MTIGT1003: 4 Credits

GIS BASED 3D VISUALIZATION IN GEOTECHNOLOGY

Unit:4 - 3D Visualization of Subsurface Lithology

For 6 Year Integrated M.Tech. Geoinformatics and Geotechnology programme

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MTIGT1003: GIS BASED 3D VISUALIZATION IN GEOTECHNOLOGY 4 Credits

Unit-1: Principles of 3D Visualization: Data Input (x, y, z) – TIN – Vertical Exaggeration – DEM based visualization – Concepts of Shaded Relief mapping. **12 Hrs.**

Unit-2: 3D Visualisation of Topographic Data: Generation of x, y, z data – 3D visualization of topography – DEM based topographic analysis – shaded relief – applications. **12 Hrs.**

Unit-3: 3D Visualisation of Geophysical Data: X, Y, Z data from different sources – Generation of DEM, Different processed outputs of DEM, Shaded relief maps of Gravity, Magnetic and Resistivity data – Its applications. **16 Hrs.**

Unit-4: 3D Visualisation of Subsurface Lithology: Collection of borehole data – working out lithology and lithotop of various horizons – DEM of shaded relief of thickness of various formations, Depth of various formations and litho top of various formation – their interpretations. **12 Hrs.**

Unit-5: 3D Visualisation of Groundwater: Collection of water level and other aquifer variables (Transmissivity, Permeability, Storage co-efficient, etc.) – Generation of x, y, z – Generation of DEM and shaded relief of groundwater systems and interpretation. **12 Hrs.**

References

- Burrough, P.A Principles of Geographical Information Systems for Land Resources Assessment, Clarandone Press, Oxford, 1986.
- Graeme F.Bonham-Carter, Geographic Information Systems for Geoscientists: Modelling with GIS, Pergamon Publications, 1994.
- Sabins, F.F.Jr., Remote Sensing Principles and Interpretation, Freeman, Sanfrancisco. 1978.
- Lillisand, T.M. and P.W.Kiefer, Remote Sensing and Image Interpretation, John Wiley & Sons, New York, 1986.

MTIGT1004: PRACTICAL – GEOTECNOLOGY AND 3D VISUALIZATION 2 Credits

1. Generation of DEM and 3D visualization. **6 Hrs.**
2. DEM based topographic analysis. **6 Hrs.**
3. Satellite Image wrapped DEM based topographic analysis **6 Hrs.**
4. Shaded relief of topographic data and its interpretations. **6 Hrs.**
5. 3D visualization, DEM and shaded relief of gravity data and its interpretation. **6 Hrs.**
6. 3D visualization of DEM and shaded relief of magnetic – airborne magnetic data and its interpretation. **6 Hrs.**
7. 3D visualization of DEM and shaded relief of muti depth gravity data and its interpretations. **6 Hrs.**
8. **3D visualization of DEM and shaded relief of bore hole depth and subsurface lithology and interpretations 10 Hrs.**
9. 3D visualization of DEM and shaded relief of Ground water levels and interpretations. **6 Hrs.**
10. 3D visualization of DEM and shaded relief of Aquifer variables (T, K & S). **6 Hrs.**

Monoscopic methods of Depth Perception

Distances to objects, or depth can be perceived monoscopically on the basis of

- **Relative sizes of objects**
- **Hidden objects**
- **Shadows and**
- **Differences in focusing of the eye for viewing objects at varying distances.**

Concepts of Shaded Relief mapping

Initially, to create shaded Relief map, slope and aspect are to be calculated based on the plane defined for each triangle.

Slope can be written in degrees by specifying degree and Aspect is always reported in degrees. Zero is north, and values increase clockwise like a compass. Flat triangles will be assigned an aspect value of -1.

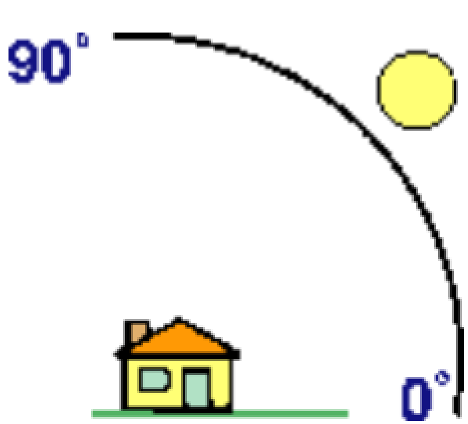
Optionally, a hillshade field can be written containing a brightness value for each triangle. Values range from zero to 255.

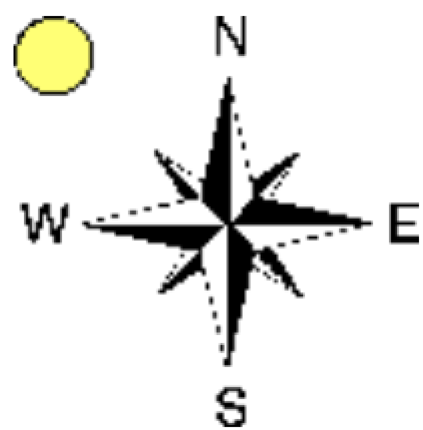
The brightness value is based on the relation between the plane defined by each triangle and a **light source**. The position of the light source defaults to the northwest, with an azimuth of 315 degrees (compass-based with 0 north, positive clockwise) and an altitude of 45.

For Hill shade, it is necessary to obtain the hypothetical illumination of a surface by determining illumination values for each cell in a raster.

It should be done by setting a position for a hypothetical light source and calculating the illumination values of each cell in relation to neighboring cells.

It can greatly enhance the visualization of a surface for analysis or graphical display, especially when using transparency.



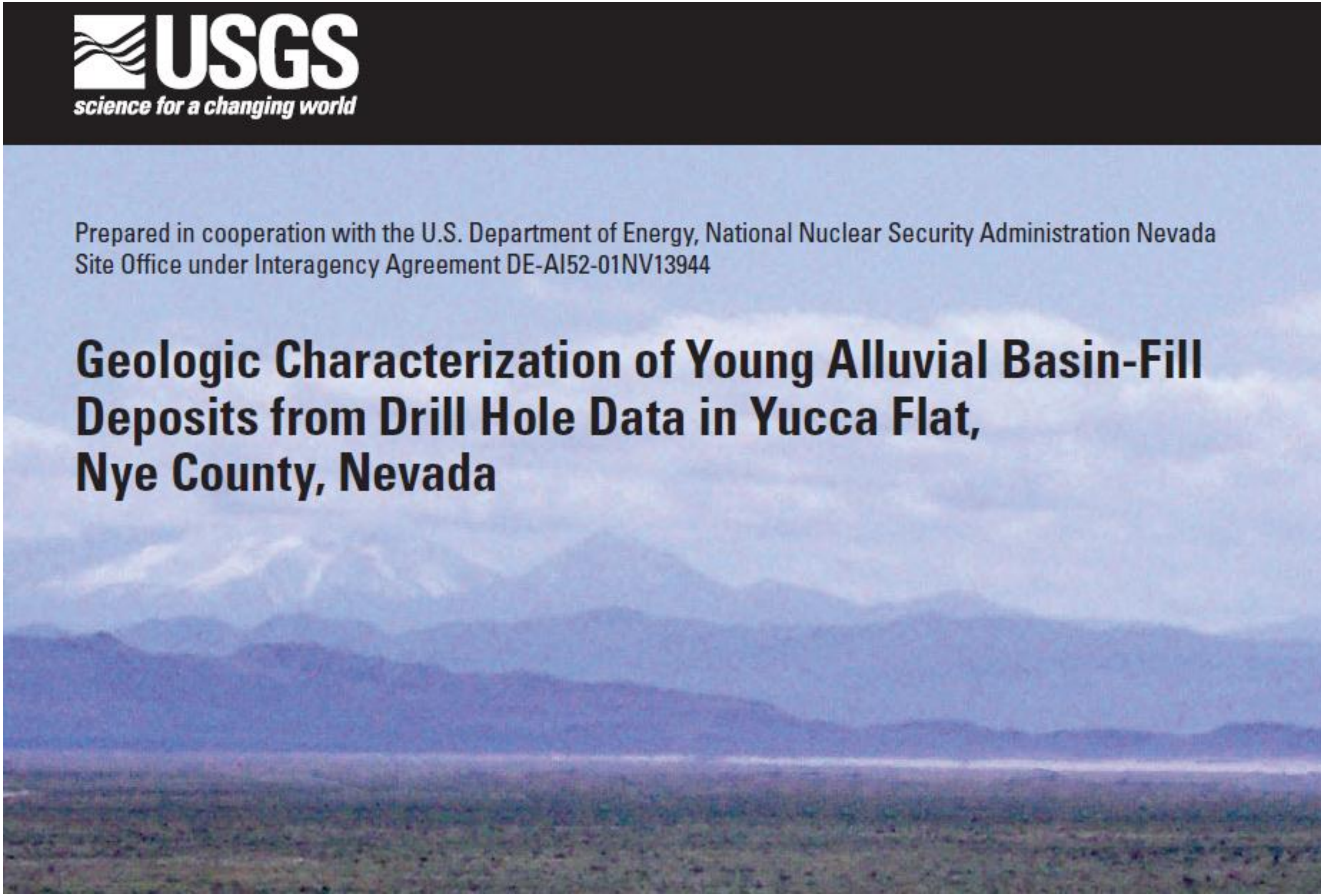


Depiction of Litho Bore hole data

- 2D Vertical cross section of bore holes
- 3D Vertical cross section of bore holes
- 3D Fence Diagram
- 3D Perspective view of distinct Layer
- 3D Layered Stacking in Combination

Reference: Open-File Report 2006–1390, By Donald S. Sweetkind and Ronald M,

U.S. Department of the Interior, U.S.G.S.



USGS

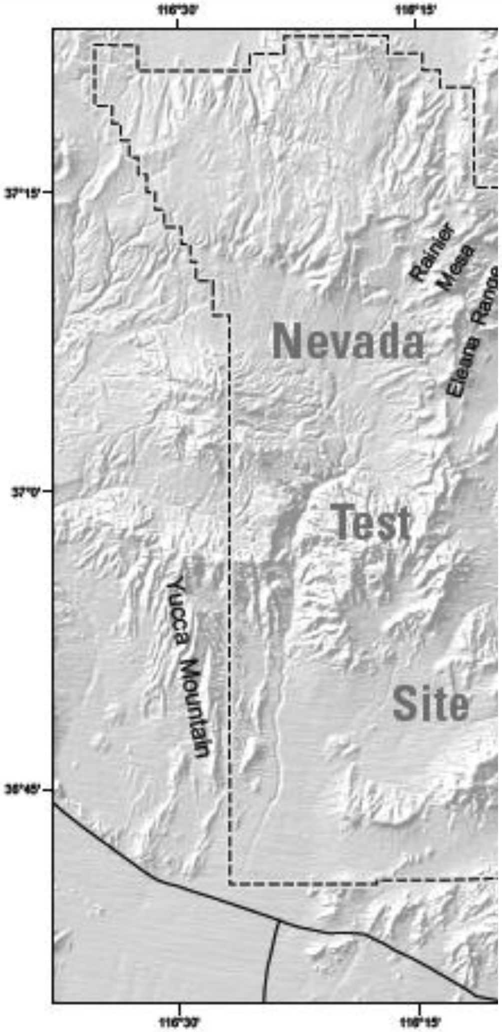
science for a changing world

Prepared in cooperation with the U.S. Department of Energy, National Nuclear Security Administration Nevada Site Office under Interagency Agreement DE-AI52-01NV13944

Geologic Characterization of Young Alluvial Basin-Fill Deposits from Drill Hole Data in Yucca Flat, Nye County, Nevada

The purpose of this study is to

- Develop an understanding of lateral and vertical lithologic variability of Neogene sediments that make up the shallow basin fill of Yucca Flat.
- Understanding the configuration and character of the basin-fill sedimentary units is critical to delineating hydraulic properties and reducing uncertainty in three-dimensional simulations of ground-water flow in the Yucca Flat area.
- Recent stratigraphic studies of Cenozoic basins to the south of the NTS, including the Amargosa Desert Basin (Sweetkind and others, 2001; Taylor and Sweetkind, 2005) and the Pahrump Valley (Sweetkind and others, 2003) have shown that the three-dimensional stratigraphic variability of shallow alluvial sediments can be adequately characterized through interpretation of drill hole lithologic data.
- It is hoped by the authors that the use of similar techniques would yield similar results in the Yucca Flat basin.



Base from U.S. Geological Survey digital data, 1:250,000; Universal Transverse Mercator projection, Zone 11.
Shaded-relief base from 1:250,000-scale Digital Elevation Model; sun illumination from northwest at 30° above horizon

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EXPLANATI

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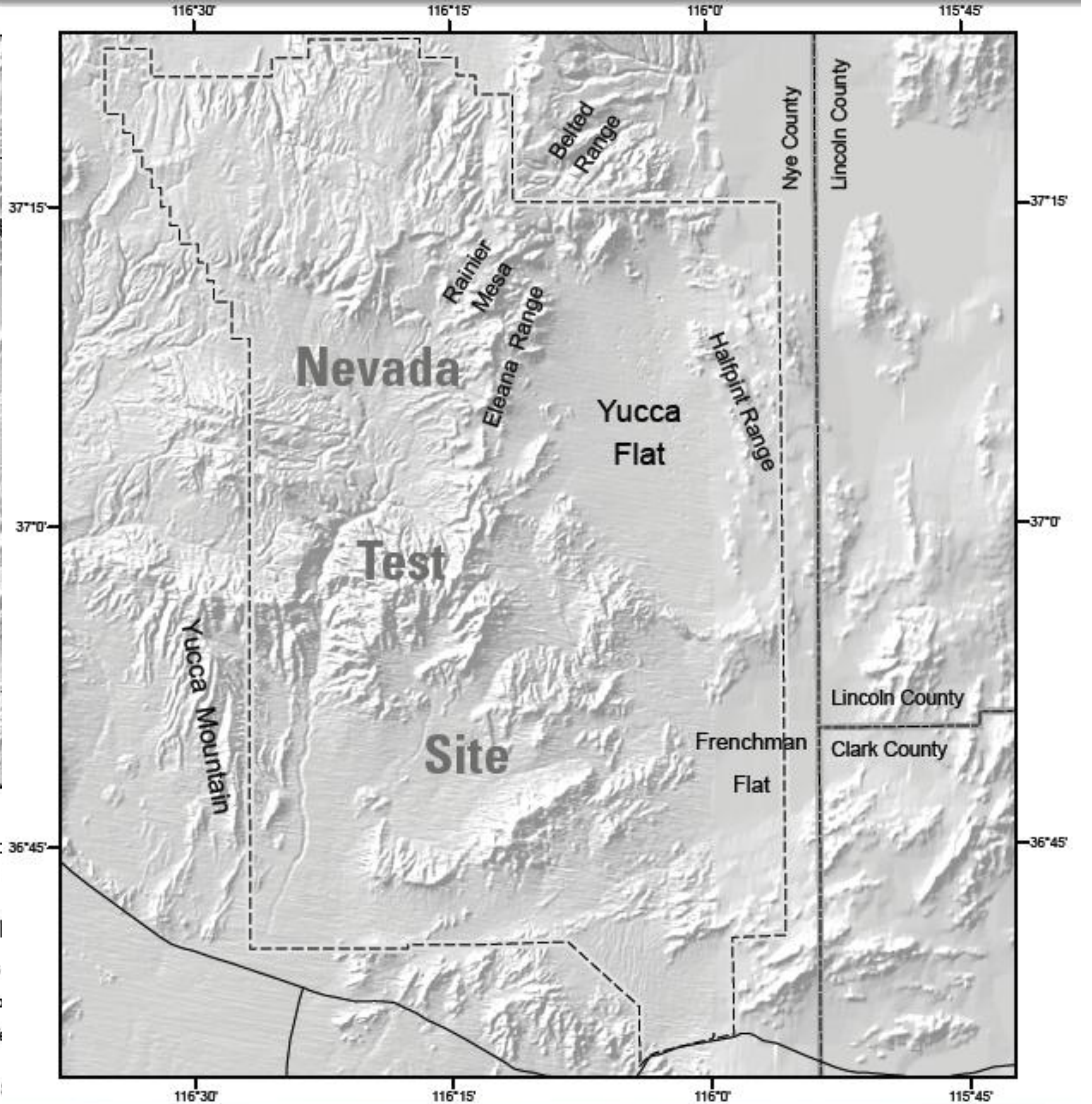


Figure 1. Index map of Yucca Flat and the Nevada Test

Physiographic Setting

Yucca Flat is a topographically closed drainage basin that occupies much of the eastern part of the Nevada Test Site (fig. 1). The valley floor has no perennial surface water; Yucca Flat acts as a catchment for surface-water runoff and is a local depositional center for sediment. The low-relief topographic basin has a playa (seasonally dry lake) at the south end (fig. 2) and the basin is surrounded by low ranges that are underlain by Tertiary volcanic rocks and underlying Paleozoic and Late Proterozoic sedimentary rocks (fig. 2) (Slate and others, 2000). In general, the valley floor slopes upward toward the surrounding ranges on a series of coalescing alluvial fans that ring the margins of the basin. Large, active alluvial channels extend into the basin from topographic highlands of Rainier Mesa, the Eleana Range and the Halfpint Range (figs. 1 and 2).

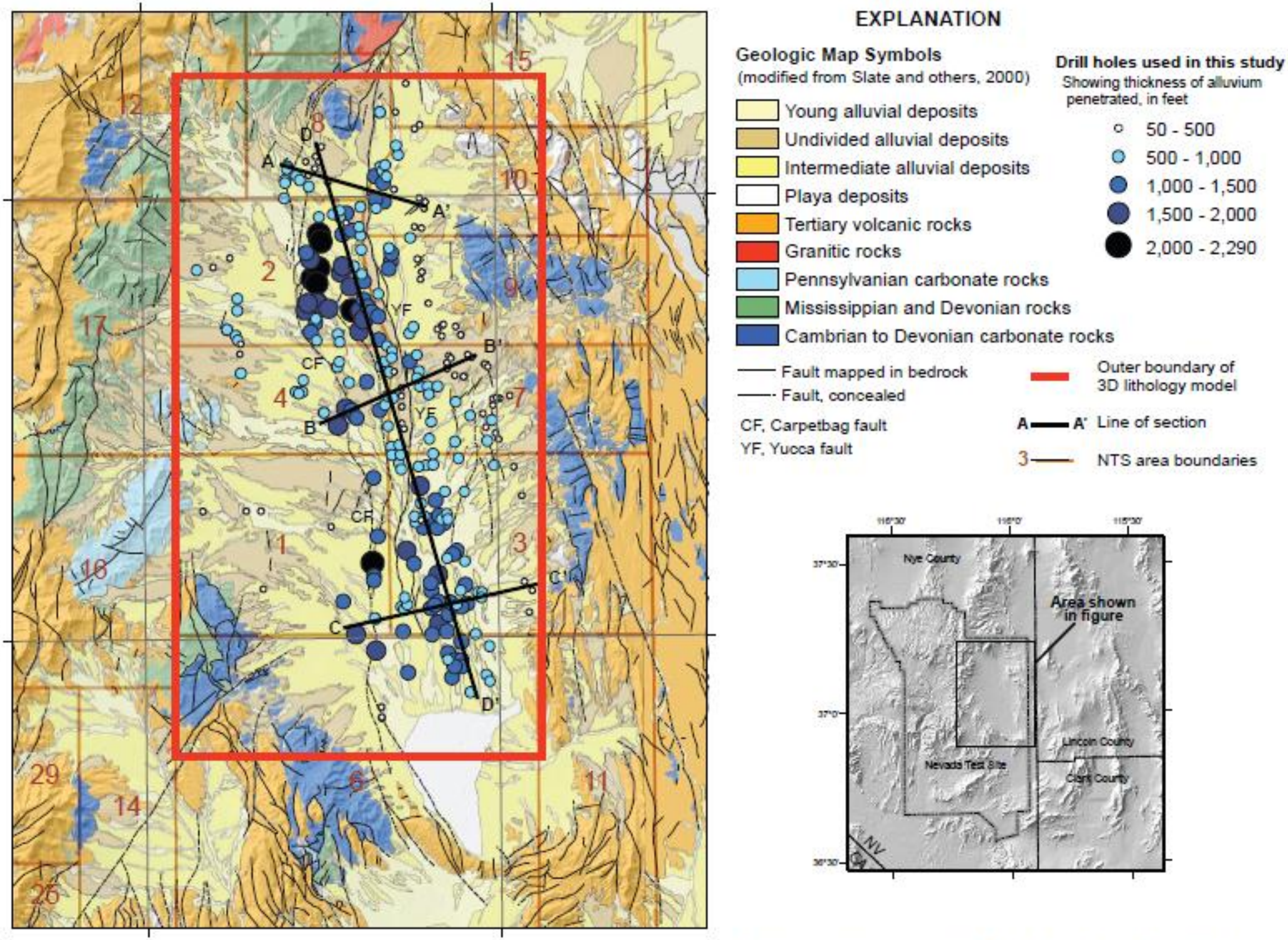


Figure 2. Geologic map of Yucca Flat showing drill hole locations, cross section lines, and boundary of 3D lithology model.

Table 1. Generalized lithologic classes based on drill hole descriptions.

Lithology class	Drill hole intervals	Rationale for classification
Gravel	63	Used for cobble beds, boulder beds, and where gravel was reported as having no fine-grained matrix.
Sandy gravel	229	Used for sand and gravel mixtures where gravel, clasts, or cobbles were 70% or more of the total.
Gravelly sand	341	Used for sand and gravel mixtures where gravel, clasts, or cobbles were subequal in abundance to the sand component; used where sand was 30% to 70% of the total.
Sand and minor gravel	360	Used for sand and gravel mixtures where the sand component was much more abundant than gravel, clasts, or cobbles; typically sand was 70-80% of the total, often greater than 90% of the total.
Sand, clay and gravel	42	Used for sand and gravel mixtures where silt or clay was identified as an additional important component. Typically these intervals are dominated by the sand-silt component with relatively minor gravels.
Coarse sand	263	Used for sand sizes greater than 0.5 mm, typically greater than 1 mm, often with scattered pebbles up to 1 cm.
Fine sand	44	Used for sand sizes less than 0.5 mm, rare pebbles.
Clay and sand	12	Used for intervals where sands are interbedded with clay layers. Typically explicitly interpreted in the description as alluvial material interbedded with playa deposits.
Clay	2	Used for intervals described as almost completely clay. Typically explicitly interpreted in the description as playa deposit.
Clay and limestone	4	Used for intervals where clays are interbedded with thin-bedded limestone. Typically explicitly interpreted in the description as playa deposits.
Basalt	3	Used for intervals where basalt was specifically identified.
Nonwelded tuff	9	Used for intervals where nonwelded tuff was specifically identified.
No data	39	Intervals with no useful lithologic information, such as “alluvium”.

3D Lithologic Modeling

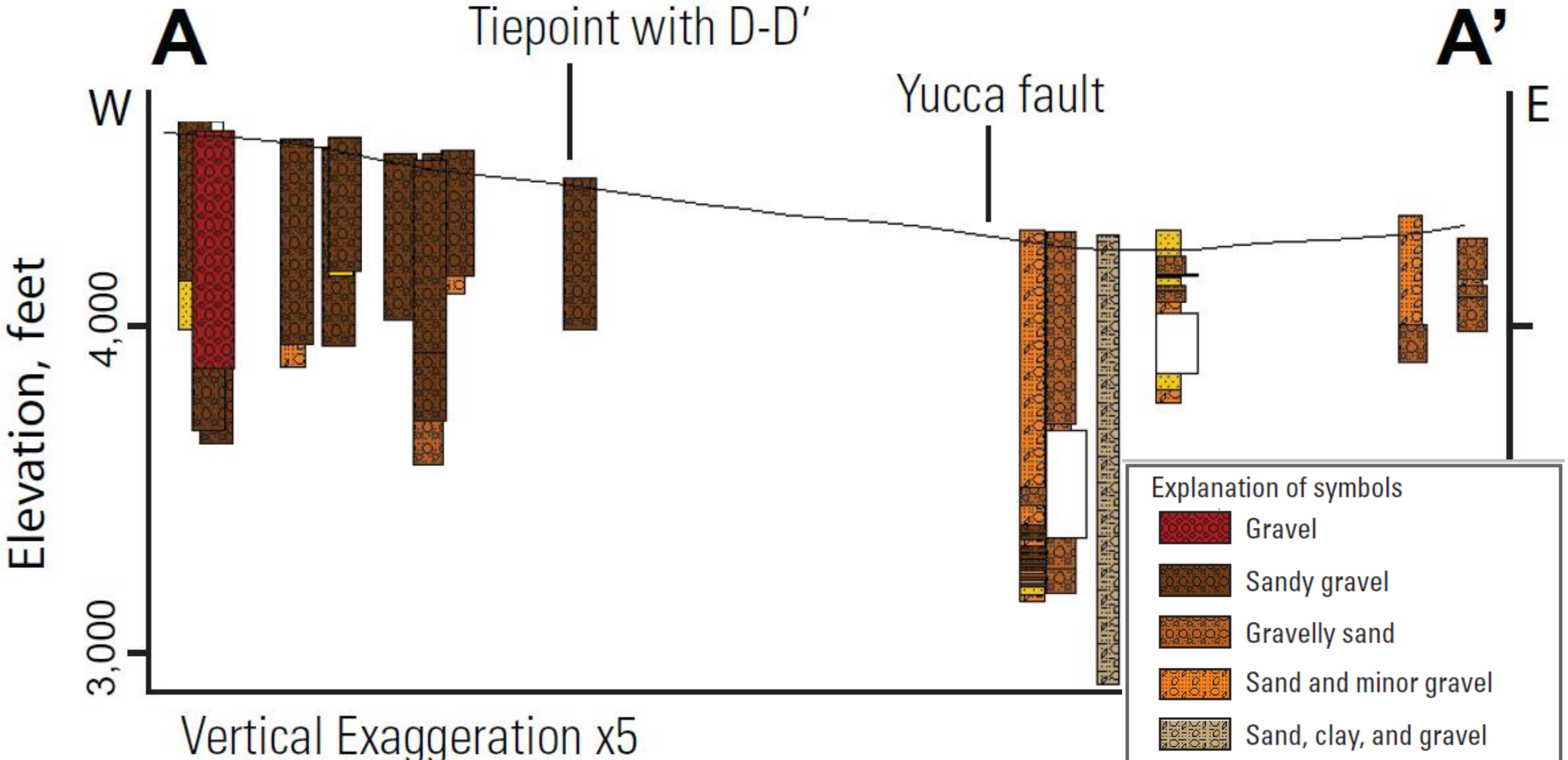
Interpreted drill hole lithologic data were numerically interpolated between drill holes using a cell-based interpolation called horizontal lithoblending within the RockWorks 2004 software package (Rockware©, 2004). Grid nodes are sequentially assigned a value that corresponds to the interpreted lithologic classes based on the proximity to each drill hole. The interpolation routine looks outward horizontally from each drill hole in search circles of ever-increasing diameter. The algorithm assigns the lithology values from the drill hole data in each vertical interval to cells immediately surrounding each drill hole. Then the interpolation moves out by a cell, and assigns the next "circle" of cells a lithology value for each vertical interval.

The interpolation continues in this manner until the program encounters a cell that is already assigned a lithology (presumably interpolating toward it from an adjacent drill hole), in which case it skips the node assignment step. Cell dimensions for the 3D interpolation were 3,281 ft in the horizontal dimensions and 33 ft in the vertical dimension. We trimmed the resulting model at the top by a grid representing land surface elevations and at the base by a grid that represents the smoothed base of alluvium encountered in the selected drill holes. Because there was no information regarding stratal dip in the alluvial section, strata were assumed to be horizontal in this 3D interpolation. The assumption of horizontality is likely more valid for the younger, upper parts of the basin fill than for the deeper parts of the alluvial section.

The strength of this method is that the interpolated data in the resulting 3D grid have the appearance of stratigraphic units, with aspect ratios that emphasize the horizontal dimension over the vertical. Also, the method preserves the local variability of the lithology encountered in each drill hole with no smoothing or averaging. Thus, where data are abundant, local lithologic variability is incorporated.

One limitation of this numerical interpolation is the sensitivity to the distribution of the data, where values from an isolated drill hole tend to extrapolate outward to fill an inordinate amount of the model area. The effect is particularly noticeable where a small number of deep drill holes are interspersed with shallower holes; data from the deepest drill holes tend to over-extrapolate over the entire model area. We mitigated this effect by a trimming of the base of the model, using a grid that represents the smoothed base of alluvium encountered in the selected drill holes.

Faults were not explicitly included in the creation of these solid models, due to the limitations of the software package used. However, the interpolation methods used here produce lithologic variations that approximate fault truncations of lithologic units where data density is high.



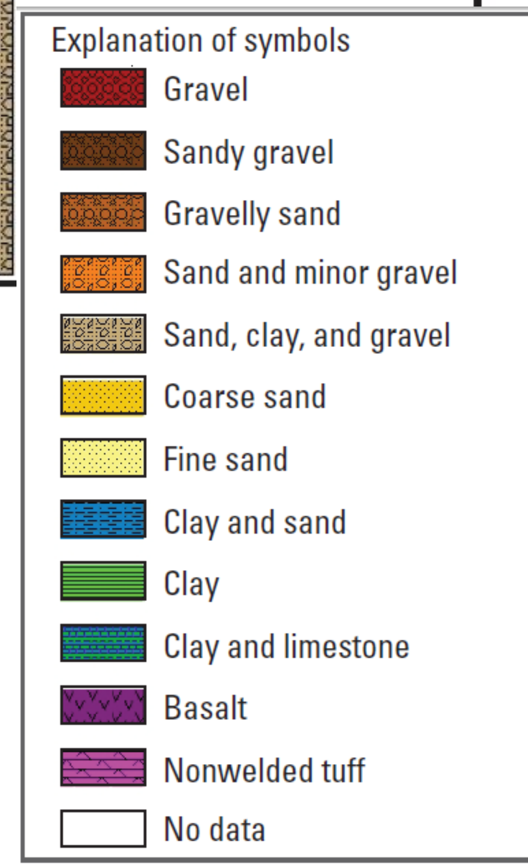
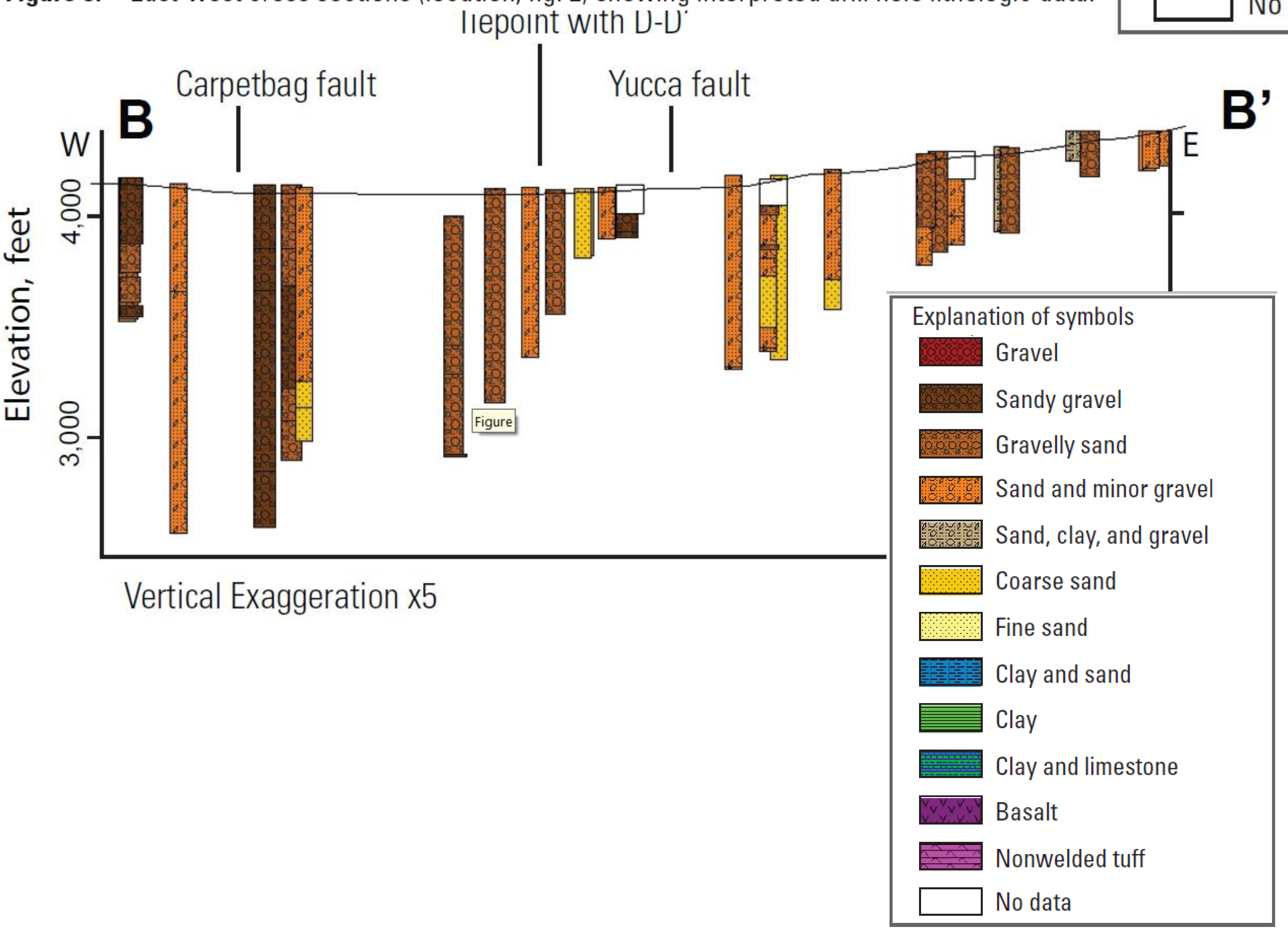


Figure 3. East-west cross sections (location, fig. 2)
showing interpreted drill hole lithologic data.

2D Vertical cross section of bore holes

Figure 3. East-west cross sections (location, fig. 2) showing interpreted drill hole lithologic data.



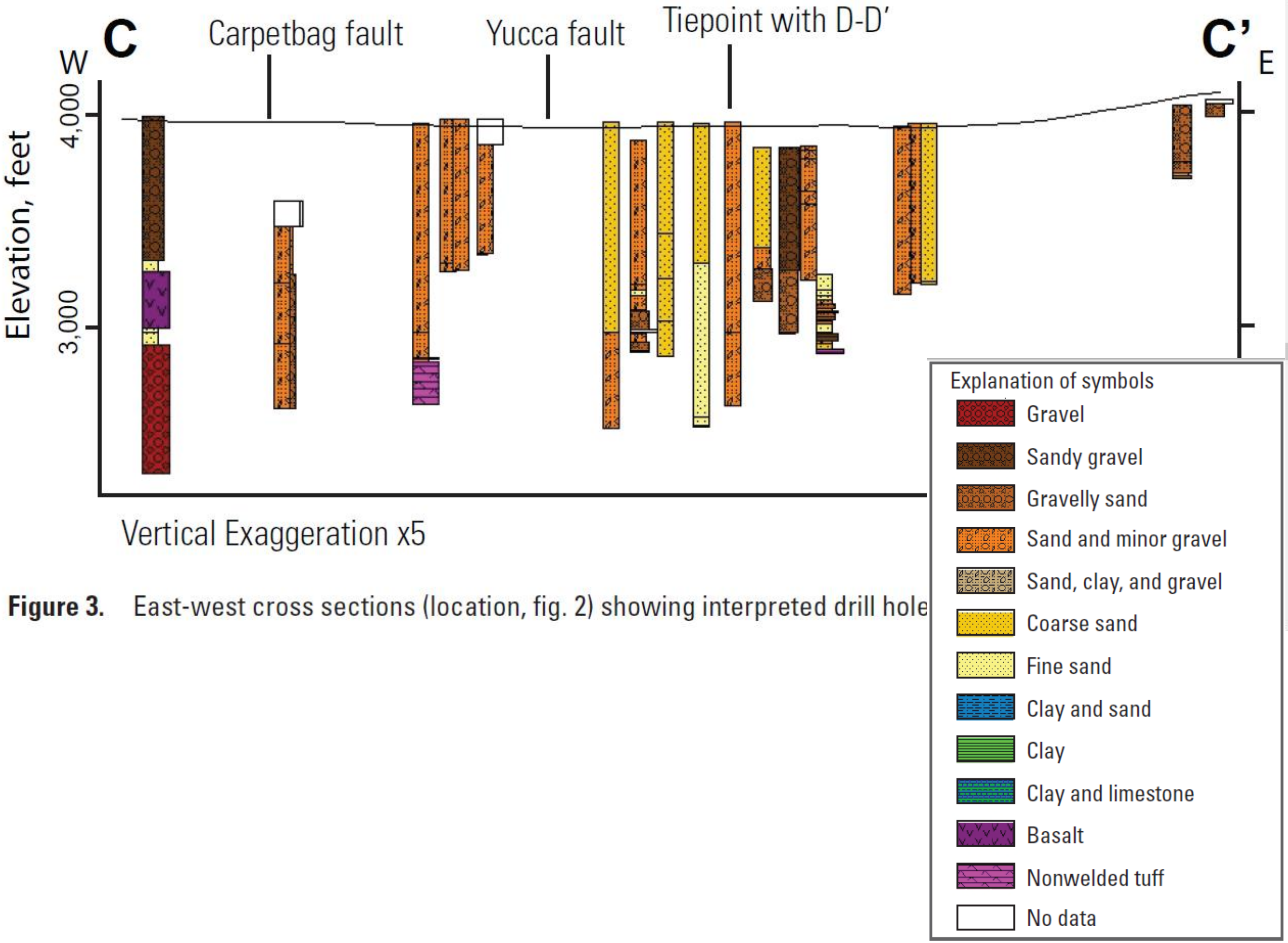


Figure 3. East-west cross sections (location, fig. 2) showing interpreted drill hole

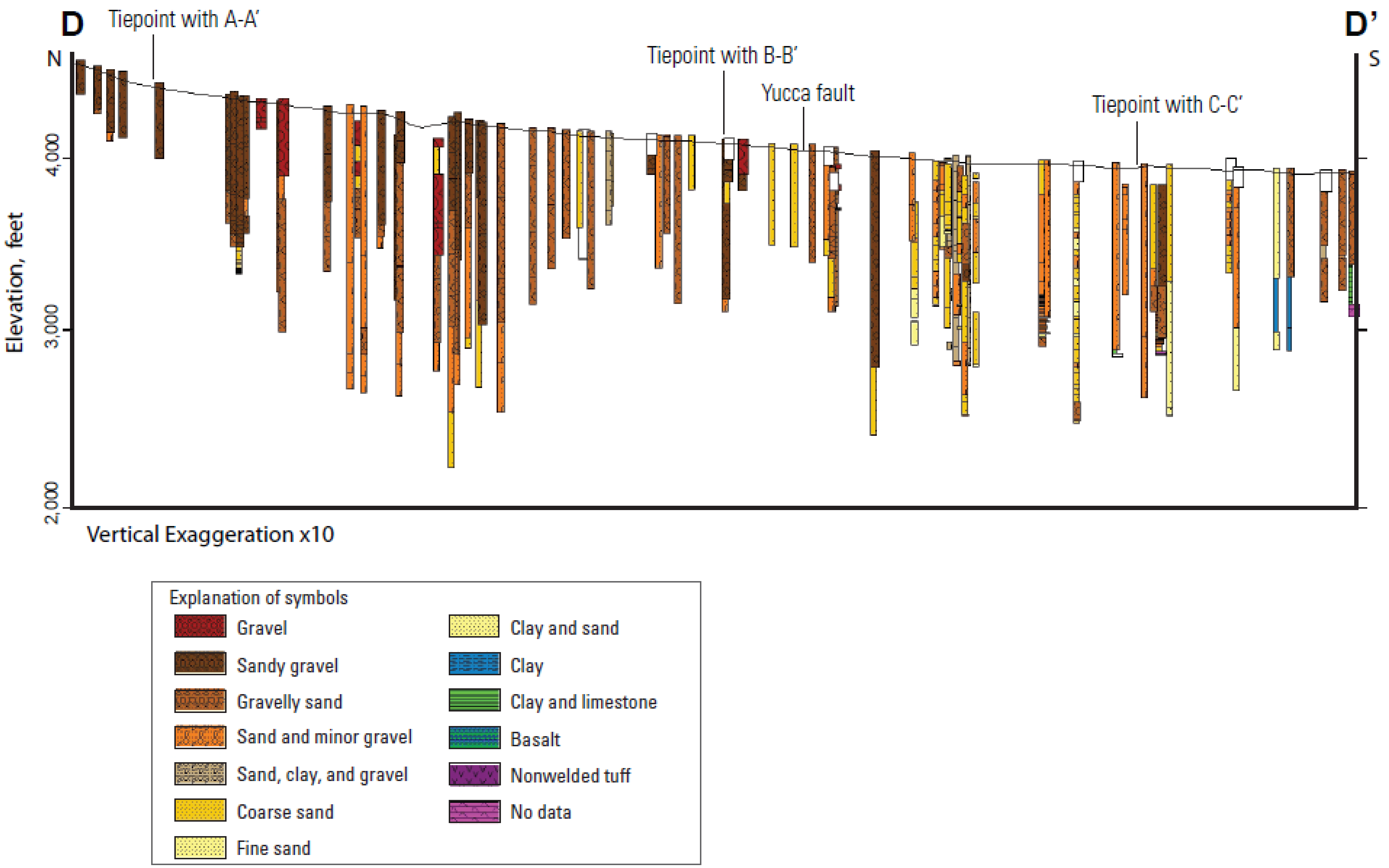
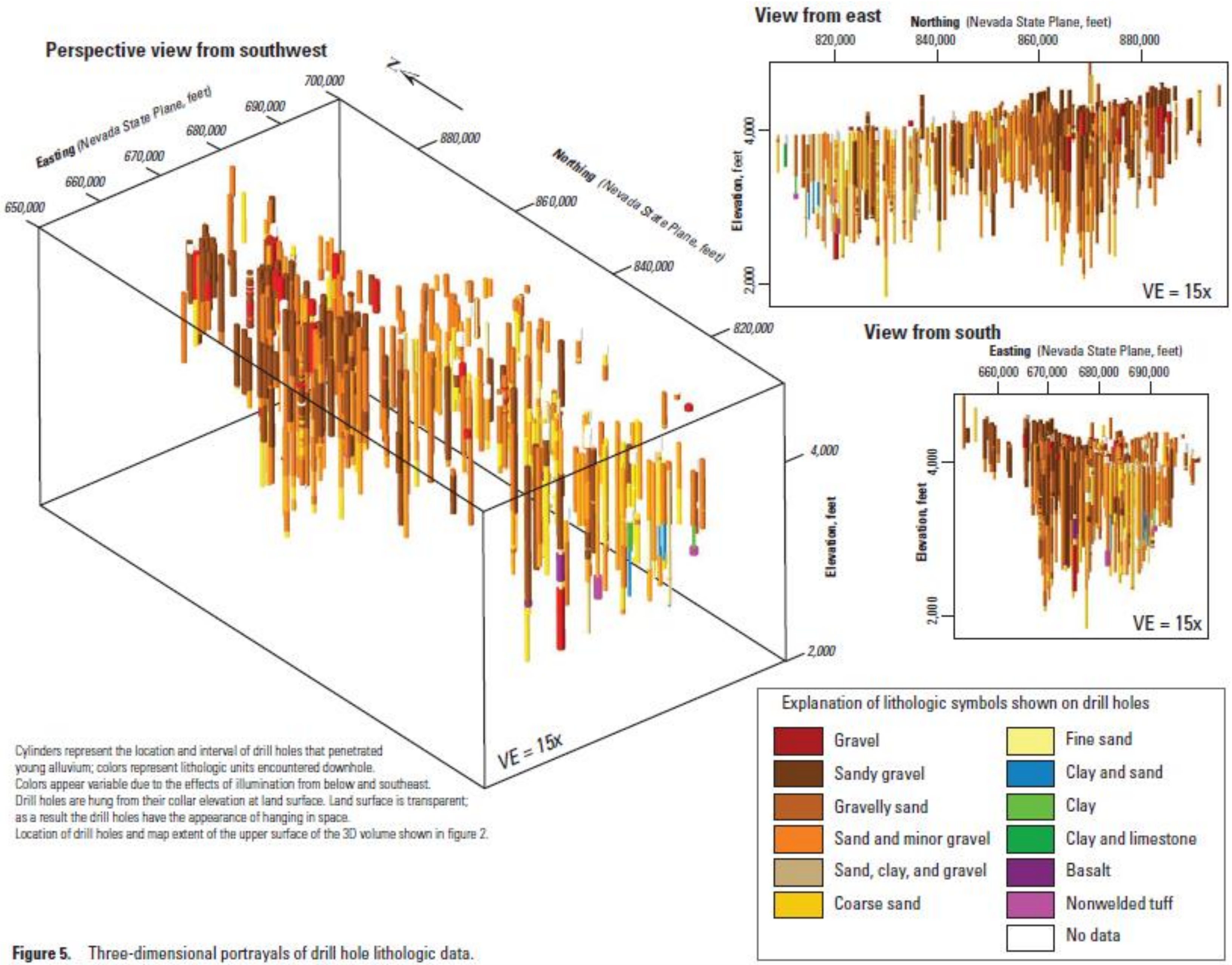


Figure 4. North-south cross section (location, fig. 2) showing interpreted drill hole lithologic data.

3D Vertical cross section of bore holes



Cylinders represent the location and interval of drill holes that penetrated young alluvium; colors represent lithologic units encountered downhole.
Colors appear variable due to the effects of illumination from below and southeast.
Drill holes are hung from their collar elevation at land surface. Land surface is transparent; as a result the drill holes have the appearance of hanging in space.
Location of drill holes and map extent of the upper surface of the 3D volume shown in figure 2.

Figure 5. Three-dimensional portrayals of drill hole lithologic data.

3D Fence Diagram

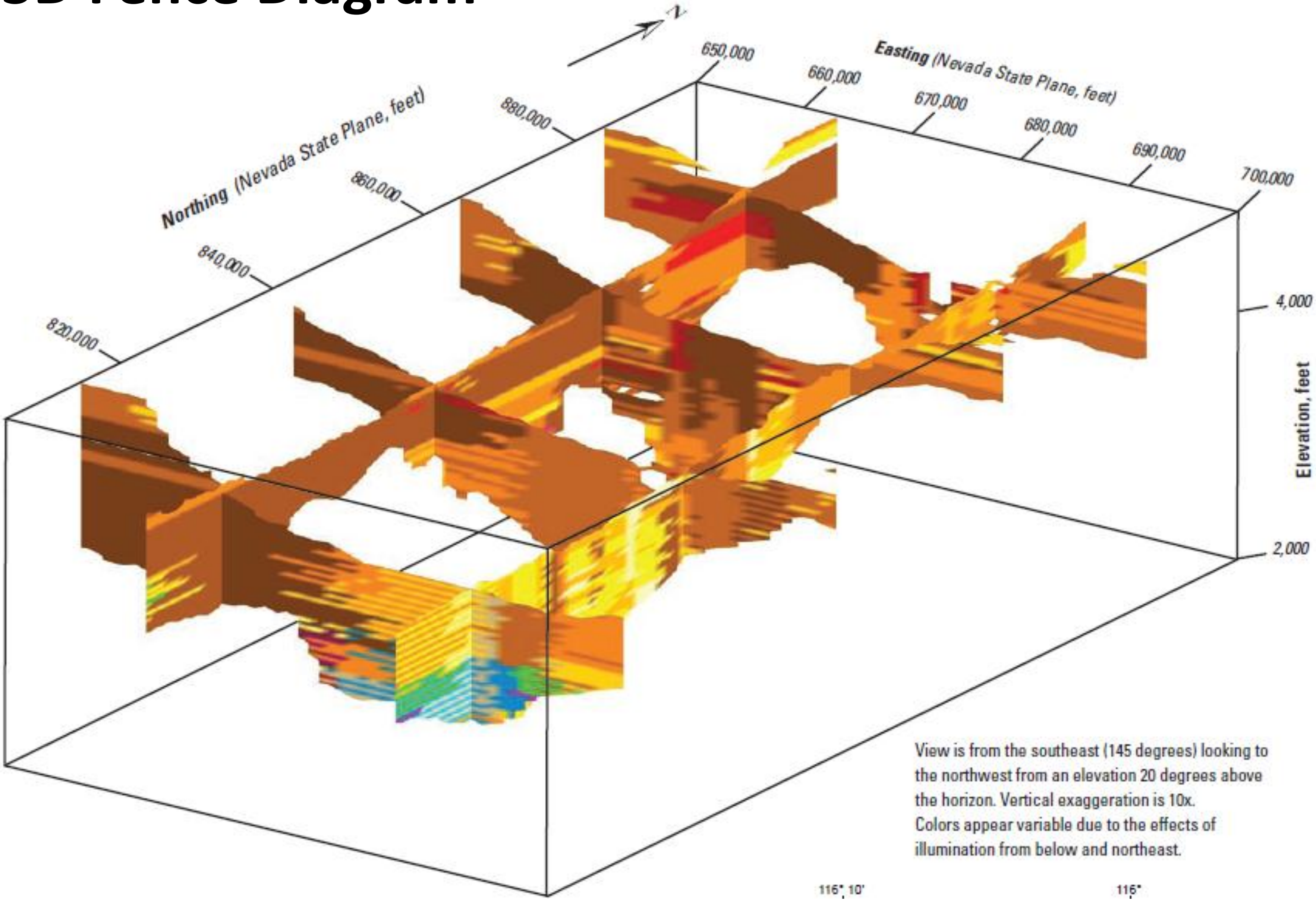


Figure 6. Perspective view of vertical sections cut through 3D lithology model of Yucca Flat.

…Fig. Contd…

Explanation of symbols shown on sections

- Gravel
- Sandy gravel
- Gravelly sand
- Sand and minor gravel
- Sand, clay, and gravel
- Coarse sand
- Fine sand
- Clay and sand
- Clay
- Clay and limestone
- Basalt
- Nonwelded tuff
- No data

Explanation of symbols shown on geologic index map
(modified from Slate and others, 2000)

- Young alluvial deposits
- Undivided alluvial deposits
- Intermediate alluvial deposits
- Playa deposits
- Tertiary volcanic rocks
- Granitic rocks and gabbro dikes
- Pennsylvanian carbonate rocks
- Mississippian and Devonian rocks
- Cambrian to Devonian carbonate rocks

- 8 NTS area boundaries
- Outer boundary of 3D lithology model
- Location of vertical section cut through 3D lithology model

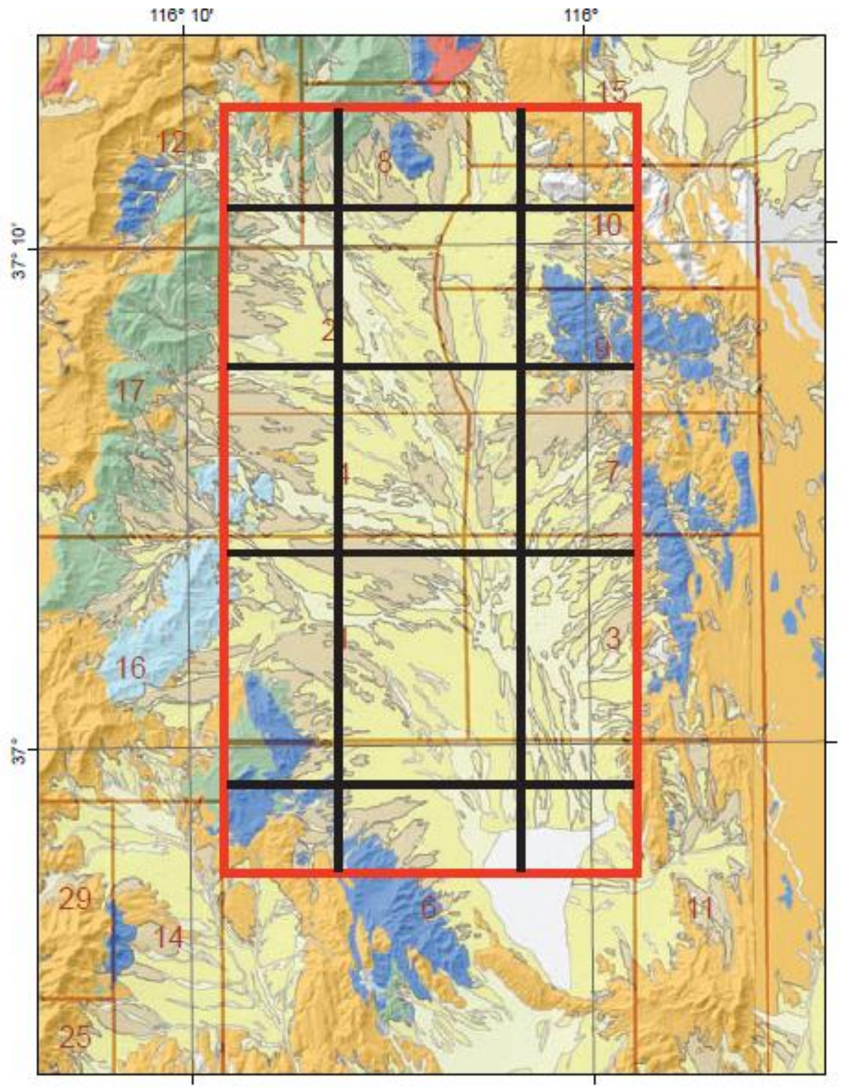


Figure 6. Perspective view of vertical sections cut through 3D lithology model of Yucca Flat.

3D Perspective view of distinct Layers

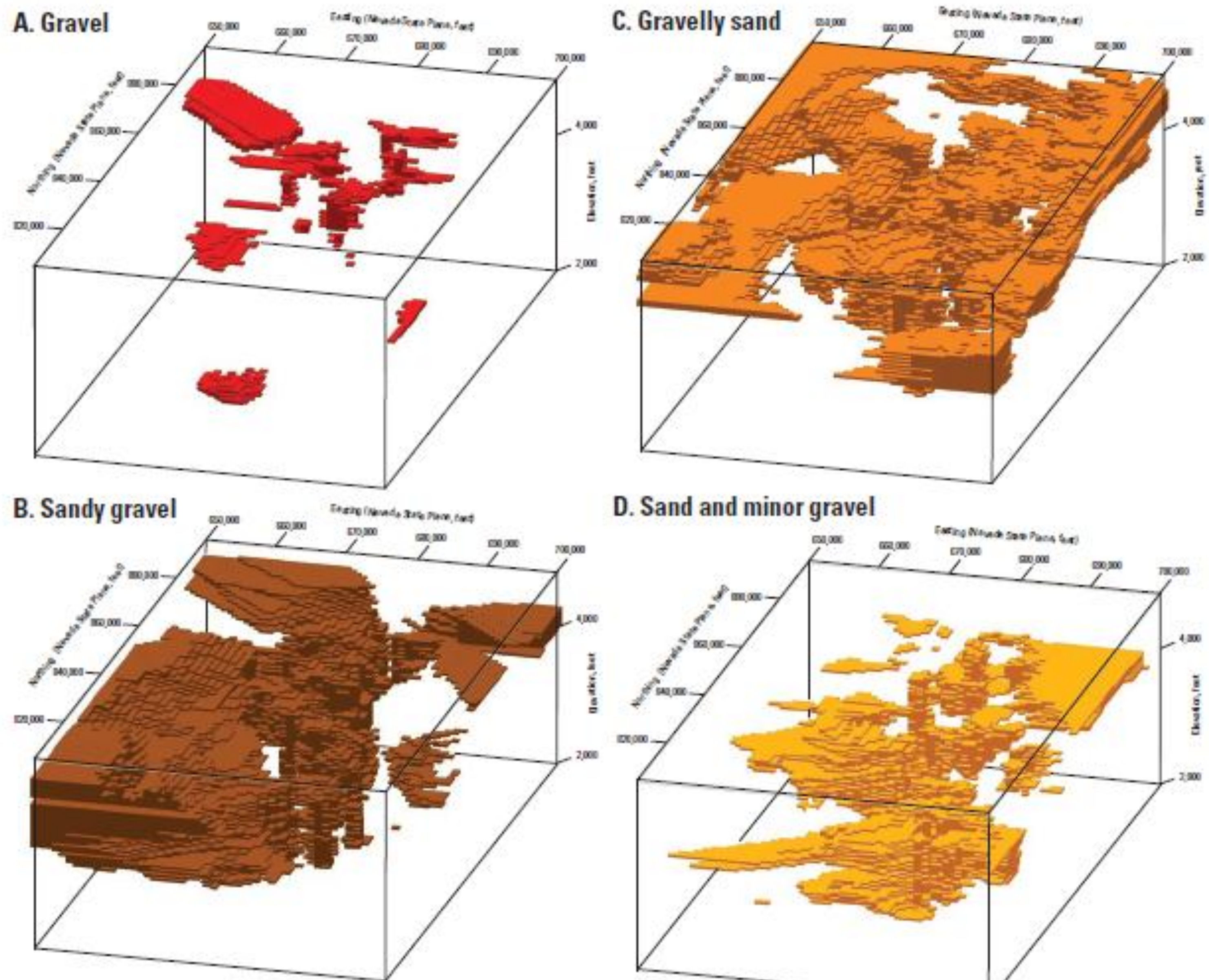


Figure 7. Perspective views of 3D lithologic model showing distribution of lithologic classes.

All views are from the southeast (145 degrees)looking to the northwest from an elevation 20degrees above the horizon. Vertical exaggeration is 10x. Colors appear variable due to the effects of illumination from above and northeast.

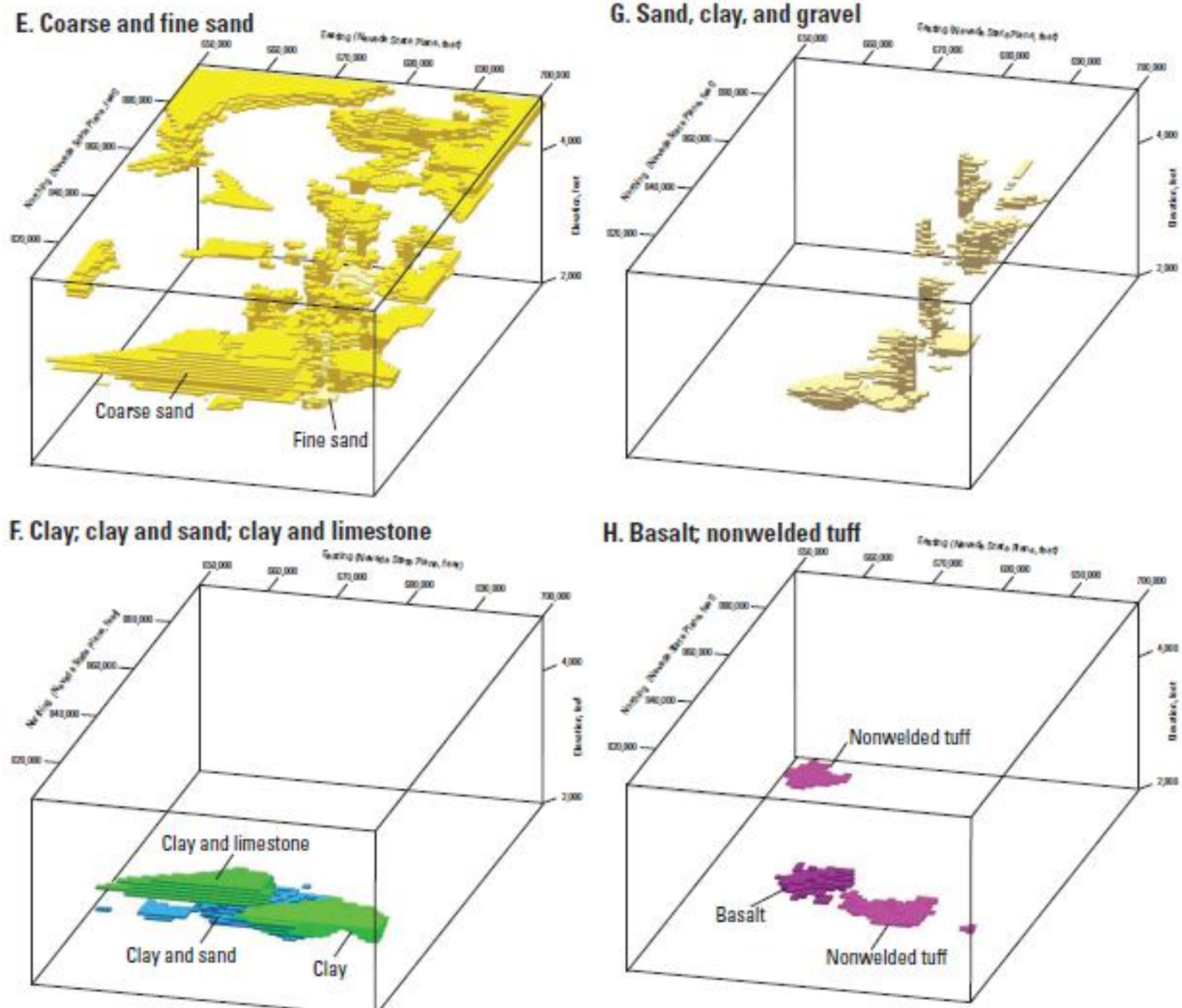


Figure 7—Continued. Perspective views of 3D lithologic model showing distribution of lithologic classes.

All views are from the southeast (145 degrees)looking to the northwest from an elevation 20degrees above the horizon. Vertical exaggeration is 10x. Colors appear variable due to the effects of illumination from above and northeast.

3D Layered Stacking

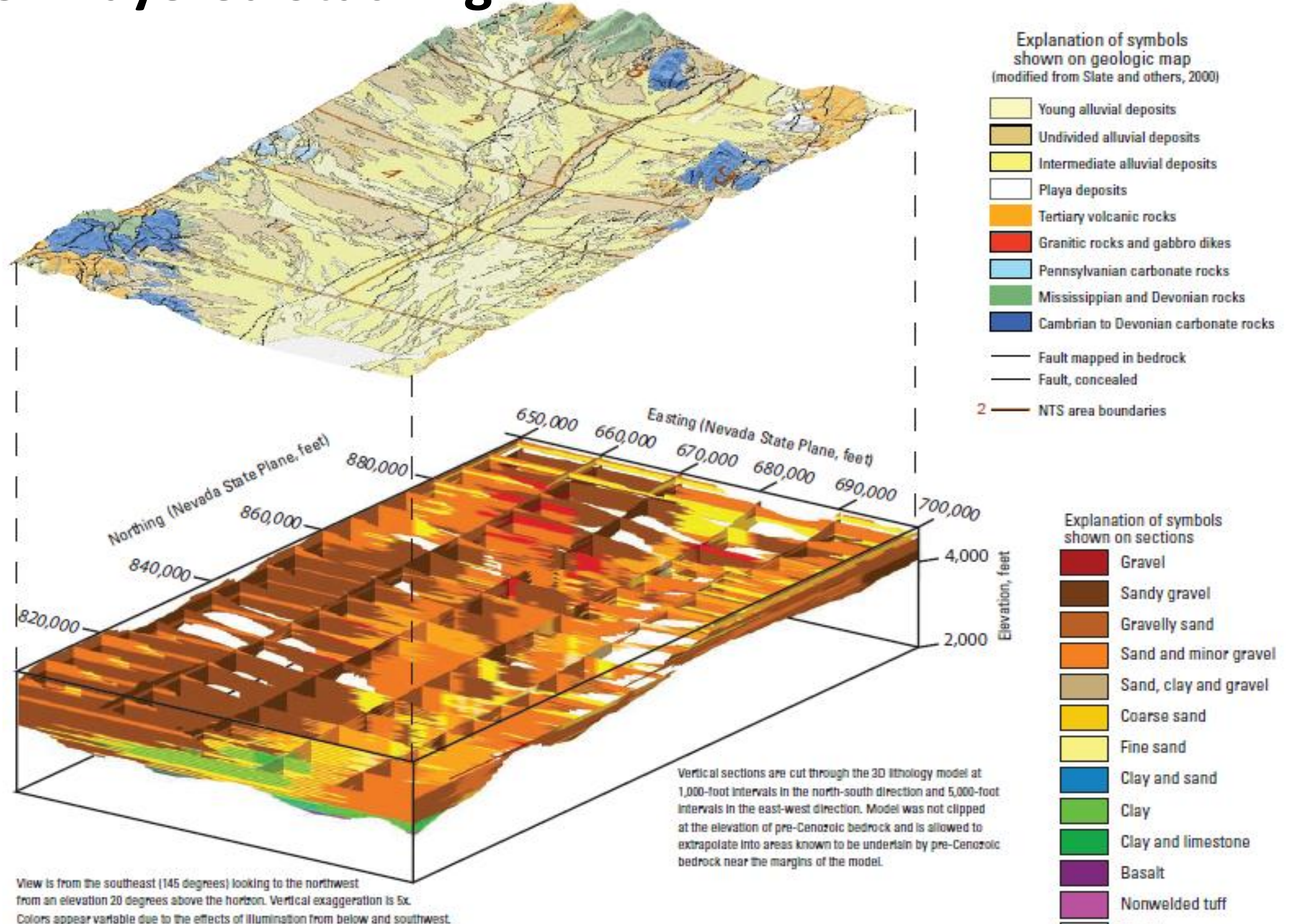


Figure 8. Perspective view of multiple vertical sections cut through 3D lithology model of Yucca Flat.