, N = north, NE = northeast, NW = northwest, S = south, SE = southeast, SW = southwest, and W = west.

SLIPRATE
Slip rate of fault (if known). Defines the assigned slip rate category. Allowable values are between 1 and 4 and determines line width:
1=>5 mm/year (extra wide; .048):
2 =1-5 mm/year (wide; .0325):
3 =0.2-1 mm/year (medium; .025);
4 =< .2 mm/year (thin; .015)

SLIPSENSE
Sense of slip (if known). Allowable choices are: normal, reverse, strike slip, and thrust.

SUBSURFACE
Define if fault is subsurface (if known). Yes if a subsurface fault. No if surface fault. Default is null.

QUALITY
Self-reported estimate of the quality of the fault location. Examples listed.
Excellent (3-D seismic, outcrop field mapping)
Good (2-D seismic with well control, inferred field mapping)
Fair (dense well control)
Poor (sparse well control)
Unknown

DATASOURCE
Type of information used to control fault location.
Seismic (2-D)
Seismic (3-D)
Well log
Field mapping
Other

MAPPEDSCALE
One of four allowable choices provided in a pull-down menu. Mapped scale can be used to control visualization of the fault at various scales. Allowable values:
1:24,000, fault should be more continuous than discontinuous and mapping is accurate at <10,000 scale.
1:50,000, fault should be more continuous than discontinuous and mapping is accurate at <25,000 scale.
1:100,000, fault could be more discontinuous than continuous and mapping is accurate at <50,000 scale.
1:250,000, fault location may be inferred or is poorly constrained.
Other

COMPANY
Name of company. This is a private field and will not be shared with the public.

CONTRIBUTOR
Name of contributor. This is a private field and will not be shared with the public.

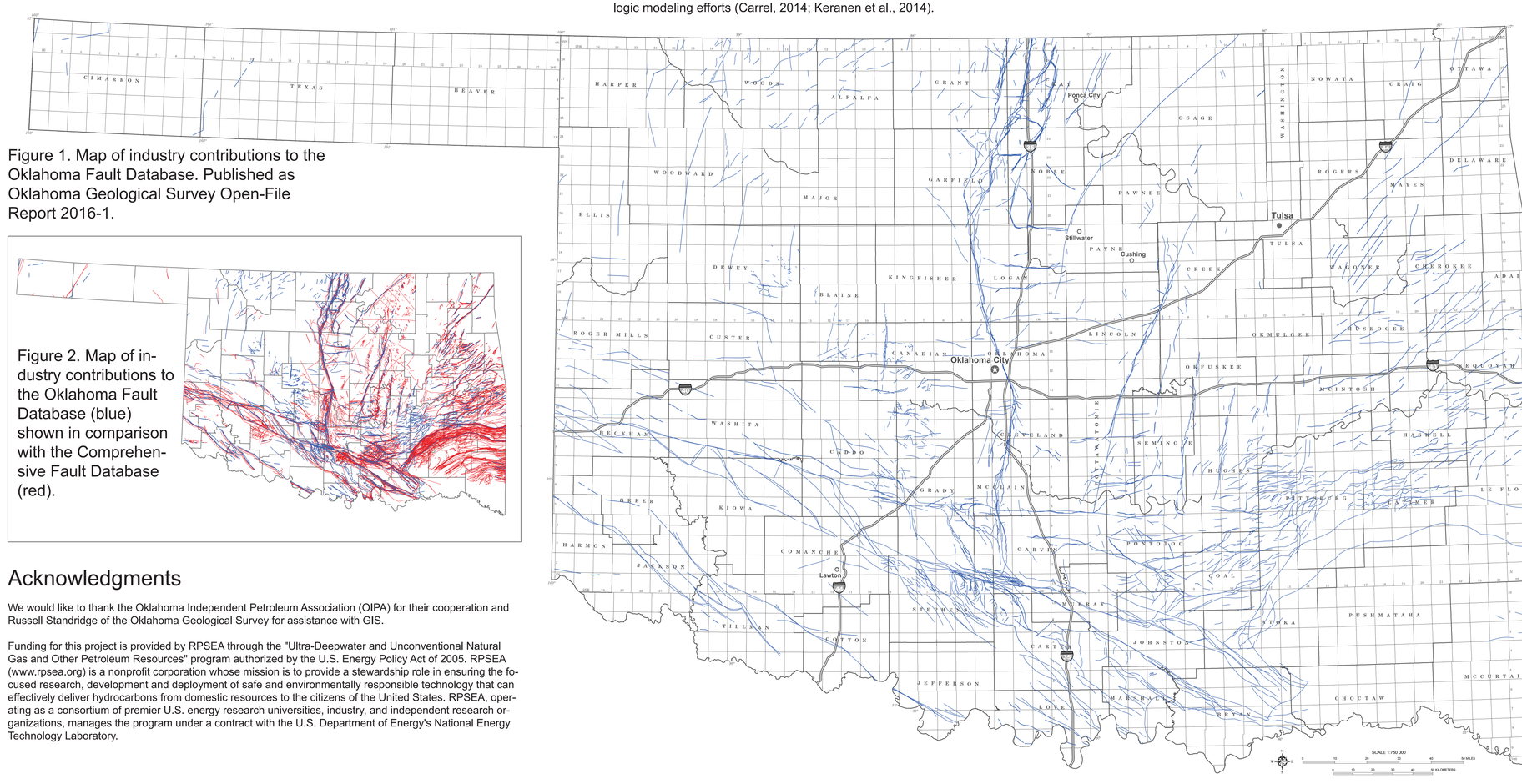

Figure 1. Map of industry contributions to the Oklahoma Fault Database. Published as Oklahoma Geological Survey Open-File Report 2016-1.

Figure 2. Map of industry contributions to the Oklahoma Fault Database (blue) shown in comparison with the Comprehensive Fault Database (red).

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Discussion

As of May, 2016, seven companies have provided contributions and with a highly varied rate of metadata reporting. The data contributions from the oil and gas industry contain more than 6,000 individual features (Figure 1). There are still significant areas where the Oklahoma Fault Database would benefit from additional contributions from the oil and gas industry, but the current contributions have added a great deal of information about faults within Oklahoma, particularly in Western Oklahoma (Figure 2). This effort represents a culmination of many discussions with individuals and organizations within the oil and gas industry that started in 2010. It took a broad industry acceptance and the leadership of the Oklahoma Independent Petroleum Association to make this effort a reality.

The oil and gas contributions to the Oklahoma Fault Database will be an ongoing process as more data contributions are received the data and metadata will be formatted such that it is compatible and added to the database. As new data is added to the database it will become available through the access methods provided on the Oklahoma Fault Database webpage. The Oklahoma Geological Survey welcomes future data contributions, especially in areas without existing coverage (Figure 1).

Capturing adequate metadata has proven the most challenging aspect of this effort. In order to aid in the submission process, it may be beneficial to allow aggregated metadata for entire or partial data contributions. This change may mean that more metadata is submitted for contributed faults. Adequate representation and understanding of fault orientations including strike and dip will allow researchers to conduct assessments of fault stability within the regional stress-field such as done by Hurd and Zoback (2012). The other commonly reported metadata such as formations the faults intersect may aid in various hydrologic modeling efforts (Carrel, 2014; Keranen et al., 2014).

References

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