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San Joaquin Hills thrust (Class A) No. 186

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Synopsis	Northeast-vergent blind thrust fault postulated to underlie the San Joaquin Hills in the westernmost Peninsular Ranges. Grant and others (1999) first proposed that a flight of emergent marine terraces flanking the San Joaquin Hills, and the general anticlinal structure of the San Joaquin Hills, are the surface expression of a contractional fault-bend fold that probably is the result of slip-partitioning along the southern Newport-Inglewood fault zone [127b]. Elevation of stage 5e marine terraces indicates an uplift rate of 0.21–0.27 mm/yr. Although their data and geomorphic analysis do not provide detailed constraints on the geometry of the San Joaquin Hills thrust (Grant and others 2000), Grant and others (1999) proposed a 20–30° SW-dipping fault plane. Grant and others (2002) reported that uplifted mid to late Holocene marine terraces along the coast and an uplifted marsh bench in Newport Bay were due to a large earthquake generated by the San Joaquin Hills thrust. Calibrated calendar ages of AD 1635–1955

	for the uplifted marsh deposits in Newport Bay, based on charred plant and shell material, constrain the age of the earthquake. Mueller and Ponti (2005) documented about 1 m of uplift (minimum) of the 12–18 ka Talbert aquifer along the north limb of the San Joaquin Hills thrust in the Newport Mesa.
Name comments	Grant and others (1999) first proposed that a blind thrust fault at depth is associated with uplifted marine terraces and fold structure of San Joaquin Hills. They named this fault the San Joaquin Hills thrust. **Fault ID:** Jennings (1994) and Jennings and Bryant (2010) do not depict this structure.
County(s) and State(s)	ORANGE COUNTY, CALIFORNIA
Physiographic province(s)	PACIFIC BORDER
Reliability of location	Poor Compiled at 1:350,000 scale. *Comments:* Location of fault from Qt_flt_ver_3-0_Final_WGS84_polyline.shp (Bryant, W.A., written communication to K.Haller, August 15, 2017) attributed to data provided by Grant and Runnerstrom (written communication to W. Bryant, 11/2/2001); at that time, they proposed three models. The first model (Model A, their weight of 20%) extends from –2 km to – 17 km, has an average dip of 30–35° SW. (27.5° to 44°), and truncates the Newport-Inglewood fault zone [127]. The second model (Model B, their weight 45%) is a modified backthrust of the Oceanside thrust (Rivero and others 2000), extends from -2 km to –8 km, dips approximately 23° SW., and truncates at the offshore Newport-Inglewood fault zone [127]. The third model (Model C, their weight 35%) extends from –2 km to – 17 km, dips approximately 45° SW., and is linked to the Newport-Inglewood fault system [127] (Grant and others 2000; Bender, 2000).
Geologic setting	The San Joaquin Hills are located in the northwestern Peninsular Ranges. The San Joaquin Hills predominantly are underlain by mid to late Miocene age marine sedimentary rocks, including the Topanga and Monterey Formations. The San Joaquin Hills are structurally complex due to regional uplift, folding, and faulting

	associated with northwest-striking Tertiary to Quaternary age faults including the Pelican Hill [137] and Shady Canyon faults (Barrie and others 1992). Grant and others (1999) consider the San Joaquin Hills to be the surface expression of a faulted anticline parallel to the Newport-Inglewood fault zone [127]. Grant and others (1999) interpret displacement on the San Joaquin Hills blind thrust as the result of partitioned strike-slip displacement and contractional shortening across the southern Newport-Inglewood fault zone [127]. Maximum displacement along the San Joaquin Hills thrust is not known.
Length (km)	33 km.
Average strike	
Sense of movement	Thrust *Comments:* Grant and others (1999) postulated a northeast-vergent blind thrust fault to account for coastal uplift and Quaternary folding in the San Joaquin Hills.
Dip	23-30° SW. *Comments:* 30° dip of fault is based on structural modeling by Grant and others (1999). Rivero and others (2000) imaged (seismic reflection) an offshore portion of the San Joaquin Hills blind thrust and reported an average dip of 23°.
Paleoseismology studies	
Geomorphic expression	San Joaquin Hills are the topographic expression of a northwest-trending anticline between San Juan Capistrano and Huntington Mesa. Uplifted flight of emergent marine terraces indicates late Quaternary and Holocene activity (Grant and others 1999, 2002). Figure 4 in Grant and others (1999) suggest that the active axial surface of the fault-bend fold affects the northeastern side of Newport Mesa, but there is no documentation to support the precise location of the axial surface. Newport Mesa is underlain by late Pleistocene shallow marine and fluviomarine deposits that range in age from Oxygen Isotope Stage 9 (300–350 ka) to Stage 5 (80–125 ka) (Guptil and Egli, 1986). Newport Mesa is folded into an east-dipping surface that is characterize by about 30 m of relief (Mueller and Ponti, 2005).

Age of faulted surficial deposits	Age of faulted deposits is poorly constrained. Best constrained data is for deposits and geomorphic surfaces that are deformed due to folding or uplift. Grant and others (2002) reported calibrated 14C calendar ages of AD 1635–1955 for uplifted marsh deposits in Newport Bay, based on charred plant and shell material. Uplifted marine terraces Grant and others associate with a pre-1855 earthquake have not been dated, but Grant and others assume their age to be mid to late Holocene (<6 ka), based on the relative position between current sea level and dated late Pleistocene terraces. Grant and others (1999) report structural contour isopach maps by Sprotte and others (1980) can be interpreted to infer that the Talbert aquifer, a latest Pleistocene to early Holocene (12–18 ka; Shlemon and others 1994, 1995) gravel deposit located in the Santa Ana Gap has been deformed due to displacement along the San Joaquin Hills thrust.
Historic earthquake	
Most recent prehistoric deformation	latest Quaternary (<15 ka) *Comments:* Grant and others (2002) infer that uplifted late Holocene marsh deposits in upper Newport Bay and emergent shoreline along southwestern flank of San Joaquin Hills indicates tectonic uplift due to an earthquake larger than M7 sometime between AD 1635 and AD 1855. Grant and others (2002) reported late Holocene marine terrace platform to be vertically displacement between 1 m and 3.6 m above the active shoreline. the timing of the penultimate event is not known. Mueller and Ponti (2005) reported deformation of the Holocene-Pleistocene boundary along the northern part of Newport Mesa, indicating about 1 m of uplift since onset of deposition of the early Holocene Talbert Aquifer.
Recurrence interval	
Slip-rate category	Between 0.2 and 1.0 mm/yr *Comments:* Grant and others (1999) reported an uplift rate of 0.21–0.27 mm/yr for the past 122 kyr, based on elevations of uplifted emergent marine terraces flanking the San Joaquin Hills anticline. Age of the uplifted terraces was established based on ^{230}Th dating of solitary corals from three localities (stage 5e and stage 7 terraces). Their preferred geometry to account for this

	Quaternary uplift is a 20–30° SW. dipping thrust fault. This input suggests a slip rate that would fall in the assigned category. Holocene deposits uplifted about 1 meter along the northern flank of Newport Mesa (Mueller and Ponti, 2005). This suggests an uplift rate less than the uplifted stage 5e terraces, although Mueller and Ponti noted that their CPT borings did not extend across the entire NE facing forelimb of the anticline, suggesting that the reported displacement is a minimum. Mueller and Ponti (2005) did not consider that regional uplift along the Pacific Coast (up to 0.14 mm/yr; Miller and others, 2009) to be a significant factor in the uplift rate for the San Joaquin Hills thrust.
Date and Compiler(s)	2017 William A. Bryant, California Geological Survey
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