Figure 1.1 Oblique aerial view of Southern California and northern Mexico showing the San Jacinto DUSEL site and other landmarks discussed in the text. The Pennisular Ranges Geomorphic province exists south of the Transverse Ranges (San Gabriel and San Bernardino Mountains) and west of the southern San Andreas fault. The Penninsular Ranges extend off the right side of the picture. Mt. San Jacinto is bounded by the active San Andreas and San Jacinto faults. The San Jacinto structural block, like the Perris block west of the San Jacinto fault, is relatively aseismic. (Photograph source: Ocean Oasis).
Figure 1.2 Chino Canyon - Granodiorite
The ternary plutonic igneous rock classification used by the International Union of Geological Sciences is based on varying percentages of quartz, and plagioclase feldspar. Granodiorite and tonalite rock at the San Jacinto DUSEL site display very similar chemical composition and make up the largest amount of rock by volume. Gabbro and pegmatites locally occur in the Chino Canyon area, make up a small volume of the rock mass, but they have the greatest chemical variation.
Figure 1.4  Chino Canyon-Taken from Aerial Tram-Light felsic dikes in tonalite.
Figure 1.5 Chino Canyon - dark gabbro dikes in granodiorite.
Figure 1.6 Forest Road 3S08 steeply northeast dipping northwest trending medium spaced joints in granodiorite.
Figure 1.7  Chino Canyon at Tram station-felsic dikes in tonalite that is closely and vertically jointed. Spring flow from bedrock
Geologic Map of northern San Jacinto Mountains from Morton, Matti and Cox (unpublished)

Figure 1.8
Cross section A-A’ interpreted from Morton, Matti and Cox (unpublished) geologic map.

Figure 1.9
Figure 1.10  Twin Pines Road east of McMullen Flat showing septa of quartzite and schist in weathered medium gray granodiorite.
Figure 1.11 Chino Canyon-Light felsic dikes in tonalite.
Figure 1.12  Snow Canyon on upper plateau
Figure 1.13 Snow Canyon granodiorite on upper plateau.
Figure 1.14A
From Tarbuck and Lutgens, Chapter 8, Figure 20A; EARTH SCIENCE, 9th ed., Edward J. Tarbuck and Frederick K. Lutgens, Digital Image Gallery for Interactive Teaching, 0-13-031641-5, © 2000 by Prentice Hall, Inc. A Pearson Company, Upper Saddle River, NJ 07458

A. Implacement of igneous structures
Figure 1.14C  From Tarbuck and Lutgens, Chapter 8, Figure 20A; EARTH SCIENCE, 9th ed., Edward J. Tarbuck and Frederick K. Lutgens, Digital Image Gallery for Interactive Teaching, 0-13-031641-5, © 2000 by Prentice Hall, Inc.A Pearson Company, Upper Saddle River, NJ 07458
Figure 1.15  Snow Canyon-granodiorite hills-looking north to Mt. San Gorgonio.
Figure 1.16 Aerial Photographic Interpretation Map
Figure 1.17 Seismically-induced Peak Ground Acceleration (PGA) map for the state of California shows that most major California cities are located in seismically active areas. The color codes express seismic shaking as a percent of gravitational acceleration (%g). The numbers on larger scale maps are also %g. (Source: California Geologic Survey).
Figure 1.18 Much of the world’s population lives in seismically active areas. Of the 10 most populated cities in the world (ranked from 1 to 10 in table), 4 are located in very high hazard seismic areas and 4 are located in either low or moderate hazard areas. Source: 1998 population data. Seismic data from Giardini, D.; Grünthal, G.; Shedlock, K.M.; Zhang, P., (1999), The GSHAP Global Seismic Hazard Map; http://www.gfz-potsdam.de/pb5/pb53/projects/en/gshap/final_result.html
Figure 1.19 Most earthquakes occur along plate tectonic boundaries. Super-K (Japan) and Gran Sasso (Italy) experience subduction generated seismicity while San Jacinto (United States) experiences strike-slip generated seismicity.
Holocene Volcanoes Near Super-K, Gran Sasso, and San Jacinto


B. Italian volcanoes that have erupted in the Holocene. Source: http://boris.vulcanonetna.com/Italiahome.html

C. California and Mexico volcanoes that have erupted in the Holocene. Source: California: USGS Cascades Volcanic Observatory; Mexico: Volcano World

Figure 1.20 Occurrence of Holocene volcanoes near Super-K, Gran Sasso, and San Jacinto. Holocene implies volcanic activity within the last 11,000 years. Radius of the three circles are 100, 200, and 300 km, respectively. At Super-K there are 55 volcanoes within 300 km of the site; the closest is 10 km away. At Gran Sasso there are 19 volcanoes within 300 km of the site; the closest is 40 km away. At San Jacinto there are 2 volcanoes within 300 km of the site; the closest is 230 km away.
Comparing the number of micro-earthquakes from 1994-2004

Figure 1.21 These histograms show the occurrence of micro-earthquakes, within a 25 km radius of each site, that occurred during a 10 year period from 1994 to 2004. Micro-earthquakes are defined as ranging from M0.1 to M2.9. San Jacinto has the largest number of micro-earthquakes at 9,915 (note scale change on vertical axis); Super-K has the next largest number at 783, and Gran Sasso has the fewest at 148. There is a similar pattern at all sites and shows that micro-earthquakes comprise the largest percentage of the total number of earthquakes: 99.6% at San Jacinto; 87% at Super-K; and 86% at Gran Sasso. Source: IRIS earthquake catalogs for Gran Sasso & Super-K; ANSS earthquake catalog for San Jacinto
Comparing the number of medium & large earthquakes from 1994-2004

Figure 1.22 These histograms show the occurrence of medium and large earthquakes, within a 25 km radius of each site, that occurred during a 10 year period from 1994 to 2004. Medium and large earthquakes are defined as ranging in magnitude M3.0 to M9.0. Super-K has the largest number of events at 117, San Jacinto the next highest at 36, and Gran Sasso has the smallest number at 25. Source: IRIS earthquake catalogs for Gran Sasso & Super-K; ANSS earthquake catalog for San Jacinto
**Figure 1.23** Regional map of faults and historic epicenters at the San Jacinto structural block. USGS mapped faults shown as white lines. Only the San Jacinto and San Andreas faults are considered to have Holocene activity (activity in the last 11,000 years). The tram and tunnel are shown as turquoise colored lines. There are a relatively low number or epicenters within the San Jacinto structural block. The epicenters that do occur are not aligned along a fault and they are of low magnitude. (Source: SCEC earthquake data; represents 75,150 events from 1932 to 2003.)
Figure 1.24 Statistical plots showing occurrence and magnitudes of earthquakes in the San Jacinto area. Both diagrams include all event magnitudes and are based on data from 1932 to 2003. Spatial occurrence of earthquakes, depicted as a pie diagram on the left, shows that 99.8% of earthquakes occur outside of the San Jacinto structural block. The histogram on the right shows that most earthquakes that do occur in the region are small micro-earthquakes that are less than magnitude M3.0. Of all earthquakes occurring since 1932 only 2.45% have been larger than M3.0.
Figure 1.25 Local map of faults and historic epicenters at the San Jacinto structural block, Enlarged section from previous figure. A relatively low number of epicenters occur within the San Jacinto structural block. The epicenters that do occur are not aligned along any particular faults and they are of low magnitude.
Figure 1.26  Attenuation relationship for horizontal motion in hard rock produced by strike slip faults (Sadigh, et.al., 1997).
Figure 1.27 Estimated probability of exceedance of seismic acceleration for the portal area. Attenuation relationship is Sadigh et. al., 1997 for rock. Curves represent the 50, 100, 475, and 1,000 year events. The 0.51g reported acceleration for the portal is at the 84th percentile for the 475 year event.
Figure 1.28 Estimated probability of exceedance of seismic acceleration for the laboratory area. Attenuation relationship is Sadigh et. al., 1997 for rock. Curves represent the 50, 100, 475, and 1,000 year events. The 0.42g reported acceleration for the laboratory area is at the 84th percentile for the 475 year event.
Figure 1.29  Estimated maximum underground acceleration distribution at the Shin-Kobe substation produced by the Hyogo-Ken Nanbu earthquake, Japan of 1995 showed decreasing acceleration with depth. The acceleration unit gal=1 cm/sec². The graph shows significant attenuation down to 40 meters depth, continued attenuation from 40 to 100 meters depth and then slight attenuation down to the maximum measured depth of about 152 meters. Materials could affect results because terrace sediments comprise the upper 35 meters, weathered granite exists from 35 to 65 meters, and then crushed granite makes up the remainder of the deeper material.
Figure 1.30 Joint Mapping Locations.
Figure 1.31  All Joints, Dip Direction, Upper Hemisphere, Equal Area Projection.
Figure 1.32 Chino Canyon, Dip Direction, Upper Hemisphere, Equal Area Projection.
Figure 1.33 Devils Slide, Dip Direction, Upper Hemisphere, Equal Area Projection
Figure 1.34  Hwy 243, Dip Direction, Upper Hemisphere, Equal Area Projection
Figure 1.35 Long Valley, Dip Direction, Upper Hemisphere, Equal Area Projection

San Jacinto DUSEL S2 Proposal
Figure 1.36  Suicide Rock, Dip Direction, Upper Hemisphere, Equal Area Projection
Figure 1.37 Snow Creek Canyon, Dip Direction, Upper Hemisphere, Equal Area Projection
Figure 1.38  Black Mountain, Dip Direction, Upper Hemisphere, Equal Area Projection