Transitioning to Open-Source Geological Data and Analysis

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Summary

There has been a recent surge in the quality and quantity of available open-source software applications. By developing a workflow that utilizes these applications, software overhead costs can be significantly reduced. Many of these applications are complementary to more expensive solutions and can be integrated into current workflows. Finding the most appropriate open-source software for your application is often the most challenging aspect. As geologists, we investigated several open-source mapping solutions and have found the options and integration Quantum Geographical Information System (QGIS) provides meets many of our technical needs while remaining accessible to a large user base.

Paralleling the surge of open-source software has been a push to make data more freely and publicly available. Between public, private, and non-profit institutions there is an abundance of digitized data being published regularly. By capitalizing on this freely available data and software, we have been able to optimize our geological mapping, improve our spatial data analysis, and increase the efficiency and complexity of many of our workflows. Additionally, the limitless customization offered by some of these platforms, particularly QGIS, facilitates enhanced beautiful data visualizations. This talk hopes to distill some of the key features and capabilities relevant to the modern-day subsurface geologist by using some examples from some of our recent projects in the Montney Formation. In particular, we will focus on work conducted in a study area in northeast British Columbia centered on the Kiskatinaw Seismic Monitoring and Mitigation Area (KSSMA). The goal of this work was to investigate induced seismicity and assess the fault slip potential of related structural features.

Method / Workflow

Typically, our analysis workflow begins with development of a database of publicly available geological data. This process includes searching regulatory agency data portals for fault vectors, seismic activity logs, formation tops, wellbores, wellbore details, production data and other information. Public literature is also searched, related data compiled, and relevant maps are georeferenced using the QGIS plug in “Freehand raster georeferencer”. Unfortunately, not all data are publicly available so some data, such as well logs and pressure tests, are sourced through Petro Ninja™ and other private entities.

For the KSMMA study, a series of pressure and stress grids (P_P, S_{Hmax}, S_V, and S_{hmin}) were created and plotted into the QGIS interface. A shapefile of published and inferred faults (Fox and Watson, 2019) was added to the map and subdivided into 100m intervals using the v.split GRASS7 algorithm. A buffer zone was then created around each 100m fault segment using the v.buffer GRASS7 algorithm (Figure 1). Statistics for the grid node values from each grid within each buffer zone were compiled using the zonal statistics QGIS algorithm. These statistics are shown in Figure 1 (note the example buffer zone contains 215 grid nodes). These grid sampled values were then used to calculate and map the critical pressure perturbation (CPP) for each of the 4500+ fault segments.

Segment ID	3870
Strike	285
Dip Direction	15
Segment Length	100
Grid Node Sampling Count	215
IMM Effective Shmin Gradient (kPa/m)	5.6
IMM Pp Gradient (kPa/m)	13.9
IMM Pp (MPa)	31.7
IMM SHmax (MPa)	73.4
IMM Shmin Gradient (kPa/m)	20.6
IMM Shmin (MPa)	42.6
IMM TVD (m)	2184.4
Shmin Gradient (kPa/m)	19.5
IMM Sv (MPa)	54.7

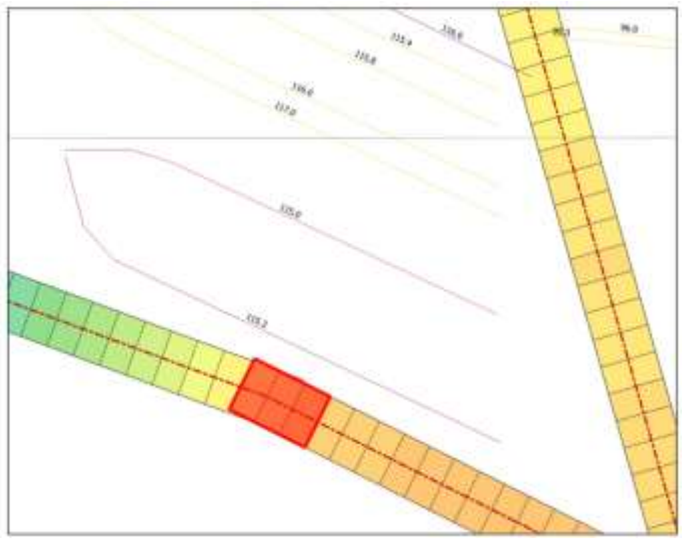

Figure 1: 100m fault segment details and buffer zone sampled grid values with wells and well azimuths.

Results, Observations, Conclusions

To build upon this work further we can perform a similar process for deviated and horizontal Montney wells. Each of these well polylines were divided into segments with a maximum length of 100m. The distance from each of these wellbore segments to the nearest fault segment, along with the CPP value of that fault segment was obtained using QGIS and GRASS7 algorithms. These numbers were manipulated to obtain a value that represents the potential to induce slip along a nearby fault, and then displayed in a map view (Figure 2).

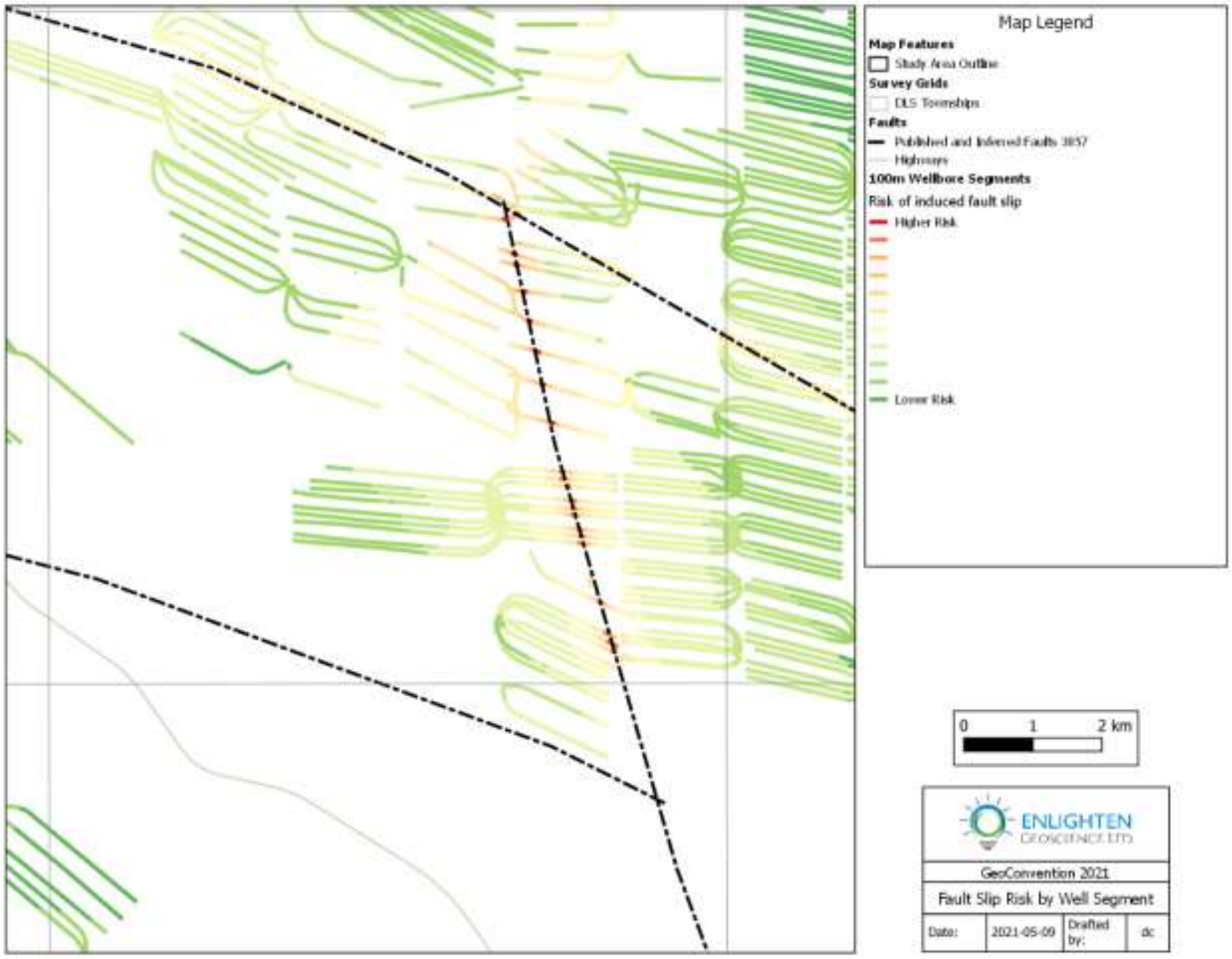

Figure 2: A map showing relative theoretical risk of inducing slip along the nearest fault at each wellbore segment.

Further analysis was done by creating 50m buffer zones around the well bores and obtaining the statistical summary of the grid values within each buffer zone. These values were then compared to other attributes such as 12 month normalized production values using the Data Plotly QGIS plug-in to illustrate broad scale trends (Figure 3 & 4).

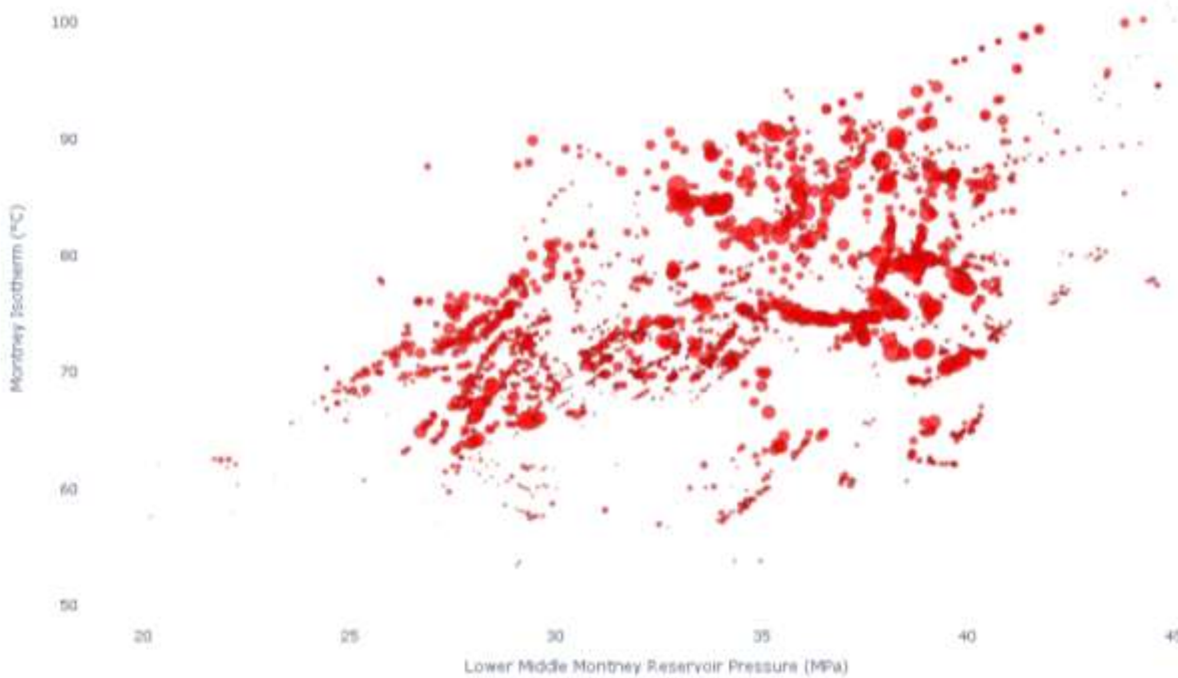

Figure 3: A cross plot showing values obtained from a Montney isotherm grid and a Montney reservoir pressure grid, with data points sized by 12 month normalized gas production.

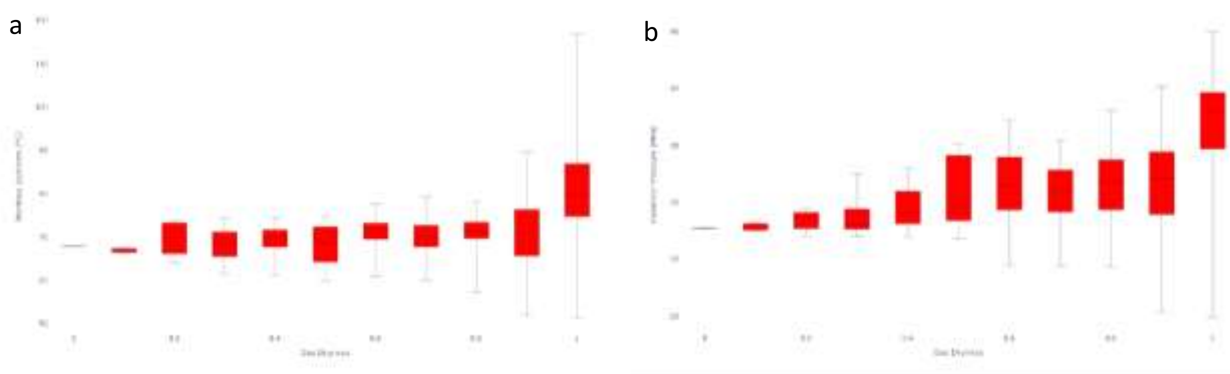

Figure 4: Box plots showing the relationship between; a) 12 month normalized gas dryness and reservoir temperature, b) 12 month normalized gas dryness and reservoir pressure.

Novel/Additive Information

QGIS and the associated open-sourced tools and plug-ins are powerful tools for spatial and statistical analyses. These capabilities can be applied to address geological uncertainties while producing impactful visuals. The combination provides a “one stop shop” for geological mapping, data plotting, databasing, statistical analysis, georeferencing and more. There are rudimentary plug-ins for wellbore analysis currently available and more sophisticated cross-section packages are under development which will bring the whole platform to a higher level and provide a fully functional geological software for little to no cost.

Our future efforts will be integrating the connection of PostgreSQL, an open-source relational database program that integrates seamlessly with QGIS, into our workflow.

A complete report documenting the KSMMA study is available via the website of the B.C. Oil and Gas Research and Innovation Society: http://www.bcogris.ca/projects/complete.

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