GSA Data Repository Item # 8520

Title of article Holocene Rate of Slip and Tentative Recurrence Interval for Large Earthquakes on the San Andreas Fault, Cajon Pass, Southern California

Author(s) Ray J. Weldon II and Kerry E. Sieh

see GSA Bulletin v. 96, p. 793 - 812

Contents 3 pages

Figure A - Worst-Case Evaluation of the Slip Rate of the San Andreas at Cajon Creek

Worst-Case Evaluation of the Slip Rate of the San Andreas at Cajon Creek

In Figure A, the same data from which Figure 10 (in the text) has been constructed are presented without all of the inferences that have gone into constructing a reasonable geologic history. In Case No. 1, the channel in which Qoa-c was deposited could have accumulated some offset before the sediment was deposited in it. Also, the edge of the channel is defined by outcrops that could have been modified by later erosion by Cajon Creek and may not define the original channel shape exactly. Either of these unlikely scenarios would lead to less offset than was actually measured, making the slip rate a maximum.

Neither of these possibilities is likely. Had offset occurred before the deposition of Qoa-c, an upstream-facing bedrock protrusion would have formed and Cajon Creek would have eroded or, at least, beveled it. On the southwest side of the fault there is no evidence that the smooth curve of the pre-Qoa-c channel was disrupted until Qoa-c buried and, thereby, protected it from erosion. Since the onset of deposition of Qoa-c Cajon Creek has only been low enough to modify the Qoa-c bedrock contact immediately before Qoa-a was laid down. The edge of the bedrock has not been modified since before the small landslide east of Cajon Creek was emplaced (Fig. 9). Its offset of about 150 m indicates that the landslide occurred while the creek was near the Qt-5 level, long before the creek was low enough to modify the offset contact. Therefore, the bedrock edge must have been established immediately before Qoa-c as discussed in the text.

Case No. 2 has two possible problems; first, the rate of filling of Qoa-c, indicated by the radiocarbon dates, could change dramatically above the youngest date. The top of Qoa-c (Qt-1) is absolutely bracketed between 8350^{+950}_{-500} B.P. and 13.2 ± 1 ka, the age of the base of the sediments on Qt-3 and the youngest date in Qoa-c. These limits yield a rate between 20 and 41 mm/yr (Fig. A, 2a). Another possibility is that Cajon Creek remained at the Qt-1 level long after it reached that level. The offsets measured on features incised into Qoa-c could therefore be minimums, yielding a minimum slip rate of 20 mm/yr (Fig. A, Case 2b). Neither of these cases are likely because of the lack of any geomorphic evidence that the creek remained at the Qt-1 level for any period of time and the necessity of having to incise and form two terraces (Qt-2 and Qt-3) between the deposition of Qoa-c and 8350^{+950}_{-500} B.P.

Case No. 3 has two possible problems that are considered here. First, the sediments in Lost Swamp lie on both Qt-2 and Qt-3. The history of the swamp and the continuity of the sediments suggest that the dated lake clays were deposited after Qt-3 was abandoned, but it is possible that the sediments on the Qt-2 terrace surface are older than Qt-3. If so, the 8350^{+950}_{-500} B.P. basal sediments are bracketed by the Qt-1 offsets of about 290^{+30}_{-10} m and the Qt-3 offset of 200^{+35}_{-20} m, limiting the rate to 19-41 mm/yr (Case 3a, Fig. A). Even if all of Lost Swamp rests on Qt-2, another constraint can be added because the formation of Pink River cut off the flow down Qt-3 into the swamp (Fig. 7). The flow of streams carrying pink sand ended by 5900 $\pm$ 900 B.P. So Qt-3, across which these streams flowed, must be much older than 5900 $\pm$ 900 B.P. This observation places a 47 mm/yr maximum limit on the rate since the abandonment of Qt-3 (Fig. A, 3b).

It is inferred that the sedimentation on Qt-3 at Lost Swamp began immediately after the Qt-3 level was abandoned by Lone Pine Creek. As Pink River had not yet captured the drainage from the north, streams flowing across Qt-2 and Qt-3 to the future site of Lost Swamp must have continually provided water and sediment to fill the depression as soon as Lone Pine Creek abandoned the Qt-3 level. If some time passed before the lake clays began to accumulate, the 180-235 m offset of Qt-3 is a maximum. A maximum rate of 30 mm/yr can be calculated (Fig. A, Case 3c).

The only possible problem with Case No. 4 is the assumption that the sedimentation in the lake can be tied to the history of the streams that fed and drained it. Even if this causality is removed, the presence of pink sand in the fan on the edge of the swamp and mixed into the clay requires that some part of the lake predates the incision which isolated it from the flow from the north that delivered the pink sand. The incision is postdated by 145 ± 5 m, so a minimum of 15 mm/yr, based on the earliest age of the swamp, is calculated.

Because Figure A summarizes unlikely and extreme possibilities, the maximum additional error possible due to the discreteness of the slip events (estimated from the data in the excavation to be 300 years), has been added to all of the values. This assumes that all of the offset features formed immediately after earthquakes and that it has been 300 years since the last earthquake.

In summary, the "worst-case" analyses combine to suggest a slip rate of 20 to 28 mm/yr over the last 14,400 years because the combination of all of the "worst cases" require maximum or minimum rates that overlap in that range (Fig. A). This is not significantly different from the errors associated with the "best estimates". Only completely eliminating several of the cases or alternating changes in the rate can invalidate a slip rate of 20 to 28 mm/yr. However, if several of the "worst cases" are true, the inference of a constant slip rate is weakened.

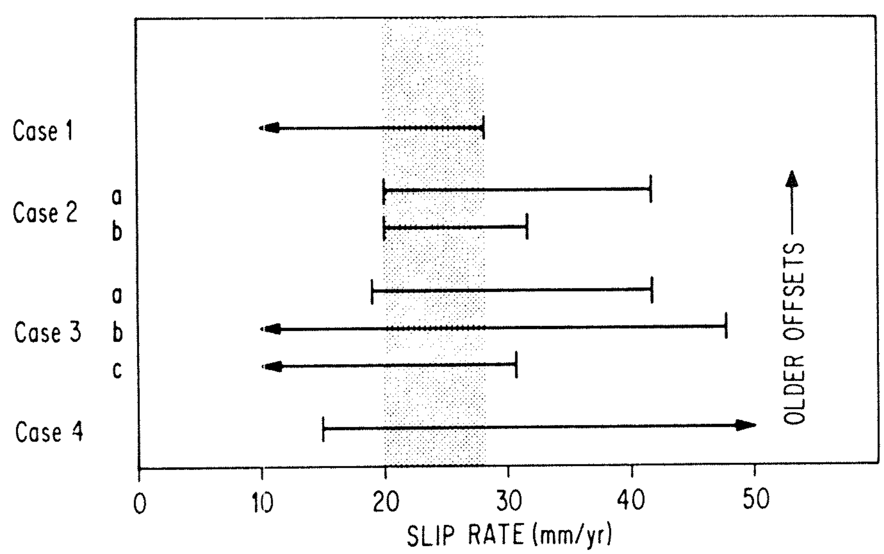

Fig. A