LTSP Trenching Investigation

next slide:
San Simeon fault sites

San Miguelito and San Luis Bay faults

Los Osos fault
Edna fault
Wilmar Ave. fault
SAN SIMEON FAULT
Findings and Interpretations

• San Simeon Cove Exposures
  – 4 strands recognized in zone ≥ 120 m wide.
  – W to E: Monterey (Tm)/Careaga Fm. (Tc)/Franciscan (KJf).
  – Continues offshore ≥ 2 km SE.

• Borrow Pit Trenches
  – Boreholes indicate up to 6 strands present.
  – Trenches exposed one major strand that offsets wave cut platform in KJf down-to-the-west; clear evidence for second strand to the W.
  – Major strand dips steeply SW—strike rotates upwards from N36ºW at depth of 6.7 m to N22ºW near surface in trench T-3.
  – San Simeon fault is right-lateral strike-slip fault.

• Airport Creek Trenches
  – Both walls of Airport Creek channel show dextral deflection of 1.6 m.
  – Interpreted as one or two slip events.

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– Trenches exposed major near vertical fault with N40ºW strike and slickenlines plunging 6º to 7º SE.
– Vertical separation of 11 sedimentary layers with radiocarbon ages \(\leq 11,150\) years increases with depth—fault cuts base of A horizon.
– Major fault in T-1 has experienced multiple slips during the Holocene.
– Restoration of vertical separations on this one strand yield slip rate estimates \(~ 1\) to \(3\) mm/yr, a likely minimum value for the entire zone.
– Recurrence estimates on this one strand range from 600 to 1800 years.

• Oak Knoll Creek Trenches
– \(\geq 400\) m wide fault zone.
– Trenches exposed vertical fault with strike of N26ºW—slickenlines plunge 10º-15º NW.
– Isopachs on fluvial sand bed \(~ 5\) ka offset dextrally \(~ 1.2\) m across fault.
– Vertical separation of sedimentary layers does not increase with depth to a depth of at least 4 m below ground surface.
– Holocene active fault strand, but the lack of evidence for multiple slip events indicates it is a minor strand within the San Simeon fault zone.

LTSP Trenching Investigation
• **Summary**
  
  – The San Simeon fault is a complex zone of right-lateral strike-slip faults and is an onshore segment of the coastal San Andreas fault system that includes the Hosgri, Sur, and San Gregorio faults.
EDNA FAULT
Findings and Interpretations

• Trenching Sites in the Irish Hills Sub-Block

  – Pereira Site: Fault oriented N85ºW, 70ºS puts serpentinite on N against Vaqueros sandstone on S; sheared depositional contact, soil not affected.

  – Pereira Site: Fault not active—shearing could be flexural slip that occurred during folding of Pismo Syncline.

  – Andre Site: Shear within KJf mélangé trends N85ºW, 35ºN; subhorizontal Vaqueros sandstone deposited on KJf; soil not affected across shears.

  – Andre Site: Shear in KJf mélangé ancient, probably subduction-related.

  – George Site: Shear zone trending N65º-80ºW dipping steeply SW puts KJf mélangé on N against Vaqueros (?) sandstone and claystone on S; soil not affected across shears.

  – George Site: Fault not active—shearing could be flexural slip that occurred during folding of Pismo Syncline.
— **Avila Ranch Site**: Shear contact oriented N60°-65°W, 42°-63°SW separates overlying Obispo Fm. from underlying older colluvium derived from KJf mélange; younger colluvium and overlying soil not faulted.

— **Avila Ranch Site**: Obispo Fm.-older colluvium contact is landslide slip surface, not a tectonic fault.

- **Natural Exposures in the Irish Hills Sub-Block**
  - **Jeep Trail, Montana de Oro State Park**: Tilted wave-cut platform, multiple small scale faults and folds in overlying terrace deposits.
  - **Jeep Trail, Montana de Oro State Park**: Faults dip downslope; observed deformation due to slope failures, not tectonic faulting.
  - **Camp Keep, Montana de Oro State Park**: Multiple downslope-facing steps in marine terrace platform.
  - **Camp Keep, Montana de Oro State Park**: Multiple downslope-facing steps in marine terrace platform are landslide features.
— **See Canyon Road Cuts**: Several (8) moderate to steeply dipping, small NW-trending faults cutting older alluvium at elevation ~1000 ft. Older alluvium unconformably overlies the Miguelito Member of the Pismo Formation.

— **See Canyon Road Cuts**: Older alluvium may be of pre-Quaternary age; faults might reflect ancient landslide failures or could be tectonic features related to the structural evolution of the Pismo Syncline.

• **Summary**

  — Faults and shears exposed in both trench and natural exposures have two origins: slip that occurred during deposition and subsequent deformation of the Pismo Syncline, including uplift of the San Luis/Pismo block, and subsequent landslide failures within the uplifted block.

  — Faults within the Edna fault zone are not considered late Quaternary active, a conclusion supported by marine and fluvial terrace studies performed during the LTSP.
SAN MIGUELITO & SAN LUIS BAY
FAULTS—Findings and Interpretations

• Trenching Sites for the San Miguelito Fault
  – Bald Knob Site: Fault in T-1 oriented N46ºW, 90º to 70º NE juxtaposes Obispo Fm. on the NE against Squire Member of the Pismo Fm. on the SW. Slickenlines plunge gently (5º) SE. Fault strike rotates clockwise as it approaches the surface. Soil overlying fault is thin and unfaulted.
  – Bald Knob Site: In T-1 the San Miguelito fault is a right-lateral strike-slip fault of unknown but possible early Quaternary activity.
  – Mello Site: Fault oriented N78ºW, 37ºNE juxtaposes Obispo Fm. on the NE over Pismo Fm. on the SW; weakly developed striae plunge 33º towards N46ºE—the fault is truncated near the surface by a landslide. The overlying soil is affected by the landslide, not the fault.
  – Mello Site: The fault exposed here is an oblique slip fault (left-reverse), possibly related to folding of the Pismo Syncline, and may not be the main San Miguelito fault.
– **Golf Course Site:** Trench T-4 exposed a zone of sub-vertical faulting oriented N70ºW to E-W juxtaposes Pismo Fm. on the NE against Obispo Fm. on the SW. One mullion plunges 18º towards N70ºW. Steeply dipping NW-trending shears also exposed within Obispo Fm. Thin residual soil not affected by faulting. Faults not observed in late Holocene alluvium of San Luis Creek.

– **Golf Course Site:** The orientation of mega-mullions exposed in trench T-4 confirms that the San Miguelito fault at this site is a right-lateral strike-slip fault.

– **Mallagh Landing Site:** No shears encountered in trench, only unfaulted landslide deposits and colluvium.

– **Mallagh Landing Site:** Although LTSP studies found no obvious vertical dislocation of the marine terraces here, a strike slip fault like the San Miguelito fault, might not deform the terraces noticeably. However, no shearing was observed along the projected trend of the fault in the wave-cut platform at Pirate’s Cove.
• Natural Exposure of the San Luis Bay Fault at Mouth of San Luis Creek
  
  – Avila Beach Site: Fault exposed in stream and road cuts is oriented N70°W to N75°E and dips 25°-46°N. Mullions indicate predominantly dip-slip movement. Fault juxtaposes KJf bedrock over Squire Member of the Pismo Fm. and its slip has yielded 5 to 8.5 m of vertical separation across the local 120 ka wave-cut platform.
  
  – Avila Beach Site: The San Luis Bay fault is a thrust fault active in the late Quaternary.

• Summary
  
  – Although it is a strike-slip feature located near the SW boundary of the Irish Hills sub-block, the San Miguelito fault does not appear to be an active structure in the contemporary tectonic setting. LTSP studies have shown that marine terraces are not deformed where they cross its NW and SE on-strike projections.
  
  – The San Luis Bay fault is a late Quaternary active thrust fault that has apparent en echelon step-over geometry with the Wilmar Avenue fault to the SE, as well as comparable marine terrace deformation.

LTSP Trenching Investigation
LTSP Trenching Investigation
WILMAR AVENUE FAULT
Findings and Interpretations

• Sea Cliff Exposure at Pismo Beach
  – *Fault Orientation*: Exposed faults oriented N40ºW to E-W and dipping 45º-70ºNE define a zone 2 to 6 m wide—slickenlines and mullions are subparallel to fault dip.
  – *Stratigraphy*: The fault separates mid-Tertiary (Oligo-Miocene) deposits of the Rincon and Obispo formations in the NE (hanging wall) block from the Squire Member of the Pismo Fm. (Pliocene) in the SW (foot wall) block. Marine terrace deposits on the 120-ka wave-cut platform unconformably overlie the Tertiary section.
  – *Structural Features*: Near the fault, beds of the Squire Member are folded into an overturned syncline with locally developed bedding-parallel shears (*flexural slip faulting*) that cut the terrace platform.

LTSP Trenching Investigation
– **Fault Slip**: The 120-ka (Stage 5e) platform is vertically separated 6.4 m yielding an estimated late Pleistocene net slip rate of 0.04-0.08 mm/yr. Vertical separations of the overlying terrace deposits decrease progressively up section.

– **Type of Fault**: The Wilmar Avenue fault is a recurrently active, late Quaternary, SW-verging reverse fault.

• **Trench and Natural Exposures at the Farmboy Site (N of Hwy 101)**
  – **Hanging Wall Deformation**: 200 m of trench exposures and extensive cut slopes at the quarry site expose beds of the Squire Member folded into an anticline overturned to the SW. The beds are cut by many small conjugate shears that locally displace the 120-ka marine terrace platform. Main trace of Wilmar Avenue fault not exposed.
  
  – **Hanging Wall Deformation**: The overturned anticline is a fault propagation fold developed at the tip of a reverse/thrust fault. Conjugate shears within the Squire Fm. beds indicate the maximum compressive stress (sigma 1) is subhorizontal and directed along a subvertical plane striking N25ºE (i.e., ~normal to the fault strike).
• **Drainage Ditch at Farmboy Site (S of HWY 101)**
  – *Foot Wall Deformation*: 9-m-deep drainage cut exposes faulted 120-ka marine terrace platform carved across ~horizontal beds of the Squire Member. Main trace of Wilmar Avenue fault not exposed.

• **Synthesis of Farmboy Site Exposures**
  – *Fault Location*: The Wilmar Avenue fault lies beneath Highway 101 between the S end of the quarry and the N end of the ditch sites.
  – *Fault Slip*: Projecting the elevation of the 120-ka (stage 5e) platform between the two locations (with a seaward slope of ~ 1°), the platform is vertically separated 6.4 m across the inferred trace of the fault yielding a consistent net slip rate with the Pismo Beach sea cliff exposure.

• **Summary**
  – The Wilmar Avenue fault is late Pleistocene, NW- trending, SW-verging reverse fault forming the SW boundary of the San Luis/Pismo structural block.
LOS OSOS FAULT
Findings and Interpretations

• Trenching Sites in the Irish Hills Sub-Block (Irish Hills Segment)
  – Ingley Site: Fault in T-1 trends N62ºW, 80ºNE and juxtaposes KJf on NE against deformed Paso Robles Fm.; minor fault cuts latest Pleistocene soil. Stream cut exposes same fault oriented N48ºW, 43º-57ºNE that cuts Paso Robles Fm., but not overlying younger alluvium. T-2, located NE of T-1, exposed up-to-the-NE thrust faults oriented N54º-64ºW, 22º-29ºSW with slickenlines plunging 18º towards S60ºW; faults cut a buried A horizon soil.
  – Ingley Site: Fault exposed in T-1 and stream cut is similar to Ellsworth fault (see below) and may be Pleistocene active. The displaced buried A horizon in T-2, estimated to be 15-30 ka, has a total vertical separation of 2.0 + 0.4/-0.5 m for a vertical slip rate of 0.5-0.16 mm/yr. This NE-verging thrust fault is interpreted as the main Holocene active Los Osos fault.
– **Ellsworth Site**: Exposed fault trending N55°W and dipping 74°NE with dominantly dip-slip slickenlines that places serpentinite on the NE against fluvial deposits of the Paso Robles Fm.(?) on the SW; overlying soil unfaulted.

– **Ellsworth Site**: Lithologic juxtaposition opposite of that expected for the Los Osos fault. Relationships ay record strike-slip in the Pliocene overprinted by current compressional tectonic style, or the shear is a “backthrust” branching upwards within the hanging wall of the main Los Osos fault.

– **Cuesta Site**: Well-expressed scarps, springs, tonal lineaments and stream nick-points. T-2 exposed a fault oriented N30°W, 46°NE with down-dip slickenlines that place KJf on the NE against Paso Robles Fm. T-3 exposed four faults, three are NE dipping reverse faults and one is a thrust fault trending ~N55°W, 15°SW. Thrust penetrates the topsoil and truncates a late Holocene krotovina; the reverse faults do not cut the soil.

– **Cuesta Site**: Trenches here all excavated in hanging wall of Los Osos fault. Main zone of up-to-the-NW reverse/thrust faulting lies to NE. Only the thrust, which places colluvium over KJf, is Holocene active.

**LTSP Trenching Investigation**
• **Trenching Sites in the Edna Sub-Block (Lopez Reservoir Segment)**
  
  – **Guidetti Site**: Trench exposed a buried NE-facing escarpment of fluvial origin in Paso Robles Fm. **No tectonic faulting encountered.**
  
  – **Brughelli Site**: Trench exposed only depositional contacts with minor shearing within Obispo Fm. **No major faults encountered.**
  
  – **Glick Site**: One trench exposed Monterey Fm. (Miocene) thrust over overturned(?) beds of the Paso Robles Fm. (Plio-Pleistocene) by a fault oriented E-W and dipping 0º to 36º S. Overlying colluvium of late Holocene age not faulted.
  
  – **Lopez Reservoir Site**: Natural exposures here also revealed Monterey Fm. thrust over overturned beds of the Paso Robles Fm. by a fault trending N73ºW and dipping 50ºSW.
  
  – **Glick and Lopez Reservoir Sites**: These exposures establish that the SE end of this Los Osos fault segment has been active in the Pleistocene.
• **Summary**

  – The Los Osos fault is interpreted to be a zone of NE verging thrust/reverse faulting that forms the NE boundary of the uplifted Irish Hills sub-block.

  – The Los Osos fault is interpreted to be a zone of NE verging thrust/reverse faulting that forms the NE boundary of the uplifted Irish Hills sub-block.

  – Although the Lopez Reservoir segment of the Los Osos fault is contiguous with the Irish Hills segment, it is a poorly defined range-front fault that did not provide trenching data that could be used to directly quantify its late Pleistocene and Holocene slip rate and behavior during the LTSP investigation.
Source:
Source:
Figure 11. Detailed log of San Simeon fault strand exposed in northwest wall of Airport Creek trench T-1.

Source:
Quaternary deformation of the San Luis Range

Figure 7. Schematic geologic section across the Wilmar Avenue fault exposed in the sea cliff, Pismo Beach. Wave-cut platforms designated by the gravel lag are 120 ka based on faunal assemblage analyses of fossil samples on both sides of the main trace of the Wilmar Avenue fault. The platform on the downthrown side of the main trace of the fault may have been reoccupied during the 80-ka sea-level highstand. Depending on the age of the platform in this area, vertical separation of the 120-ka terrace across the fault ranges from 4.3 to 6.4 m.

Source:
Figure 9. Geologic map of the Cuesta, Ingley, and Ellsworth sites showing location of the Los Osos fault zone identified by Hall et al. (1979) and additional faults and fault-related features identified during this geologic investigation.

Figure 18. Diagrammatic log of Ingley trench T-2 showing the primary zone of thrust faulting within the southwest-dipping Los Osos fault zone. The fault clearly offsets and deforms late Pleistocene and Holocene alluvium. Slickensides show left-oblique reverse displacement.