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From: Ray, Phillip M [pmray@tva.gov]
Sent: Wednesday, January 07, 2009 9:44 AM
To: Joseph Sebrosky
Cc: Sterdis, Andrea Lynn
Subject: RAI Response
Attachments: RAI Letter 123 with signature 01072009.pdf

Joe,

Attached is a courtesy copy of our supplemental response to Letter 123. The official submittal to the Document Control Desk has been shipped via Federal Express.

If you have any questions, please call me.

Phillip M. Ray

Nuclear Generation Development & Construction
Tennessee Valley Authority
423-751-7030

Hearing Identifier: Bellefonte_COL_Public_EX
Email Number: 1313

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Subject: RAI Response
Sent Date: 1/7/2009 9:44:14 AM
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From: Ray, Phillip M

Created By: pmray@tva.gov

Recipients:
"Sterdis, Andrea Lynn" <alsterdis@tva.gov>
Tracking Status: None
"Joseph Sebrosky" <Joseph.Sebrosky@nrc.gov>
Tracking Status: None

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Tennessee Valley Authority, 1101 Market Street, LP 5A, Chattanooga, Tennessee 37402-2801

January 6, 2009

10 CFR 52.79

U.S. Nuclear Regulatory Commission
ATTN: Document Control Desk
Washington, D.C. 20555

In the Matter of)
Tennessee Valley Authority)

Docket No. 52-014 and 52-015

BELLEFONTE COMBINED LICENSE APPLICATION – RESPONSE TO REQUEST FOR ADDITIONAL INFORMATION – BASIC GEOLOGIC AND SEISMIC INFORMATION

Reference: 1) Letter from Joseph Sebrosky (NRC) to Andrea L. Sterdis (TVA), Request for Additional Information Letter No. 123 Related to SRP Section 02.05.01 for the Bellefonte Units 3 and 4 Combined License Application, dated September 4, 2008.

2) Letter from Andrea Sterdis (TVA), to Document Control Desk (NRC), Response to Request for Additional Information Basic Geologic and Seismic tutorial, dated October 3, 2008.

This letter revises the Tennessee Valley Authority's (TVA) response (Reference 2) to the Nuclear Regulatory Commission's (NRC) request for additional information (RAI) items included in Reference 1. This revised response is submitted as requested by NRC following verbal clarifications of the requested information.

The revised response to RAI 02.05.01-01 in Reference 1 is addressed in the enclosure which also identifies any associated changes that will be made in a future revision of the BLN application. This response replaces the original response in Reference 2.

If you should have any questions, please contact Phillip Ray at 1101 Market Street, LP5A, Chattanooga, Tennessee 37402-2801, by telephone at (423) 751-7030, or via email at pmray@tva.gov.

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

Executed on this 6th day of Jan, 2009.

Andrea L. Sterdis
Manager, New Nuclear Licensing and Industry Affairs
Nuclear Generation Development & Construction

Enclosure
cc: See page 2

cc: (w/ Enclosures)
J. P. Berger, EDF
J. M. Sebrosky, NRC/HQ
E. Cummins, Westinghouse
S. P. Frantz, Morgan Lewis
M. W. Gettler, FP&L
R. Grumbir, NuStart
P. S. Hastings, NuStart
P. Hinnenkamp, Entergy
M. C. Kray, NuStart
D. Lindgren, Westinghouse
G. D. Miller, PG&N
M. C. Nolan, Duke Energy
N. T. Simms, Duke Energy
K. N. Slays, NuStart
G. A. Zinke, NuStart

cc: (w/o Enclosure)
B. C. Anderson, NRC/HQ
M. M. Comar, NRC/HQ
B. Hughes/NRC/HQ
R. G. Joshi, NRC/HQ
R. H. Kitchen, PGN
M. C. Kray, NuStart
A. M. Monroe, SCE&G
C. R. Pierce, SNC
R. Reister, DOE/PM
L. Reyes, NRC/RII
T. Simms, NRC/HQ

Enclosure
TVA letter dated January 6, 2009
RAI response

Revised response to NRC Request for Additional Information letter No. 123 dated September 4, 2008
(eight pages, including this list)

Subject: Basic geologic and seismic information in the Final Safety Analysis Report

RAI Number	Date of TVA Response
02.05.01-01	Revised response this letter – see following pages
02.05.01-02	Letters Dated October 3, 2008 and November 14, 2008
02.05.01-03	Letter Dated October 3, 2008
02.05.01-04	Letter Dated October 3, 2008

Associated Additional Attachments / Enclosures	Pages Included
Attachment 02.05.01-01A	2
Attachment 02.05.01-01B	3

NRC Letter Dated: September 4, 2008

NRC Review of Final Safety Analysis Report

NRC RAI NUMBER: 02.05.01-01

FSAR 2.5.1.1.3.2 describes sub-vertical, upward-widening features in a soil exposure and states that they "resemble non-tectonic soil weathering features (cutans) …." Please present observations, measurements, or analyses, and figures, photographs, or other illustrations that demonstrate whether or not these features could be seismically induced.

BLN RAI ID: 2411

BLN RESPONSE:

This revised response is submitted as requested by NRC following verbal clarifications of the requested information.

Consistent with statements in the FSAR, the features are found to be non-tectonic soil weathering features. The discussion below further supports this conclusion, and a new FSAR Figure is added as provided in Attachment 02.05.01-01A.

Field location KH-9 is located in Gadsden, Alabama in an abandoned excavation or old borrow pit near the intersection of Highway 278 and Armstrong Street. The excavation exposes three subvertical cuts, 4 to 9 feet high, made into early to middle Pleistocene fluvial sediments of the Coosa River. The excavation is on the crest of a low hill at elevation 620 ft. based on the USGS topographic map, approximately 120 feet above the level of the Coosa River, which flows 0.8 mi. north of the excavation. As stated in the FSAR, the age of the deposits is not known, but based on the regional denudation rate (100 ft./myr) (FSAR Reference 220) and the strong soil development, it is likely that the terraces are several hundreds of thousands to a million years old.

The exposures at KH-9 reveal terrace sediments consisting of sandy gravels and gravelly sands capped with up to 5 ft of fine sand and silt. The sands and gravels exhibit the cross-bedding typical of fluvial sediments. The material is highly weathered with bright red and yellowish red colors, and the upper few meters host a partially eroded mature soil profile.

The Natural Resources Conservation Service (NRCS) maps the soil as belonging to the Holston soil series (Reference 1). Holston soils are classified as Paleudults, highly weathered soils, leached of the elements calcium, sodium, magnesium, and potassium, that have a horizon of translocated clay, or *argillic horizon*. They form on very old, stable land surfaces with gentle slopes and commonly have a small amount of *plinthite*, an iron cementation, at depth (Reference 2). The soils observed in the excavations at KH-9 are consistent with this description.

The most complete soil profile, observed in the easternmost cut, consists of a partially eroded, leached horizon of light yellowish brown silt loam, capping an argillic horizon of yellowish red and brown mottled silty clay loam, with distinct clay films. At 3 ft. depth, the argillic horizon grades downward into an iron-rich, or plinthite, horizon, with visually striking dark red and light gray mottling indicating iron mobilization and accumulation under fluctuating redox conditions (Reference 3). At 4.5 ft. the mottled silty clay loam abruptly terminates at the upper contact of a gravelly sand layer. The iron cementation continues downward into this gravelly sand, giving the sandy matrix a dark red color. In this and other exposures in this excavation, mottling is more pronounced in the finer textured sediments and often absent in the coarse sediments.

The sub-vertical features are found in the iron-rich horizons of the western and central cut faces of the excavation, in either the mottled or unmottled horizons. The features appear as sub-vertical vein-like bands 0.5 to 2 in. wide, lighter in color than the surrounding soil matrix (FSAR Figure 2.5-209, panels A and B). The bands are seen to occasionally branch upward or downward, and may be part of a group of parallel bands. Band width is fairly constant with depth, though examples can be found that pinch out with depth or widen near the surface. Some end abruptly at a bedding contact. The edges of the bands are typically lined with reddish iron cementation.

The bands pass through stratigraphic contacts without offsetting or disturbing them. FSAR Figure 2.5-209 panel B shows several bands passing through a gravel lens bounded by mottled silty clay loam. The gravel is not displaced, and gravel clasts occur within the band where it passes through the lens. Gravel is not found upward within the band, suggesting no upward movement of material within the band.

A typical band through sandy alluvium at the Gadsden exposure features a reddish border on either side (about 0.4 inches thick), slightly darker than the soil matrix, with diffuse outer edges and abrupt inner edges (FSAR Figure 2.5-209 panels C and D). At the inner edge, the soil becomes lighter in color, but maintains the same texture. This light-colored portion is 0.1 to 0.3 inches thick on either side of the band center. The center of the band contains either a hairline fracture coated with clay films (FSAR Figure 2.5-209 panel C), or a fracture lined with layers (<0.2 inches thick) of silt and clay (FSAR Figure 2.5-209 panel D). The edges of the clay layer are sharp. Fine roots are often found along the fracture.

Features such as these are documented in the soil science literature and referred to as *bleached fractures* formed from the depletion of iron along a fracture face (Reference 3). They are a form of *redoximorphic* feature, color patterns in the soil formed by the oxidation and reduction of iron and/or manganese, caused by periodic saturated conditions within the soil (Reference 4). Mottling, in which spots or patches of different colors occur, is the most common type of redoximorphic feature, and is also present in the Gadsden soils.

Bleached fractures form from the cracking of a partially cemented or brittle soil horizon during seasonal drying, followed by infiltration of rainwater into the soil (FSAR Figure 2.5-209 panel E) (Reference 4). As rainwater soaks through the soil, microbial respiration from the decomposition of organic matter such as dead roots, consumes oxygen from the water. The oxygen-depleted water flows down the cracks, reducing and mobilizing iron from the walls of the fracture. Water is drawn into the dry partially cemented block on the margins of the fracture where the iron is then oxidized and precipitated, forming the red borders adjacent to the iron-depleted zones. The fracture becomes a preferred pathway for the infiltration of water and for root penetration, and over time its walls take on a bleached appearance. Clay and silt can be translocated downward and accumulate as clay films or fracture fillings on the walls of the fracture (FSAR Figure 2.5-209 panels D and E).

In plan view the fractures form a rough polygonal pattern bounding blocks of more cemented soil (Reference 3). In addition to fractures, iron-depleted zones may also develop adjacent to root channels and animal burrows. Some of the irregular bleached shapes in Figure 2.5-209 panel A may result from bleaching along these alternate pathways of water infiltration.

These features do not have characteristics consistent with seismically induced liquefaction features or tectonic faulting. The bands do not consist of liquefiable silt and sand and do not appear to originate from a layer of liquefiable material at depth. They disappear upward into the argillic horizon instead of widening into a surficial deposit of erupted silt and sand. Bedding is not observed to be displaced across the bands.

Textural features of the host sediment are preserved across the reddish band border and into the yellowish bleached material of the band. Stratigraphic features such as gravel stringers are seen to pass through the band (FSAR Figure 2.5-209 panel B). The bleached material on either wall of the fracture matches the texture and composition of the host sediments; the grain sizes of the reddish border are indistinguishable from those of the bleached portion of the band. Only the color of the grain coatings is different.

The band may have a central zone of silt and clay, and clay films typically line the vertical fracture face. The fracture filling is clay and silt, and is always finer grained than the host material. These fine grained linings of the fractures indicate translocation of material downward from the relatively finer upper horizons. These characteristics are not consistent with a model of upward translocation of liquefied silts and sands through fractures during an earthquake.

Tectonic fault features are expected to have a preferred orientation and to displace host materials. The lack of displacement of the bedding across the bands, and the random orientation of these features are inconsistent with a faulting origin.

Abbott and others (Reference 227) document similar features in Tertiary coastal plain sediments in South Carolina. There, the upper five feet of sandy sediments host vein-like bleached zones, each with a limonite (iron) cemented rind. They are subvertical, curviplanar in shape, and less than 6 inches wide, and cross pebbly horizons without disrupting or offsetting the bedding. Thin sheets of gray clay are locally evident near the center of the bleached zones. Abbot and others (Reference 227) use field observations to discount a seismic origin for these features, and interpret them as soil weathering features formed by geochemical processes.

The evidence provided in the Gadsden exposure and similar sites on the Coastal Plain of South Carolina support a non-seismically induced origin of these features. A pedogenic process involving the geochemical interaction of soil, water, and oxygen along a physical discontinuity or fracture (Reference 4) best accounts for their observed characteristics.

References

1. Natural Resources Conservation Service Web Soil Survey 2.0, accessed 9/17/08.
2. Soil Survey Staff, 1999, Soil Taxonomy: a basic system of soil classification for making and interpreting soil surveys: U.S Department of Agriculture, Agriculture Handbook No. 436, revised edition, Chapter 19, Ultisols, pp. 721-781.
3. Soil Survey Staff, 1975, Soil Taxonomy: a basic system of soil classification for making and interpreting soil surveys: U.S Department of Agriculture, Agriculture Handbook No. 436, pp. 42-43.
4. Vepraskas, M. J., 1995, (revised) Redoximorphic features for identifying aquic conditions: Technical Bulletin 301, North Carolina State University, Raleigh, NC.

This response is **PLANT SPECIFIC**.

ASSOCIATED BLN COL APPLICATION REVISIONS:

1. COLA Part 2, FSAR Chapter 2 Figures are modified by replacing Figures 2.5-208 and 209 as follows:

   a. The existing Figure 2.5-208, 25-Mi. Radius Geologic Map, will be renumbered as 2.5-208a (Attachment 2.5.1-01B)

   b. The existing Figure 2.5-209, Explanation of Geologic Map Units and Symbols 25-Mi., will be renumbered as 2.5-208b (Attachment 2.5.1-01B)

   c. Add new Figure 2.5-209, Soil Weathering Features in Pleistocene Terrace Deposits, Gadsden, Alabama. (Attachment 2.5.1-01A)

2. COLA Part 2, FSAR. Chapter 2, subsection 2.5.1.1.3.2, last paragraph, from:

At one location in Gadsden (Field Stop KH9, Figure 2.5-208) subvertical features characterized by subvertical bands of alternating red and light brownish gray color were observed in the lower, more clay-rich, strongly mottled part of the soil. The features appeared to flare upward and become less distinct in the upper part of the mottled horizon and could not be traced into the upper 0.6 m (2 ft.) of the soil. The contact between the mottled unit and gravelly sand does not show any apparent vertical displacement across the features. These features resemble non-tectonic soil weathering features (cutans) seen elsewhere in the Coastal Plain region of the southeastern U.S. (Reference 227).

To read:

At an excavation into these high terrace deposits in Gadsden (Field Stop KH9, Figure 2.5-208a) subvertical features characterized by narrow bands of very pale brown to yellowish brown material transecting yellowish red terrace sediments are observed within the lower horizons of the soil. The excavation exposes cut faces, 4 to 9 feet high, at the crest of a low hill at elevation 620 ft., approximately 120 ft. above the level of the Coosa River which flows 0.8 mi. north of the excavation.

The exposed terrace sediments consist of sandy gravels and gravelly sands capped with up to 5 feet of fine sand and silt. The sands and gravels exhibit the cross-bedding typical of fluvial sediments. The age of the deposits is not known, but based on the regional denudation rate (100 ft/myr, Reference 220) and the mature soil development, it is likely that the terraces are several hundreds of thousands to a million years old. They are highly weathered to bright red and yellowish red colors, and the upper few meters host a partially eroded mature soil profile.

The Natural Resources Conservation Service (NRCS) maps the soil as belonging to the Holston soil series (Reference 479). Holston soils are classified as *Paleudults*, highly weathered soils, leached of the elements calcium, sodium, magnesium, and potassium, that have a horizon of translocated clay, or *argillic horizon*. They form on very old, stable land surfaces with gentle slopes and commonly have a horizon of iron cementation, below the argillic horizon (Reference 478). The soils observed in the excavations at KH-9 are consistent with this description.

The sub-vertical features are found in the iron-rich horizons of the western and central cut faces of the excavation. The features appear as sub-vertical vein-like bands 0.5 to 2 in. wide, lighter in color than the adjacent soil matrix and bounded by a zone of reddish iron cementation (Figure 2.5-209, panels A and B). The bands are seen to occasionally branch upward or downward, and may be part of a group of parallel bands. Band width is fairly constant with depth, though examples can be found that pinch out with depth or widen near the surface. Some end abruptly at a bedding contact.

The bands pass through stratigraphic contacts without offsetting or disturbing them. Figure 2.5-209, panel B shows several bands passing through a gravel lens bounded by mottled silty clay loam. The gravel is not displaced, and gravel clasts occur within the band where it passes through the lens. Gravel is not found upward within the band, suggesting no upward movement of material within the band.

A typical band through sandy alluvium at the Gadsden exposure features a reddish border on either side (about 0.4 inches thick), slightly darker than the soil matrix, with diffuse outer edges and abrupt inner edges (Figure 2.5-209, panels C and D). At the inner edge, the soil becomes lighter in color, but maintains the same texture. This light-colored portion is 0.1 to 0.3 inches thick on either side of the band center. The center of the band contains either a hairline fracture coated with clay films (Figure 2.5-209, panel C), or a fracture lined with layers (<0.2 inches thick) of silt and clay (Figure 2.5-209, panel D). The edges of the clay layer are sharp. Fine roots are often found along the fracture.

Features such as these are documented in the soil science literature and referred to as *bleached fractures* formed from the depletion of iron along a fracture wall (Reference 477). They are a type of *redoximorphic* feature, or color patterns in the soil formed by the oxidation and reduction of iron and/or manganese, resulting from periodic saturated conditions within the soil (Reference 480). Mottling, in which spots or patches of different colors occur, is the most common type of redoximorphic feature and is also present in the Gadsden soils.

Bleached fractures form from the cracking of a partially cemented or brittle soil horizon during seasonal drying, followed by infiltration of rainwater into the soil. Figure 2.5-209 panel E (Reference 480) illustrates this process. As rainwater soaks through the soil, microbial respiration from the decomposition of organic matter such as dead leaves and roots, consumes oxygen from the water. The oxygen-depleted water flows down the cracks, reducing and mobilizing iron from the walls of the fracture. Water is drawn into the dry partially cemented block on the margins of the fracture where the iron is then oxidized and precipitated, forming the red borders adjacent to the iron-depleted zones. The fracture becomes a preferred pathway for the infiltration of water and for root penetration, and over time its walls take on a bleached appearance. Clay and silt can be translocated downward and accumulate as clay films or fracture fillings on the walls of the fracture, especially in the lower horizons of the soil (Figure 2.5-209 panels D and E).

In plan view the fractures form a rough polygonal pattern about blocks of more cemented soil (Reference 477). In addition to fractures, iron-depleted zones may also develop adjacent to root channels and animal burrows. Some of the irregular bleached shapes in Figure 2.5-209 panel A may result from bleaching along these alternate pathways of water infiltration.

These features do not have characteristics consistent with seismically induced liquefaction features or tectonic faulting. The bands do not consist of liquefiable silt and sand and do not appear to originate from a layer of liquefiable material at depth. They disappear upward into the argillic horizon instead of widening into a surficial deposit of erupted silt and sand. Bedding is not observed to be displaced across the bands.

Textural features of the host sediment are preserved across the reddish band border and into the yellowish bleached material of the band. Stratigraphic features such as gravel stringers are seen to pass through the band (Figure 2.5-209 panel B). The bleached material on either wall of the fracture matches the texture and composition of the host sediments; the grain sizes of the reddish border are indistinguishable from those of the bleached portion of the band. Only the color of the grain coatings is different.

The band may have a central zone of silt and clay, and clay films typically line the vertical fracture face. The fracture filling is clay and silt, and is always finer grained than the host material. These fine grained linings of the fractures indicate translocation of material downward from the relatively finer upper horizons. These characteristics are not consistent with a model of upward translocation of liquefied silts and sands through fractures during an earthquake.

Tectonic fault features are expected to have a preferred orientation and to displace host materials. The lack of displacement of the bedding across the bands, and the random orientation of these features are inconsistent with a faulting origin.

Abbott and others (Reference 227) document similar features in Tertiary coastal plain sediments in South Carolina. There, the upper five feet of sandy sediments host vein-like bleached zones, each with a limonite (iron) cemented rind. They are subvertical, curviplanar in shape, and less than 6 inches wide, and cross pebbly horizons without disrupting or offsetting the bedding. Thin sheets of gray clay are locally evident near the center of the bleached zones. Abbot and others (Reference 227) use field observations to discount a seismic origin for these features, and interpret them as soil weathering features formed by geochemical processes.

The evidence provided in the Gadsden exposure and similar sites on the Coastal Plain of South Carolina support a non-seismically induced origin of these features. A pedogenic process involving the geochemical interaction of soil, water, and oxygen along a physical discontinuity or fracture (Reference 480) best accounts for their observed characteristics.

3. COLA Part 2, FSAR. Chapter 2, subsection 2.5.1.1.3.2, 3rd paragraph from:

In northern Alabama, extensive alluvial terrace deposits are mapped in the Coosa River Valley in the Gadsden to Weiss Reservoir area (Etowah and Cherokee Counties) (Reference 224) (Figure 2.5-208). The alluvial and terrace deposits are preserved within a broad valley underlain by the Cambrian Conasauga Formation. Structural cross-sections and maps indicate that the Cambrian unit beneath the valley is a near horizontal thrust sheet, referred to as the Rome thrust (Reference 225) (see discussion in Subsection 2.5.1.1.4.2). The meandering river morphology is prominent where the widest part of the Rome thrust sheet is preserved. Downstream of the confluence of Big Canoe Creek and the Coosa River (about 10-mi. southwest of Gadsden), the valley narrows and the Coosa River takes a sharp bend to the south and cuts across the regional structural grain. Quaternary deposits are not shown on the State Geologic Map of Alabama (Reference 225) (Figures 2.5-208 and 2.5-209) downstream…

To read:

In northern Alabama, extensive alluvial terrace deposits are mapped in the Coosa River Valley in the Gadsden to Weiss Reservoir area (Etowah and Cherokee Counties) (Reference 224) (Figure 2.5-208a). The alluvial and terrace deposits are preserved within a broad valley underlain by the Cambrian Conasauga Formation. Structural cross-sections and maps indicate that the Cambrian unit beneath the valley is a near horizontal thrust sheet, referred to as the Rome thrust (Reference 225) (see discussion in Subsection 2.5.1.1.4.2). The meandering river morphology is prominent where the widest part of the Rome thrust sheet is preserved. Downstream of the confluence of Big Canoe Creek and the Coosa River (about 10-mi. southwest of Gadsden), the valley narrows and the Coosa River takes a sharp bend to the south and cuts across the regional structural grain. Quaternary deposits are not shown on the State Geologic Map of Alabama (Reference 225) (Figure 2.5-208a and 2.5-208b) downstream…

4. COLA Part 2, FSAR Chapter 2, Section 2.5.7 is modified to add new references.

477. Soil Survey Staff, 1975, Soil Taxonomy: a basic system of soil classification for making and interpreting soil surveys: U.S Department of Agriculture, Agriculture Handbook No. 436, pp. 42-43.

478. Soil Survey Staff, 1999, Soil Taxonomy: a basic system of soil classification for making and interpreting soil surveys: U.S Department of Agriculture, Agriculture Handbook No. 436, revised edition, Chapter 19, Ultisols, pp. 721-781.

479. Natural Resources Conservation Service Web Soil Survey 2.0, accessed 9/17/08.

480. Vepraskas, M. J., 1995, (revised) Redoximorphic features for identifying aquic conditions: Technical Bulletin 301, North Carolina State University, Raleigh, NC.

ASSOCIATED ATTACHMENTS/ENCLOSURES:

Attachment 02.05.01-01A, New FSAR Figure 2.5-209

Attachment 02.05.01-01B, Renumbered FSAR Figure 2.5-208a and 2.5-208b

Attachment 02.05.01-01A

(2 pages including cover)

New Figure 2.5-209

Soil Weathering Features in Pleistocene Terrace Deposits, Gadsden, Alabama

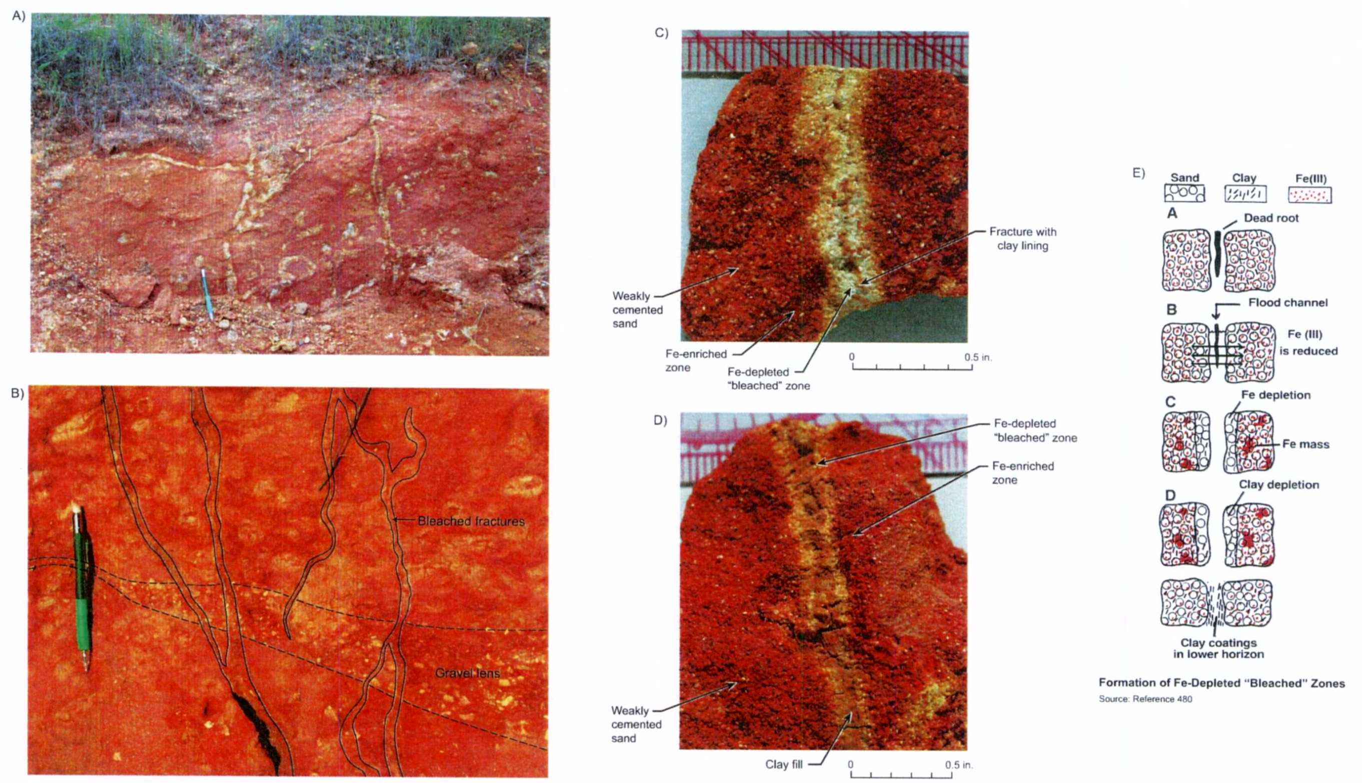
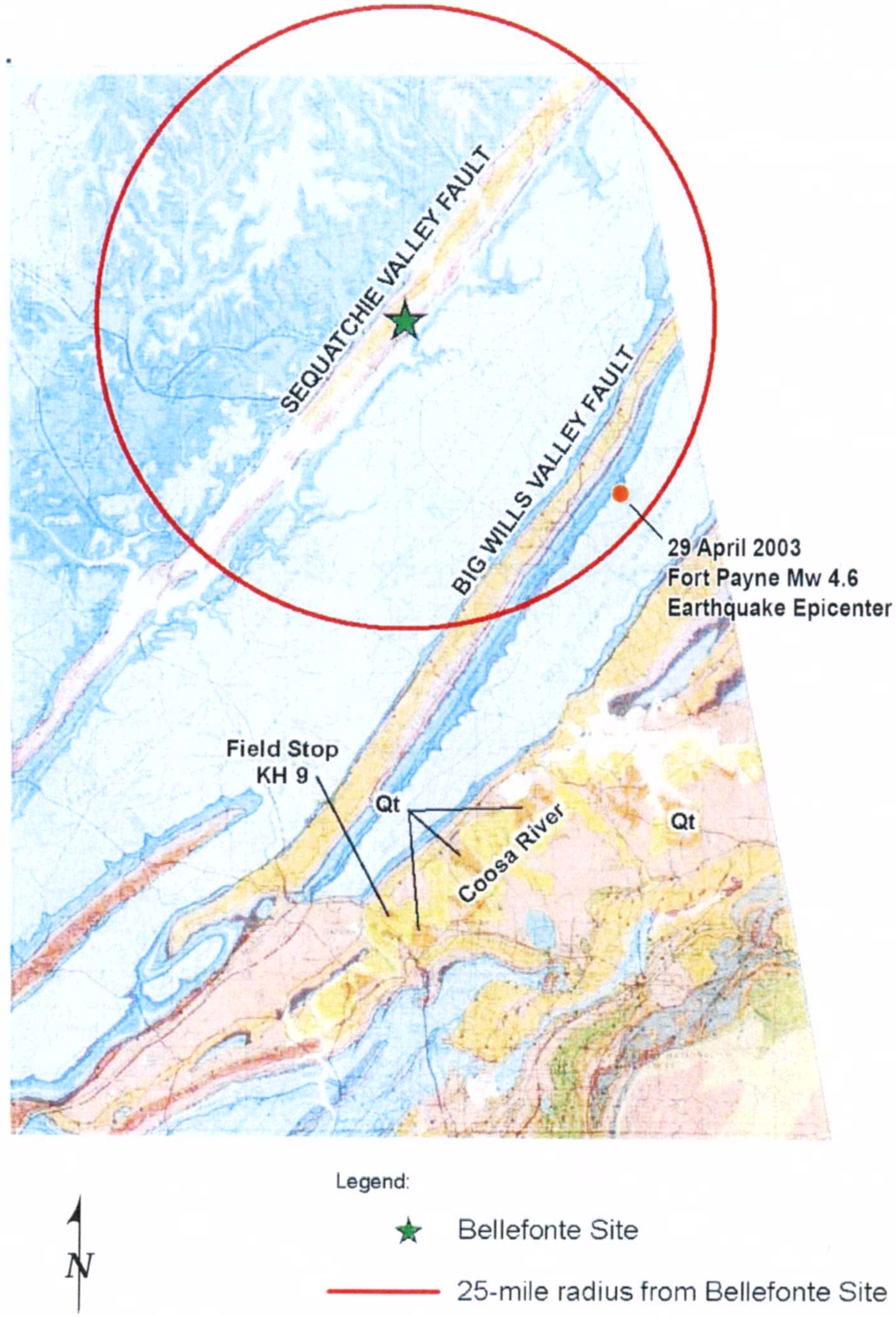


FIGURE 2.5-209
Soil Weathering Features in Pleistocene Terrace Deposits in Gadsden, Alabama

Attachment 02.05.01-01B

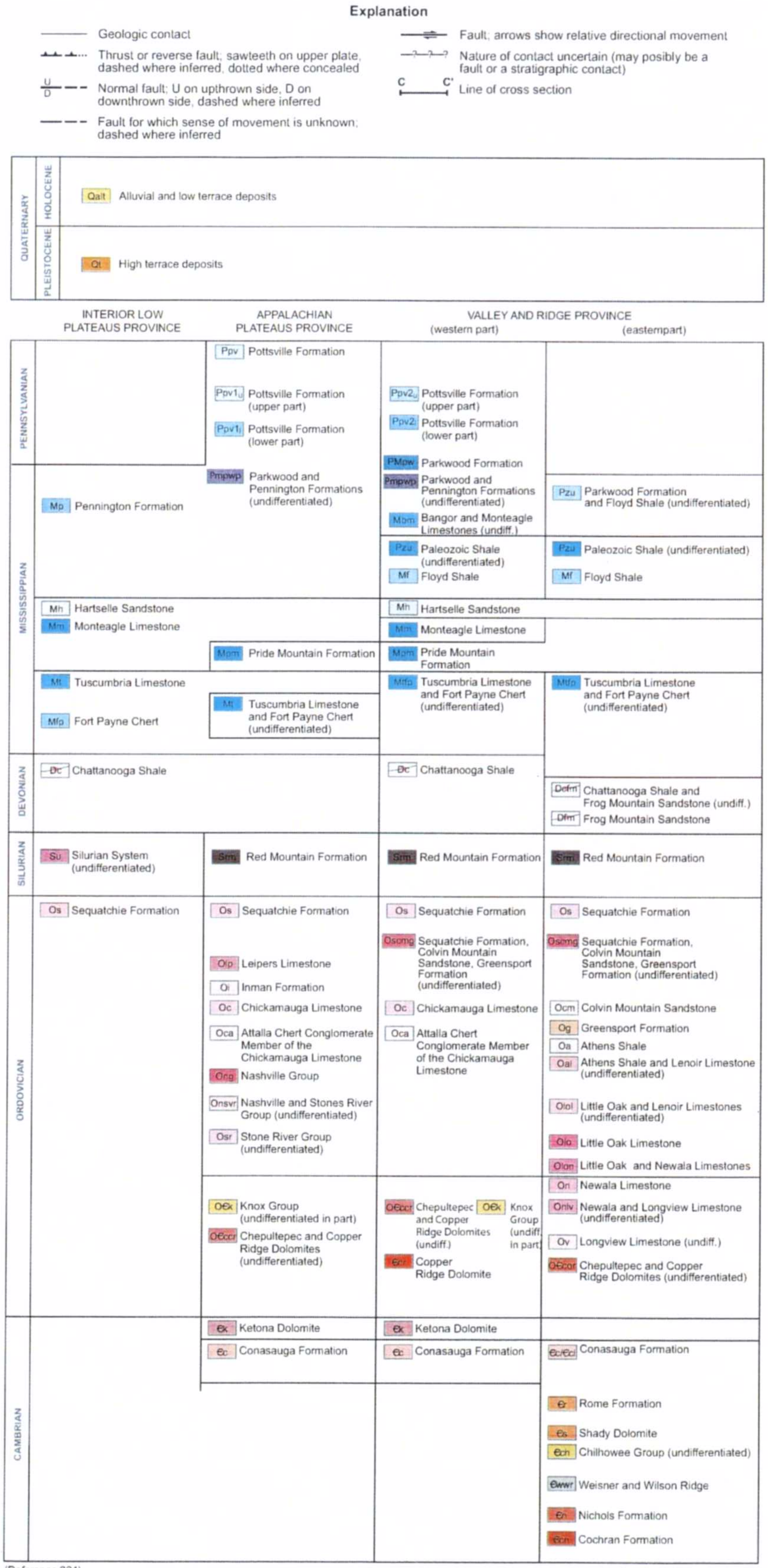
(3 pages including cover)

Renumbered FSAR Figure 2.5-208a and 2.5-208 b



(Reference 224)

FIGURE 2.5-208a
25-Mile Radius Geologic Map



(Reference 224)

FIGURE 2.5-208b
Explanation of Geologic Map Units and Symbols, 25-Mile Radius