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August 19, 2010

U. S. Nuclear Regulatory Commission
Document Control Desk
Washington, DC 20555
ATTN: David B. Matthews, Director
Division of New Reactor Licensing

SUBJECT: COMANCHE PEAK NUCLEAR POWER PLANT, UNITS 3 AND 4
DOCKET NUMBERS 52-034 AND 52-035
RESPONSE TO REQUEST FOR ADDITIONAL INFORMATION NO. 4725

Dear Sir:

Luminant Generation Company LLC (Luminant) submits herein the response to Request for Additional Information (RAI) No. 4725 for the Combined License Application (COLA) for Comanche Peak Nuclear Power Plant Units 3 and 4. The RAI involves seismic sources and vibratory ground motion. The enclosed responses do not have significant individual or collective impact on the seismic hazard analysis, the ground motion response spectra, or the vibratory ground motion previously described in the COLA and RAI responses.

Data Report TUXT-1908-01 Rev. 0 is enclosed with this letter on a CD. Distribution addressees will receive the Data Report electronically. Should you have any questions regarding this response, please contact Don Woodlan (254-897-6887, Donald.Woodlan@luminant.com) or me.

There are no commitments in this letter.

I state under penalty of perjury that the foregoing is true and correct.

Executed on August 19, 2010.

Sincerely,

Luminant Generation Company LLC

RD Bird
Rafael Flores for

Attachment: Response to Request for Additional Information No. 4725 (CP RAI #168)

Enclosure: Data Report TUXT-1908-01 Rev 0 (on CD)

D090
NRO

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RESPONSE TO REQUEST FOR ADDITIONAL INFORMATION

Comanche Peak, Units 3 and 4

Luminant Generation Company LLC

Docket Nos. 52-034 and 52-035

RAI NO.: 4725 (CP RAI #168)

SRP SECTION: 02.05.02 - Vibratory Ground Motion

QUESTIONS for Geosciences and Geotechnical Engineering Branch 1 (RGS1)

DATE OF RAI ISSUE: 6/9/2010

QUESTION NO.: 02.05.02-22

In response to RAI 2.5.2-2 (ML092820486), you stated "The list of contributing seismic sources in Tables 2.5.2-202 through 2.5.2-207 were taken from the original EPRI PSHA study, and were confirmed with the updated calculations that used the EPRI (2004) ground motion equations." Your statement suggests that the use of the new ground motion equations did not result in any increase in hazard contributions of those EPRI-SOG seismic sources that originally contributed less than 1% of the total hazard and were not used in the final hazard calculations. As a result, you revised the FSAR text to state this explicitly (ML092820486). However, in your responses to RAI 2.5.2-16 (ML092740182; ML0935611011; ML100550203), you presented additional seismic sources in the updated tables (FSAR Tables 2.5.2-202 through 2.5.2-207) which show new seismic sources that did not exist in the earlier version. In response to RAI 2.5.2-16 you also eliminated the revised text of the FSAR and removed the revisions inserted as part of the response to RAI 2.5.2-2 without providing justification. In accordance with NUREG-0800, Standard Review Plan, Chapter 2.5.2, "Vibratory Ground Motion," and Regulatory Guide (RG) 1.208, "A Performance-Based Approach to Define the Site-Specific Earthquake Ground Motion", please:

a. Clarify these apparent discrepancies between the two RAI responses and provide revised answers to the respective RAIs, as necessary.

b. Add brief geologic descriptions of these new sources in the appropriate subsections of the FSAR.

c. Describe why you added the new sources that do not appear to be contributing to the total hazard. Did the original submission not list the original EPRI-SOG sources correctly?

ANSWER:

This response has four parts: a response to each of the three issues raised in the question (issues a, b and c) and a discussion of an updated description of the maximum magnitude (Mmax) distribution for an EPRI-SOG source zone (Bechtel BZ1) in the CPNPP Units 3 and 4 COLA. This question does not raise any issues with this source zone, but the updated description of the Mmax distribution is included in this response because: (1) the characterization of the zone needs to be updated in the FSAR, and (2) the response to this question addresses FSAR sections and tables that are impacted by the updated Mmax characterization for Bechtel zone BZ1.

a. The apparent discrepancy noted in this question is due to the fact that different versions of the EPRI ground motion equations were used in the screening analyses described in the responses to RAI No. 1889 (CP RAI #11) Questions 02.05.02-2 and 02.05.02-16. The screening analyses supporting Tables 2.5.2-202 to 2.5.2-207 in FSAR Rev 0 and described in the response to Question 02.05.02-2 were developed using the EPRI Gulf Coast Region ground motion equations (FSAR Ref. 2.5-401). In contrast, the updated screening analyses described in response to Question 02.05.02-16 used the Mid-Continent Region ground motion equations (FSAR Ref. 2.5-401). Furthermore, because the updated screening analysis used different ground motion equations, additional source zones were included in the analysis. The combination of these factors resulted in additional sources being identified as contributing sources.

   FSAR Subsection 2.5.2.2.1 has been revised to describe the updated screening analysis that was used to generate the lists of contributing source zones shown in FSAR Tables 2.5.2-202 to 2.5.2-207. Note "e." of Tables 2.5.2-202 to 2.5.2-207 has been modified to clarify that the column for "Contributes to 99% of Hazard" indicates that the zones were evaluated using the updated PSHA for CPNPP Units 3 and 4.

   In addition, the Dames & Moore Mt. View/Meers source zone (zone 31) is within 200 miles of the site, but was left off of FSAR Table 2.5.2-203 because the zone was replaced with the updated Meers fault characterization (see FSAR Subsection 2.5.2.4.2.3.2). This source zone has been added to FSAR Table 2.5.2-203 for completeness.

b. FSAR Subsection 2.5.2.2.1 did not have descriptions of some of the contributing sources indicated within FSAR Tables 2.5.2-202 through 2.5.2-207. Descriptions of these source zones have been added to the FSAR text.

c. As described in the response to a. above, an updated screening analysis was conducted in response to Question 02.05.02-16 (see also supplemental response to RAI 02.05.02-16 in Luminant letter TXNB-10011, ML100550203). In that screening analysis, all EPRI-SOG source zones within 200 miles of the CPNPP Units 3 and 4 site were evaluated to determine what sources contribute to seismic hazard at the site. Contributing sources were defined as all EPRI-SOG sources within 200 miles of the site that contribute at least 1% of the seismic hazard. FSAR Tables 2.5.2-202 through 2.5.2-207 list all the sources within 200 miles of the site and highlight the contributing sources to the site hazard. These tables in FSAR Rev 0 did not include all of the source zones within 200 miles of the site.

Updated Mmax Distribution for Bechtel BZ1

FSAR Subsection 2.5.2.4.2.2.3 describes an updated Mmax distribution for the Bechtel Gulf Coast source zone (BZ1) that was developed in response to earthquakes that have occurred in the Gulf of Mexico since the original EPRI-SOG study. This updated Mmax distribution was adopted from the South Texas Project Units 3 & 4 COL Application (STP, 2007) and was used in the screening analysis to determine the contributing EPRI-SOG sources for the CPNPP Units 3 and 4 site. A letter from Exelon to the NRC (referenced below) noted that there was an error in the updated Mmax distribution for this zone. The incorrect updated distribution, with weights in parentheses, presented in FSAR Subsection 2.5.2.4.2.2.3 and Table 2.5.2-210 is: m_b 6.1 (0.1), 6.4 (0.4), and 6.6 (0.5). The correct updated distribution presented in the Exelon letter is: m_b 6.1 (0.1), 6.4 (0.4), 6.6 (0.1), 6.7 (0.4).

Revising the incorrect magnitude distribution for Bechtel zone BZ1 does not result in any changes to the CPNPP Units 3 and 4 FSAR besides the text modifications because the source zone does not contribute to seismic hazard at the site (FSAR Table 2.5.2-202), and therefore the zone was not used in the site hazard calculations. The incorrect Mmax distribution was used in the screening study to determine what sources contribute to the site hazard, but the corrected Mmax distribution does not result in zone BZ1 becoming a contributing source. This conclusion is based on the facts that:

- The two Mmax distributions are very similar (mean Mmax from incorrect distribution = 6.47; mean Mmax from correct distribution = 6.51); and
- The contribution to the site hazard from zone BZ1 using the incorrect distribution is well below 1% (i. e., at 1 Hz spectral accelerations amplitude where the total hazard from the Bechtel zones is $1x10^{-4}$, the contribution from BZ1 is approximately $2x10^{-8}$; at PGA amplitude where the total hazard from the Bechtel zones is $1x10^{-4}$, the contribution from BZ1 is approximately $2x10^{-7}$).

Reference

Exelon letter, Kray to Document Control Desk, "Early Site Permit Application Correction Notification," NP-10-0006, May 13, 2010 (ML101460203).

Impact on R-COLA

See attached marked-up FSAR Revision 1 pages 2.5-78, 2.5-80, 2.5-81, 2.5-82, 2.5-83, 2.5-84, 2.5-100, 2.5-314, and 2.5-320.

Impact on DCD

None.

~~the EPRI (2004) ground motion equations (Reference 2.5-401). A subset of these sources was determined to contribute to hazard at CPNPP Units 1 and 2 through a screening process that excludes all sources that contribute less than 1% of the hazard at a particular site (Reference 2.5-327).~~ These contributing sources ~~are indicated in Table 2.5.2-202 through Table 2.5.2-207 and~~ are shown in Figure 2.5.2-203 through Figure 2.5.2-208 and indicated in Tables 2.5.2-202 through 2.5.2-207. These contributing sources were selected from the larger group by excluding all sources that contribute to less than 1% of the hazard at the site, as determined in a screening evaluation that used the updated source characterizations described in Subsection 2.5.2.4.2 and the updated ground motion equations described in Subsection 2.5.2.4.3. These contributing source zones are the starting point for the PSHA at CPNPP Units 3 and 4. Also shown in Figure 2.5.2-203 through Figure 2.5.2-208 are earthquakes from the combined catalog for CPNPP Units 3 and 4 (see Subsection 2.5.2.1) for earthquakes with Emb > 3.0. RCOL2_02.05.02-16 S02 RCOL2_02.05.02-22

In Subsection 2.5.2.2.1.1 through Subsection 2.5.2.2.1.6, the contributing source zones for each EST are briefly discussed. More detailed information on each source zone is provided in the EST volumes of the EPRI-SOG documentation (Reference 2.5-369).

2.5.2.2.1.1 Sources identified by Bechtel Group

Five source zones from ~~T~~the Bechtel Group EST ~~defined five source zones that~~ contribute~~d~~ to hazard at CPNPP Units ~~1~~3 and ~~2~~4 (Table 2.5.2-202) (Figure 2.5.2-203) (References 2.5-369, 2.5-370, and 2.5-335): Texas Platform (zone BZ2), Ouachita (zone 38), Oklahoma Aulacogen (zone 39), North Great Plains (zone BZ3), and Combination (zone C04). Bechtel defined four additional zones that extended to within the site region that ~~did~~do not contribute to hazard ~~at CPNPP Units 1 and 2~~ (Table 2.5.2-202) (References 2.5-369, 2.5-370, and 2.5-335): Meers Fault (zone 40), El Reno (zone 65), Gulf Coast (zone BZ1), and S.E. Oklahoma (zone 55). Following is a brief discussion of the seismic source zones that contribute~~d~~ to hazard ~~at CPNPP Units 1 and 2 and are used in the PSHA for CPNPP Units 3 and 4~~: RCOL2_02.05.02-16 S02 RCOL2_02.05.02-16 S02 RCOL2_02.05.02-16 S02

Texas Platform (zone BZ2)

The Texas Platform source zone is a large background source zone extending from eastern New Mexico into Texas (Figure 2.5.2-203). The zone is characterized by an upper-bound Mmax of m_b 6.6 (Table 2.5.2-202). CPNPP Units 3 and 4 are contained within the zone.

Ouachita (zone 38)

The Ouachita source zone extends from Arkansas into east Texas (Figure 2.5.2-203) and was defined to encompass the extent of the Ouachita fold belt within this region. The zone is characterized by an upper-bound Mmax of m_b 6.6 (Table 2.5.2-202). The closest approach of the zone to CPNPP Units 3 and 4 is 125 mi.

The Ouachitas Fold Belt source zone encompasses the Ouachita orogenic front extending from Arkansas through Oklahoma, Texas, and into eastern Mexico (Figure 2.5.2-204). The zone is characterized by an upper-bound Mmax of m_b 7.2 (Table 2.5.2-203). The closest approach of the zone to CPNPP Units 3 and 4 is 26 mi.

Kink in Ouachita Fold Belt (zone 25a)

The Kink in Ouachita Fold Belt source zone is an alternative interpretation of the Ouachitas Fold Belt (zone) representing the opinion of the Dames & Moore EST that seismicity within the fold belt may be preferentially associated with a kink in the fold belt located at the Texas-Oklahoma border (Figure 2.5.2-204). The zone is characterized by an upper-bound Mmax of m_b 7.2 (Table 2.5.2-203). The closest approach of the zone to CPNPP Units 3 and 4 is 75 mi.

Southern Oklahoma Aulacogen (zone 28)

The Southern Oklahoma Aulacogen source zone extends along the Texas-Oklahoma border into the Texas panhandle (Figure 2.5.2-204). The source was defined to encompass the Southern Oklahoma Aulacogen. The zone is characterized by an upper-bound Mmax of m_b 7.2 (Table 2.5.2-203). The closest approach of the zone to CPNPP Units 3 and 4 is 91 mi.

Default for Southern Oklahoma (zone 28b)

The Default for Southern Oklahoma Aulacogen source zone extends along the Texas-Oklahoma border into the Texas panhandle (Figure 2.5.2-204). The source is a default source zone used to represent the seismic activity of the Southern Oklahoma Aulacogen in conjunction with the Southern Oklahoma Aulacogen (zone 28) source zone. The zone is characterized by an upper-bound Mmax of m_b 7.2 (Table 2.5.2-203). The closest approach of the zone to CPNPP Units 3 and 4 is 70 mi.

New Mexico (zone 67)

The New Mexico source zone extends from Texas into New Mexico and part of northern Mexico (Figure 2.5.2-204). Dames & Moore describe the boundaries of the zone as being defined largely on the basis of the extent of arches and basins formed during the Paleozoic (Reference 2.5-369). The zone is characterized by an upper-bound Mmax of m_b 7.2 (Table 2.5.2-203). CPNPP Units 3 and 4 are located within this source zone.

Combination (zone C08) RCOL2_02.05.02-22

The Combination source zone (zone C08) is comprised of the Ouachitas Fold Belt (zone 25) and the Kink in Ouachitas Fold Belt (zone 25A) source zones (Figure 2.5.2-204). The zone is characterized by an upper-bound Mmax of m_b 7.2

(Table 2.5.2-203). The closest approach of the zone to CPNPP Units 3 and 4 is 26 miles. RCOL2_02.05.02-22

2.5.2.2.1.3 Sources identified by Law Engineering

Two source zones from ~~T~~the Law Engineering EST ~~defined two source zones that~~ contribute~~d~~ to hazard at CPNPP Units ~~1~~3 and ~~2~~4 (Table 2.5.2-204) (Figure 2.5.2-205) (References 2.5-369, 2.5-370, and 2.5-335): New Mexico-Texas Block (zone 124) and Oklahoma Aulacogen-Arbuckle Wichita Rift (zone 26). Law Engineering defined ~~two~~three additional zones that extend to within the site region that ~~did~~do not contribute to hazard ~~at CPNPP Units 1 and 2~~ (Table 2.5.2-204) (References 2.5-369, 2.5-370, and 2.5-335): Eastern Mid-Continent (zone 119), Western Mid-Continent (zone 120) and South Coastal Block (zone 126). Following is a brief discussion of the seismic source zones that contribute~~d~~ to hazard ~~at CPNPP Units 1 and 2 and are used in the PSHA for CPNPP Units 3 and 4.~~: RCOL2_02.05.02-16 S02 RCOL2_02.05.02-16 S02

New Mexico-Texas Block (zone 124)

The New Mexico-Texas Block source zone is a large areal source defined by the boundaries of the Southern Oklahoma Aulacogen, the Ouachita gravity high, and the magnetic trend of the Rio Grande Rift-Colorado Front Ranges (Reference 2.5-369). This zone encompasses the majority of Texas, excluding the Gulf Costal Plain, and extends into eastern New Mexico (Figure 2.5.2-205). The zone is characterized by an upper-bound Mmax of m_b 5.8 (Table 2.5.2-204). CPNPP Units 3 and 4 are located within this source zone.

Oklahoma Aulacogen-Arbuckle Wichita Rift (zone 26)

The Oklahoma Aulacogen-Arbuckle Wichita Rift source zone overlaps the Texas-Oklahoma border and extends into the Texas panhandle and New Mexico (Figure 2.5.2-205). The source zone geometry was defined to encompass the extent of the Southern Oklahoma Aulacogen. The zone is characterized by an upper-bound Mmax of m_b 6.8 (Table 2.5.2-204). The closest approach of the zone to CPNPP Units 3 and 4 is 93 mi.

2.5.2.2.1.4 Sources identified by Rondout Associates

Four source zones from ~~T~~the Rondout Associates EST ~~defined two source zones~~ that contribute~~d~~ to hazard at CPNPP Units ~~1~~3 and ~~2~~4 (Table 2.5.2-205) (Figure 2.5.2-206) (References 2.5-369, 2.5-370, and 2.5-335): Southern Oklahoma Aulacogen-Ouachita Mountains (zone 16), Nemaha-Anadark (zone 23), Gulf Coast to Bahamas Fracture Zone (zone 51) and Grenville Crust (zone C02). Rondout Associates defined ~~two~~one additional zone~~s~~ that extends to within the site region that ~~did~~does not contribute to hazard ~~at CPNPP Units 1 and 2~~ (Table 2.5.2-205) (References 2.5-369, 2.5-370, and 2.5-335): ~~Nemaha Anadark (zone 23) and Gulf Coast to Bahamas Fracture (zone 51)~~Pre-Grenville Precambrian Craton (zone 52). Following is a brief discussion of the seismic source zones that RCOL2_02.05.02-16 S02 RCOL2_02.05.02-16 S02 contributed to hazard~~ at CPNPP Units 1 and 2 and are used in the PSHA for CPNPP Units 3 and 4.~~: RCOL2_02.05.02-16 S02

Southern Oklahoma Aulacogen-Ouachita Mountains (zone 16)

The Southern Oklahoma Aulacogen-Ouachita Mountains source zone extends from Arkansas into Texas and Oklahoma along the Texas-Oklahoma border (Figure 2.5.2-206). The zone geometry was defined to encompass the Oklahoma Aulacogen (Reference 2.5-369). The zone is characterized by an upper-bound Mmax of m_b 6.8 (Table 2.5.2-205). The closest approach of the zone to CPNPP Units 3 and 4 is 80 mi.

Grenville Crust (zone C02)

The Grenville Crust source zone is a set of discrete source zones that extend across the eastern and southern margin of the U.S. (Figure 2.5.2-206). The closest portion of the source zone to CPNPP Units 3 and 4 encompasses central and eastern Texas. The source zone is a background source representing all of the Grenville age crust that is not contained within a source zone based on the presence of tectonic features (Reference 2.5-369). The zone is characterized by an upper-bound Mmax of m_b 5.8 (Table 2.5.2-205). CPNPP Units 3 and 4 are located within this source zone.

Nemaha-Anadark (zone 23) RCOL2_02.05.02-22

The Nemaha-Anadark source zone is an elongated zone extending from southern to northern Oklahoma (Figure 2.5.2-206). The zone geometry was defined to encompass the intersection of possible extensions of the Humboldt fault zone and the Nemaha anticline (Reference 2.5-369). The zone is characterized by an upper-bound Mmax of m_b 7.0 (Table 2.5.2-205). The closest approach of the zone to CPNPP Units 3 and 4 is 140 miles.

Gulf Coast to Bahamas Fracture (zone 51)

The Gulf Coast to Bahamas Fracture source zone is a large background source zone extending from the coastal plains of the Gulf of Mexico into the central Gulf of Mexico (Figure 2.5.2-206). The zone geometry was defined to represent the Paleozoic crust of the Gulf of Mexico region as distinct from that of the Appalachians (Reference 2.5-369). The zone is characterized by an upper-bound Mmax of m_b 5.8 (Table 2.5.2-205). The closest approach of the zone to CPNPP Units 3 and 4 is 57 miles.

2.5.2.2.1.5 Sources identified by Weston Geophysical Corporation

Four source zones from ~~T~~the Weston Geophysical Corporation EST ~~defined three source zones that~~ contribute~~d~~ to hazard at CPNPP Units ~~1~~3 and ~~2~~4 (Table 2.5.2-20~~6~~7) (Figure 2.5.2-20~~7~~8) (References 2.5-369, 2.5-370, and 2.5-335): Southwest RCOL2_02.05.02-16 S02 (zone 109), Combination (zone C31), ~~and~~ Ancestral Rockies (zone 36) and Gulf Coast (zone 107). Weston Geophysical Corporation defined one additional zone that extends to within the site region that ~~did~~does not contribute to hazard ~~at CPNPP Units 1 and 2~~ (References 2.5-369, 2.5-370, and 2.5-335): ~~Gulf Coast (zone 107)~~Delaware Basin (zone 37). Following is a brief discussion of the seismic source zones that contributed to hazard ~~at CPNPP Units 1 and 2 and are used in the PSHA for CPNPP Units 3 and 4~~: RCOL2_02.05.02-16 S02

Southwest (zone 109)

The Southwest source zone is a large background source that extends over much of Texas, New Mexico, Colorado, and Wyoming (Figure 2.5.2-207). The zone is characterized by an upper-bound Mmax of m_b 6.6 (Table 2.5.2-206). CPNPP Units 3 and 4 are located within this zone.

Combination (zone C31)

The Combination (zone C31) source zone is an alternative geometry for the Southwest (zone 109) background zone that excludes the Delaware Basin in west Texas (Figure 2.5.2-207). The zone is characterized by an upper-bound Mmax of m_b 6.6 (Table 2.5.2-20~~5~~6). CPNPP Units 3 and 4 are located within this zone. RCOL2_02.05.02-16 S02

Ancestral Rockies (zone 36)

The Ancestral Rockies source zone extends from Arkansas, through the majority of Oklahoma, and into the Texas panhandle (Figure 2.5.2-207). The geometry of this zone was defined to encompass the extent of the Southern Oklahoma Aulacogen and associated tectonic features. The zone is characterized by an upper-bound Mmax of m_b 6.0 (Table 2.5.2-20~~5~~6). The closest extent of this zone to CPNPP Units 3 and 4 is ~~85~~79 mi. RCOL2_02.05.02-16 S02

Gulf Coast (zone 107) RCOL2_02.05.02-22

The Gulf Coast source zone is a large background source zone extending from the coastal plains of the Gulf of Mexico into the central Gulf of Mexico (Figure 2.5.2-207). The zone geometry encompasses regions for which no other source zones were defined (Reference 2.5-369). The zone is characterized by an upper-bound Mmax of m_b 6.0 (Table 2.5.2-206). The closest approach of the zone to CPNPP Units 3 and 4 is 79 miles.

2.5.2.2.1.6 Sources identified by Woodward-Clyde Consultants

Four source zones from ~~T~~the Woodward-Clyde Consultants EST ~~defined three source zones that~~ contributed to hazard at CPNPP Units ~~1~~3 and ~~2~~4 (Table 2.5.2-207) (Figure 2.5.2-208) (References 2.5-369, 2.5-370, and 2.5-335): Central U.S. Background (zone BG44), Southern Oklahoma Aulacogen (zone 46), ~~and~~ Alternate Configuration of Southern Oklahoma Aulacogen (46a) and Southern RCOL2_02.05.02-16 S02 RCOL2_02.05.02-16 S02

Oklahoma Gravity Anomaly (zone 48). Woodward-Clyde Consultants defined threetwo additional zones that extend to within the site region that diddo not contribute to hazard at CPNPP Units 1 and 2 (Table 2.5.2-207) (References 2.5-369, 2.5-370, and 2.5-335): Meers Fault (zone 49), and Eastern Oklahoma Seismic Zone (zone 52), and Southern Oklahoma Gravity Anomaly (zone 48). Following is a brief discussion of the seismic source zones that contributed to hazard: at CPNPP Units 1 and 2 and are used in the PSHA for CPNPP Units 3 and 4: RCOL2_02.05.02-16 S02 RCOL2_02.05.02-16 S02

Central US Background (zone BG44)

The Central US Background (zone BG44) is a large areal background source centered on CPNPP Units 1 and 2. The zone is a quadrilateral shape with sides approximately 6° long, in both longitude and latitude (Figure 2.5.2-208). The zone is characterized by an upper-bound Mmax of m_b 6.5 (Table 2.5.2-207). CPNPP Units 3 and 4 are in this zone.

Southern Oklahoma Aulacogen (zone 46)

The Southern Oklahoma Aulacogen source zone extends from south-central Oklahoma along the Oklahoma-Texas border into the Texas panhandle (Figure 2.5.2-208). The zone geometry is defined to encompass the extent of the Southern Oklahoma Aulacogen. The zone is characterized by an upper-bound Mmax of m_b 7.2 (Table 2.5.2-207). The closest approach of the zone to CPNPP Units 3 and 4 is 100 mi.

Alternate Configuration for Southern Oklahoma Aulacogen (zone 46A)

The Alternate Configuration for Southern Oklahoma Aulacogen source zone is an alternative geometry for the Southern Oklahoma Aulacogen (zone 46) source zone that extends further to the northeast into New Mexico. The zone is characterized by an upper-bound Mmax of m_b 7.2 (Table 2.5.2-207). The closest approach of the zone to CPNPP Units 3 and 4 is 100 mi.

Southern Oklahoma Gravity Anomaly (zone 48) RCOL2_02.05.02-22

The Southern Oklahoma Gravity Anomaly source zone is a northwest trending, elongated zone that extends from northern Texas into southern Oklahoma. (Figure 2.5.2-208). The zone geometry was defined to encompass the Bouguer gravity low north of the Oklahoma aulacogen (References 2.5-369). The zone is characterized by an upper-bound Mmax of m_b 7.1 (Table 2.5.2-207). The closest approach of the zone to CPNPP Units 3 and 4 is 131 miles.

2.5.2.2.2 Post-EPRI-SOG Source Characterization Studies

Since publication of the EPRI-SOG seismic source characterizations for the CEUS in 1986 (Reference 2.5-369), there have been several regional-scale

The updated Mmax values of 6.1, 6.4, 6.6, and 6.7 with weightings of 0.1, 0.4, 0.1, and 0.4 used here (Table 2.5.2-210) follow from Bechtel's methodology of defining Mmax distributions (Reference 2.5-369): RCOL2_02.05.02-22 RCOL2_02.05.02-16 S02

- The lower bound magnitude of the distribution is defined as the greater of either the largest observed earthquake magnitude within the zone, or mb 5.4.
- The next higher magnitude is 0.3 magnitude units greater than the minimum.
- The third magnitude is 0.6 magnitude units above the minimum.
- The fourth magnitude, and upper bound of the distribution, is mb 6.6.
- The weightings on the four Mmax values are 0.1, 0.4, 0.4, and 0.1, respectively. RCOL2_02.05.02-22

2.5.2.4.2.2.4 Mmax Update for Rondout Gulf Coast to Bahamas Fracture Zone

RCOL2_02.05.02-16 S02

Rondout Associates assigned Mmax values of 4.8, 5.5, and 5.8 to the Gulf Coast to Bahamas Fracture Zone source zone (zone 51) (Table 2.5.2-210). Because both the 2006 Emb 5.5 and Emb 6.1 earthquakes in the Gulf of Mexico occur within this zone, and because these magnitudes are greater than the lowest Mmax values for the source zone, the Mmax distribution for this source zone has been updated.

The updated Mmax values of 6.1, 6.3, and 6.5 with weightings of 0.3, 0.55, and 0.15, respectively, used here (Table 2.5.2-210) follow from reclassifying the source zone as one capable of producing moderate earthquakes instead of the original classification of the source zone as one only capable of producing smaller than moderate earthquakes (Reference 2.5.2-369). The original Rondout Mmax distribution for moderate earthquake source zones is 5.2, 6.3, and 6.5 with weightings of 0.3, 0.55, and 0.15, respectively. The updated Mmax distribution follows this distribution with the exception of an increase in the lower bound of the distribution to 6.1 to account for the observed Emb 6.1 earthquake within this zone.

2.5.2.4.2.2.5 Mmax Update for Weston Gulf Coast

Weston Geophysical Corporation assigned Mmax values of 5.4 and 6.0 to the Gulf Coast source zone (zone 107) (Table 2.5.2-210). Both the 2006 Emb 5.5 and Emb 6.1 earthquakes in the Gulf of Mexico occur within this zone. Because these magnitudes are greater than the original Mmax values for the source zone, the Mmax distribution for this source zone has been revised.

CP COL 2.5(1)

Table 2.5.2-203 (Sheet 2 of 2)
Summary of Dames & Moore Seismic Source Zones

Source	Description	Distance[a] (km)	Distance[a] (mi)	Pa[b]	M_{max} (m_b) and Wts.[c]	Smoothing Options and Wts.[d]	Contributes to 99% of Hazard[e]	
32	Ardmore Basin	230	140	0.51	6.0 [0.75] 7.2 [0.25]	3 [0.75] 4 [0.25]	No	RCOL2_02.05.02-16 S02
33	Anadarko Basin	266	165	1.0	5.8 [0.75] 7.2 [0.25]	1 [0.34] 2 [0.11] 3 [0.41] 4 [0.14]	No	
31	Mt. View/Meers	210	130	0.45	6.0 [0.75] 7.2 [0.25]	3 [0.75] 4 [0.25]	NA - replaced	RCOL2_02.05.02-22

a) Shortest distance between CPNPP 3 & 4 and source zone.

b) Probability of activity (EPRI, 1989a).

c) Maximum earthquake magnitude (M_{max}) in body-wave magnitude (m_b) and weighting (Wts.) (EPRI 1989a).

d) Smoothing options (EPRI, 1989a):

1 = no smoothing on a, no smoothing on b, strong b prior of 1.04:

2 = no smoothing on a, no smoothing on b, weak b prior of 1.04;

3 = constant a, constant b, strong b prior of 1.04;

4 = constant a, constant b, weak b prior of 1.04;

Weights on magnitude intervals are [0.1, 0.2, 0.4, 1.0, 1.0, 1.0, 1.0].

e) Whether or not the source contributes to 99% of the hazard at CPSES Units 1 & 2.

CP COL 2.5(1)

RCOL2_02.05.02-16 S02

Table 2.5.2-210
Mmax Update for ~~Dames & Moore South Coastal Margin~~EPRI Team Sources

RCOL2_02.05.02-22

Team	Source Zone	Original Mmax Distribution and Weights (EPRI, 1989)	Updated Mmax Distribution and Weights
Bechtel	Background (BZI)	5.4 [0.1] 5.7 [0.4] 6.0 [0.4] 6.6 [0.1]	6.1 [0.1] 6.4 [0.4] 6.6 [0.1] 6.7 [0.4]
Dames & Moore	South Coastal Margin (zone 20)	5.3 [0.8] 7.2 [0.2]	5.5 [0.8] 7.2 [0.2]
Law Engineering	New Mexico-Texas Block (zone 124)	4.9 [0.3] 5.5 [0.5] 5.8 [0.2]	5.0 [0.3] 5.5 [0.5] 5.8 [0.2]
Law Engineering	South Coastal Block (zone 126)	4.6 [0.9] 4.9 [0.1]	5.5 [0.9] 5.7 [0.1]
Rondout	Gulf Coast to Bahamas Fracture zone (zone 51)	4.8 [0.2] 5.5 [0.6] 5.8 [0.2]	6.1 [0.3] 6.3 [0.55] 6.5 [0.15]
Weston	Gulf Coast (zone 107)	5.4 [0.71] 6.0 [0.29]	6.6 [0.89] 7.2 [0.11]

RESPONSE TO REQUEST FOR ADDITIONAL INFORMATION

Comanche Peak, Units 3 and 4

Luminant Generation Company LLC

Docket Nos. 52-034 and 52-035

RAI NO.: 4725 (CP RAI #168)

SRP SECTION: 02.05.02 - Vibratory Ground Motion

QUESTIONS for Geosciences and Geotechnical Engineering Branch 1 (RGS1)

DATE OF RAI ISSUE: 6/9/2010

QUESTION NO.: 02.05.02-23

In response to RAI 2.5.2-1 (ML093080116), you provided an updated supplementary earthquake catalog which extended the spatial coverage of the initial Comanche Peak Nuclear Power Plant (CPNPP) earthquake catalog to enclose all seismic sources used in the CPNPP hazard study. In your response, you stated that based on the supplementary earthquake catalog there are two seismic sources whose maximum earthquake magnitude (Mmax) values need to be updated and you did not discuss updates to the probability of activity (Pa) values based on the occurrence of earthquakes. In accordance with NUREG-0800, Standard Review Plan, Chapter 2.5.2, "Vibratory Ground Motion," and Regulatory Guide (RG) 1.208, "A Performance-Based Approach to Define the Site-Specific Earthquake Ground Motion", please explain the following:

a. While you stated that the updated earthquake catalog required only updates to two of the Electric Power Research Institute (EPRI) sources Mmax values, as part of your response to RAI 2.5.2-16 you updated FSAR Table 2.5.2-10 which shows five additional Mmax updates to the EPRI sources. Please clarify this apparent discrepancy and explain the source of Mmax updates shown in the RAI 2.5.2-16 response.

b. The supplementary earthquake catalog includes a moderate-sized earthquake that occurred on 08/10/2005 with a magnitude of 5.4 within a few of the seismic sources used for the CPNPP hazard study. Although you evaluated the impacts of this earthquake on Mmax model parameters and conducted a sensitivity study to assess its impacts as part of your RAI response, your response did not address the issue of Pa values of these sources. The Law Engineering Earth Science Team's (EST's) seismic source zone 26, for which you updated the Mmax value, has a Pa value of 0.6. Since there is now already a large earthquake in this source, its Pa value requires updating. Similarly, this earthquake also falls within the Bechtel EST's zone 39 with a Pa value of 0.2 and the Woodward Clyde EST's zone 46a with a Pa value of 0.08. Please provide an update to your RAI 2.5.2-1 response considering the impacts of Pa updates.

c. Please also provide an assessment of the impacts of the updated Mmax and Pa values on the EPRI-Seismicity Owners (SOG) seismic sources that were not used in the original calculations because their initial hazard contributions were less than 1% of the total hazard, such as the Gulf coast sources and the

Rondout and Dames & Moore ESTs sources. Do these sources still contribute less than 1% of the total hazard after the necessary Mmax and Pa updates?

ANSWER:

a. The updated maximum magnitude (Mmax) distributions presented in FSAR Table 2.5.2-210 were not discussed in the response to Question 02.05.02-1 because these Mmax updates were identified as part of the original FSAR investigations and not efforts associated with the response. In particular, in preparing FSAR Chapter 2, it was noted that in South Texas Project (STP) Units 3 & 4 FSAR Subsection 2.5.2.4.3 (STP, 2007), two post-1986 earthquakes were identified in the Gulf of Mexico with Mmax values that were higher than the lower-bound Mmax of some of the zones that contained the earthquakes. STP Units 3 & 4 developed Mmax updates for the relevant EPRI-SOG source zones to address these earthquakes.

The same Mmax updates were adopted for sources zones that were included in the seismic hazard analysis provided in CPNPP Units 3 and 4 FSAR, Rev. 0. In CPNPP FSAR Chapter 2, Rev. 0, only one of the Gulf of Mexico source zones updated in the STP 3 & 4 FSAR (i. e., the Dames & Moore South Coastal Margin zone 20) was used in the seismic hazard calculations, so it was the only zone presented in FSAR Table 2.5.2-210, Rev. 0. However, as part of the response to Question 02.05.02-16, an updated screening analysis was conducted (response to Question 02.05.02-22), and this screening analysis included the other four source zones from the Gulf of Mexico that were updated within the STP 3 & 4 FSAR: Bechtel Background zone BZ1, Law South Coastal Block zone 126, Rondout Gulf Coast to Bahamas Fracture zone 51, and Weston Gulf Coast zone 107. Some of these four zones were determined to not contribute to hazard at the site (FSAR Tables 2.5.2-202 through 2.5.2-207), but the updated Mmax values for all the zones were presented in FSAR Table 2.5.2-210 for completeness.

The fifth zone that was added to Table 2.5.2-210 (Law New Mexico-Texas Block zone 124) is also listed in Table 2.5.2-211, Rev. 0. As part of changes made in FSAR Rev. 1, Table 2.5.2-211 was removed and the updated Mmax values for the zone were instead listed in Table 2.5.2-210.

b. The 10 August 2005 earthquake noted in this question occurred in northeastern New Mexico and is referred to throughout this response as the New Mexico earthquake.

<u>New Mexico Earthquake</u>

In the response to Question 02.05.02-1, the New Mexico earthquake is reported as a Mw 5.0 event based on the reported magnitude within the Advanced National Seismic System (ANSS) catalog. However, an Emb magnitude is needed for the earthquake so that it can be evaluated against the existing EPRI-SOG source characterizations. The ANSS lists the reporting agency for the location and magnitude as the National Earthquake Information Center (NEIC), and the NEIC catalog also lists the event with an mb magnitude of 5.0 (NEIC, 2010). The original methodology of the EPRI-SOG study to estimate Emb was to use direct measurements of mb magnitudes instead of conversions from other magnitude estimates (e.g., Ms to Emb) as the best magnitude estimate. This methodology is outlined on page 3-6 of Volume 1, Part 1 and page 4-8 of Volume 1, Part 2 of the EPRI-SOG documentation (EPRI, 1986-1989), and on page 3-2 of the EQHAZARD Primer (EPRI, 1989). Based on this methodology, the appropriate Emb magnitude for the New Mexico earthquake for comparison to the existing EPRI-SOG source characterizations is 5.0.

<u>Impact on Existing EPRI-SOG Source Characterizations</u>

The Emb 5.0 New Mexico earthquake occurs within zones for each of the six EPRI-SOG earth science teams (ESTs), but the earthquake only impacts three source zones. The zones for each team and the impacts are reviewed below. A summary of changes is presented in Table 1.

Bechtel

The New Mexico earthquake occurs in Bechtel zone 39 (Oklahoma Aulacogen) and zone BZ3 (N. Great Plains). Zone BZ3 is the background for the zone 39 and both zones have lower-bound Mmax values that are greater than or equal to mb 5.0. Therefore, there is no need to update the Mmax distribution for either zone, but the potential for updating the probability of activity (Pa) value for zone 39 needs to be investigated.

The Pa values for Bechtel source zones were developed by evaluating the probability of activity of tectonic features using what the Bechtel EST referred to as a matrix of physical characteristics. The details of the methodology are presented within the Bechtel EST volume (EPRI, 1986-1989, vol. 9, section 4), but a brief outline of the methodology is presented below.

The basis for the Bechtel Pa value for a given zone is the weight given to the applicability of three characteristics to each source zone, where the sum of the weights for each characteristic is 1.0. The characteristics are:

- The zone's association with seismicity. This characteristic was evaluated for moderate to large earthquakes (mb ≥ 5.0), small earthquake only, and no seismicity.
- How favorably oriented tectonic features are within the zone relative to the dominant stress direction. This characteristic was described as either favorable or unfavorable.
- Whether the zone is associated with tectonic features that have a deep crustal expression. This characteristic was described as either yes or no.

The weights of these characteristics are applied to the matrix of physical characteristics to develop a Pa value. For some sources this Pa value is adjusted by a subjective amount to account for other information identified by the EST. For example, with zone 39 Bechtel applied a subjective increase of 0.05 to the Pa value to account for the observation that the Quaternary Meers fault occurs within the zone (EPRI, 1986-1989, vol. 9, p. 4-56).

The Bechtel EST evaluated the characteristics of zone 39 as follows (weights in parentheses) (EPRI, 1986-1989, vol. 9, p. 4-55 to 4-56):

- Association with seismicity – moderate to large (0.1), small (0.25), none (0.65);
- Geometry – favorable (0.5), unfavorable (0.5); and
- Deep crustal association – yes (1.0), no (0.0).

Applying these evaluations to the matrix of physical characteristics gives a Pa of 0.133, and adding on the additional 0.05 weight results in a Pa of 0.183. The occurrence of the New Mexico earthquake requires updating the Pa evaluation for zone 39 because the largest observed earthquake in the zone prior to the New Mexico earthquake was less than 5.0. Therefore, the weight that the zone is associated with moderate-to-large seismicity needs to be increased from the original value of 0.1. The Bechtel EST methodology does not provide enough information to determine how the occurrence of the New Mexico earthquake would impact that EST's evaluation of association with seismicity, so a conservative change is made to the weights by increasing the association with moderate to large earthquakes to 1.0 and by decreasing the association with small earthquakes and no seismicity to 0. Applying these changes results in a conservative, updated Pa for zone 39 of 0.65, including the additional 0.05 probability for the Meers fault.

Dames & Moore

The New Mexico earthquake occurs within Dames & Moore zone 68a. This zone is not considered because it is approximately 300 miles from the site (NRC, 2007).

Law

The New Mexico earthquake occurs in Law zone 26 (Oklahoma-Aulacogen-Arbuckle-Wichita Rift) and zone 120 (Western Mid-Continent). Zone 120 is the background for zone 26 and both zones have lower-bound Mmax values that are greater than or equal to mb 5.0. The lower-bound Mmax for zone 120 is listed as 4.9 in FSAR Table 2.5.2-204, but the actual lower-bound Mmax used in the PSHA calculations is mb 5.0 based on the minimum magnitude used in the EPRI-SOG study (EPRI, 1989). Therefore, there is no need to update the Mmax distribution for either of the zones, but the potential for updating the probability of activity value for zone 26 needs to be investigated.

Similar to the Bechtel source zones, the Pa values for Law source zones were developed by evaluating the probability of activity of tectonic features using a matrix of physical characteristics. The details of the methodology are presented within the Law EST volume (EPRI, 1986-1989, vol. 7, section 4), but a brief outline of the methodology is presented below.

The basis for the Law Pa value for a given zone is weights given to the applicability of two characteristics for each source zone, where the sum of the weights for each characteristic is 1.0. The characteristics and their weights for zone 26 are:

- Association with seismicity – moderate to large (0.4), small (0.55), none (0.05); and
- Geometry – favorable (0.5), unfavorable (0.5).

Applying these evaluations to the matrix of physical characteristics gives a Pa of 0.6.

The occurrence of the New Mexico earthquake requires updating the Pa evaluation for zone 26 because the largest observed earthquake in the zone prior to the New Mexico earthquake was less than 5.0. Therefore, the weight that the zone is associated with moderate to large seismicity needs to be increased from the original value of 0.4. The Law EST methodology does not provide enough information to determine how the occurrence of the New Mexico earthquake would impact that EST's evaluation of association with seismicity, so a conservative change is made to the weights by increasing the association with moderate to large earthquakes to 1.0 and by decreasing the association with small earthquakes and no seismicity to 0. Applying these changes results in a conservative, updated Pa for zone 26 of 0.84.

Rondout

The New Mexico earthquake occurs within Rondout zone 17. This zone is not considered because it is over 300 miles from the site (NRC, 2007).

Weston

The New Mexico earthquake occurs within Weston zone 36. This zone does not need to be updated for the CPNPP Units 3 and 4 site because it has a lower-bound Mmax of 5.4 and a Pa of 1.0 (FSAR Table 2.5.2-206).

Woodward Clyde

The New Mexico earthquake occurs in Woodward Clyde zone 46A (Alternate configuration of 46). Zone 46A is mutually exclusive with zone 46 (S. Oklahoma Aulacogen). The Pa values for 46 and 46A are 0.084 and 0.083, respectively. These two zones represent equally weighted alternative interpretations of the extent of the Oklahoma aulacogen (EPRI, 1986-1989, vol. 8, p. B-23 to B-24) with 46A extending significantly further west than 46 (FSAR Figure 2.5.2-208). The original Pa values for the zones are based on Woodward Clyde's development of a single Pa value for the Oklahoma Aulacogen using a matrix of physical characteristics and then developing two different interpretations of the aulacogen (zones 46 and 46A) that were equally weighted. Because there is no background zone for zone 46A, and because the largest observed earthquake in the zones prior to the New Mexico earthquake was mb 4.9, the Pa value for 46A needs to be updated.

There are two alternate interpretations of how the Pa value for 46A could be modified.

- ALT 1: This alternative represents the interpretation that the occurrence of the New Mexico earthquake would not have led the Woodward-Clyde EST to change the equal weights they assigned to the two interpretations of the Oklahoma aulacogen (i.e., zones 46A and 46). In this interpretation the New Mexico earthquake only impacts zone 46A because this is the only zone within which the earthquake occurs. Because the New Mexico earthquake has a magnitude of 5.0 and because there is no background zone, the Pa for zone 46A would then need to be 1.0. However, the 0.5 weight Woodward Clyde puts on 46A as the correct representation of the aulacogen results in a final Pa of 0.5 for zone 46A. The weight on zone 46 remains the same because the earthquake did not occur within the zone. This alternative is the preferred interpretation of how the Woodward Clyde EST would have addressed the New Mexico earthquake because the New Mexico earthquake does not significantly change the pattern of seismicity associated with the zone, and thus is not likely to have changed Woodward Clyde's equal weighting of the alternate interpretations of the aulacogen.
- ALT 2: This alternative represents the interpretation that the New Mexico earthquake would have led the Woodward-Clyde EST to change the equal weights they assigned to the two interpretations of the Oklahoma aulacogen (i.e., zones 46A and 46). The Woodward Clyde EPRI-SOG volume (EPRI, 1986-1989, vol. 8) does not provide enough details of their methodology to determine how they may have changed their weightings of the two alternatives. Therefore, for ALT 2 the Pa of 46A is conservatively set to 1.0, and the Pa of 46 is set to 0. This represents the interpretation that the Woodward Clyde EST would have interpreted the New Mexico earthquake as conclusive evidence that zone 46A is the correct interpretation of the Oklahoma aulacogen.

<u>Sensitivity Analyses of Updated EPRI-SOG Characterizations</u>

To investigate the impact of these potential changes to the EPRI-SOG source characterizations on the seismic hazard at the CPNPP Units 3 and 4 site, a sensitivity analyses was conducted with the updated source characterizations presented in Table 1. The updated characterizations were used with the other contributing source zones identified within the FSAR (Tables 2.5.2-202 through 2.5.2-207) to calculate the rock ground motions following the same procedure as described in FSAR Subsection 2.5.2.4.4. The rock ground motion was scaled by the corresponding amplification factors for the GMRS (Subsection 2.5.2.5), and the horizontal GMRS was calculated following the procedure outlined in Subsection 2.5.2.6.1.1. Revised amplification factors were not calculated for this sensitivity analysis because the changes in ground motions are small and the materials at the site are assumed to behave linearly (strain independent).

The results of these calculations are shown in Table 2 as the percent increase in GMRS over that presented within the FSAR for both alternative interpretations of the Woodward Clyde Oklahoma aulacogen sources. As can be seen in the percent increases in GMRS values, the potential impact of the updated EPRI-SOG characterizations in light of the New Mexico earthquake are very small, especially considering the fact that all of the potential Pa changes are made using conservative assumptions.

The information provided in this response supersedes the response to Question 02.05.02-1

c. As described in the response to Question 02.05.02-22, an updated screening assessment was conducted as part of the response to Question 02.05.02-16 to determine the sources that contributed to seismic hazard at the site. The updated assessment utilized the updated Mmax values for the source zones in the Gulf of Mexico that are discussed in response to Item a. The changes to the Pa values of the zones listed in Table 1 would not result in additional sources being identified as contributing sources because the sources in Table 1 are already contributing sources (FSAR Tables 2.5.2-202, 2.5.2-204, and 2.5.2-207). Therefore, the potential changes discussed in this response would not impact the evaluation of contributing sources shown in Tables 2.5.2-202 through 2.5.2-207.

References

(EPRI, 1986-1989), Seismic hazard Methodology for the Central and Eastern United States (NP-4726), Vol. 1-3 & 5-10, EPRI.

(EPRI, 1989), EQHAZARD Primer (NP-6452-D), EPRI, prepared by Risk Engineering for Seismicity Owners Group and EPRI

(NEIC, 2010), NEIC PDE-W earthquake summary for 10 August 2005 earthquake, USGS, ftp://hazards.cr.usgs.gov/edr/mchedr/mchedr200508.dat.Z.

(NRC, 2007), Reg. Guide 1.208: A Performance-Based Approach to Define the Site-Specific Earthquake Ground Motion, US NRC, p. 53

(STP, 2007), South Texas Project COL application for STP Site, Units 3 & 4, Rev. 0, NRC Docket Nos. 52-012 and 52-013

Attachments

Table 1: Summary of EPRI-SOG changes from New Mexico earthquake

Table 2: Potential impact of updating EPRI-SOG sources for the New Mexico earthquake on the site GMRS

Impact on R-COLA

None.

Impact on DCD

None.

Table 1: Summary of EPRI-SOG changes from New Mexico earthquake

Source Zone	Pa	Other notes
Bechtel Oklahoma Aulacogen (39)	0.65	NA
Law Oklahoma – Aulacogen – Arbuckle – Wichita Rift (26)	0.84	NA
Woodward Clyde S. Oklahoma Aulacogen Alternate Configuration (46A)	0.5	ALT 1 scenario. No update to zone 46 with this scenario.
Woodward Clyde S. Oklahoma Aulacogen Alternate Configuration (46A)	1.0	ALT 2 scenario. Update zone 46 with this scenario.
Woodward Clyde S. Oklahoma Aulacogen (46)	0.0	ALT 2 scenario. Update zone 46A with this scenario.

Table 2: Potential impact of updating EPRI-SOG sources for the New Mexico earthquake on the site GMRS

Freq. (Hz)	GMRS from FSAR	Percent increase for: ALT 1	ALT 2
100/PGA	0.0372	0.3%	0.5%
25	0.0418	0.5%	0.7%
10	0.0509	0.1%	0.3%
5	0.0545	0.2%	0.3%
2.5	0.0729	0.0%	0.2%
1	0.0450	0.3%	0.4%
0.5	0.0355	0.2%	0.4%

RESPONSE TO REQUEST FOR ADDITIONAL INFORMATION

Comanche Peak, Units 3 and 4

Luminant Generation Company LLC

Docket Nos. 52-034 and 52-035

RAI NO.: 4725 (CP RAI #168)

SRP SECTION: 02.05.02 - Vibratory Ground Motion

QUESTIONS for Geosciences and Geotechnical Engineering Branch 1 (RGS1)

DATE OF RAI ISSUE: 6/9/2010

QUESTION NO.: 02.05.02-24

In response to RAI 2.5.2-4 (ML092820486), you stated that "1) the EPRI-SOG model does not adequately describe the Alpine earthquake and 2) it is not legitimate technical interpretation of the earthquake to account for its occurrence by updating the Mmax values of the contributing EPRI-SOG source zones that contain the earthquake." You stated that you reached this conclusion by using your expert judgment and based on input you received from Dr. Diane Doser, and subsequently you created a new seismic source model to incorporate the potential contributions of such similar future earthquakes in your hazard estimations. You have not conducted a Senior Seismic Hazard Analysis Committee (SSHAC) study for the development of your new seismic source. The staff examined the e-mail correspondence between you and Dr. Doser at the site audit conducted on April 7-8, 2010, and found that even though she believes this earthquake is a result of the tectonic forces related to the Rio Grande Rift system, she clearly indicated that the scientific work on this earthquake is quite limited and uncertainties exist. Given the uncertainty surrounding the tectonic causes of this earthquake, the staff is concerned that your model does not adequately represent the potential hazard at the site. Because this event is within the area of the several EPRI-SOG source models that host the CPNPP site and all of these sources have Mmax values lower than the observed earthquake, and based on the criteria in NUREG-0800, Standard Review Plan, Chapter 2.5.2, "Vibratory Ground Motion," and Regulatory Guide (RG) 1.208, "A Performance-Based Approach to Define the Site-Specific Earthquake Ground Motion", please update these models, similar to what you did in many of the other EPRI sources you used in your hazard calculations (FSAR Table 2.5.2-210). The updated analysis should incorporate the impacts of the Mmax updates to the EPRI-SOG sources based on the occurrence of this magnitude 5.8 earthquake. Also, please evaluate if any of the unused seismic sources should now be used because their seismic source model parameters need to be updated due to the occurrence of this earthquake (i.e., will this update bring the unused seismic sources' hazard contributions above the 1% threshold?)

ANSWER:

The response to this RAI question addresses two topics:

- The Alpine earthquake issue as presented within this RAI question.

- The combined impacts of the Alpine earthquake issue, the NMSZ rate issue addressed in the response to Question 02.05.02-25, and the New Mexico earthquake issue addressed in the response to Question 02.05.02-23.

ALPINE EARTHQUAKE ISSUE

The response to the Alpine earthquake issue is divided into six components. First, the seismotectonic setting of the Alpine earthquake is discussed, and it is demonstrated that the most widely held and parsimonious interpretation is that the Alpine earthquake is related to Rio Grande Rift (RGR) seismotectonics. Second, the EPRI-SOG source zones that contain the Alpine earthquake are reviewed, and it is demonstrated that the EPRI-SOG ESTs did not intend for the source zones containing the Alpine earthquake to characterize regions associated with the RGR. Based on these observations, it is concluded that it is not appropriate to use the Alpine earthquake as a basis for updating the source zone parameters. The third component discusses the sensitivity analysis that was conducted as part of the effort to demonstrate that the RGR does not need to be considered as a source for the CPNPP site. Despite the conclusion that the EPRI-SOG sources should not be updated to account for the Alpine earthquake, the forth and fifth components presented below describe how the Alpine earthquake could potentially be used to conservatively modify the EPRI-SOG source characterizations and how these updates would impact the CPNPP GMRS. This analysis demonstrates that the impacts of these conservative updates on the GMRS are minor, with a maximum change in the GMRS over the value in the FSAR that is less than 2 percent. Finally, the last component discusses the impact of these conservative changes on the screening of contributing sources for the CPNPP site and concludes that these potential changes would not result in there being any additional contributing sources for the site.

Seismotectonic Setting of the Alpine Earthquake

To further investigate the conclusion of the FSAR that the Alpine earthquake was related to the seismotectonics of the RGR, a second detailed review was conducted (i.e., in addition to that done as part of the FSAR preparation) of published information regarding the seismotectonic setting of the region surrounding the Alpine earthquake and numerous interviews with technical experts were conducted in an effort to more accurately document the opinion of the informed technical community with respect to the appropriate characterization of the Alpine earthquake. The results of these efforts, summarized below, support the conclusion of the FSAR that the Alpine earthquake is associated with the RGR.

Background

The 14 April 1995, Emb 5.7 Alpine earthquake was felt over an area of approximately 760,000 km^2 and had a maximum intensity of MMI VI (Frohlich and Davis, 2002). Figure 1 shows the general setting of the 1995 Alpine earthquake in relation to physiographic provinces (Fenneman and Johnson, 1946) and the terrain of western Texas, faults from the USGS Quaternary fault and fold database (USGS, 2006), and historical earthquakes (FSAR Subsection 2.5.2.1). The CMT focal mechanism for the Alpine earthquake indicates normal slip on moderately dipping nodal planes (Global CMT Project, 2007). It is the second largest earthquake recorded in Texas (the 1931 Valentine earthquake was Emb 5.8). Many small landslides were triggered in the mountains surrounding the epicentral region (Frohlich and Davis, 2002), but no fault-related surface deformation has been identified. Also, the earthquake has not been associated with a causative fault.

Published Studies Related to the 1995 Alpine Earthquake

There are no published studies specifically related to the source characteristics and setting of the Alpine earthquake. The earthquake location, magnitude, and source parameters were routinely catalogued by the USGS. Frohlich and Davis (2002) describe the general setting as well as effects and felt reports of the Alpine earthquake. The Alpine earthquake was widely recorded on seismic networks worldwide and several geophysical studies were conducted using those recordings (Das and Nolet, 1998; Melbourne and Helmberger, 1998; Rodgers and Bhattacharyya, 2001; Xie, 1998). The primary focus of these studies was on continental scale lithospheric structure and seismic wave propagation.

Overview of Tectonic History in the Region of the 1995 Alpine Earthquake

The Alpine earthquake was located adjacent to or astride several tectonic boundaries spanning several tectonic episodes. The region of the Alpine earthquake lies near the southwest margin of the North American craton where Proterozoic rifting separated the North and South American Plates (Figure 2). This rifting is proposed to have created structural trends that were reactivated in subsequent stages of tectonism (Page et al., 2008; Poole et al., 2005). Following this rifting, four to five distinct Phanerozoic tectonic episodes are generally recognized (Figure 3) as reflected in the regional geologic structure.

The first major tectonic event was intense deformation within the Marathon Basin (the region directly southwest of the Alpine earthquake) that resulted from the late Paleozoic collision of the North and South American Plates along the Ouachita-Marathon-Sonora orogen (Poole et al., 2005) (Figure 4). The deformation included reactivation of some northwest- to north-striking Proterozoic faults (e.g., Ross, 1986). However, thick Permian Basin deposits to the north and east of the area overlap these faults indicating that the region was relatively stable during that time period (Ross, 1986).

Through the early Mesozoic (Figure 3) the region experienced minor deformation associated with renewed rifting between North and South America, which ultimately led to the opening of the Gulf of Mexico (Page et al., 2008) and a complex array of basins to the west (Haenggi and Muehlberger, 2005). During this time, the Alpine-Marathon region was part of the Diablo Platform, a relatively high region east of the subsiding Chihuahua Trough (Figures 5 and 6).

The late Cretaceous to early Tertiary Laramide orogeny represented a shift to east-northeast shortening in the region (Ewing, 1991a, b). The eastern edge of the fold-thrust belt represented by the Chihuahua basin was about 200 km to the west of the Alpine earthquake, but basement-cored structures of Laramide age extend inland to east of the Alpine-Marathon area (Figures 7 through 9). Southwest of the Alpine area, this orogeny is recorded as northwest-trending folds in Cretaceous units as readily apparent on the Tectonic Map of Texas (Figure 10) (Texas BEG, 1997).

The late stages of subduction of the Farallon plate lead to major episodes of middle Tertiary volcanism and plutonism and development of the Trans-Pecos volcanic field in the region (Figures 3 and 11) (Henry et al., 1991). The 1995 Alpine earthquake occurred within this field (Figures 12 and 13). Although the major preserved outcrops of this volcanism lie to the west of the Alpine earthquake, small remnants of similar intrusive rocks are mapped just to the east of the epicenter (Figure 14). The northeastern extent of these rocks is near the Brewster and Pecos County line, northeast of the Alpine-Marathon area, and this boundary continues along the same southeast same trend into Mexico (see Figure 10).

Normal faulting related to Basin and Range and RGR extension began in the Alpine-Marathon region about 25 Ma (Figure 3) and is marked by the beginning of predominantly basaltic volcanism (Henry and Price, 1986). Basaltic volcanism in the region peaked about 20 Ma, but eruptions continued to about 10 Ma (C. Henry, Pers. Comm. 2010). Unmapped basaltic dikes thought to be of this age are present in the Glass Mountains (C. Henry, pers. Comm., 2010), near the epicentral region of the 1995 Alpine earthquake. Neogene faulting associated with extension is distributed in a broad region across west Texas and extends several kilometers east of the epicentral region of the 1995 Alpine earthquake (Figures 14 and 15) (Henry and Price, 1986; Muehlberger, 1980). The closest Quaternary faults identified in the USGS Quaternary Fault and Fold Database (USGS, 2006) are: an unnamed fault near Santiago Peak 50 km south of the epicenter, the West Lobo Valley fault about 120 km to the northwest of the epicenter, unnamed faults near Ruidosa about 120 km southwest of the epicenter, and the West Wyle fault about 140 km northwest of the epicenter (Figure 1).

Evaluation of Alpine Earthquake Seismotectonic Setting

In addition to expert interviews, five explicit criteria were used in evaluating the seismotectonic setting of the Alpine earthquake. These criteria and the conclusions with respect to the criteria are presented below.

1. Neogene and Quaternary faulting

No Quaternary faults have been identified in the vicinity of the epicenter of the 1995 Alpine earthquake. The closest Quaternary faults identified in the USGS Quaternary Fault and Fold Database (USGS and TBEG, 2010) are: an unnamed fault near Santiago Peak 50 km south of the epicenter, the West Lobo Valley fault about 120 km to the northwest of the epicenter, unnamed faults near Ruidosa about 120 km southwest of the epicenter, and the West Wyle fault about 140 km northwest of the epicenter (Figure 1). However, available literature does not fully document the extent and detail of Quaternary faults in the region closer to the earthquake epicenter. Muehlberger et al. (1978) depict a belt of northwest-striking late Cenozoic extension-related faults that extends as far east as Marathon, TX. The northeastern edge of this belt of faulting is near the epicentral area of the 1995 earthquake (Figure 15). Dickerson and Muehlberger (1994) describe this faulting as being related to RGR extension. In addition, Henry and Price (1985) include the area of the 1995 earthquake within the extent of Basin and Range faulting in west Texas (Figure 14).

Based on these observations, there is existing geologic evidence that the Alpine earthquake occurred within a region that is dominated by Cenozoic seismotectonics related to the RGR.

2. Extent of Basaltic Volcanism

Basaltic intrusive and extrusive rocks related to late Cenozoic extension are shown on existing maps within a few kilometers to the west and northwest of the 1995 Alpine Earthquake epicenter (Figure 14). In addition, unpublished mapping (C.Henry, pers. Comm., 2010) indicates that basaltic dikes related to late Cenozoic extension are present in the Glass Mountains near the epicentral area.

The presence of this volcanism related to RGR extension near the Alpine earthquake is strong evidence that RGR-related extension was the latest major tectonic event impacting the region of the earthquake, and thus the earthquake is likely related to modern RGR extension.

3. Region of Recurrent Deformation

As discussed above, the Alpine earthquake lies within a belt of recurrent late Mesozoic to Cenozoic tectonic activity in western Texas. This region is tectonically distinct from the stable craton region of Texas to the east and northeast of the Alpine earthquake and near the CPNPP Units 3 and 4 site (Figure 11). The earthquake lies with a belt of silicic volcanism, as evident in the extensive outcrops of mid-Cenozoic silicic volcanic rocks of the Trans-Pecos volcanic field within ~15 km of the epicenter (Figures 11 and 14). Related intrusive rocks, preserved as sills, laccoliths, necks, and plugs also are scattered through the region in a belt that extends at least 15 km east of the epicenter (Figures 10 and 14).

These repeated tectonic episodes provide evidence that the seismotectonic setting of the region surrounding the Alpine earthquake is significantly different than that of the region immediately surrounding the CPNPP site (see FSAR Subsection 2.5.1.1.4).

4. Comparisons to Regional Seismicity

The style of faulting and kinematic indications of the state of stress from earthquakes in west Texas (e.g., 1931 Valentine earthquake, Alpine earthquake) are indicative of extensional or trans-tensional mechanisms (Figure 16) (Doser, 1987; Doser et al., 1992; Frohlich and Davis, 2002). This region of west

Texas also experiences higher rates of seismicity than observed in central Texas (Frohlich and Davis, 2002) (FSAR Figure 2.5.2-201).

These observations support the hypothesis that the region surrounding the Alpine earthquake is seismologically distinct from the region of central Texas proximal to the CPNPP site and is likely related to the seismotectonics of the RGR as opposed to the stable continental interior of central Texas.

5. Regional Stress Maps and Models

The Alpine earthquake was located along the western boundary of the Southern Great Plains stress province of Zoback and Zoback (Zoback, 1992; Zoback and Zoback, 1980b; Zoback and Zoback, 1989), defined as a transitional zone between active extension of the WUS and compressional stress of the midcontinent. The current compilation of the World Stress Map (Reinecker et al., 2008) includes the 1995 earthquake focal mechanism as a normal fault mechanism as discussed above, but does not define stress provinces or boundaries. At the continental scale, the 1995 Alpine earthquake lies within the western US extensional region defined by Humphries and Coblentz (2007).

These observations suggest that the region surrounding the Alpine earthquake is within a stress domain that is different from that of central Texas near the CPNPP site and is likely related to the RGR seismotectonics.

Expert interviews

Ten interviews with technical experts were conducted either over the phone or via email in an effort to more accurately document the opinion of the informed technical community with respect to the appropriate characterization of the Alpine earthquake. Each expert was asked a series of questions that included the following:

1. Are you familiar with the 1995 Alpine, Texas earthquake?
2. Have you conducted any specific investigations or studies related to this earthquake?
    a. Other earthquakes or tectonic features in the region?
3. Our data review has found relatively few studies of this earthquake. Are you aware of any unpublished or pending investigations or evaluations of this earthquake?
4. Our initial evaluations have considered this earthquake related to Rio Grande Rift/Basin and Range extensional tectonics.
    a. Do you consider this a defensible characterization of the 1995 earthquake?
    b. Are there alternative characterizations that should be considered?
    c. In your view, what might be the eastern extent of extensional tectonics in west Texas at the latitude of Alpine?
    d. Is the Alpine EQ plausibly related to tectonic regimes of central Texas?
5. In your view, what is the appropriate tectonic characterization of the 1995 Alpine Texas earthquake?
    a. What are the key data or factors on which that characterization is based?
    b. Are there large uncertainties in this conclusion, or gaps in available data that might influence characterization of this earthquake?
6. Are there other experts that you would recommend we contact who might be knowledgeable regarding this earthquake?

A summary of these interviews is presented below in Table 1. The general conclusions based on the interviews are that: (1) experts with more direct knowledge of the earthquake and familiarity with geologic data in the surrounding region have stronger held opinions that the earthquake is related to RGR extension and not the seismotectonics of central Texas (e.g., Henry, Doser); (2) experts with less familiarity of the earthquake or those with opinions based on more regional data are more open to alternate characterizations of the earthquake (e.g., Wong, Harmsen); (3) the predominant expert opinion is that the Alpine earthquake is related to the extensional tectonics of the RGR (e.g., only one of the ten experts gives significant weight [50 percent] to the interpretation that the earthquake could be related to the seismotectonics of central Texas).

Conclusion Regarding Seismotectonic Setting of the Alpine Earthquake

Based on review of the available geologic, geophysical, and seismological information presented in this RAI response and in FSAR Subsections 2.5.1.1.4.3.7.1 and 2.5.2.4.2.3.3, and on interviews with technical experts familiar with the Alpine earthquake and/or the seismotectonic setting of region surrounding the Alpine earthquake, it was concluded that the best characterization of the Alpine earthquake is that it is related to the extensional tectonics of the RGR and not the tectonic setting of central Texas. As with all scientific inquires there is some uncertainty in this conclusion. However, the strongest evidence and majority opinion of the experts is that the earthquake is related to the RGR.

<u>EPRI-SOG ESTs Tectonic Characterization of the Alpine Earthquake Region</u>

The Alpine earthquake occurs within 5 EPRI-SOG source zones (Figure 17). In general, the EPRI-SOG ESTs defined and characterized source zones based on their evaluations of tectonic features (EPRI, 1986-1989). The tectonic characteristics used by each EST to define their respective source zones that contain the Alpine earthquake are summarized below. Based on the descriptions of the source zones it is clear that they were not intended to represent the seismotectonic setting of the RGR, and therefore, updating the characterizations of these source zones (e.g., maximum magnitude and Pa values) based on the Alpine earthquake is conservative with respect to the seismic hazard at the CPNPP site.

Dames & Moore

The Alpine earthquake occurs within Dames & Moore zone 26b (default zone for Delaware basin [zone 26] and Delaware aulacogen [zone 27]). As indicated by the zone names, these zones were designed to characterize the Delaware basin and aulacogen, a Permian basin associated with the thrust-loading of the Ouachita orogenic belt and a hypothesized failed rift arm associated with the early Paleozoic rifting of Rodinia, respectively (e.g., Denison, 1989; Ewing, 1991b; Walper, 1977; Whitmeyer and Karlstrom, 2007). Based on the descriptions of these tectonic features and the resulting seismic source zones by the Dames & Moore EST (EPRI, 1986-1989, vol. 6, p. A-19, A-93, and B-24), it is clear that the zones are not meant to characterize the RGR seismotectonic region.

Law

The Alpine earthquake occurs within Law zone 124 (New Mexico – Texas Block). The Law EST explicitly states that the western boundary of this zone was defined by the "north-south magnetic trend of the Rio Grande-Colorado Front Ranges," a region that was explicitly excluded from their source characterizations (EPRI, 1986-1989, vol. 7, p. B-8 and 5-8). Based on these descriptions of the zone, it is clear that the zone was not meant to characterize the RGR seismotectonic region. In addition, the largest earthquake within zone 124 that was known to the Law EST during their characterization of the zone was the 16 August 1931 Emb 5.8 Valentine earthquake in west Texas. This earthquake has a larger magnitude than the Alpine earthquake, but the lower-bound Mmax for the zone is less than this magnitude (mb 4.9) (FSAR Table 2.5.2-204). There is no explanation within the Law EST volume (EPRI, 1986-1989, vol. 7) as to why the lower-bound Mmax is less than the magnitude of this earthquake. Given the similarity in location and magnitude between the Valentine and Alpine earthquakes, it is reasonable to assume that the Alpine earthquake would not have served as motivation for the Law EST to update zone 124.

Rondout

The Alpine earthquake occurs within Rondout zone C02 (Grenville Crust). The Rondout EST states that this zone is defined by areas of the central and eastern US that were: (1) not within source zones that were characterized based on tectonic features, and (2) were of Grenville age (EPRI, 1986-1989, vol. 10, p. B-19 to B20). Based on the description of this source zone, it is clear that the zone was not intended to represent the RGR seismotectonic region.

Weston

The Alpine earthquake occurs within Weston zone 37 (Delaware basin) and zone 109 (Southwest [background zone for 37]). The Weston EST does not provide a basis for either zone 37 or 109. However, the Weston EST does provide a source zone meant to describe the RGR (zone 38) (EPRI, 1986-1989, vol. 5, p. 5-10). The eastern boundary of zone 38 is coincident with the western boundary of zone 37 and is approximately 6 km from the location of the Alpine earthquake. Based on Weston's inclusion of a zone intended to represent the RGR and the proximity of that zone to the Alpine earthquake, it is reasonable to conclude that zone 37 and 109 should not be updated to account for the Alpine earthquake.

RGR Sensitivity Study from FSAR

Recognizing that updating the existing EPRI-SOG source zones described above to account for the Alpine earthquake was not appropriate, an initial sensitivity analysis was conducted of the RGR to determine: (1) whether the RGR had the potential to contribute to the seismic hazard at CPNPP Units 3 and 4, and (2) whether a new characterization of the RGR needed to be developed (FSAR Subsections 2.5.2.4.2.3.3 and 2.5.2.4.4). Instead of developing both area and fault sources for the RGR to use in the sensitivity analysis, an initial analysis was conducted using well characterized fault sources and a simplified representation of the closest likely, uncharacterized RGR fault. The justification for such a simplified approach is that:

- The RGR is over 400 km from the site and well outside of the site region defined in RG 1.208 for regional investigations of potential seismic sources.
- If initial RGR sources indicated that there was any potential the RGR could contribute to the site hazard, a more robust characterization of the RGR would be developed.

The results of the sensitivity analysis showed that at the 10^{-4} ground motion for 1 Hz and 10 Hz, all of the RGR sources combined contributed approximately three orders of magnitude less hazard than that from the combined contributing EPRI-SOG source zones and the NMSZ. Therefore, it was concluded that no modifications to the EPRI-SOG model were required to account for the RGR or the Alpine earthquake.

Updated EPRI-SOG Source Characterizations

Despite the conclusion that the EPRI-SOG sources describe above should not be updated based on the Alpine earthquake, a sensitivity analysis has been performed to investigate the potential impact of the Alpine earthquake on the EPRI-SOG source zones. The updates to these source zones have been made following the original methodology of the EPRI-SOG study as closely as possible (EPRI, 1986-1989). This section describes these updates and a summary of the updates is presented in Table 2.

Alpine Earthquake

In the updated seismicity catalog developed for the CPNPP 3 and 4 COLA (FSAR Subsection 2.5.2.1.2 and Table 2.5.2-201), the Alpine earthquake has an Emb 5.8 magnitude based on a conversion from an Ms 5.7 magnitude reported in the USGS/NEIC PDE catalog (NEIC, 2010). However, the same catalog reports an mb 5.6 magnitude for the Alpine earthquake. The original methodology of the EPRI-SOG study was to use direct measurements of mb magnitudes instead of conversions from other magnitudes as the best estimate of the Emb magnitude (e.g., an mb magnitude would be used as the preferred Emb estimate over an Ms-to-Emb conversion). This methodology is outlined on page 3-6 of volume 1, part 1 of the EPRI-SOG documentation (EPRI, 1986-1989), page 4-8 of volume 1 part 2 of the EPRI-SOG documentation (EPRI, 1986-1989), and on page 3-2 of the EQHAZARD Primer (EPRI, 1989). Based on this methodology, the appropriate Emb magnitude for the Alpine earthquake would be Emb 5.6. For the updates to the EPRI-SOG model described below, a conservative Emb value of 5.7 was used for the Alpine earthquake (i.e., the mean value of the magnitude estimate in the FSAR and that presented here).

Dames & Moore

The Alpine earthquake occurs in Dames & Moore zone 26b, the default zone for the Delaware basin (zone 26) and the Delaware aulacogen (zone 27). These three zones are mutually exclusive interpretations of the seismicity in the region of the zones. The Pa values for zones 26, 26b, and 27 are 0.15, 0.72, and 0.13, respectively (EPRI, 1989). Because the Alpine earthquake only occurred in an area covered by zone 26b, and because the previous largest magnitude earthquake in the zone was an Emb 3.9, the Pa values of zones 26, 26b, and 27 need to be updated to 0.0, 1.0, and 0.0.

The original weighted Mmax distribution for zone 26b was mb 5.2 (0.8) and mb 7.2 (0.2). Because the lower-bound Mmax of this distribution is less than the magnitude of the Alpine earthquake (Emb 5.7), the Mmax distribution needs to be updated. The Dames & Moore methodology for defining Mmax used two "base" values: mb 7.2 and an estimate based on the observed seismicity rate within a zone (EPRI, 1986-1989, vol. 6, p. 6-4). For zone 26B the rate-based estimate is mb 5.2 (EPRI, 1986-1989, vol. 6, p. 6-9). Because this estimate is less than the magnitude of the Alpine earthquake, the Dames & Moore methodology cannot accurately describe the Mmax for the zone. Therefore, the observed magnitude of the Alpine earthquake was used as the lower bound Mmax for the zone and retain the existing weights. The updated Mmax distribution for the zone is thus: mb 5.7 (0.8) and mb 7.2 (0.2).

Law

The Alpine earthquake occurs within Law zone 124 (New Mexico – Texas Block). This zone is a background zone with a weighted Mmax distribution of mb 4.9 (0.3), mb 5.5 (0.5), and 5.8 (0.2) (EPRI, 1989). As previously described, the maximum observed earthquake in this zone, and the largest earthquake within the zone known to the Law EST, is the 1931 Valentine earthquake with magnitude Emb 5.8. Because this earthquake is larger than the Alpine earthquake (Emb 5.7), the 5.8 magnitude was used as the basis for updating the Mmax distribution of the zone despite the fact that the Law EST knew of the event during their original characterization of the source zone.

Law based their Mmax distribution on three different estimates of Mmax (EPRI, 1986-1989, vol. 7, p. 6-8 to 6-14):

- Mhist – the historical maximum observed earthquake in the zone;
- Mbmax – a judgment-based estimate chosen from one of six options; and
- Mb1000 – the magnitude associated with a 1000-year return period.

The Mhist value for the zone is mb 5.8 based on the Valentine earthquake. The Mb1000 value is mb 5.74 based on the seismicity within the zone. Mbmax was selected as mb 6.8 based on options 1b and 2 from the Law guidance on determining Mbmax (EPRI, 1986-1989, vol. 7, p. 6-9). The decision is based on the following:

- Option 1a does not seem appropriate because the majority of the zone is not a rift and does not end in oceanic or extensional crust;
- Option 1b describes rift structures that are surrounded by continental crust;
- Option 1b is conservative for zones with Mb1000 << 6.8; and
- Option 2 describes regions where earthquakes are associated with significant thicknesses of brittle crust where features are poorly defined.

According to the Law methodology, the Mmax weights are based on the relative magnitudes of the three estimates. For example, if Mbmax>Mb1000>Mbhist, the weights on these three estimates should be 0.3, 0.5, and 0.2 (EPRI, 1986-1989, vol. 7, p. 6-14). The methodology also states that if any estimates are within 0.1 magnitude units, the weights of these estimates should be combined and the higher magnitude should be used. In this case Mb1000 and Mbhist are within 0.1 magnitude units, so the updated Mmax distribution is: mb 5.8 (0.7) and mb 6.8 (0.3).

Rondout

The Alpine earthquake occurs within Rondout zone C02 (Grenville Crust). Zone C02 is a background zone with a Mmax distribution of mb 4.8 (0.2), mb 5.5 (0.6), and mb 5.8 (0.2) (EPRI, 1989). Because the lower-bound Mmax of this distribution is less than the magnitude of the Alpine earthquake (Emb 5.7), the Mmax distribution needs to be updated. The Rondout methodology defines Mmax by classifying zones into one of several classes based on the size of expected earthquakes (EPRI, 1986-1989, vol. 10, p. 5-4 to 5-6). The Rondout volume states that zones capable of moderate earthquakes have Mmax values between 5.8 and 6.8, so the updated Mmax distribution is given a range between 5.8 and 6.8 with weights taken from similar zones as reported in the EQHAZARD Primer (EPRI, 1989). The updated distribution is then mb 5.8 (0.15), mb 6.5 (0.6), and mb 6.8 (0.25).

Weston

The Alpine earthquake occurs within Weston zone 37 (Delaware basin) and zone 109 (Southwest; the background zone for 37). Because the Alpine earthquake is larger than the maximum observed earthquake in the zone from the EPRI-SOG study (Emb 4.6), and because that earthquake is less than mb 5.0, the Pa of zone 37 needs to be reevaluated. Also, the original Mmax distribution for zone 37 and 109 is 5.4 (0.33), 6.0 (0.49), and 6.6 (0.18). Because the lower-bound value of this distribution is less than the magnitude of the Alpine earthquake (Emb 5.7), the Mmax distribution for both zones 37 and 109 needs to be updated.

The Pa values for Weston source zones were developed by evaluating the probability of activity of tectonic features using what the Weston EST referred to as a matrix of physical characteristics. The details of the methodology are presented within the Weston EST volume (EPRI, 1986-1989, vol. 5, section 4), but a brief outline of the methodology is presented below.

The basis for the Pa value for a given zone is weights given to the applicability of three characteristics for each source zone, where the sum of the weights for each characteristic is 1.0. The characteristics are:

- The zone's association with seismicity. This characteristic was evaluated for moderate to large earthquakes (mb ≥ 5.0), small earthquake only (mb < 5.0), and no seismicity.
- How favorably oriented tectonic features are within the zone relative to the dominant stress direction. This characteristic was described as either favorable or not favorable.
- Whether the zone is associated with tectonic features that have a deep crustal expression. This characteristic was described as: (1) having a deep expression and a barrier to extension of the feature, (2) having a deep expression without a barrier, and (3) only having a shallow expression.

The weights of these characteristics are then applied to the matrix of physical characteristics to develop a Pa value.

The Weston EST evaluated the characteristics of zone 37 as follows (weights are in parentheses) (EPRI, 1986-1989, vol. 9, p. 4-55 to 4-56):

- Association with seismicity – moderate to large (0.7), small (0.3), none (0.0);
- Geometry – favorable (0.7), unfavorable (0.3); and
- Deep crustal association – deep with barrier (0.5), deep without barrier (0.5), shallow (0.0).

Applying these evaluations to the matrix of physical characteristics gives a Pa of 0.81, the Pa value for zone 37 from the EPRI-SOG study (EPRI, 1989).

The occurrence of the Alpine earthquake requires updating the Pa evaluation for zone 37 because the largest observed earthquake in the zone prior to the Alpine earthquake was less than 5.0. Therefore, the weight that the zone is associated with moderate-to-large seismicity needs to be increased from the original value of 0.7. The Weston EST methodology does not provide enough information to determine how the occurrence of the Alpine earthquake would impact that ESTs evaluation of association with seismicity, so a conservative change is made to the weights by increasing the association with moderate to large earthquakes to 1.0 and by decreasing the association with small earthquakes to 0. Applying these changes results in a conservative updated Pa for zone 37 of 0.865.

The Weston EST methodology for the original Mmax distribution of zone 37 was based on developing a cumulative probability of activity distribution for earthquakes, dependent on their mb magnitude, from Pa evaluations made at several magnitudes using matrices of physical characteristics (EPRI, 1986-1989, vol. 5, section 4). From this cumulative distribution, a discrete probability density function (PDF) describing the probability that a given Mmax value is appropriate for the source zone was determined. The final Mmax distribution was then calculated by truncating the PDF at the lowest magnitude of the discrete PDF that was greater than or equal to the largest observed earthquake within the zone and renormalizing the PDF.

The occurrence of the Alpine earthquake potentially impacts this methodology of determining Mmax in two ways. First, the occurrence of the Alpine earthquake may change some of the Pa evaluations that were used in developing the cumulative probability of activity distribution. However, for this sensitivity analysis these evaluations were not updated because: (a) the Weston EST volume does not present enough information to evaluate how the Alpine earthquake would change the cumulative probability of activity distribution, and (b) if updating the cumulative probability of activity distribution could be done following the Weston methodology, it is estimated the change in the mean Mmax for both zones 37 and 109 would be less than mb 0.1. The second impact of the Alpine earthquake is that it changes the magnitude at which the PDF for both zones 37 and 109 should be truncated. The Mmax distributions were updated to account for this impact. The updated Mmax distributions are: zone 37 – mb 6.0 (0.68), mb 6.6 (0.29), mb 7.2 (0.03); and zone 109 – mb 6.0 (0.76), mb 6.6 (0.21), mb 7.2 (0.03).

<u>Sensitivity Study for Impact of Potential Changes to Site GMRS</u>

A sensitivity analyses was conducted to investigate the impact of these potential changes to the EPRI-SOG source characterizations on the seismic hazard at the CPNPP Units 3 and 4 site and the updated source characterizations are presented in Table 2. The updated characterizations were used with the other contributing source zones identified in FSAR Tables 2.5.2-202 through 2.5.2-207 to calculate the rock ground motions following the same procedure as described in Subsection 2.5.2.4.4. The rock ground motion was scaled by the corresponding amplification factors for the GMRS (FSAR Subsection 2.5.2.5), and the horizontal GMRS was calculated following the procedure outlined in Subsection 2.5.2.6.1.1. Revised amplification factors were not calculated for this sensitivity analysis because the changes in ground motions are small and the materials at the site are assumed to behave linearly (strain independent).

The results of these calculations are shown in Table 3 as the percent increase in GMRS over that presented in the FSAR. As can be seen in the percent increases in GMRS values, the potential impact of the updated EPRI-SOG characterizations in light of the Alpine earthquake are small, especially considering:

- The fact that many of the potential Pa and Mmax changes are made using conservative assumptions.
- The conclusion that the parameters of the EPRI-SOG sources should not be updated in response to the Alpine earthquake because it is related to the RGR.

As an alternative to updating the EPRI-SOG source zones, it is also not necessary to develop a new characterization of the RGR for the CPNPP Units 3 and 4 site because:

- The RGR, if the eastern extent were defined by the Alpine earthquake, is over 300 miles from the site.
- Initial sensitivity analyses of the RGR faults indicate that it is unlikely any RGR source would contribute to the seismic hazard at the site.

Impact of Updates on Contributing Sources

As described in the response to Question 02.05.02-22, an updated screening assessment was conducted as part of the response to Question 02.05.02-16 to determine the sources that contributed to seismic hazard at the site. Of the seven EPRI-SOG sources with potential updates for the Alpine earthquake (Table 2), three were not included in the screening because they are approximately 400 km or greater from the site (Dames & Moore zones 26, 26b, 27), three were originally screened as contributing sources (Law 124, Weston 109, and Rondout C02) (FSAR Tables 2.5.2-204, 2.5.2-205, and 2.5.2-206), and one was screened as not contributing (Weston 37) (FSAR Table 2.5.2-206). With the updates for the Alpine earthquake, none of these four zones that were not included in the FSAR hazard calculations contributes enough seismic hazard at the CPNPP site to be considered a contributing source.

COMBINED IMPACT OF SENSITIVITY STUDIES ON GMRS

Three sensitivity analyses were conducted for three separate issues as part of the responses to the questions contained in this RAI. These issue were referred to in the responses as the New Madrid Seismic Zone (NMSZ) issue (Question 02.05.02-26), the New Mexico earthquake issue (RAI 02.05.02-23), and the Alpine earthquake issue (this question). In each of these responses, it was demonstrated that the potential changes to the source model used in the FSAR result in small changes in the site GMRS, especially when considered in light of the fact that many of the potential changes are conservative. A summary of the results and some of the sources of conservatism for each issue are presented below:

- NMSZ Issue: A range of exposure times from 40 to 60 years and start times from the planned start date to a 10-year delay were considered for the renewal model of the NMSZ. Based on these ranges, the scenario with the lowest increase in NMSZ rate (2.85 percent) results in potential increases in GMRS of 0.5 percent at PGA to 2.6 percent at 0.5 Hz, and the scenario with the highest increase in NMSZ rate (8.7 percent) results in potential increases in GMRS of 1.4 percent at PGA to 8 percent at 0.5 Hz. The higher values are conservative because a 10-year delay in the start of commercial operation it is not expected.
- New Mexico Earthquake Issue: Potential changes in the Pa values for five EPRI-SOG source zones were considered to address the occurrence of the New Mexico earthquake, including two alternate interpretations (ALT 1 and ALT 2) of how the earthquake could be addressed for the Woodward Clyde EST. The impact of these potential changes on the GMRS for the ALT 1 scenario varies between a 0.0 percent and 0.5 percent increase with the largest increase at 25 Hz. For the ALT 2 scenario the percentage increase varies between 0.2 percent and 0.7 percent with the largest increase at 25 Hz. Based on the likelihood that the occurrence of the New Mexico earthquake would not have served as the basis for the Woodward Clyde EST to reject one of their two interpretations of the Oklahoma aulacogen, it was determined that the ALT 1 scenario is the best interpretation of the potential impact of the earthquake on the GMRS. However, even this estimate is conservative because of the conservative assumptions used updating the Pa values for the zones.
- Alpine Earthquake Issue: Potential changes in the Pa and/or Mmax values for seven EPRI-SOG source zones were considered to address the occurrence of the Alpine earthquake. The impact of these potential changes on the GMRS varies between a 0.4 percent to 1.9 percent increase with the largest increase at 25 Hz. The impacts of these potential changes

are conservative for the CPNPP site because: (1) the Alpine earthquake is most likely related to the RGR and not the seismotectonic setting of central Texas, and thus the EPRI-SOG zones not meant to characterize the RGR should not be updated, and (2) many of the potential Pa and Mmax changes are made using conservative assumptions.

Acknowledging the conservatism of the three sets of potential changes on the GMRS, it is useful to look at the combined impact of the potential changes. Table 4 presents the combined impact of the three sets of potential changes as percent increase in GMRS over that presented within the FSAR. Column 3 of the table shows the lower bound of the potential increase accounting for:

- The NMSZ scenario that resulted in the smallest increase in NMSZ rate (40-year exposure period, planned start time; i.e. 2.85 percent increase in rate).
- The ALT 1 scenario for the New Mexico earthquake issue (the Woodward Clyde EST retained two interpretations of the Oklahoma aulacogen).
- The potential changes from the Alpine earthquake listed in Table 2. The percentage increases for this scenario range between 2.0 percent and 3.5 percent with the largest impact at 1 Hz.

Column 4 of the table shows the upper bound of the potential increase accounting for:

- The NMSZ scenario that resulted in the largest increase in NMSZ rate (60-year exposure period, 10 year delay in start time; i.e. 8.7 percent increase in rate)
- The ALT 2 scenario for the New Mexico earthquake issue (the Woodward Clyde EST has only one interpretation of the Oklahoma aulacogen)
- The potential changes from the Alpine earthquake listed in Table 2. The percentage increases for this scenario range between 3.1 percent and 8.8 percent with the largest impact at 0.5 Hz.

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<u>Attachments</u>

Table 1: Summary of expert interviews for Alpine earthquake. Comments are in *italics*.

Table 2: Summary of EPRI-SOG changes from Alpine earthquake.

Table 3: Potential impact of updating EPRI-SOG sources for the Alpine earthquake on the site GMRS.

Table 4: Combined potential increase in GMRS from NMSZ issue, Alpine earthquake issue, and New Mexico earthquake issue.

Figure 1: Location of Alpine earthquake (Sources in Legend).

Figure 2: Proterozoic structure from Page et al. (2008)

Figure 3: Phanerozoic tectonic events from Page et al. (2008)

Figure 4: Map of Marathon orogenic belt from Page et al. (2008).

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Figure 7: Extent of Laramide fold and thrust belt from Page et al. (2008).

Figure 8: Laramide faults and folds in the Alpine-Marathon region from Muehlberger (1980).

Figure 9: Mid-Cretaceous to Eocene tectonic features of Texas from Ewing (1991b).

Figure 10a: Tectonic map of Texas in the Alpine-Marathon region (Ewing, 1990).

Figure 10b: Explanation for the Tectonic map of Texas (Ewing, 1990).

Figure 11: Cenozoic tectonic features of Texas from Ewing (1991b). Note igneous bodies and faults of the Trans-Pecos volcanic field.

Figure 12: Extent of the Trans-Pecos volcanic field from Henry et al. (1991).

Figure 13: Temporal evolution of Trans-Pecos volcanism from Henry et al. (1991).

Figure 14a: Geologic map of the Alpine earthquake region from Henry and Price (1985).

Figure 14b: Explanation for the geologic map of the Alpine earthquake region from Henry and Price (1985).

Figure 15: Cenozoic faults in the Alpine-Marathon region from Muehlberger (1980).

Figure 16: Focal mechanisms of west Texas earthquakes from Frohlich and Davis (2002).

Figure 17: EPRI-SOG source zones containing the Alpine earthquake (Sources in Legend).

Impact on R-COLA

None.

Impact on DCD

None.

Table 1: Summary of expert interviews for Alpine earthquake. Comments are in *italics*.

Expert	Background	Familiar with Alpine EQ?	Conducted Studies Related to Alpine EQ?	Other W. Texas EQs or tectonic features?
M. Machette	Retired USGS geologist specializing in Quaternary fault studies and the RGR	Yes, somewhat	No	Quaternary faults in west Texas and RGR region
C. Frohlich	Seismologist at Univ. Texas specializing in Texas earthquakes	Yes	No	1931 Valentine EQ in west Texas
D. Doser	Seismologist at Univ. Texas El Paso specializing in Texas earthquakes	Yes	Yes	Yes, Valentine EQ, Permian Basin seismicity
C. Henry	Volcanologist previously at Texas Bureau of Economic Geology specializing in volcanism in Texas	Generally	No	Compilations of Basin and Range faulting in west Texas *[Basin and Range and RGR extension are often considered to be equivalent at these latitudes]*
I. Wong	Seismic hazard consultant at URS with extensive experience in characterizing seismic hazard of RGR	Yes	Examined focal mechanisms and information on stress regines	*[no reply]*
S. Olig	Seismic hazard consultant at URS with extensive experience in characterizing seismic hazard of RGR	No	No	No
J. Pulliam	Geophysicist at Baylor Univ. with experience in RGR lithospheric structure and tectonics	Yes	Currently conducting regional scale investigation north of Alpine TX	*[no reply]*
S. Harmsen	Geophysicist at the USGS with experience in central US seismicity	No	No – have reviewed other people's work	No
E. Collins	Geologist at Texas Bureau of Economic Geology specializing in earthquake and geologic hazard evaluations for Texas	Vaguely	No	Paleoseismic compilations in the region
R. Wheeler	Seismologist at the USGS responsible for earthquake hazard evaluations throughout the central and eastern US	No	No	Brief review of local maps

Table 1 (cont.): Summary of expert interviews for Alpine earthquake. Comments are in *italics*.

Expert	Unpublished or pending investigations of Alpine EQ?	RGR extension defensible characterization of Alpine EQ?	Alternative characterization?	Eastern extent of extension tectonics in TX?
M. Machette	No	Yes	No	Eastern side of Sierra Vieja *[approx. 100 km west of Alpine EQ epicenter]*
C. Frohlich	No	Yes	No	Don't know
D. Doser	Has unpublished relocations of aftershocks	Yes	No	Pecos river area *[approx. 150 km east of Alpine EQ epicenter]*
C. Henry	No	Yes	No	East of the eastern boundary of the map of Henry and Price (1985) *[approximately 50 km east of the Alpine EQ]*
I. Wong	No	Toss up between RGR related or southern great plains	*[no reply]*	Boundary proposed by Zoback and Zoback (1980a), but there is large uncertainty in that boundary *[boundary is approximately 50 km west of Alpine EQ]*
S. Olig	No	Yes	Yes	*[no reply]*
J. Pulliam	No	Yes	No	Between 102° and 103° W *[epicenter is at 103.35, i.e. within the region of RGR extension defined by Pulliam]*
S. Harmsen	D. Doser might have some	Partially	Yes because there is no clear boundary between RGR and Texas craton	Near Alpine TX, but it is a fuzzy boundary
E. Collins	No	*[no reply]*	*[no reply]*	*[no reply]*
R. Wheeler	*[no reply]*	Yes	Maybe cratonic EQ, but weight would be much less than 50% for this interpretation	Near the Alpine EQ

Table 1 (cont.): Summary of expert interviews for Alpine earthquake. Comments are in *italics*.

Expert	Alpine EQ related in central TX tectonics?	Appropriate tectonic characterization of Alpine EQ?	Based on what data/factors?	Uncertainties or gaps in data that might influence characterization?
M. Machette	No	RGR	Location	Focal mechanism
C. Frohlich	Unrelated, but also some small normal faulting EQs in Central Texas	Mid-plate normal faulting EQ	*[no reply]*	*[no reply]*
D. Doser	Focal mechanism is consistent with extensional tectonics, not the reverse mechanisms observed further to the northeast	RGR	Focal mechanism, geophysical expression of crust (e.g., thinned crust occurs east of earthquake), aftershock behavior distinguished as different than events in the Permian basin	Better instrumental recordings of earthquake
C. Henry	Unlikely	RGR	Extent of faulting and extension-related volcanism; the tectonic province of the region *[extensional]*	*[no reply]*
I. Wong	Doubt it	Normal faulting on NW-trending planes	Focal mechanism and in situ stress data	Yes, uncertainty in focal mechanism and boundaries of stress provinces
S. Olig	Don't know	*[No reply]*	*[No reply]*	*[No reply]*
J. Pulliam	No	Normal faulting related to Basin and Range extension *[Basin and Range and RGR extension are often considered to be equivalent at these latitudes]*	Focal mechanism, general knowledge of tectonic environment, and crustal and lithospheric thickness estimates	Yes. No identified fault, reliance on regional data
S. Harmsen	Yes	50% RGR related, 50% craton related	Distance between mapped Quaternary faults and the lack of data showing change in stress orientation near epicenter	Yes. Focal mechanism alone is weak evidence that RGR related; no clear western boundary of craton.
E. Collins	*[no reply]*	*[no reply]*	*[no reply]*	*[no reply]*
R. Wheeler	Not likely	RGR	Presence of volcanic rocks associated with rifting, extensive Cenozoic normal faulting to the east and some to the west	*[no reply]*

Table 2: Summary of EPRI-SOG changes from Alpine earthquake.

Source Zone	Mmax (mb)	Weight	Pa
Rondout Grenville Crust Background (C02)	5.8	0.15	No change
	6.5	0.60	
	6.8	0.25	
Weston Delaware Basin (37)	6.0	0.68	0.865
	6.6	0.29	
	7.2	0.03	
Weston Southwest (109)	6.0	0.76	NA
	6.6	0.21	
	7.2	0.03	
Law New Mexico – Texas Block (124)	5.8	0.7	No change
	6.8	0.3	
Dames & Moore Default for Delaware Basin and Delaware Aulacogen (26B)	5.7	0.8	1.0
	7.2	0.2	
Dames & Moore Delaware Basin (26)	No change		0.0
Dames & Moore Delaware Aulacogen (27)	No change		0.0

Table 3: Potential impact of updating EPRI-SOG sources for the Alpine earthquake on the site GMRS.

Freq. (Hz)	GMRS from FSAR	Percent increase
100/PGA	0.0372	1.3%
25	0.0418	1.9%
10	0.0509	1.2%
5	0.0545	1.2%
2.5	0.0729	0.8%
1	0.0450	0.6%
0.5	0.0355	0.4%

Table 4: Combined potential increase in GMRS from NMSZ issue, Alpine earthquake issue, and New Mexico earthquake issue.

Freq. (Hz)	**GMRS from FSAR**	**Percent increase in GMRS for:**	
		2.85% increase in NMSZ rate and ALT 1 New Mexico Scenario	**8.7% increase in NMSZ rate and ALT 2 New Mexico Scenario**
100/PGA	0.0372	2.3%	3.2%
25	0.0418	3.3%	4.7%
10	0.0509	2.0%	3.1%
5	0.0545	2.6%	4.6%
2.5	0.0729	2.3%	5.1%
1	0.0450	3.5%	8.7%
0.5	0.0355	3.4%	8.8%

Figure 1: Location of Alpine earthquake (Sources in Legend).

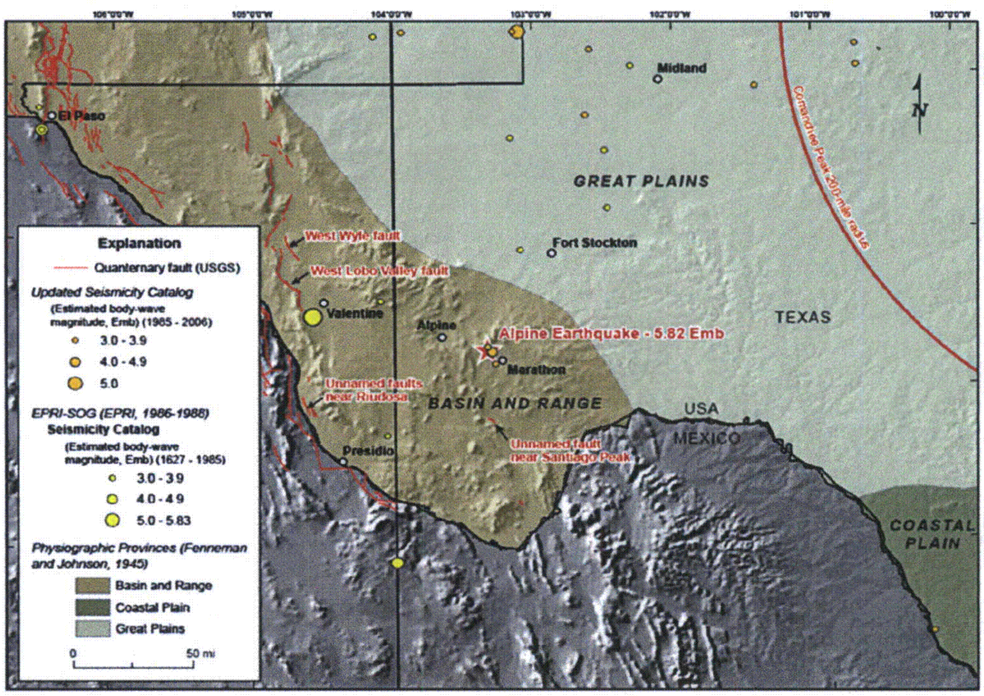


Figure 2: Proterozoic structure from Page et al. (2008)

Index map showing transform faults and lineaments related to Proterozoic rifting along the southern edge of North America. Solid black lines are Neoproterozoic continental transform faults (Poole and others, 2005; Thomas, 1991); arrows show relative motion of continental plate offset; gray double-banded line is main rift zone between North and South American plates; solid red lines are Texas lineament (Albritton and Smith, 1957; Muehlberger, 1980); and dark green area is BBNP.

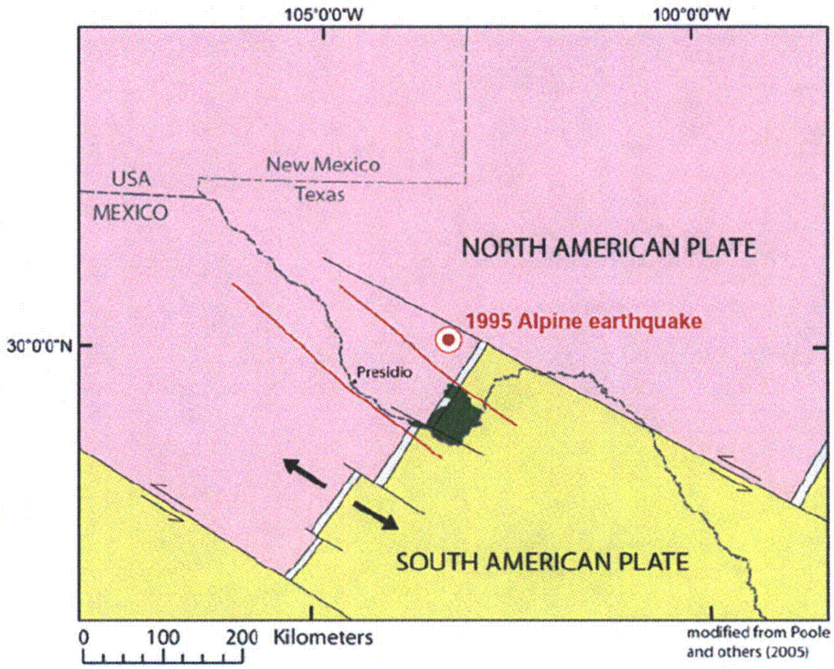


Figure 3: Phanerozoic tectonic events from Page et al. (2008)

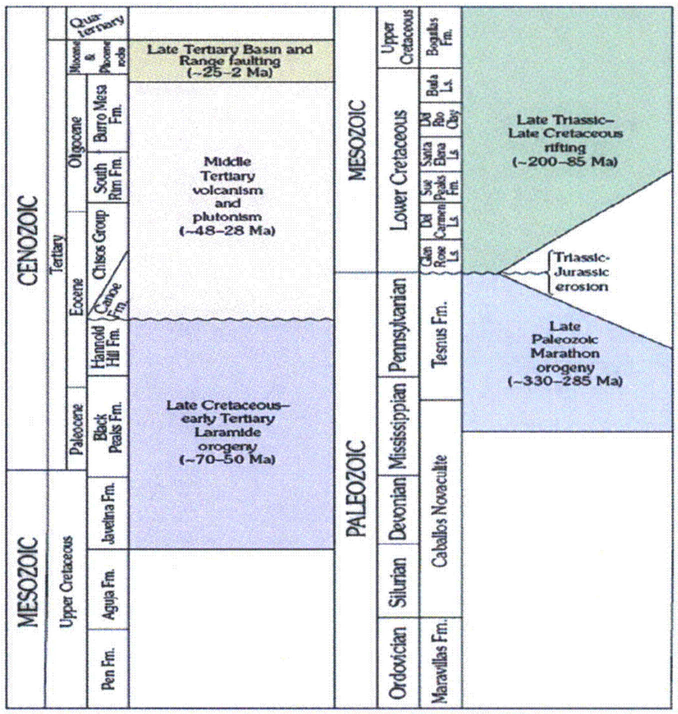


Figure 4: Map of Marathon orogenic belt from Page et al. (2008).

Map showing location of Marathon orogenic belt and subduction zone (inset figure) formed from collision between the North and South American plates. Dotted black lines are traces of transform faults shown in figure 1–2; short solid red line represents approximate line of section for inset figure; dark green area is BBNP; PG, Persimmon Gap.

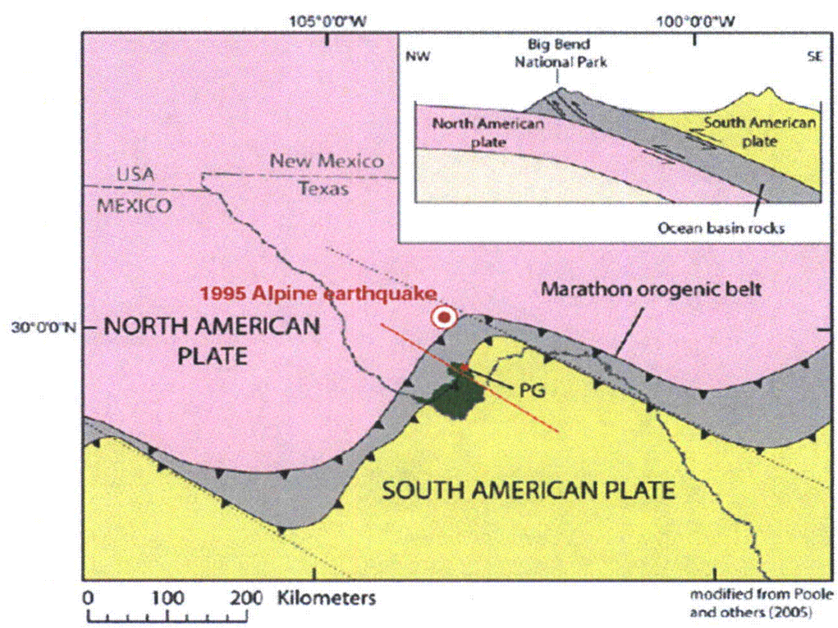
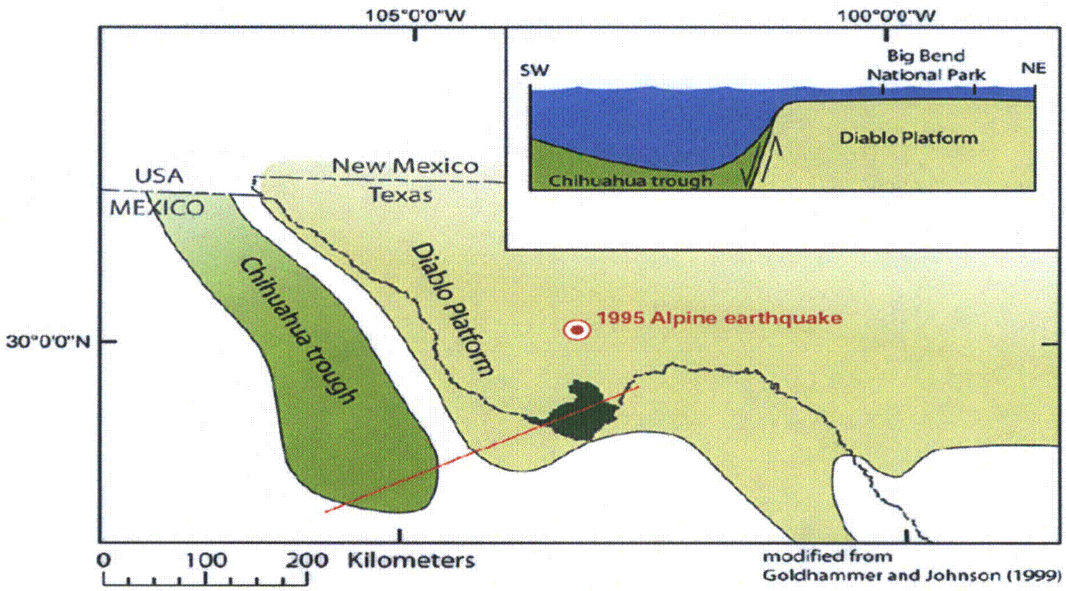
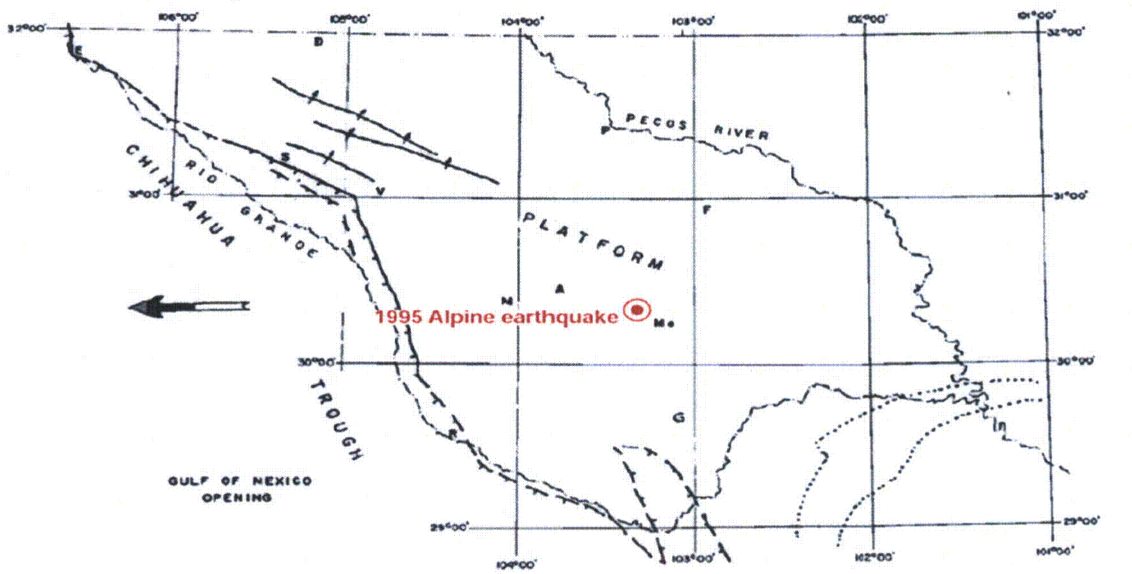


Figure 5: Map of Chihuahua Trough and Diablo Platform from Page et al. (2008).



Map showing location of the Diablo Platform and the Chihuahua trough, features that formed in the Big Bend area during Late Triassic through Late Cretaceous rifting between North and South America. Solid red line is approximate line of section for inset figure

Figure 6: Map of Chihuahua Trough and Diablo Platform from Muehlberger (1980).



Known mid-Mesozoic (Gulf of Mexico opening) faults. The principal feature is the prominent fault separating the subsiding Chihuahua Trough from the platform; reentrant into the south tip of the Big Bend is based on shapes of structures (tight asymmetrical folds) compared to those on either side. Monoclinal downwarps north of Sierra Blanca–Van Horn from King (1965). The dotted lines in the southeast corner of the map mark the boundaries of the mid-Cretaceous (Washita and Fredericksburg) reef. The landward kink lies along the northern border of the Texas Lineament as used in this paper. Symbols: as in Figures 1 and 2. Small arrows point toward down side of monocline. Large arrow shows approximate sense of motion of Mexico relative to Texas.

Figure 7: Extent of Laramide fold and thrust belt from Page et al. (2008).

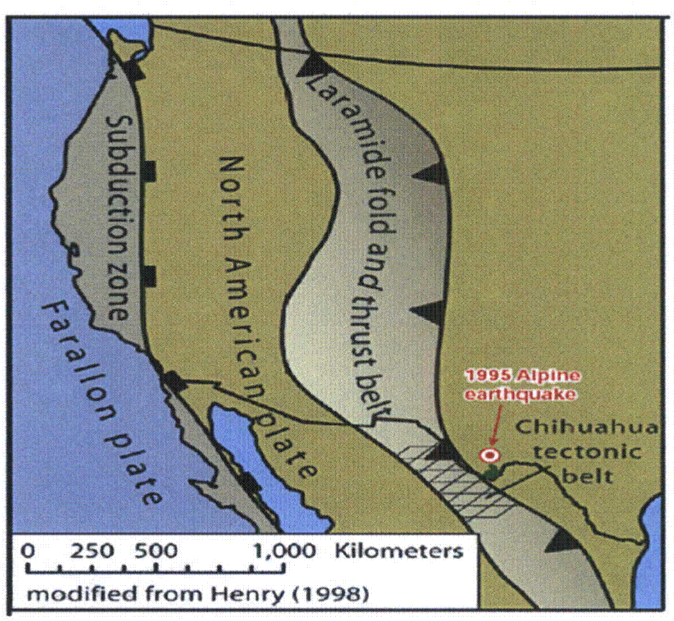
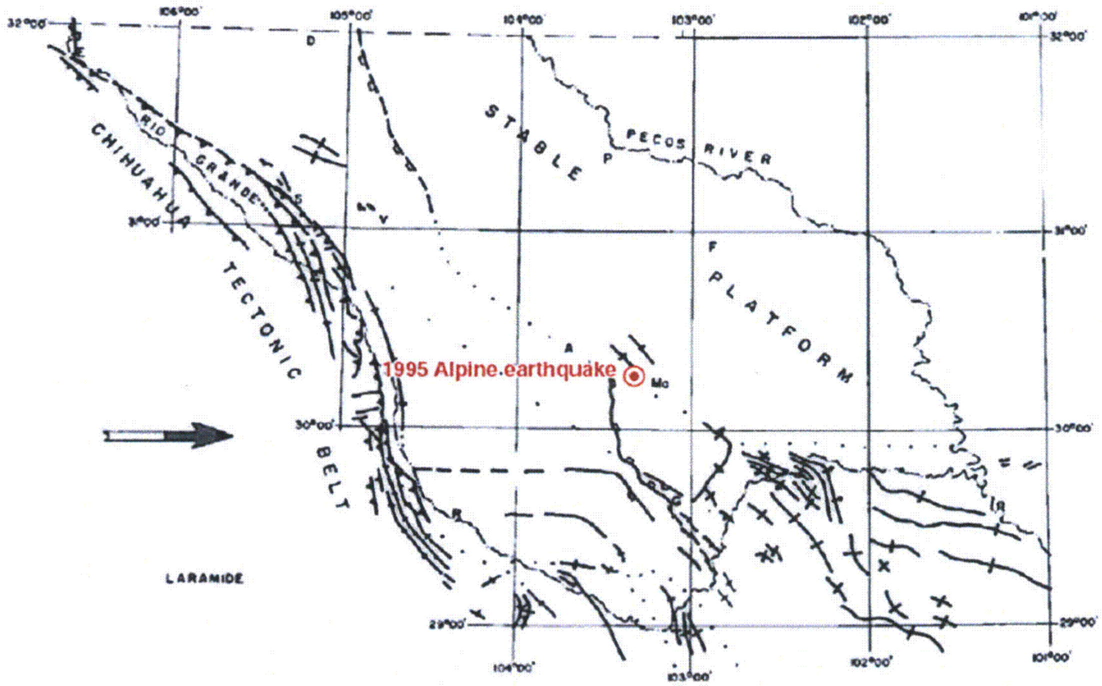
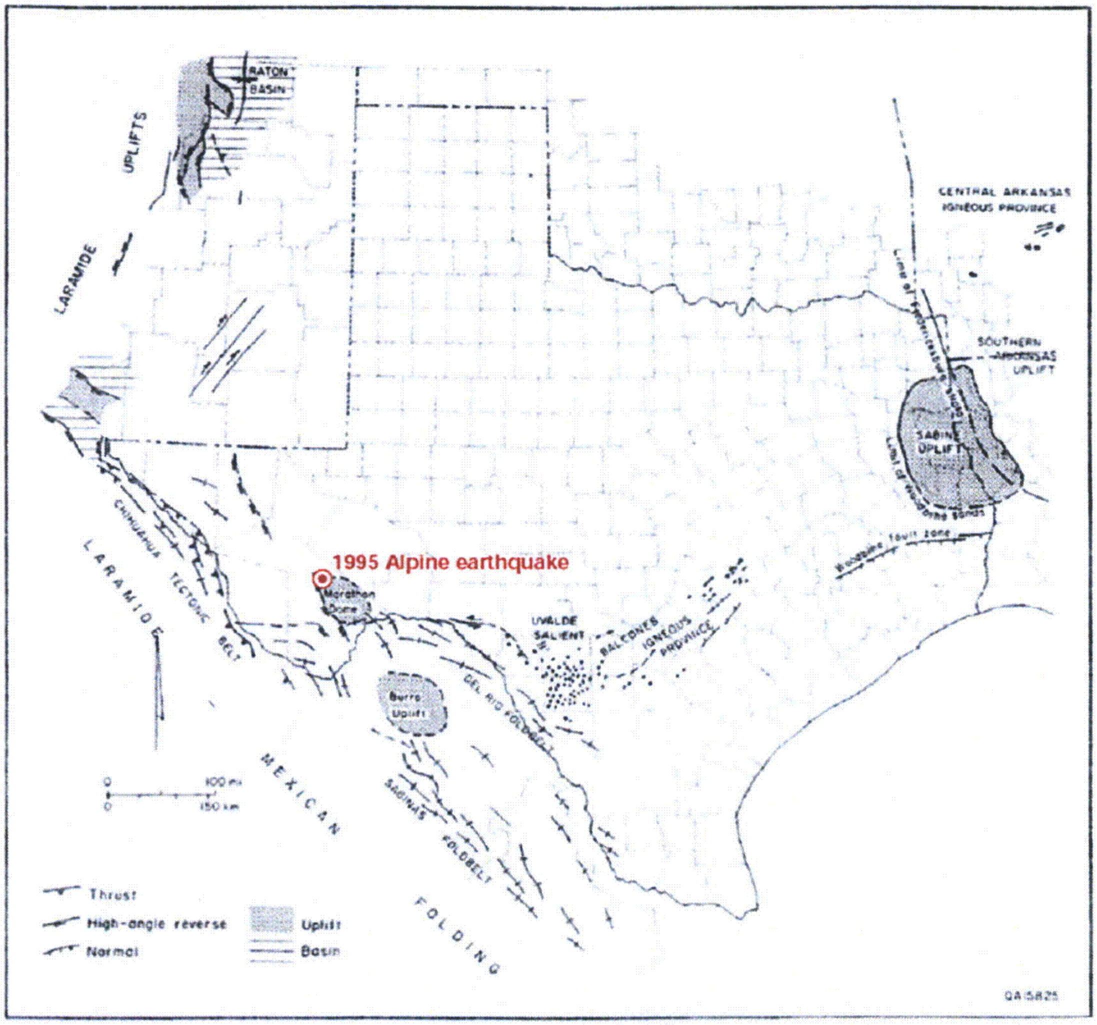


Figure 8: Laramide faults and folds in the Alpine-Marathon region from Muehlberger (1980).



Known Laramide faults and folds. Symbols: as in Figures 1 and 2, plus: short bar across fine line=anticline (open folds in Texas, mainly monoclines in Mexico); open rectangles=upthrown side of faulted monoclines. Large arrow shows approximate sense of motion of overthrust sheets and of Mexico relative to Texas.

Figure 9: Mid-Cretaceous to Eocene tectonic features of Texas from Ewing (1991b).



Map of mid-Cretaceous to Eocene tectonic elements of Texas: uplifts, volcanic centers, and faults of Late Cretaceous age in the Gulf Coast Basin; folds and faults of Laramide age (latest Cretaceous, Paleocene, and early Eocene) in West Texas and Mexico.

Figure 10a: Tectonic map of Texas in the Alpine-Marathon region (Ewing, 1990).

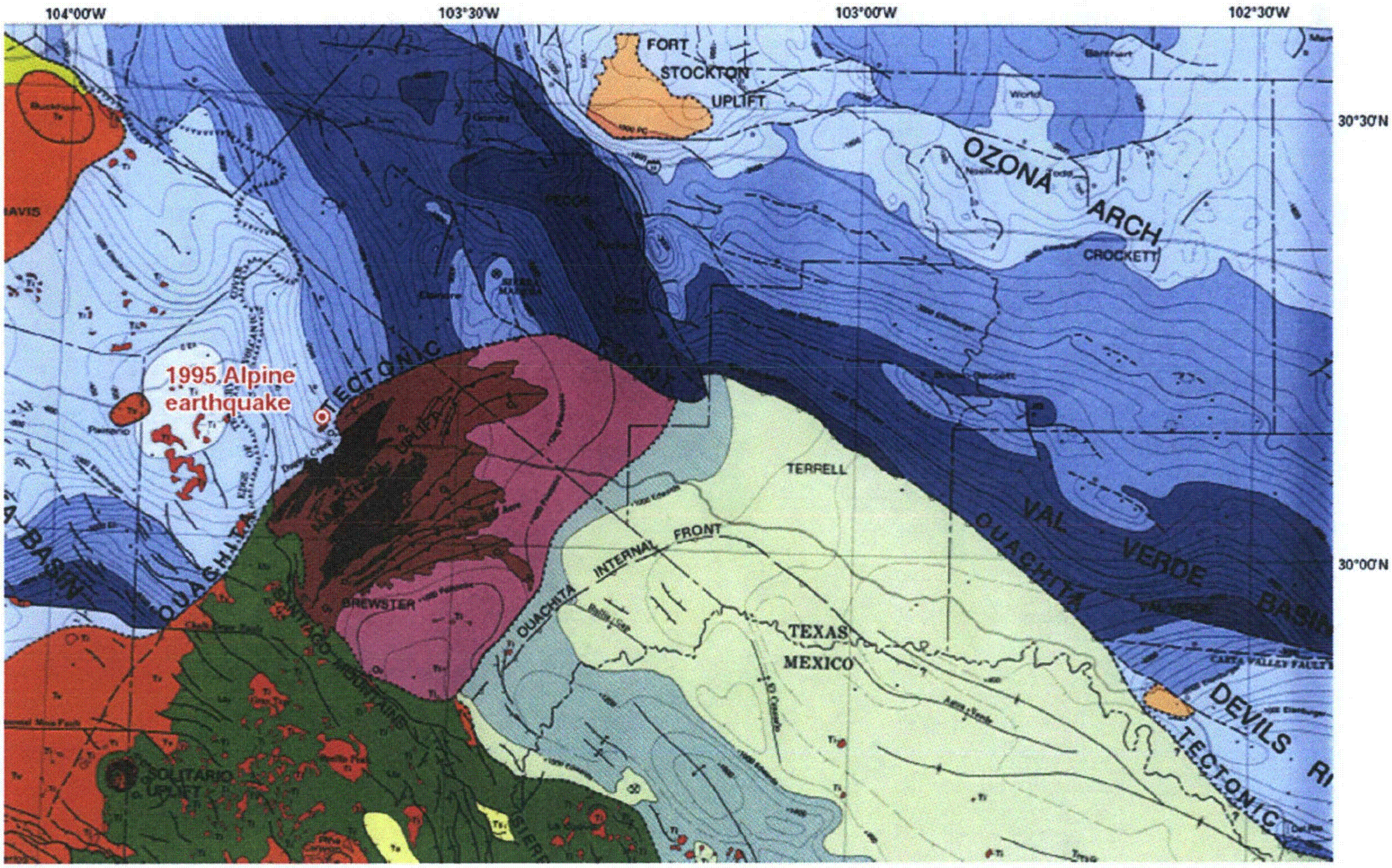
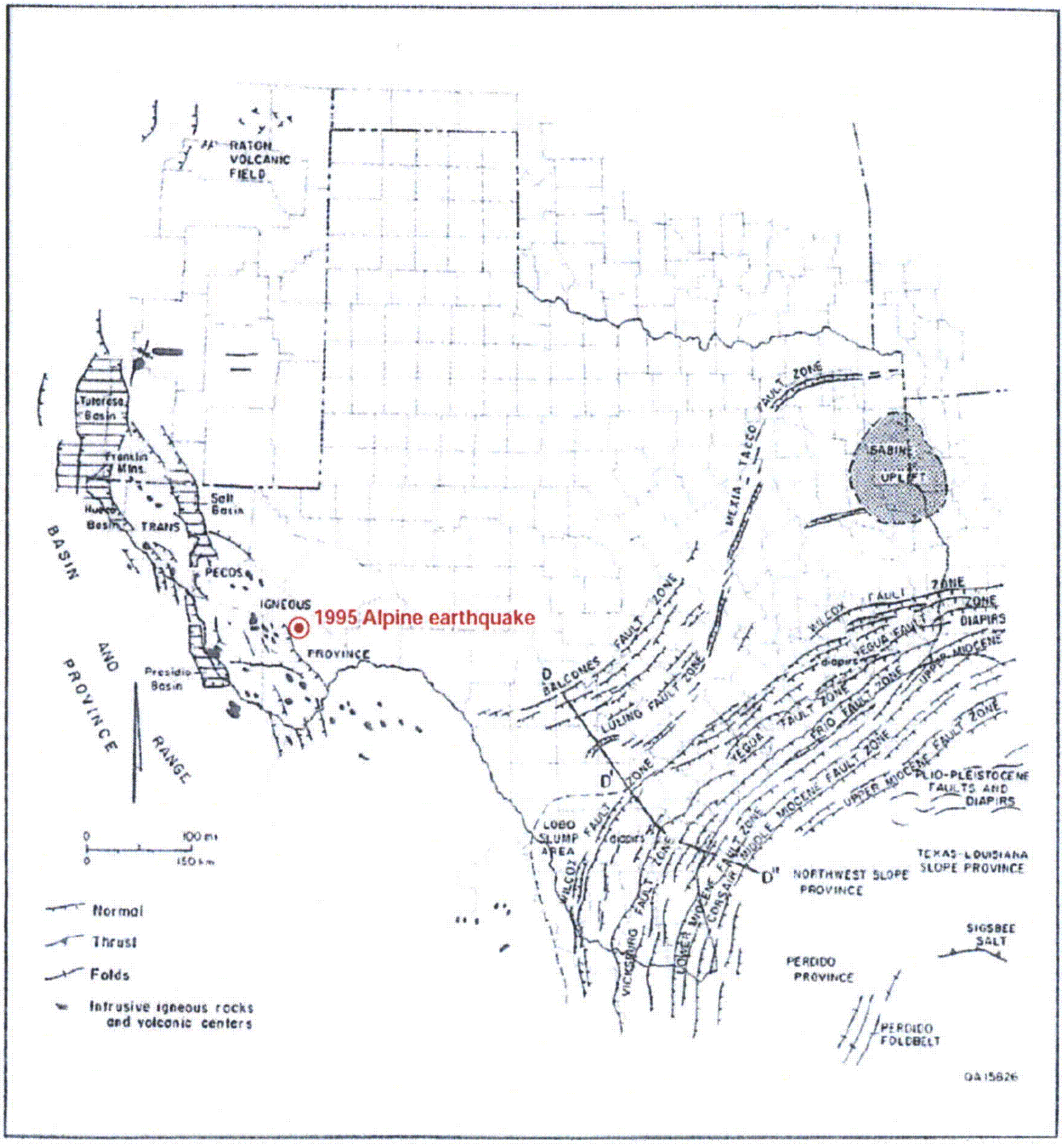


Figure 10b: Explanation for the Tectonic map of Texas (Ewing, 1990).

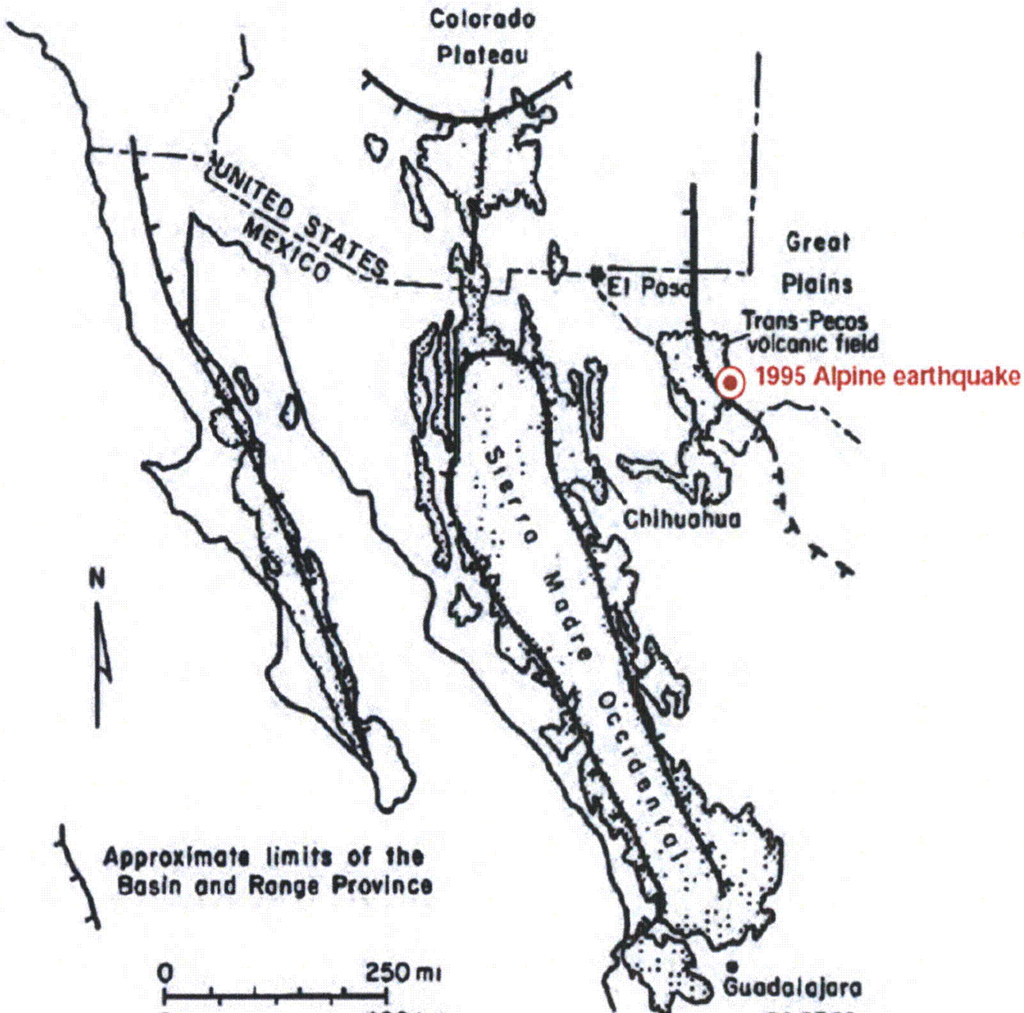
TECTONIC PERIOD		EXPOSED UNITS: SEDIMENTARY		EXPOSED UNITS: IGNEOUS		
TERTIARY (and Quaternary)		Bolson fill	Ts		Late basalts	Tb*
				TRANS-PECOS PROVINCE	Trans-Pecos volcanic rocks (mafic to felsic, slightly to highly alkalic)	Tv
				TRANS-PECOS PROVINCE	Intrusive rocks (mostly felsic or alkalic)	Ti
LARAMIDE		Deformed Cretaceous strata	Ls_2			
		Deformed Jurassic strata (including evaporites)	Ls_1			
GULF COAST	POSTRIFT	Cretaceous strata (where subsurface is not contoured)	K	BALCONES PROVINCE	Ultramafic and mafic volcanic rocks	G_2v*
				BALCONES PROVINCE	Ultramafic to felsic intrusives	G_2i
	SYNRIFT	Red beds (Eagle Mills) (identified in wells only)	G_1s		Basalt and diabase (in wells only)	G_1i
OUACHITA and ARBUCKLE		Upper Paleozoic foreland strata (where subsurface is not contoured)	P		Volcanic rocks (Hatton tuff in Ouachita Mountains, unnamed rhyolite in Sabine Island, volcaniclastics in South Texas)	Ov
		Upper Paleozoic flysch	O_2			
		Lower Paleozoic strata ("starved basin")			Metamorphic rocks (Sierra del Carmen)	
SOUTHERN OKLAHOMA		Cambrian-Ordovician strata (Carbonate platform) (O-P: Ordovician-Pennsylvanian, Hueco Mtns.)	CO		Post-Cambrian igneous rock (one well only)	Sv
		Cambrian(?) strata (Meers Quartzite)	Ss	WICHITA PROVINCE	Cambrian felsic rocks (Wichita granite, Carlton rhyolite)	Sf
				WICHITA PROVINCE	Cambrian mafic rocks (Raggedy Mountain gabbro group)	Sm
VAN HORN		Young sedimentary strata younger than Vr (Van Horn sandstone)	Vs		Late rhyolite and granite (Franklin Mtns.)	Vr
LLANO		Metasedimentary and metavolcanic rocks (Packsaddle, Carrizo Mtn.)	Ll_2		Later granites (Town Mountain)	Lli_2
		Gneisses (Valley Spring)	Ll_1		Earlier granites	
					Ultramafic rocks (Coal Creek)	
SWISHER-DE BACA		? ? ? Sedimentary rocks (Hazel, Allamoore-Van Horn area; Castner, Mundy, Lanoria and Franklin Mtns.)	Ds		(Mafic igneous rocks in Allamoore Fm and Mundy Breccia—not mapped separately)	
SIERRA GRANDE					Granite (Tishomingo)	SG
CHAVES					Gneiss, Granite (Blue River, Troy)	

Figure 11: Cenozoic tectonic features of Texas from Ewing (1991b). Note igneous bodies and faults of the Trans-Pecos volcanic field.



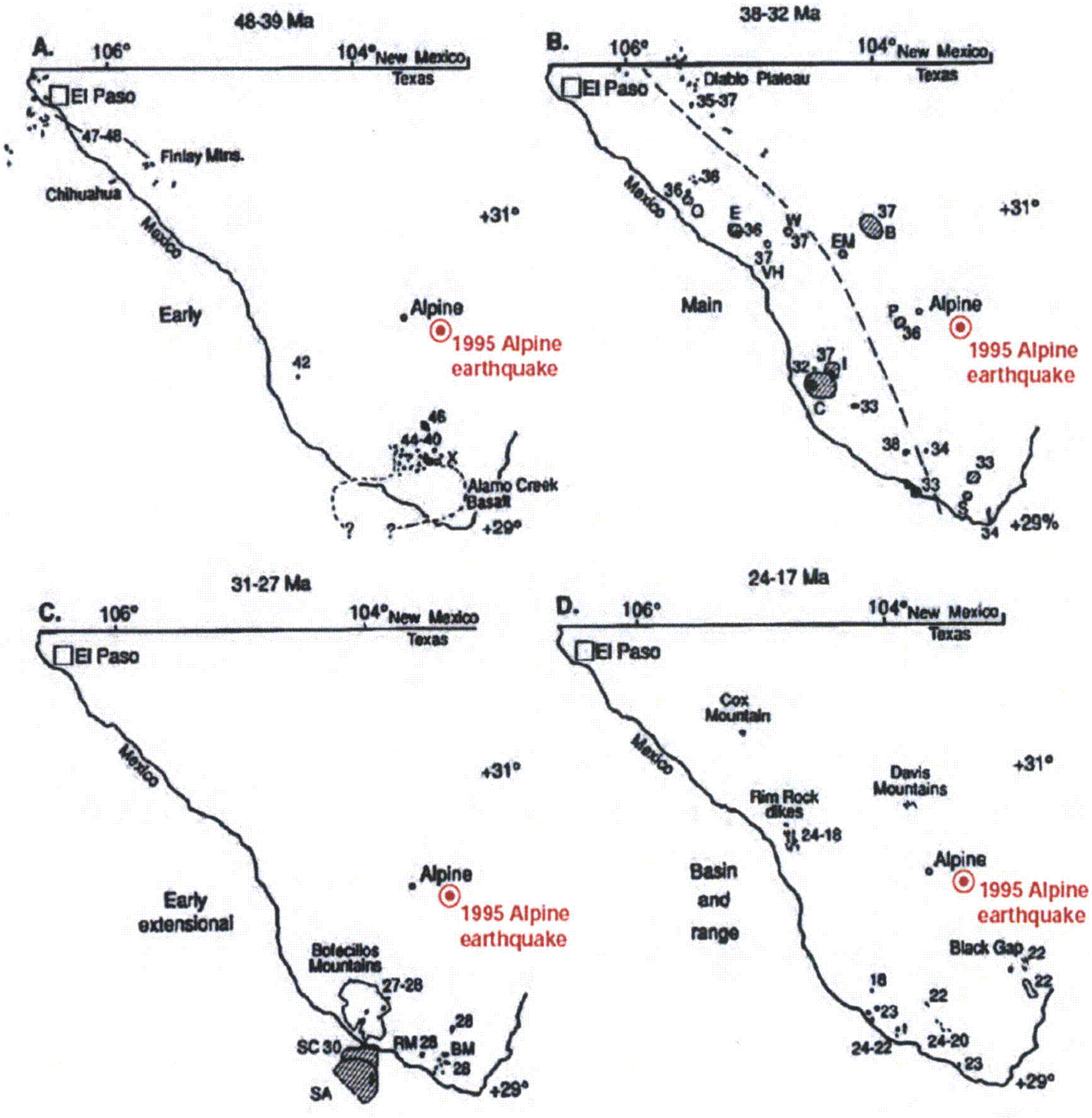
Map of Cenozoic tectonic elements of Texas: shelf-margin growth faults in the Gulf Coast; Basin and Range tectonic elements in West Texas; and Balcones faults.

Figure 12: Extent of the Trans-Pecos volcanic field from Henry et al. (1991).



Location of the Trans-Pecos volcanic field, generalized distribution of Tertiary volcanic rocks, and area of late Cenozoic extension in the southern Cordillera.

Figure 13: Temporal evolution of Trans-Pecos volcanism from Henry et al. (1991).



Distribution of magmatism through time in Trans-Pecos Texas. Numbers indicate times of major activity of individual centers or areas of magmatism. Ruled areas are calderas and solid areas are major intrusions. (a) Initial encroachment of volcanic arc (48–39 Ma). Moderate volumes of magma were emplaced in northern and southern Trans-Pecos Texas. (b) Main continental arc phase (38 to 32 Ma). Large volumes of magma were emplaced, mostly from caldera complexes, throughout Trans-Pecos. AC and A denote western alkalicalcic and eastern alkalic belts. (c) Initial extensional phase (31–27 Ma). Moderate volumes of magma were emplaced exclusively in southern Trans-Pecos Texas and Chihuahua, contemporaneous with initial east-northeast extension. (d) Main Basin and Range phase (24–17 Ma). Small volumes of magma were emplaced throughout Trans-Pecos Texas contemporaneous with major Basin and Range faulting. EP, El Paso. Letters next to calderas: X, Christmas Mountains caldera complex; Q, Quitman Mountains caldera; E, Eagle Mountains caldera; VH, Van Horn Mountains caldera; W, Wylie Mountains caldera; B, Buckhorn caldera; EM, El Muerto caldera; P, Paisano volcano; I, Infiernito caldera; C, Chinati Mountains caldera; PC, Pine Canyon caldera; S, Sierra Quemada caldera; SC, San Carlos caldera; Sa, Santana caldera.

Figure 14a: Geologic map of the Alpine earthquake region from Henry and Price (1985).

Figure 14b: Explanation for the geologic map of the Alpine earthquake region from Henry and Price

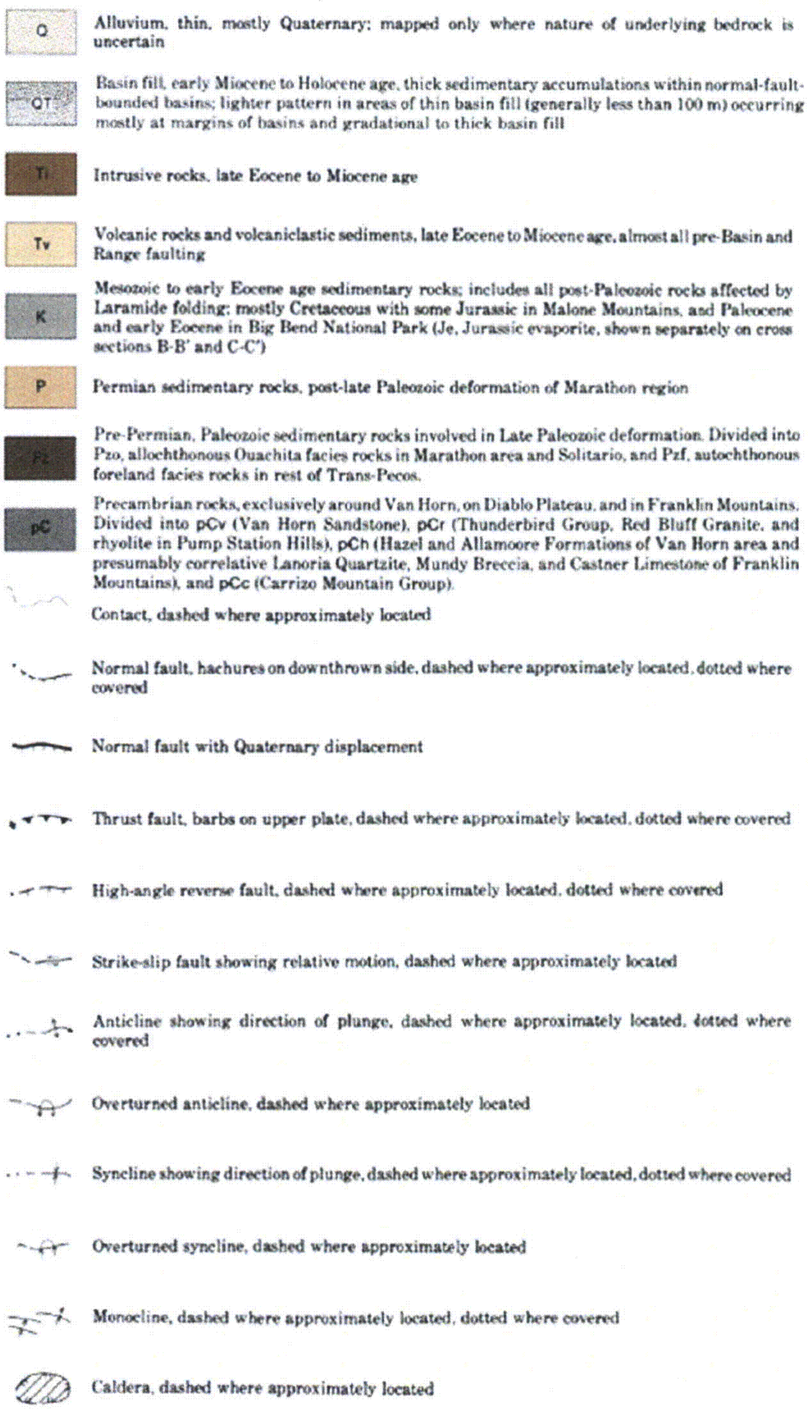
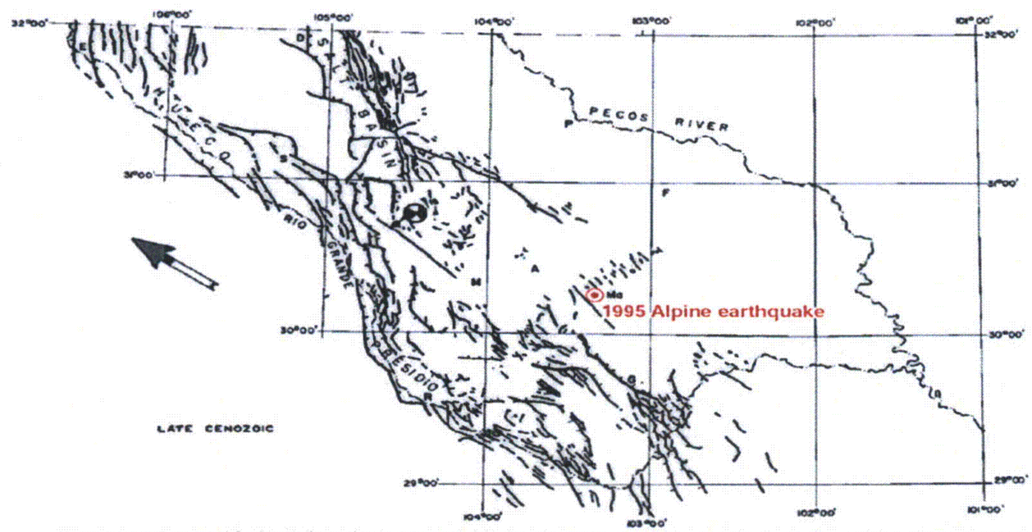
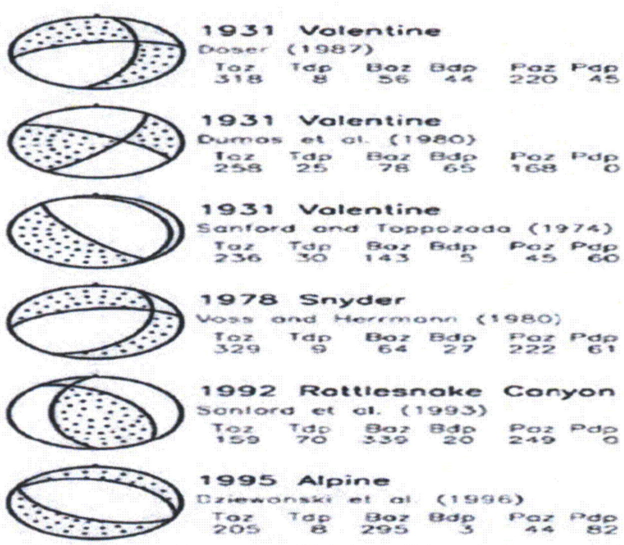


Figure 15: Cenozoic faults in the Alpine-Marathon region from Muehlberger (1980).



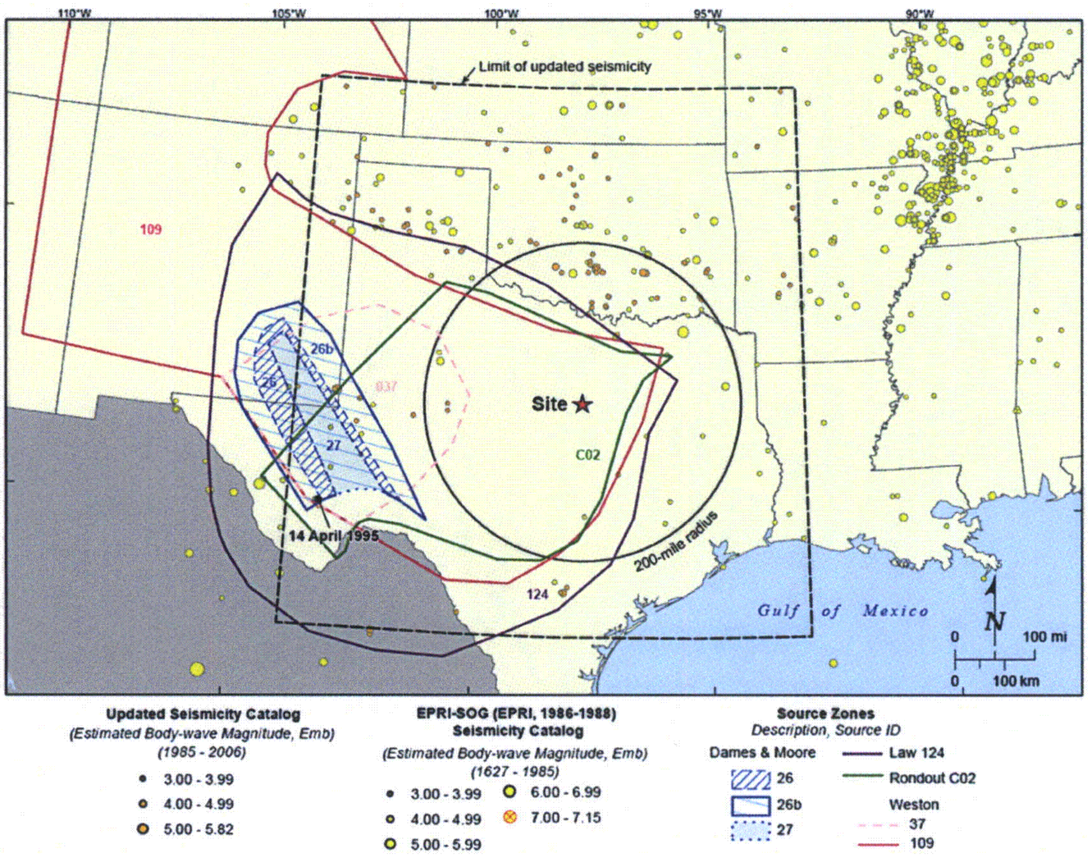
Known Late Cenozoic faults. Tick marks on major graben border faults. Main sources: Geologic Atlas of Texas—Van Horn–El Paso, Pecos, Marfa, Ft. Stockton, and Emory Peak–Presidio sheets; King, 1937; Smith, 1970; Henry, 1979. Also shown is first-motion diagram from Dumas and others (1980) for Valentine earthquake; shaded quadrants—compression; arrow from diagram points to the Valentine fault, the fault assumed to have moved during the August 16, 1931, Valentine earthquake.

Figure 16: Focal mechanisms of west Texas earthquakes from Frohlich and Davis (2002).



Summary of published focal mechanisms for Texas earthquakes. The text at right of lower-hemisphere focal plots indicates the year and location of the earthquake, the source reference for the mechanism, and the azimuth and plunge of the principal axes, labeled T (tension), B (null), and P (pressure) axes. Except for 1995 Alpine earthquake, the referenced sources either did not present numerical information for the azimuth and dip of the principal axes, or the numerical values presented were such that the T and P axes were not perpendicular. Thus we obtained the focal plots and numerical values here by fitting focal plots presented in the referenced sources.

Figure 17: EPRI-SOG source zones containing the Alpine earthquake (Sources in Legend).



RESPONSE TO REQUEST FOR ADDITIONAL INFORMATION

Comanche Peak, Units 3 and 4

Luminant Generation Company LLC

Docket Nos. 52-034 and 52-035

RAI NO.: 4725 (CP RAI #168)

SRP SECTION: 02.05.02 - Vibratory Ground Motion

QUESTIONS for Geosciences and Geotechnical Engineering Branch 1 (RGS1)

DATE OF RAI ISSUE: 6/9/2010

QUESTION NO.: 02.05.02-25

In your response to RAI 2.5.2-14, you stated that your hazard calculations used the Bellefonte FSAR's New Madrid Seismic Zone (NMSZ) source model. The Bellefonte FSAR uses both time-independent and time-dependent models for the NMSZ. In the time-dependent model, the Bellefonte model uses an exposure time of 50 years and it does not consider the possibility of any construction delays and/or possible 20-year license renewal period beyond the initially planned 40-year licensing period. The staff is concerned that combined impacts of these issues may not be negligible considering that the NMSZ is one of the main hazard contributor at the CPNPP site. In accordance with the guidance in NUREG-0800, Standard Review Plan, Chapter 2.5.2, "Vibratory Ground Motion," and Regulatory Guide (RG) 1.208, "A Performance-Based Approach to Define the Site-Specific Earthquake Ground Motion", please provide an updated analysis that incorporates the potential impacts of these issues.

ANSWER:

As discussed in FSAR Subsection 2.5.2.4.2.3.1 and in the response to Question 02.05.02-14, the seismic source characterization used for the CPNPP Units 3 and 4 site is the same as that used for the Tennessee Valley Authority Bellefonte Nuclear Site COLA (FSAR Reference 2.5-402). This characterization of the NMSZ includes: (1) a time-dependent (i.e., renewal) model where the recurrence rate depends on the exposure time $\Delta\tau$ and the start time t_0, and (2) a time-independent model (i.e., Poissonian). In calculating the final mean recurrence rate for the NMSZ, both of these models are equally weighted (see FSAR Figure 2.5-263 of FSAR Reference 2.5-402). For the NMSZ source characterization used in the Bellefonte FSAR, and thus the CPNPP FSAR, $\Delta\tau$ was 50 years and t_0 was 1/1/2003.

To illustrate how varying $\Delta\tau$ and t_0 impacts the CPNPP site ground motion, the change in NMSZ recurrence rate for six scenarios was calculated:

1. $\Delta\tau$ = 40 years and t_0 = 1/1/2018
2. $\Delta\tau$ = 40 years and t_0 = 1/1/2023

3. $\Delta\tau$ = 40 years and t_0 = 1/1/2028
4. $\Delta\tau$ = 60 years and t_0 = 1/1/2018
5. $\Delta\tau$ = 60 years and t_0 = 1/1/2023
6. $\Delta\tau$ = 60 years and t_0 = 1/1/2028

The exposure period of 40 years represents the expected duration of an initial operating license and the exposure period of 60 years represents the initial 40-year license with a 20-year renewal. The start time of 2018 represents the approximate planned start time of commercial operation for CPNPP Units 3 and 4 (FSAR Subsection 1.1.5), and the 2023 and 2028 start times represent potential 5-year and 10-year delays.

The impacts of the above scenarios on both the mean time-dependent (renewal) model recurrence rate and the final mean recurrence rate (final) for the NMSZ are shown in Table 1 as a percentage increase over the rates used in the FSAR. This table demonstrates that impact of the revised start times and exposure periods can be relatively large for the mean recurrence rate for the renewal models (e.g., 9 percent to 28 percent increase over the rates in the FSAR), but the actual impact on the mean recurrence rate for the combined NMSZ model is much less (e.g., 3 percent to 9 percent increase over the rates in the FSAR).

To illustrate the sensitivity of the CPNPP site GMRS to these increases in rate for the NMSZ source, potential increases in GMRS were calculated by scaling the NMSZ hazard by the increase in rate and calculating the impact of the increased hazard on the GMRS for the site. The results of these calculations are shown in Table 2 as the percent increase in GMRS over that presented within the CPNPP FSAR for: (1) the minimum NMSZ rate increase considered (2.85 percent), and (2) the maximum NMSZ rate increase considered (8.7 percent)

As illustrated in Table 2, the largest potential impacts on the CPNPP site GMRS occur at lower frequencies where the NMSZ dominates seismic hazard at the site.

Attachments

Table 1: Percentage Increase in NMSZ Rates Over t_0 = 1/1/2003, $\Delta\tau$ = 50 yrs

Table 2: Potential impact of NMSZ rate increases on site GMRS.

Impact on R-COLA

None.

Impact on DCD

None.

Table 1: Percentage Increase in NMSZ Rates Over t_0 = 1/1/2003, $\Delta\tau$ = 50 yrs

t_0	Exposure Time ($\Delta\tau$), years	
	40	60
1/1/2018 – Renewal	9.18%	18.60%
1/1/2018 – Final	2.85%	5.75%
1/1/2023 – Renewal	13.85%	23.27%
1/1/2023 – Final	4.30%	7.25%
1/1/2028 – Renewal	18.52%	27.94%
1/1/2028 – Final	5.75%	8.70%

Table 2: Potential impact of NMSZ rate increases on site GMRS.

Freq. (Hz)	**GMRS from FSAR**	**Percent increase for:**	
		2.85% increase in NMSZ rate	**8.7% increase in NMSZ rate**
100/PGA	0.0372	0.5%	1.4%
25	0.0418	0.7%	2.1%
10	0.0509	0.6%	1.7%
5	0.0545	1.0%	3.0%
2.5	0.0729	1.3%	4.1%
1	0.0450	2.5%	7.6%
0.5	0.0355	2.6%	8.0%

RESPONSE TO REQUEST FOR ADDITIONAL INFORMATION

Comanche Peak, Units 3 and 4

Luminant Generation Company LLC

Docket Nos. 52-034 and 52-035

RAI NO.: 4725 (CP RAI #168)

SRP SECTION: 02.05.02 - Vibratory Ground Motion

QUESTIONS for Geosciences and Geotechnical Engineering Branch 1 (RGS1)

DATE OF RAI ISSUE: 6/9/2010

QUESTION NO.: 02.05.02-26

As part of the site audit conducted on April 7-8, 2010, the staff inspected Calculation Report, TXUT-1908-01, which discusses issues, related to induced seismicity within the site region. In accordance with the guidance in NUREG-0800, Standard Review Plan, Chapter 2.5.2, "Vibratory Ground Motion," and Regulatory Guide (RG) 1.208, "A Performance-Based Approach to Define the Site-Specific Earthquake Ground Motion".

Section 2.5.1.2.5.10.2.3 of the FSAR documents that of the ~130 earthquakes identified within Texas in the past 150 years, 22 appear to be associated with oil and gas production (approximately 17% of the total). This estimate does not include the recent swarm of earthquakes that has occurred near the Dallas-Fort Worth airport (DFW). These events are located within the Fort Worth Basin and appear to be located at depths consistent with ongoing oil and gas stimulation activities (pers. comm., Prof. Brian Stump, SMU). The Comanche Peak NPP is also located within the Fort Worth Basin and is underlain by the same major geologic units (Ellenburger Limestone and Barnett Shale) as the DFW region. Figure 2.5.1-228 shows that there are a large number of active gas production wells within 10 miles of the Comanche Peak NPP site.

Section 2.5.1.2.5.10.3 contains a qualitative discussion of the bases for concluding that seismic hazards associated with induced seismicity do not need to be considered in the site-specific PSHA for the Comanche Peak site. In particular the last paragraph of this section concludes that it is unlikely that any earthquake induced by gas production or fluid injection in the Fort Worth Basin would exceed mb 5.0 The staff requests the applicant submit calculations and quantitative evaluations that support the applicant's conclusion regarding the maximum earthquake size associated with gas production or fluid injection in the Fort Worth Basin.

ANSWER:

Based on a clarification by the NRC provided during a conference call on June 21, 2010, Luminant understands that the submission of Data Report TXUT-1908-01 meets the intent of this request.

Attachment (on CD)

William Lettis & Associates, Inc. Data Report, "Technical Issues Related to Hydraulic Fracturing and Fluid Extraction/Injection near the Comanche Peak Nuclear Facility in Texas," TXUT-1908-01 Rev. 0, December 3, 2007

Impact on R-COLA

None.

Impact on DCD

None.

RESPONSE TO REQUEST FOR ADDITIONAL INFORMATION

Comanche Peak, Units 3 and 4

Luminant Generation Company LLC

Docket Nos. 52-034 and 52-035

RAI NO.: 4725 (CP RAI #168)

SRP SECTION: 02.05.02 - Vibratory Ground Motion

QUESTIONS for Geosciences and Geotechnical Engineering Branch 1 (RGS1)

DATE OF RAI ISSUE: 6/9/2010

QUESTION NO.: 02.05.02-27

In response to RAI 2.5.2-5 (ML092820486), you presented the logic tree used to describe the Meers fault's Mmax parameters and the recurrence intervals. In your response, you also indicated that you did not include this logic tree in the FSAR. Since the logic tree is a critical part of the Meers fault model and in accordance with the guidance in NUREG-0800, Standard Review Plan, Chapter 2.5.2, "Vibratory Ground Motion," and Regulatory Guide (RG) 1.208, "A Performance-Based Approach to Define the Site-Specific Earthquake Ground Motion", please incorporate this figure into the FSAR.

ANSWER:

The Meers fault logic tree presented in response to RAI 11 Question 02.05.02-5 has been included in the FSAR as Figure 2.5.2-259. Several FSAR subsections have been modified to support this logic tree.

Impact on R-COLA

See attached marked-up FSAR Revision 1 pages 2.5-107, 2.5-108, 2.5-109, and Figure 2.5.2-259

Impact on DCD

None.

- Mw 6.9 (m_b 6.9) for the maximum rupture area of 12 mi x 23 mi = 276 mi^2 (20 km x 37 km = 740 km^2).

Magnitude from Maximum Surface Displacement

The best estimates of surface displacement per event on the Meers fault come from the study of Swan, et al. (Reference 2.5-389) reviewed in Subsection 2.5.1.1.4.3.6.1, and these estimates are used with the regressions of Wells and Coppersmith (Reference 2.5-398) to estimate characteristic magnitudes. The regressions of Wells and Coppersmith (Reference 2.5-398) were determined using net surface displacements, and because the Meers fault exhibits oblique slip there is only one combined observation of vertical and lateral displacement with which net displacement can be determined (7.5 ft or 2.29 m per event). However, Swan, et al. (Reference 2.5-389) report a best estimate of vertical displacement at a different location that is greater than this net displacement (8.5 ft or 2.6 m per event). Both of these displacement values are used to estimate characteristic magnitudes for the Meers fault.

The regression on maximum surface displacement, and not the regression for the average surface displacement, of Wells and Coppersmith (Reference 2.5-398) is used to estimate magnitude because the average surface displacement regression is not appropriate for the displacement data available for the Meers fault. Wells and Coppersmith (Reference 2.5-398) explicitly state that the regression for maximum displacement was determined using the maximum reported displacement for an event, while the regressions for average displacement were done on faults where an average displacement was calculated from either an extensive study of the entire surface rupture or a minimum of 10 displacement measurements. The data available for the Meers fault is a maximum reported displacement and not an along-fault average.

Using the displacements described above results in the following magnitude estimates:

- Mw 7.0 (m_b 6.9) from a maximum vertical displacement of 8.5 ft (2.6 m); and
- Mw 7.0 (m_b 6.9) from a maximum net displacement of 7.5 ft (2.29 m).

Final Magnitude Distribution

The final characteristic magnitude distribution used for the Meers fault is: Mw 6.7 (m_b 6.7), Mw 6.85 (m_b 6.82), and Mw 7.0 (m_b 6.9) with weights 0.2, 0.6, and 0.2, respectively (Figure 2.5.2-259). Mw 6.7 (m_b 6.7) is chosen as the lower bound instead of Mw 6.6 (m_b 6.7) because it is not considered likely that only the 26 km of the Meers fault scarp is related to the Holocene ruptures. Mw 7.0 (m_b 6.9) is chosen as the maximum bound because it is the maximum estimated magnitude of any regression and it is roughly equivalent to other estimates of characteristic RCOL2_02.05.02-27 earthquake magnitude for the fault (References 2.5-389 and 2.5-321). The weighting of the distribution reflects the opinion that the best estimates of magnitude come from regressions on surface rupture length and rupture area.

2.5.2.4.2.3.2.3 Characteristic Return Period

Epistemic uncertainty in return periods for characteristic earthquakes on the Meers fault is implemented through return period branches on a logic tree (Figure 2.5.2-259). The data presented by Swan, et al. (Reference 2.5-389) on the timing of Meers earthquakes suggests that there have been two Holocene events preceded by a long period (greater than 200,000 years) of inactivity, indicating that the Meers fault exhibits clustered earthquake behavior. The initial branch of the logic tree represents uncertainty in whether or not the Meers fault is in an earthquake cluster. RCOL2_02.05.02-27

Weightings of 0.9 and 0.1 are used for the logic tree branches describing the Meers fault as in an earthquake cluster or in-between earthquake clusters, respectively. High weighting on the "in earthquake cluster" conservatively reflects the observation that there is no information to suggest that the Meers fault is not in a cluster; insufficient time has elapsed since the most recent event to conclude that there is a moderate possibility that the period of increased Holocene activity has passed. Return periods for the inter-cluster branch are based on the work of Swan, et al. (Reference 2.5-389) that estimates a minimum period of inactivity prior to the Holocene ruptures of 200,000 to 500,000 years. Based on this observation, return period branches of 500,000, 350,000, and 200,000 years with weights of 0.2, 0.6, and 0.2, respectively, are used for the inter-cluster branch (Figure 2.5.2-259). RCOL2_02.05.02-27

Return periods for the intra-cluster branch are based on the elapsed time since the oldest Holocene event and the observation of two earthquakes during that time span. Assuming that the Meers fault is currently in an earthquake cluster, this method results in a reasonable estimate of the intra-cluster return period. Swan, et al. (Reference 2.5-389) report two dates to constrain the maximum age of the oldest Holocene rupture: sample PITT-0477 with a calibrated age of 3397 years B.P and sample PITT-0373 with a calibrated age of 2918 years B.P. The mean of these two ages is taken as the most-probable maximum age of the event, and half that age (1580 years) is taken as the most-probable maximum return period for intra-cluster events. Swan, et al. (Reference 2.5-389) also report four ages that they believe best constrain the minimum age of the oldest Holocene event: PITT-0370 with a calibrated age of 1942 years B.P., PITT-0369 with a calibrated age of 1610 years B.P., PITT-0378 with a calibrated age of 1912 years B.P., and PITT-0478 with a calibrated age of 2093 years B.P. The mean of these four ages is taken as the most-probable minimum age of the event, and half the age (950 years) is taken as the most-probable minimum return period for intra-cluster events.

A direct inter-event return period for the two Holocene events can also be determined from ages reported by Swan, et al. (Reference 2.5-389) as constraining the bounds of the oldest and youngest Holocene events. The return period determined using the time elapsed between the mean upper-bound age of the oldest Holocene event and the mean lower-bound age of the youngest Holocene event is 2000 years. The return period determined using the time elapsed between the mean lower-bound age of the oldest Holocene event and the mean upper-bound age of the youngest Holocene event is 300 years. The large range in return period determined using this methodology is due to the compounded uncertainty from using the dates constraining both Holocene events as opposed to just the time elapsed since the oldest event. The 300-year lower-bound return period is unrealistic since it would imply significantly more events between the oldest Holocene event and the present time than the two observed. For this reason, and because the plausible range of return periods determined from the inter-event period is captured in the return periods previously described, the inter-event period is not used to estimate return periods.

The most probable minimum and maximum return periods are both given equal weight of 0.2 in the logic tree for the return period of intra-cluster events. The remaining 0.6 weight is given to the median of the most-probable minimum and maximum return periods (1265 years) (Figure 2.5.2-259). This weighting reflects the belief that it is most likely for the intra-cluster return period to be somewhere between the minimum and maximum bounds. RCOL2_02.05.02-27

2.5.2.4.2.3.2.4 PSHA Implementation of Updated Meers Fault Source

The updated source characterization for the Meers fault developed for CPNPP Units 3 and 4 is shown in Table 2.5.2-213 ~~and~~, Figure 2.5.2-211, and Figure 2.5.2-259. This characterization is implemented in the CPNPP Units 3 and 4 PSHA model as a line source extending to 9.3 mi (15 km) depth. The possibility of ruptures extending to 20 km depth is taken into account in estimating characteristic earthquake magnitudes, but ruptures in the PSHA do not extend to 20 km. This potential discrepancy does not affect the ground-motion estimates at CPNPP Units 3 and 4 given the large distance between the Meers fault and the site. RCOL2_02.05.02-27

2.5.2.4.2.3.3 Rio Grande Rift

The RGR is a north-south-trending continental rift system recognized to extend from central Colorado through New Mexico, Texas, and into northern Mexico (References 2.5-297, 2.5-298, 2.5-299, and 2.5-300). The RGR is generally characterized by north- to north-northwest-trending grabens centered on a broad topographic high, a well-defined gravity high, elevated heat flow, and a tensile stress regime (References 2.5-300, 2.5-313, 2.5-310, and 2.5-296) (see discussion in Subsection 2.5.1.1.4.3.7.1). At the time of the EPRI-SOG study, relatively little was known about the seismogenic potential of faults within the RGR, and only the Weston EST explicitly included the RGR as a seismic source zone. Other ESTs either (1) did not extend their source model boundaries to include the RGR, or (2 included the RGR in large background source zones (Reference 2.5-369). Research post-dating the EPRI study has documented

RCOL2_02.05.02-27

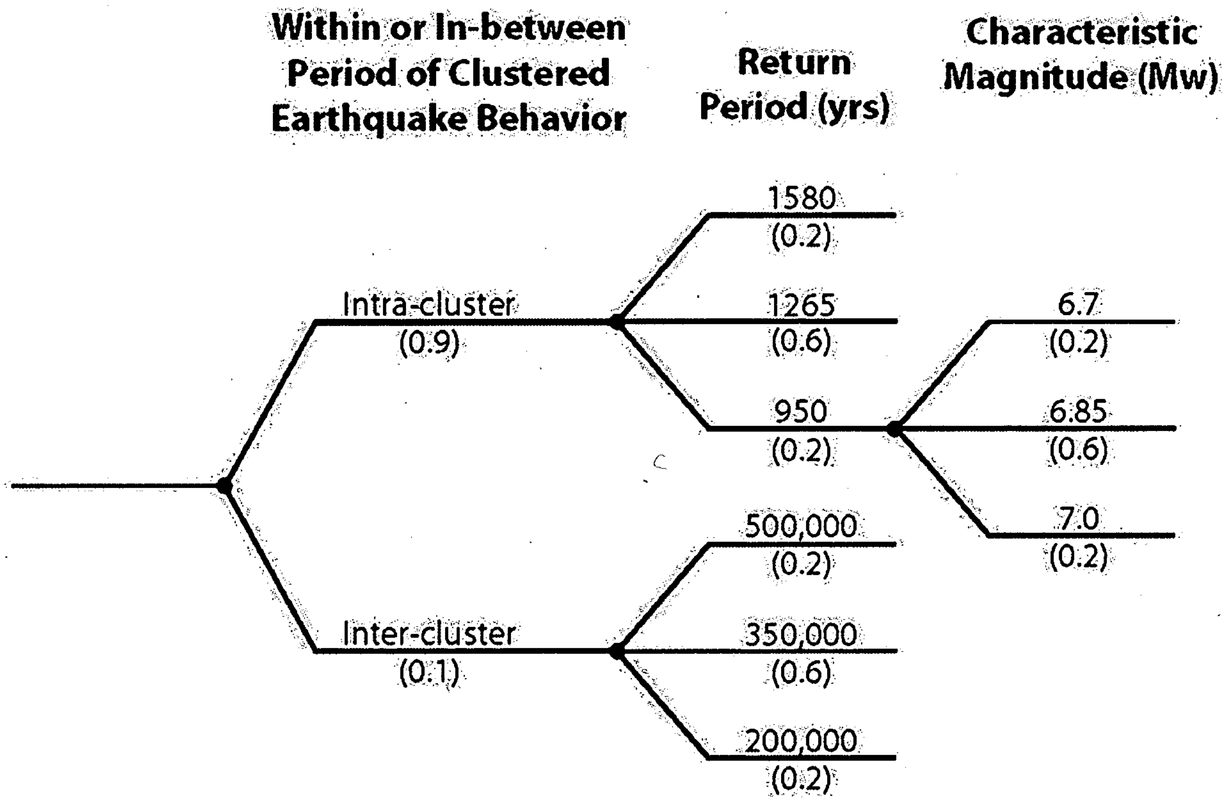


Figure 2.5.2-259 Logic Tree of Return Period and Characteristic Magnitude for the Meers Fault