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EVIDENCE OF PAST SEISMS IN CUSCO (PERU) AND TZINTZUNTZAN (MEXICO): CULTURAL RELATIONS

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*Abstract :(**Evidence of ancient seisms in Cusco, Peru and Tzintzuntzan, Mexico and their cultural relations**) At first sight the ancient pre-Columbian cultures seem to have had no awareness of seisms. Purhepecha and Andean cultures nevertheless not only show awareness of these, but also similitude between their anti seismic building techniques. This work exposes clear evidence of coseismic ruptures found In Cusco and in Tzintzuntzan-Patzcuaro. More profound research could nevertheless be helpful to reveal sceneries which are for their most part unknown to current generations.*

Keywords: Archeoseismology, clamp structures, coseismic ruptures

Introduction

Anthropological studies of American cultures frequently reveal narrow cultural relations in the fields of language, art, building techniques, etc. (Ruiz 1978). The Mexican Purhepecha culture and the Incas of Peru are a clear example of these relationships. Despite the 5000km distance, authors have noticed striking similarities between these peoples (Fig. 1).

This work explains the prehispanic background that yields evidence of the similar tectonic scenery in which Inca and Purhepecha cultures found themselves. Both settled in a Pacific plate segment with strong seismic and volcanic activity. This situation certainly induced these cultures to find similar paraseismic techniques.

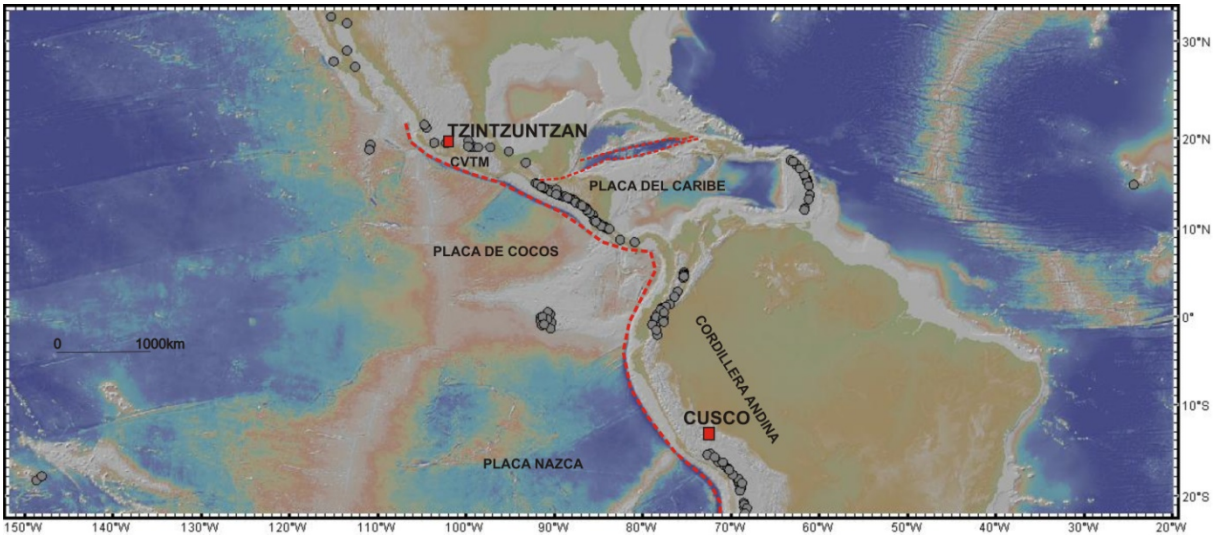

Fig. 1. Location of the Cuzco and Tzintzuntzan sites in a tectonic scheme. The grey circles represent volcanoes. The dotted red line stands for the limits of the plates.

The Inca culture

The Inca Empire extended through the eastern zone of the subcontinent (the Andean region) between the 15th and the 16th centuries. This was the period during which the Inca civilization reached its organization and territorial expansion climax. Their territory was known as Tahuantinsuyo, and its capital was Cusco. The empire covered nearly 2 million square km between the Pacific Ocean and the Amazon rainforest, and between San Juan de Pasto (Colombia) north and the river Maule (Chile) at the south.

The Inca civilization reached its cultural, technological and scientific development throughout a major part of the Andean region, which is characterized by abrupt altitude changes: in less than 100km, the Andes rise from sea level 4,600m asl. The reason for this sudden change is that the western edge of the continent is controlled by the subduction of the Nazca plate, underneath the South-American plate. Peru is therefore the scenery of much seismic activity.

The Purhepecha culture

This culture almost exclusively developed in the current state of Michoacán, between the river Lerma (north) and the river Balsas (south). Loma Alta is one of the most ancient stages of Purhepecha culture. This stage took place in Jaracuaro during the Classical period (500AD), but had its heyday during the Postclassical period (from 900 to 1500AD). Major development was to be found at the oriental shore of the lake of Patzcuaro with the development of the Purhepecha reign. The Purhepechas never submitted to the Mexicas and managed to control zones that reached Jalisco and Colima. They had, and still have, a language which is not related to the languages of central Mexico. Moreover, they developed a particular architectural style consisting of mixed plant

pyramids: rectangular and semicircular, called Yacatas. At least two great constructive periods remain of their capital center.

Historical seisms among the Incas

There is evidence that the Incas were many times laid down by earthquakes. This is the reason why they worked with such care and consistency to find and improve building techniques, until reaching their trapezoidal architecture with an antiseismic building system. This architectural technique has allowed the Inca buildings to stand through heavy seismic activity. According to historical data, the reactivation of different faults resulted in earthquakes in 1581, 1590, 1650, 1707, 1744, 1746, 1905, 1928, 1941, 1943, 1950, 1965, 1980 and 1986. The chronicles assert that many of these events heavily damaged and sometimes destroyed the city of Cuzco.

In order to broaden the seismic record of this region, we carried out neotectonics and paleoseimologic studies, because the historical and instrumental sources appeared insufficient to the achievement of research on the seismic dangers presented by the active faults of the Cusco region. Moreover, the main seisms could have been separated by major time lapses than those known by instrumental and historical records.

Seisms among the Purhepechas

The region in which the Purepecha Reign developed is situated in the active fault corridor that streches in E-W direction, called Morelia-Acambay in its oriental part. Geological studies reveal that huge earthquakes took place during the Pleistocene (2 seisms), one during the Recent Holocene, with possible M=6 magnitudes, as indicated by cosesimic ruptures.

Two other important seisms had affected the Patzcuaro area by the middle of the 17th century. Their origin remains uncertain. The 1858 earthquake is associated with intraplate subduction, but the isoseismal lines suggest a relation with the E-W faults of the Morelia-Acambay fault system. Superficial seisms have also occurred on these segments between 1912 and 1979.

Active faults in Cusco

The first results reveal two active fault systems: the Cusco fault system and the Vilcanota fault system. Both are formed by normal faults with evident quaternary and historical activity, similar to the Tambomachay faults (linked to the 1950 earthquake) and the Qoricocha fault (linked to the 1986 earthquake). These systems stretch along almost 100km (Figs. 2 and 3).

Fine stratigraphic studies were also carried out upon quaternary lacustrian deposits, in order to identify deformed sedimentary structures associated to seismic events: “seismites”. The result revealed a total of 37 seismic events. According to their appearance, these were provoked by earthquakes above 6.

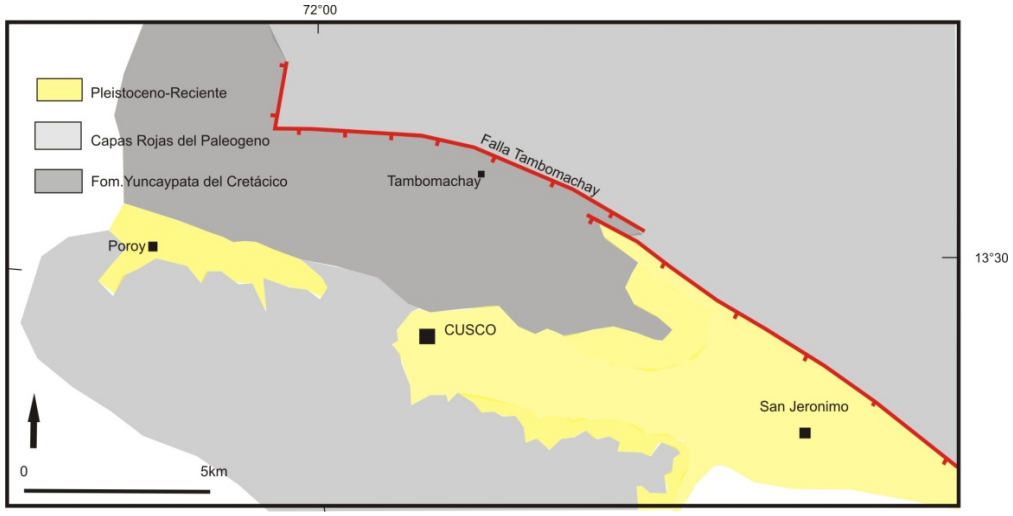

Fig. 2. Structural geology of the Cusco basin (Modified by Sebrier *et al.* 1985)

Fig. 3. Coseismic ruptures in the Cusco region

Active faults in Patzcuaro

The Patzcuaro lake is formed by volcanic and tectonic processes have played their part in its shaping. The tectonic process is more evident in the southern part of the lake, where a E-W normal fault system generates an alignment of volcanoes, avalanches-collapses and normal faults. The Patzcuaro-Jaracuaro graben developed on these active faults, which generated a rise of the bottom of the lake during the Pleistocene-Holocene, and ultimately formed the island of Jaracuaro, which means “place that appears” in Purepecha. Current paleoseismic studies reveal a seism posterior to 28,110, which caused the collapse of a whole sector of the El Estribo volcano. This collapse produced an avalanche due to a seism, the intensity of which was possibly of magnitude 7. On the other hand, coseismic ruptures in the trenches show fault scarps of approximately 70cm, possibly associated with magnitudes M=6 (Fig. 4).

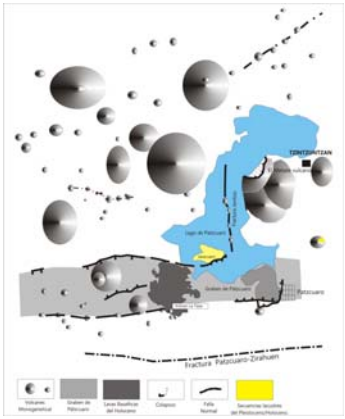

Fig. 4. Structural geology of the Patzcuaro -Tzintzuntzan lake, with visible E-W active faults.

Antiseismic architecture

With such seismic antecedents, both pre-Columbian cultures developed per force an awareness of geologic processes. It is remarkable that both used similar building techniques to protect their constructions from seismic attacks. This technique, called “Interlocking”, or “clamp structures”, has been found mainly at the base of the Yacatas, and here and there in the more recent constructions of Tzintzuntzan. These techniques have also been found in Cusco, yet presenting a different geometry.

A 

B 

Fig 5. Interlocking techniques used in Cusco (picture: Arturo Oliveros) (A) and in Tzintzuntzan (B)

Conclusions

These discoveries reveal the importance of archeoseismic studies both in Mexico (Patzcuaro-Tzintzuntzan) as in Peru (Cusco). These studies allow us to know the historical earthquakes which motivated the development of anti seismic techniques. The results are clearly visible in the structures presenting interlockingThese structures minimize the impact of earthquakes as far as horizontal movements are concerned. Interlocking structures have been found in Mitla, Oaxaca, Teotihuacan, State of Mexico an a few other sites of Maya culture.

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