

# 1987 ECUADOR EARTHQUAKES OF MARCH 5, 1987

**NEWS RELEASE:**

March 5, 1987  
Ecuador Earthquakes

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**BACKGROUND:**

The earthquakes which struck Ecuador on March 5, 1987 have proven to be of major engineering significance. An earthquake reconnaissance team from Cornell University, consisting of Esteban Crespo and Kenneth J. Nyman, has just returned with the first

engineering assessments of the earthquake effects. The earthquake reconnaissance mission was coordinated by Professor T. D. O'Rourke of Cornell. The mission was sponsored by the National Center for Earthquake Engineering Research and the Technical Committee on Lifeline Earthquake Engineering of the American Society of Civil Engineers.

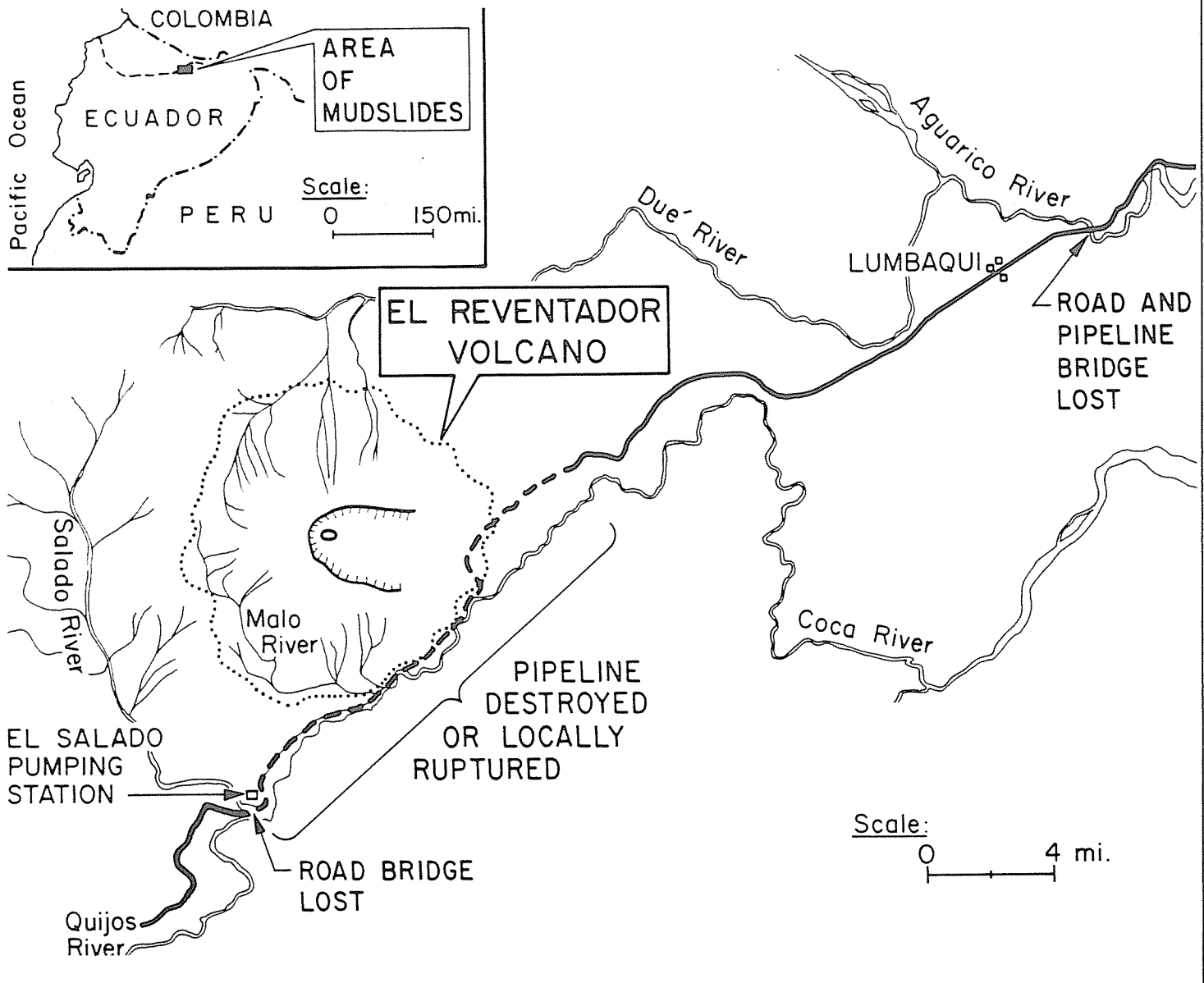




Fig. 1 Trans-Ecuadorian and Poliducto (white) Pipelines ruptured by debris flow and deep erosion along Coca River.



Fig. 2 Trans-Ecuadorian Pipeline damaged by debris flow and erosion. Note oil slick in upper left.

**OBSERVATIONS:**

The two earthquakes, which measured 6.1 and 6.9 on the Richter Scale, occurred at 8:55 and 11:11 p.m. EST, respectively, in the Napo Province of northeast Ecuador. The earthquakes occurred after a month of heavy rains, during which a total of 24 inches of precipitation was measured in the area of the earthquakes. The earthquake epicenters were located near an active volcano, El Reventador. Strong ground shaking triggered mudslides and rock avalanches near the volcano, involving over 100 million cubic yards of soil and rock. Landslide material

was washed into the surrounding rivers, causing them to swell with mud and debris. The swollen rivers flooded mountain roads and dwellings, leaving deposits of mud and saturated sediments as deep as 30 feet. The flooding and mudslides were responsible for most of the loss of life, which is estimated between 1000-2000 people.

Of major importance is the damage from mudslides to the Trans-Ecuadorian Pipeline. The failure of this facility represents the largest single pipeline loss in history. The Trans-Ecuadorian Pipeline is a 26-in.-diameter pipeline, which carries oil 260 miles from the Ecuadorian oil

fields east of the Andes Mountains to the port of Esmeraldas on the Pacific Ocean. The pipeline was commissioned in 1972. At the time of the earthquake, the flow rate was 250,000 barrels per day at an operating pressure of 1400 psi. The pipeline was of telescoping design and constructed of X-60 grade steel, ranging in wall thickness from 0.375 to 0.911 in. In all locations of damage, the pipeline was constructed as an above-ground facility, supported on 40-ft. centers by concrete pedestal foundations or double pipe piles with cross beams.

Approximately 6.5 miles of the pipeline have been completely de-

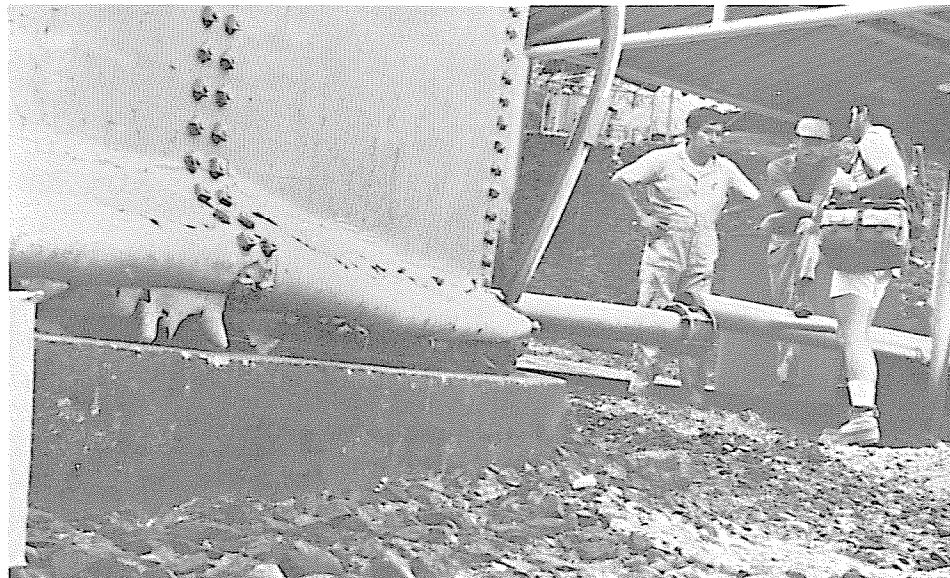


Fig. 3 Circumferential buckling and pipe pullout of water tank at Salado Pump Station.



Fig. 4 Collapsed unreinforced masonry structure at Baeza.

stroyed along the north bank of the Coca River east of its confluence with the Salado River. An additional 10 miles of the pipeline, east of the Malo River, have been damaged by local mud flows, which have severed the pipeline in at least eight places. Five miles of pipeline west of the Salado River have deformed, with significant distortion and displacement of above-ground pipeline supports. Approximately 30 miles west of the oil fields, the pipeline bridge across the Aquarico River was destroyed by flooding. The Aquarico River drains the north flanks of El Reventador, and was swollen with debris from the mudflow at the time of the bridge failure. The pipeline was pulled

off its supports over a distance of two miles west of this river crossing.

The Salado Pump Station, at the confluence of the Salado and Coca Rivers, was severely damaged. A landslide occurring uphill of the station toppled the main storage tank, spilling 4500 barrels of crude oil. All remaining structures sustained damage due to strong ground motions. Differential soil settlement across the site distorted all pump and power generator foundations, causing electrical power failure and overturning an elevated generator diesel storage tank. The fire wa-

ter tank buckled circumferentially with separation of all connecting lines, thereby rendering the emergency fire pumping system inoperable. A radio communications antenna used to transmit station operating information buckled and became inoperable. The personnel living quarters and mess hall facilities show severe cosmetic damage with some structural maintenance necessary.

An 8-in.-diameter natural gas pipeline, known as the Poliducto Pipeline, follows approximately the same route as the Trans-Ecuadorian Pipeline. It was destroyed and damaged at the same locations as the Trans-Ecuadorian Pipeline.





Fig. 5 Trans-Ecuadorian Pipeline deformed by broad debris flow into Coca River.



Fig. 6 Destroyed oil storage tank at Salado Pump Station. Landslide debris ruptured tank, spilling 4,500 barrels of crude oil over pump station.



Fig. 7 Damaged water storage tank at Salado Pump Station.

An unpaved one-lane road, which is the only vehicular route through the Andes from Quito to the eastern oil field, was lost in the areas of severe mudslides which damaged the Trans-Ecuadorian and Poliducto Pipelines. Two major Bailey Bridge crossings at the Salado and Aquarico Rivers were destroyed and washed downstream by the swollen river flows, occurring within two hours of the second earthquake.

The village of Baeza, located approximately 12 miles southwest of the epicenters, sustained structural damage and collapse of three reinforced concrete dwellings, with significant distortion of wood-framed structures. A large part of the town was evacuated to a temporary tent camp adjacent to the Baeza site. Villages in the mountainous region west of the epicenter sustained severe damage to dwellings constructed of adobe-panels.

No significant damage occurred in the capitol city of Quito, located approximately 93 miles southeast of the epicenters. Earthquake effects in Quito were primarily in the form of cosmetic cracking of concrete highrise apartment structures. There was no reported damage to water and sewer systems or support facilities. Electrical power was interrupted for approximately two hours due to proper functioning of emergency breaker switches within the power network. However, subsequent evaluation of power generating equipment by city engineers has indicated the possible need for maintenance due to minor displacements of machinery. Traffic was temporarily interrupted along the Panamerican Highway and other secondary roads north of Quito primarily by rock falls at vertical or near vertical cuts in cemented volcanoclastic deposits.

Loss of the Trans-Ecuadorian Pipeline has deprived the country of 60% of its export revenue. It contributed to a 9% increase in the world price of oil, which occurred during 4-6 March, 1987. The lost revenues and cost of reconstruction of this facility are estimated as \$1 to \$1.5 billion.