Improved Geohazard Analysis for Drilling Favorability Maps

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Section 1
Introduction to Geohazards & Favorability Mapping

Section 2
Common Practices for Favorability Mapping

Section 3
New Quantitative Approach

Section 4
Conclusions, Q&A
• Historically used to indicate likelihood of discovering oil and gas, metallic minerals, and groundwater

Favorability Map of Altered Rocks at La Escondia Mining District, Ott et al., 2006

Groundwater Favorability Map of the Otter Creek Basin, Vermont, A. Hodges, 1967
“A geological state that may lead to widespread damage or risk”

Most common in deepwater drilling:
- Shallow gas
- Faults
- Expulsion
- Steep slopes
- High pressured sands

From: ABS Pipeline Route Determination Guidance Notes (in prep)
Favorability Mapping for Geohazards

- Drilling costs >$1 million/day
- Delays caused by unanticipated hazards = $$$$ (compounded by current oil prices)
- Drilling (or pipeline) favorability maps used to identify and avoid geohazards

http://www.jwco.com/technical-litterature/p07.htm

Shallow gas blowout

http://www.canadian-wellsite.com/images/Photo%20Gallery/BFM/West_Vanguard_Blowout.jpg

West Vanguard blowout, October 6, 1985
Section 2

Common Approaches to Favorability Mapping
Map Production

• Prior to map creation, hazards are identified through interpretation of:
  • 3D/2D Seismic
  • Multibeam Bathymetry
  • Backscatter
  • Side Scan Sonar
  • Sub-bottom Profiler
• Shapefiles created showing spatial extent of each hazard
• Shapefiles are then combined or “stacked” on top of one another in GIS creating a map that shows the total presence of geohazards in the pipeline or drilling site
High Amplitude Anomalies
(indicative of shallow free gas)
Example Geohazard Data – Map View

Seafloor Failures
Example Geohazard Data – Map View

Gas Hydrates
Pockmarks or Gas Expulsion Features
Sub-seafloor Faults
Example Geohazard Data – Map View

Seafloor Faults
Example Geohazard Data – Map View

Headwall Scarps
Example Geohazard Data – Map View

Buried Slump Blocks
Moderate Seafloor Slopes (between 3 and 6°)
Steep Seafloor Slopes (greater than 6°)
Dan et al. (2014) detailed a rule-based system for favorability mapping and classified areas as:

- **Yellow** – most favorable (gentle slopes, no hazards)
- **Orange** – proceed with caution (moderate slopes)
- **Red** – least favorable (steep slopes, gas, MTDs, etc.)

In our experience, most drilling favorability maps produced today are based on similar rule-based procedures.

- Typical “Stoplight” red-yellow-green color scheme

**Underlying Problem**

Some conditions effectively prohibit exploration or production activities (shallow gas) but other areas where less extreme level of hazards are present may be offset by other advantages. These areas are unjustifiably classified as least favorable based on current rule-based procedures.
“Stoplight” Color Scheme Map

• Traditional “Stoplight” or red-yellow-green color scheme indicating level of hazard:
  • Red = Unacceptable hazards
  • Yellow = Proceed with caution or investigate further
  • Green = No known or inferred hazards
Section 3

A Quantitative Approach to Favorability Mapping
Geohazard Weighting

• Not all geohazards are the same – there is typically a range of severity or significance that each has relative to the project objectives
• Assigning a “Geohazard Weight” or “Score” to each hazard allows subjectivity and expertise to be introduced to favorability mapping
• Weights should be developed collaboratively by an interdisciplinary team with expertise comprising:
  • Seafloor geomorphology and geohazards
  • Geotechnical and facilities engineering
  • Drilling operations
• Like Dan et al. (2014), we avoid the use of green as it implies it is acceptable to move forward with minimal caution
• Instead, we use a yellow-orange-red color scale to denote areas of increasing but still acceptable hazard risk
GIS Workflow

1. Geohazard Shapefiles
2. Buffer-Dissolve-SHP to Raster
3. Reclassify (Assign weight)
4. Cell Statistics (Sum overlying weights)
5. Symbolize Map
Weighted Favorability Map

<table>
<thead>
<tr>
<th>Hazard</th>
<th>Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fault</td>
<td>5</td>
</tr>
<tr>
<td>Shallow Gas</td>
<td>20</td>
</tr>
<tr>
<td>Steep Slope</td>
<td>10</td>
</tr>
<tr>
<td>Pockmark</td>
<td>8</td>
</tr>
</tbody>
</table>
Python Automation

- Fully automated
- Prompts user to input buffer distances and hazard scores
- Create new map in ~15 minutes
Section 4

Conclusions
Comparison and Conclusions

“Stoplight” Maps
- Easy to read
- Simplified
- Commonplace

Weighted Maps
- Much greater insight
- Also easy to read
- Weights adjustable to client and consultant opinion
- Known significant hazards not lost in the classification
Questions?


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