

# Development of the SPE & DAG Geologic Framework Models

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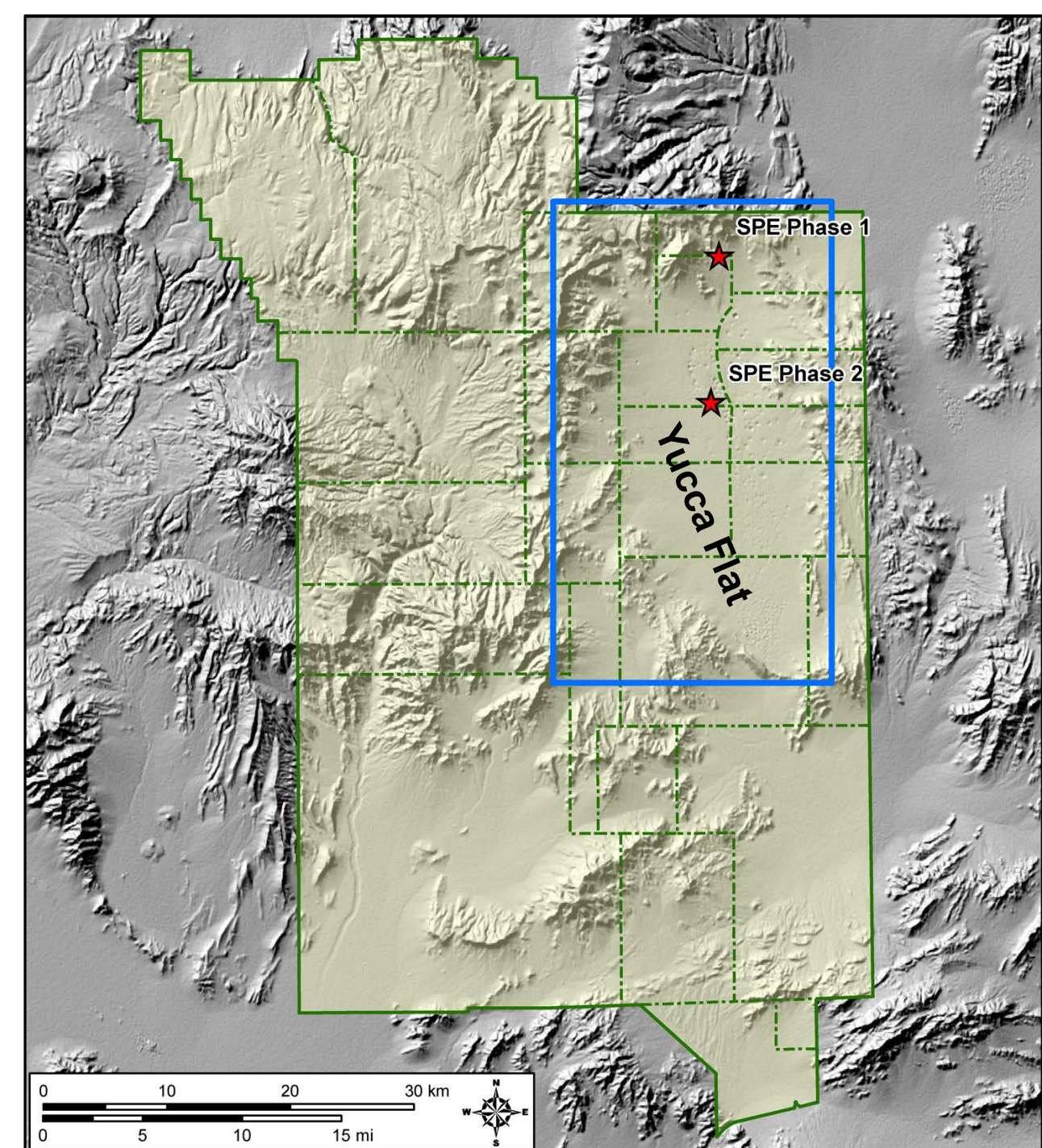
Project Number (NST17-V-SPE Phase II-PD2Pa)  
Lance Prothro (MSTS), Jeff Wagoner (LLNL), Arben Pitarka (LLNL), Karl Wagner (MSTS), and Margaret Townsend (MSTS)

## Goals and Objectives

- ▶ Provide geology-based 3-D framework for modeling seismic wave propagation from SPE explosions.
- ▶ Model the 3-D distribution of seismically relevant geologic features and physical properties.

## Introduction

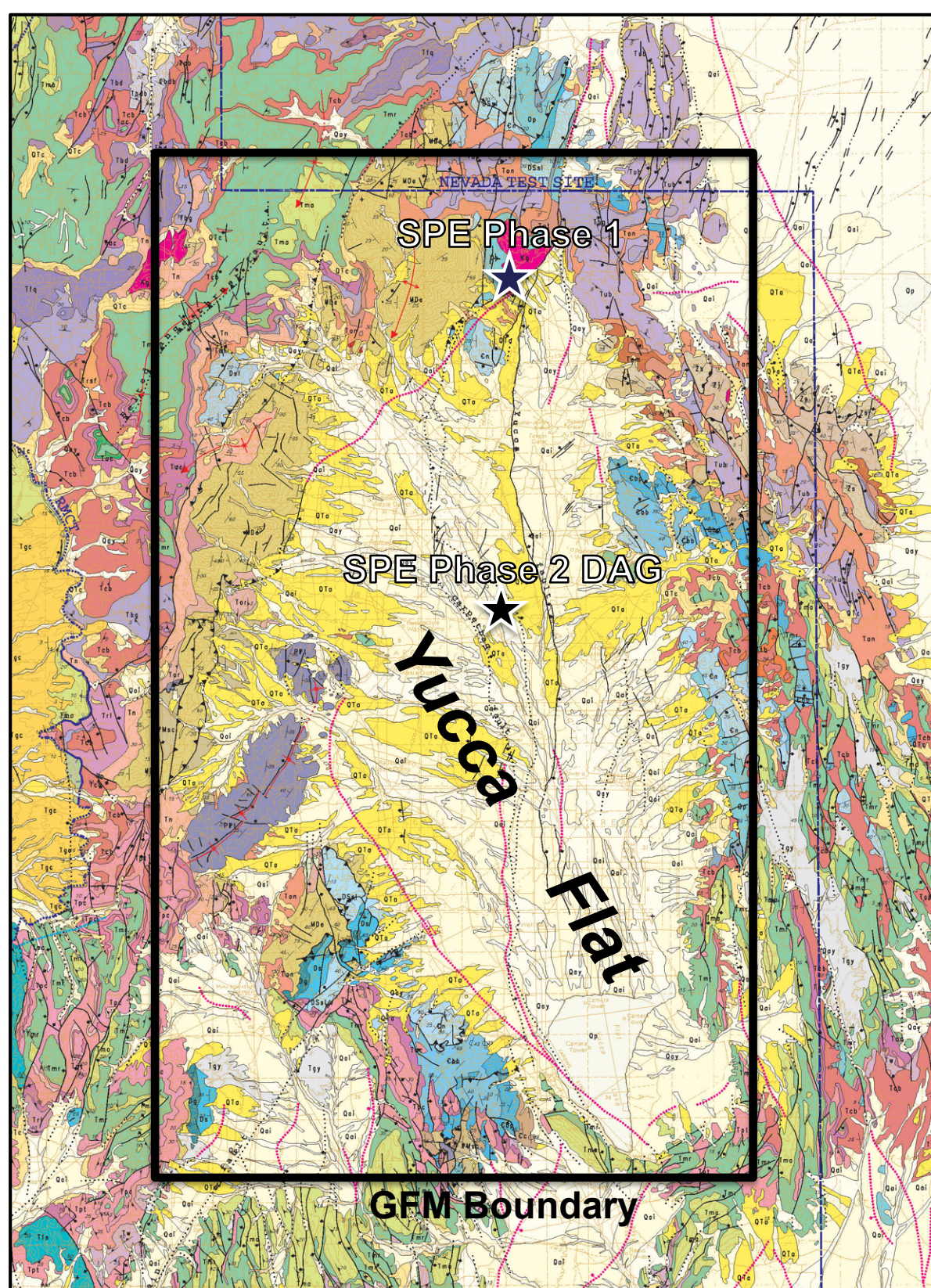
The SPE is being conducted in and around Yucca Flat, an alluvium-filled basin located at the Nevada National Security Site (NNSS). The geology in the region is complex and diverse, which creates a challenge to modeling seismic wave propagation from SPE tests. We are addressing this challenge by building 3-D geologic framework models (GFM) that provide the distribution of relevant geologic features and physical properties necessary to effectively model seismic wave propagation.



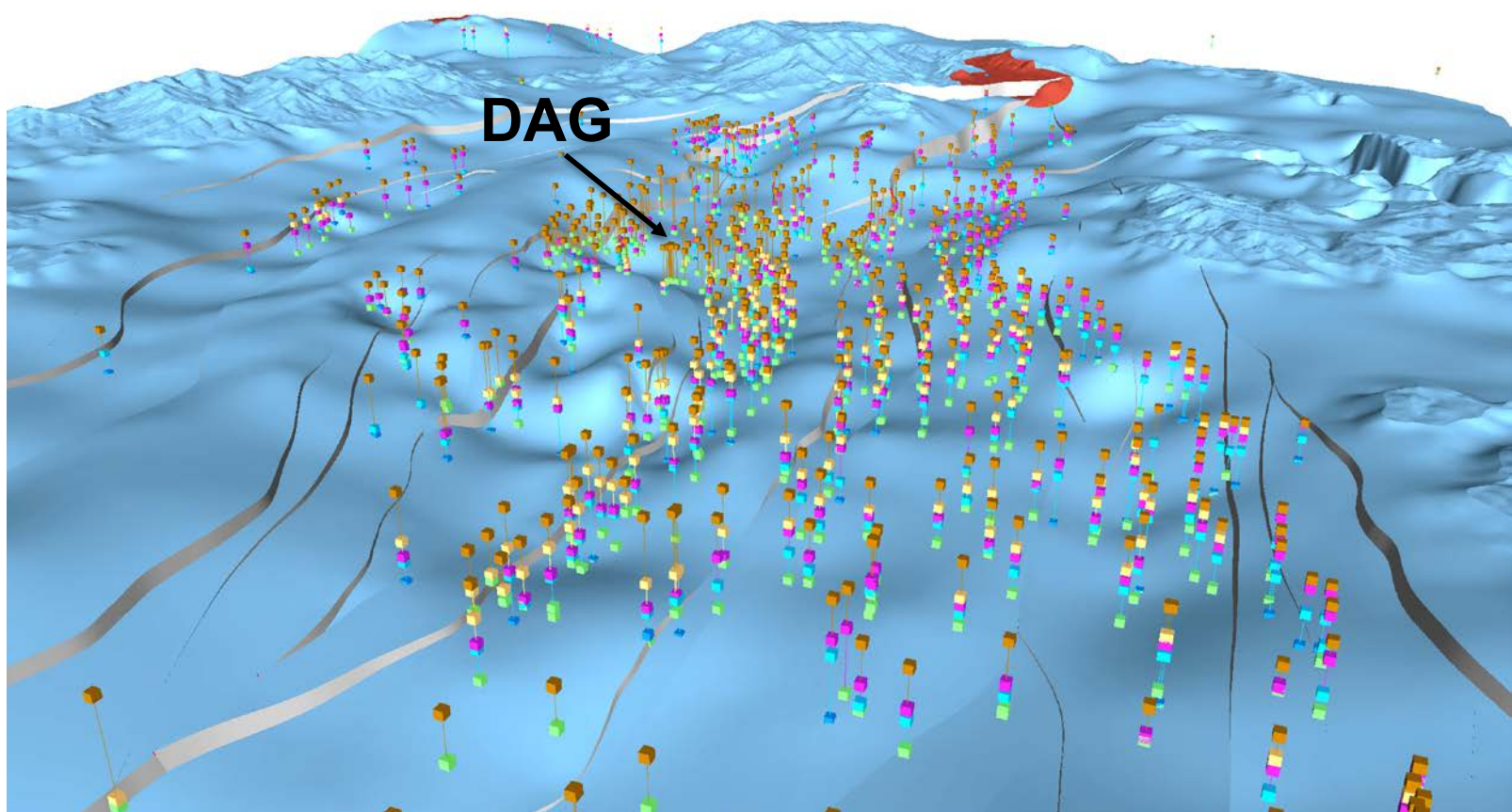
Map of the NNSS Showing Locations of the SPE and the Yucca Flat GFM Area (blue)

## Methods

We are using the sophisticated 2-D and 3-D minimum tension gridding algorithms in EarthVision® and the large historical data sets available from more than 50 years of geological and geophysical studies at the NNSS to build the GFM. Data from surface geologic maps, 659 drill holes, 2-D seismic reflection surveys, 5,400 downhole velocity measurements, and 10,000 gravity stations are used for GFM construction.



Geologic Map Illustrating the Diverse and Complex Geology of the Yucca Flat Region (Slate et al., 1999)

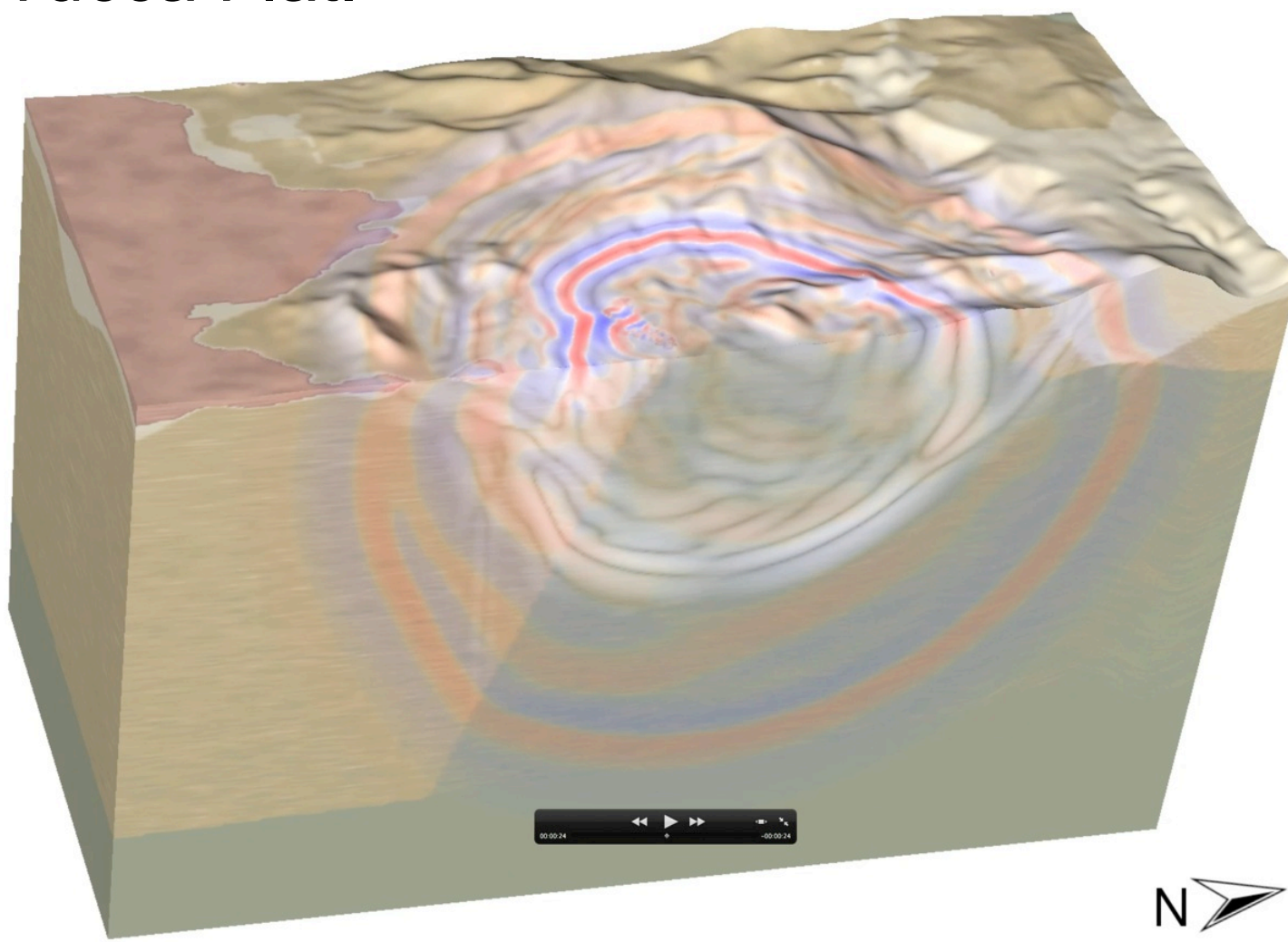


Yucca Flat GFM with Upper Layers Removed to Show Drill Hole Control in Northern Portion of Model Area Around the SPE Phase 2 DAG Site (looking northwest)

## Results

### SPE Phase I GFM

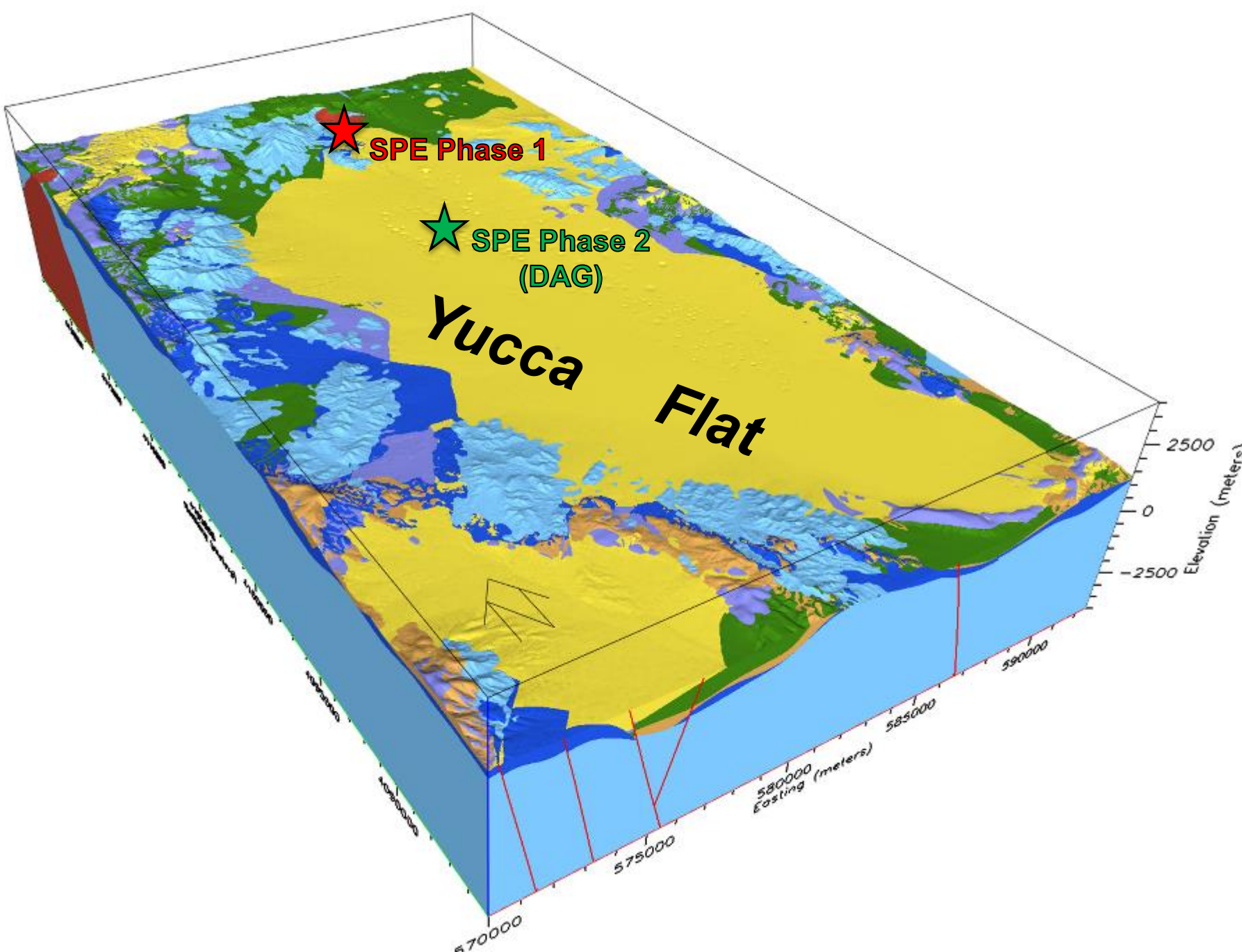
A 4-layer GFM was successfully constructed and used for modeling seismic wave propagation from the SPE Phase 1 granite site at the north end of Yucca Flat.



Slice Through the 4-Layer Phase 1 GFM Showing it Being Used for Seismic Wave Propagation Modeling

### Yucca Flat GFM

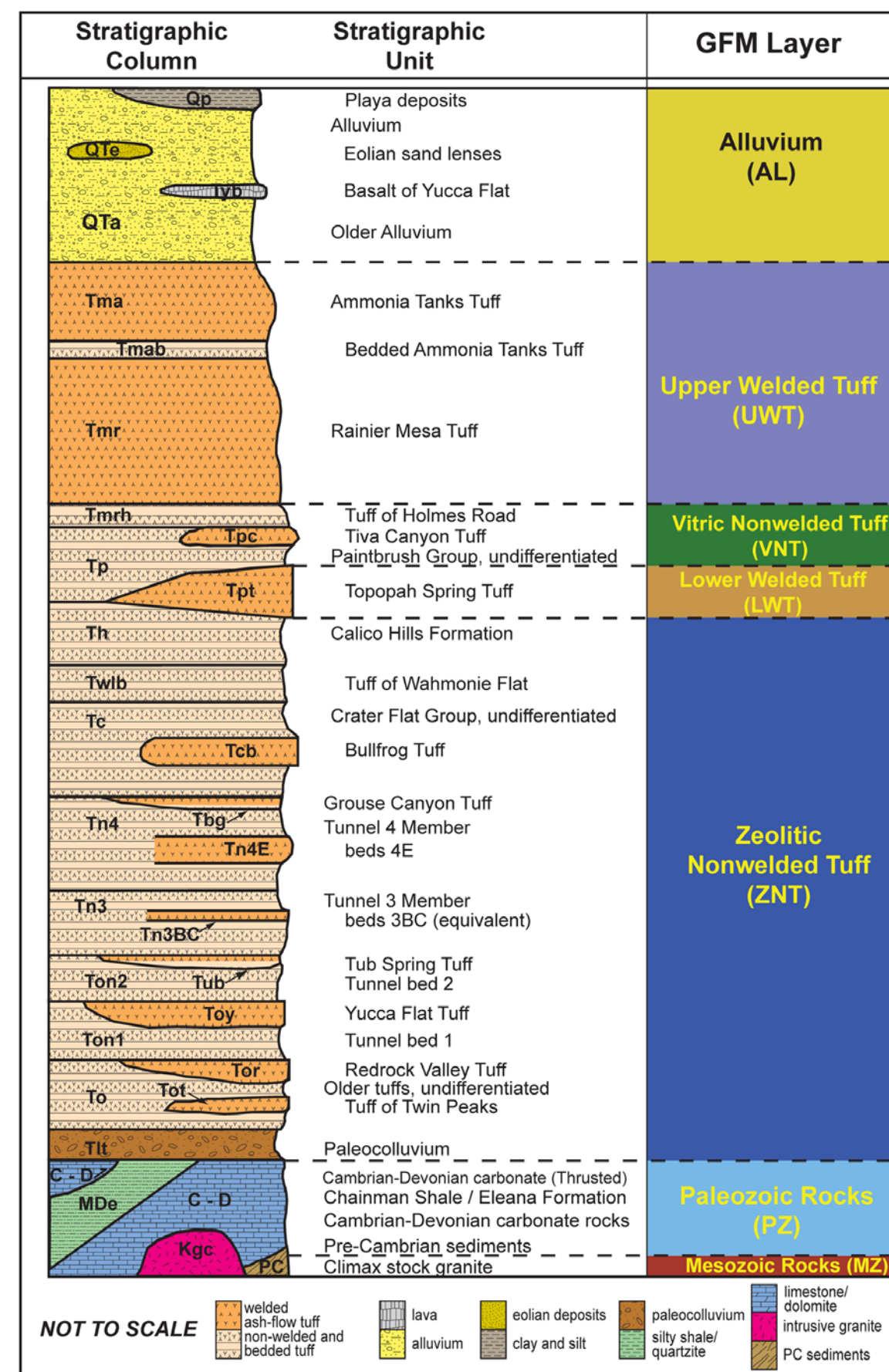
For the SPE Phase 2 Dry Alluvium Geology (DAG) series we merged the Phase I GFM with an existing, more detailed GFM developed for groundwater flow and contaminant transport modeling to increase model resolution within the Yucca Flat basin where DAG is located. This merged Yucca Flat GFM is currently being used for DAG pre-test simulations.



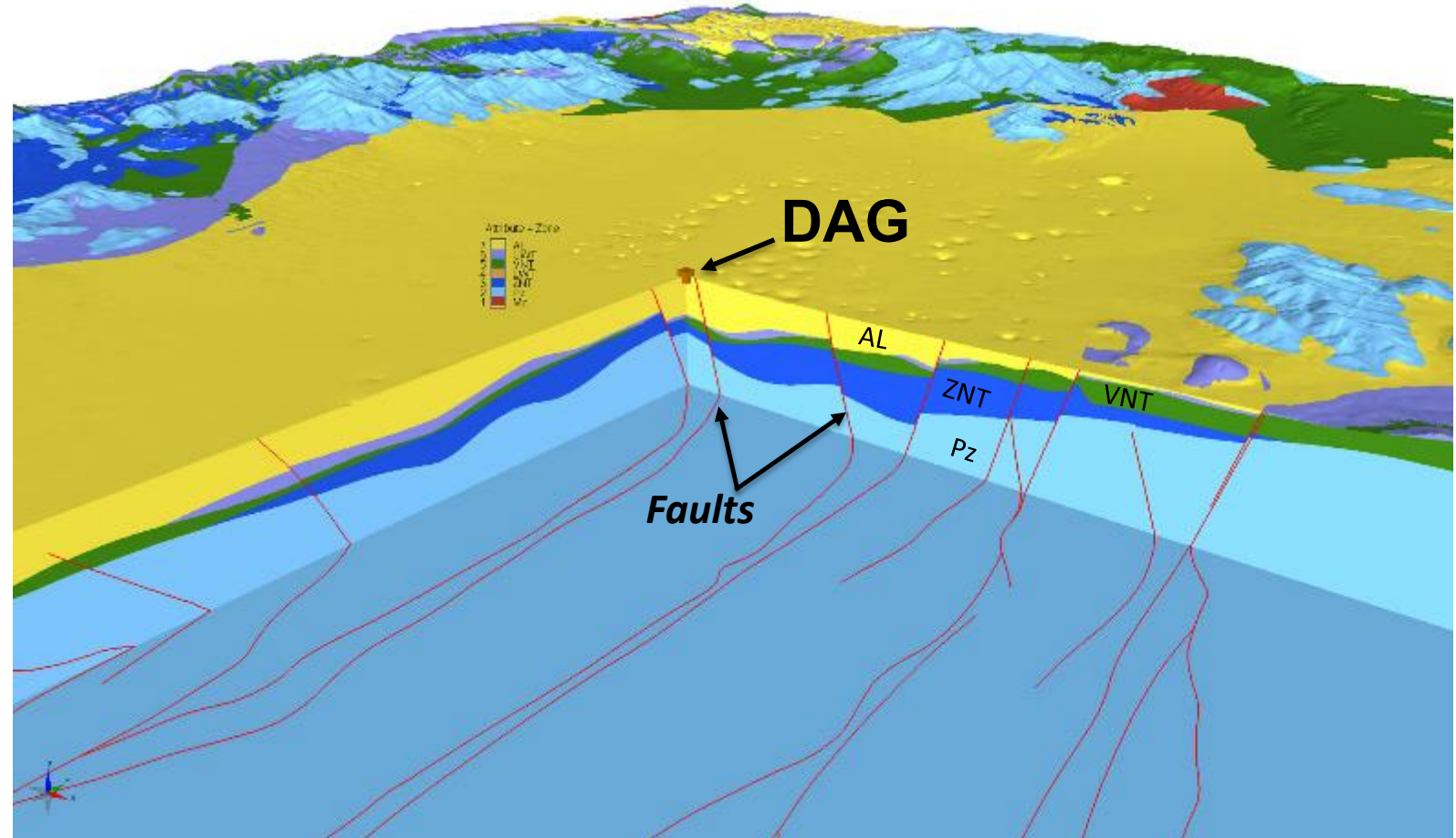
Perspective View of the 7-Layer Phase 2 Yucca Flat GFM

## Discussion

The current Yucca Flat GFM covers an area of 878 km<sup>2</sup> and includes all of Yucca Flat. The base of the model is at -4 km below sea level. The GFM includes 7 layers and 48 faults. Model layers are defined by their seismic properties, which are mainly determined by lithology and post-depositional alteration. Stratigraphic information is used to assure proper correlation of the layers throughout the model.



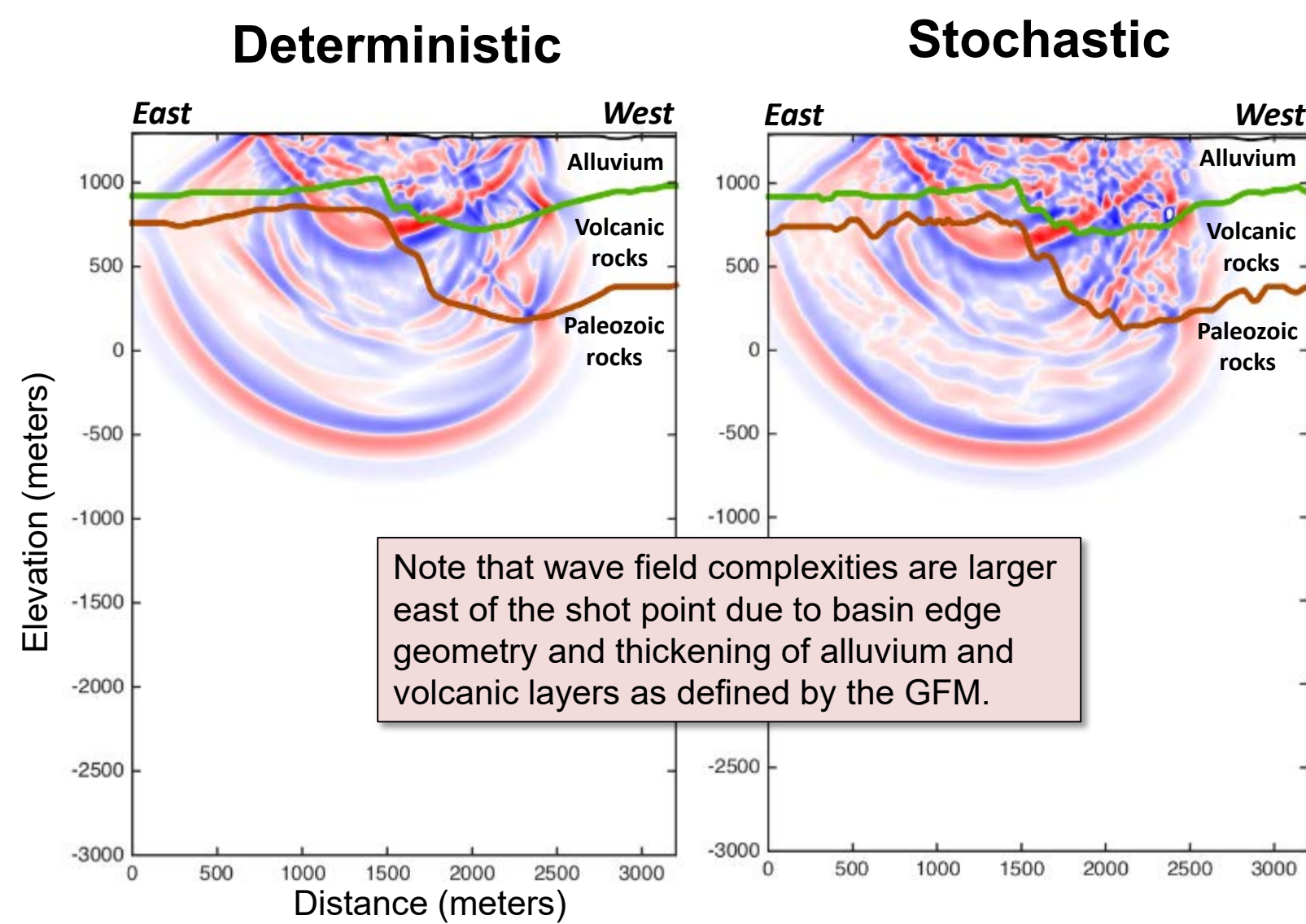
Stratigraphic Correlation Columns for the Yucca Flat GFM



Cut-Away View of the Yucca Flat GFM (looking northwest)

## Impact

GFM will continue to form the foundational frameworks for modeling seismic wave propagation from SPE detonations.



Note that wave field complexities are larger east of the shot point due to basin edge geometry and thickening of alluvium and volcanic layers as defined by the GFM.

Example of DAG Pre-Test Simulations of Seismic Wave Propagation Using the Yucca Flat GFM

## Future Work

- ▶ We will continue to refine the Yucca Flat GFM based on SPE-DAG results and to address specific needs and requests from modelers.
- ▶ We will continue to explore methods to enhance the GFM in the DAG near-field by adding detail in the alluvium and testing different fault offset configurations.

### Publications/Deliverables:

Exports of the GFM are provided as requested from modelers. These include 2-D gridded surfaces of the top of each layer, or as 3-D gridded volumes. All exports are simple ascii text files.

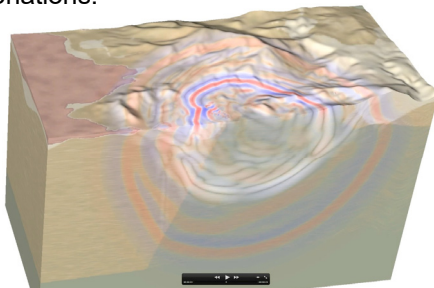


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**Development of the SPE & DAG**  
**Geologic Framework Models**

**Geologic Framework Models (GFM) – Providing 3-D frameworks for modeling seismic wave propagation**

## Background/State of the Art

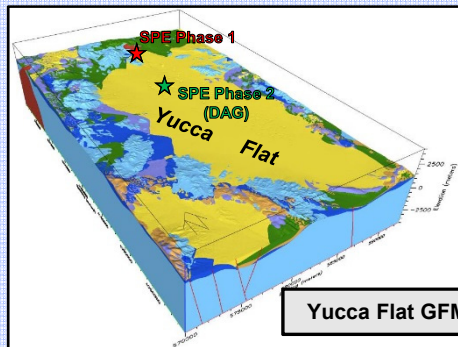
- The diverse and complex geology of the NNSS requires sophisticated 3-D geologic framework models (GFM) to effectively model seismic wave propagation from SPE detonations.



**Slice Through the 4-Layer Phase 1 GFM Showing it Being Used for Seismic Wave Propagation Modeling**

## Innovation

- We use minimum tension algorithms and large data sets from more than 50 years of scientific studies at the NNSS to model the 3-D distribution of seismically relevant geologic features and physical properties.



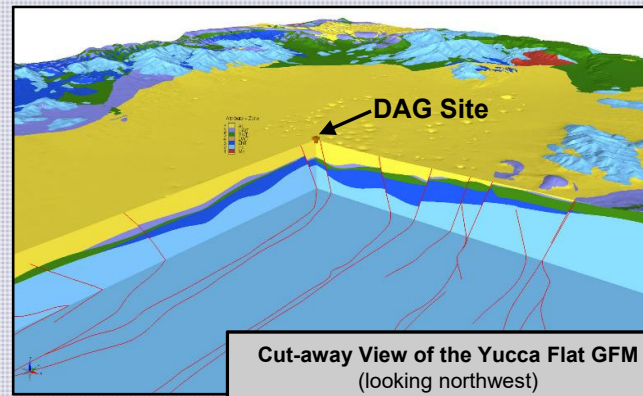
**Yucca Flat GFM**

*Defense Nuclear Nonproliferation R&D*

## Approach, Metrics and Outcomes

### MAIN ACHIEVEMENT

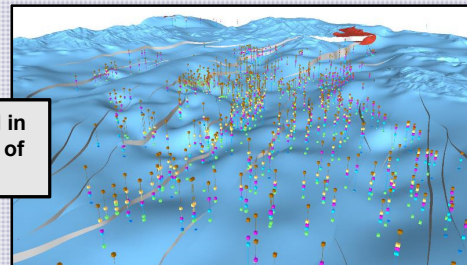
- Our GFM are being used by SPE scientists to model seismic wave propagation from SPE detonations.



**Cut-away View of the Yucca Flat GFM (looking northwest)**

### HOW IT WORKS

- Data from surface geologic maps, 659 drill holes, 2-D seismic reflection surveys, 5400 downhole velocity measurements, and 10,000 gravity stations are imported into EarthVision® geologic model building application to build GFM.



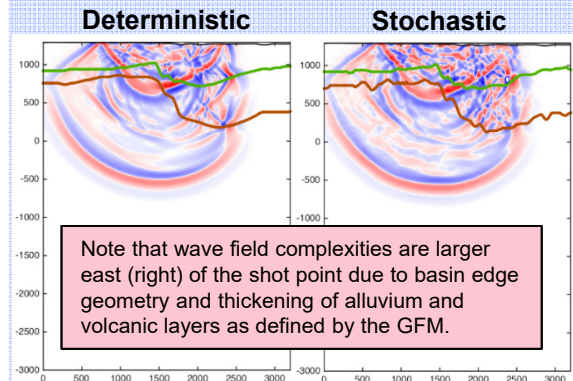
**Drill Hole Control in Northern Portion of Model Area**

### ASSUMPTIONS AND LIMITATIONS

- Uncertainty can increase rapidly away from data points due to the complex geologic environment.

## Impact

- GFM will continue to form the foundational frameworks for modeling seismic wave propagation from SPE detonations.



Note that wave field complexities are larger east (right) of the shot point due to basin edge geometry and thickening of alluvium and volcanic layers as defined by the GFM.

**Example of DAG Pre-Test Simulations of Seismic Wave Propagation Using the Yucca Flat GFM**

## Goals/Action Plan

- We will continue to refine the Yucca Flat GFM based on SPE-DAG results and to address specific needs and requests from modelers.

## Team

**L. Prothro (MSTS), J. Wagoner (LLNL),  
A. Pitarka (LLNL), K. Wagner (MSTS),  
M. Townsend (MSTS)**

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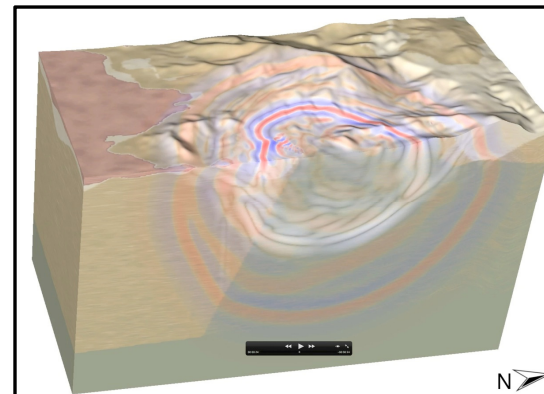
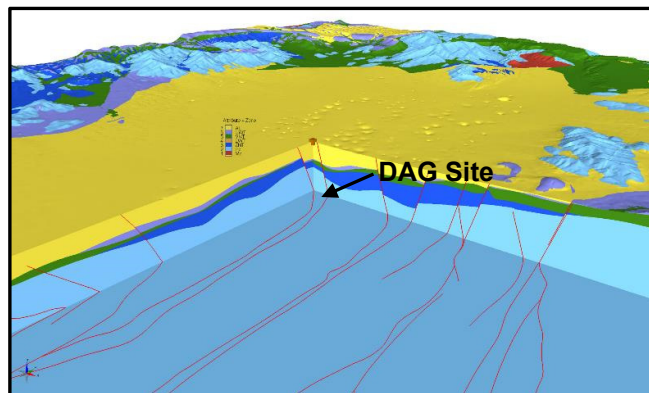
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**We are building complex 3-D geologic framework models designed to be used for modeling seismic wave propagation from SPE detonations in Yucca Flat.**

**We use sophisticated minimum tension algorithms and large data sets from more than 50 years of geologic and geophysical studies at the NNSS to model the complex 3-D distribution of seismically relevant geologic features and physical properties.**

**Our models are being used by SPE scientists to model seismic wave propagation from SPE tests in Yucca Flat.**



Poster #45  
Jeff Wagoner  
LLNL

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