NEHRP FINAL TECHNICAL REPORT, 2001

USGS External Grants 01HQGR0051 (Goldfinger) and 01HQGR0046 (Nelson)

TITLE: COLLABORATIVE RESEARCH WITH OREGON STATE UNIVERSITY AND TEXAS A&M UNIVERSITY - HOLOCENE SEISMICITY OF THE NORTHERN SAN ANDREAS FAULT BASED ON PRECISE DATING OF THE TURBIDITE EVENT RECORD

Chris Goldfinger (PI)
COAS
Oregon State University (OSU)
104 Ocean Admin Bldg.
Corvallis, OR 97331-5503
(541) 737-5214
(541) 737-2064 (fax)
email: gold@coas.oregonstate.edu
Hans Nelson (PI)
Department of Oceanography
Texas A & M University (TAMU)
College Station, TX 77843-3146
(979) 458 1816
(979) 845 6331 (fax)
email: hans@ocean.tamu.edu

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Chris Goldfinger ,COAS, Oregon State University (OSU),104 Ocean Admin Bldg., Corvallis, OR 97331, ph.(541) 737-5214, email: gold@coas.oregonstate.edu, Hans Nelson,, Department of Oceanography, Texas A & M University, TAMU 3146, College Station, TX 77843-3146, ph.(979) 458 1816, hans@ocean.tamu.edu

ABSTRACT

Two piston cores and one box core from Noyo Channel, adjacent to the northern San Andreas Fault, show a cyclic record of turbidite beds, with thirty-one turbidite beds above a Holocene/Pleistocene faunal “datum”. Ages for 20 events including the uppermost 5 events from cores 49PC/TC and adjacent box core 50BC have been determined using AMS radiocarbon methods. The uppermost event returns a "modern" age, which we interpret is likely the 1906 San Andreas earthquake. The penultimate event returns an intercept age of AD 1663 (2 sigma range 1505 - 1822). The third event and fourth event are lumped together, as there is no hemipelagic sediment between them. The age of this event is AD 1524 (1445-1664), though we are not certain whether this event represents one event or two. The fifth event age is AD 1304 (1057 - 1319), and the sixth event age is AD 1049 (981-1188). These results are in relatively good agreement with the onshore work to date, which indicates an age for the penultimate event in the mid-1600's, the most likely age for the third event of ~ 1500-1600, and a fourth event ~ 1300. The good agreement in number of events between the onshore and offshore records suggests that, as in Cascadia, turbidite triggers other than earthquakes appear not to have added significantly to the turbidite record along the northernmost San Andreas margin during the last ~ 2000 years. We are encouraged at the close agreement with these preliminary data, and believe that this also supports our inference that the San Andreas is the principal, and perhaps only trigger for turbidites along this segment of the margin during the Holocene. Planned systematic coring in 2002 may be able to resolve the origins and event patterns through spatial and temporal correlations as it has in Cascadia.

We cannot yet confirm that the observed turbidite record is entirely earthquake generated, because at present we do not have the spatial sampling needed to test for synchroneity of events along the entire northern San Andreas fault. Consequently, during 2001 considerable effort was spent preparing and submitting an NSF proposal to fund a major month-long cruise to sample all the turbidite channel systems along the northern California continental margin. This proposal was funded by NSF to support the expensive and complicated oceanographic field work necessary for turbidite paleoseismology. Since receiving our funding, we have spent a significant

amount of time planning for our upcoming NSF/USGS sponsored cruise aboard the R/V Roger Revelle in June-July 2002. Among the 40 scientific staff, several USGS paleoseismologists from Menlo Park, California will participate in our cruise.

FY 2001 Investigations Undertaken

During 2001, detailed lithologic examinations of two piston cores and a box core from Noyo Channel were undertaken. Samples of hemipelagic sediment for high-resolution AMS radiocarbon ages were collected beneath most turbidite events (~ 40 events) in the 7 m cores. Even more biostratigraphic samples were taken from hemipelagic sediment of southern Cascadia Basin and Noyo cores to help establish a Holocene/Pleistocene boundary datum. In northern Cascadia Basin, the Holocene/Pleistocene boundary is distinct with both a sharp color (olive gray to gray) and faunal change (dominantly radiolarian to dominantly foraminiferal tests). In southern Cascadia Basin and Noyo Channel, the color and faunal change is transitional over a meter or more of deposits. Consequently, all the early Holocene/Pleistocene turbidite events were sampled for ages and hemipelagic sediment was sampled every several cm for detailed biostratigraphy in the southern Cascadia and Noyo cores. All these samples were processed for microfauna. The age samples were picked for planktonic foraminifera that were submitted to the Lawrence Livermore Laboratory for AMS radiocarbon dating. The foram and radiolarian ratios were analyzed in the micro-paleontology laboratory of Alan Mix at OSU. For these studies, Nelson made several visits to the OSU core repository for core description and sampling analyses. The principal investigators, and a Ph D graduate student Joel Johnson, have presented papers on preliminary results at AGU (Goldfinger et al., 2001a), SSA (Goldfinger et al., 2001c) and San Andreas earthquake hazards meetings (Goldfinger and Nelson, 2000). A detailed explanation of the turbidite paleoseismic method that we have developed in Cascadia Basin and that we will use for the San Andreas research has been submitted as a USGS Open File and Professional Paper (Nelson et al., 2002)

During 2001 considerable effort was spent preparing and submitting an NSF proposal to fund a major month-long cruise to sample all the turbidite channel systems along the northern California continental margin (Goldfinger et al., 2001d). Several reviewers commented that it was one of the best proposals they had ever reviewed for NSF. This proposal was funded by NSF to support the extremely expensive and complicated oceanographic field work. Since receiving our funding, we have begun planning for our upcoming NSF/USGS sponsored cruise aboard the R/V Roger Revelle in June-July 2002. A myriad of tasks to prepare for this cruise are underway as we complete FY 2001 tasks and transition into 2002. Recruitment of the science party and training students and participants in core logging, core analysis, GIS tasks, and multibeam mapping is underway at OSU and TAMU. We are gathering existing sonar, bathymetric, core, coastal river data and other data sets for incorporation into out GIS for the San Andreas fault. We have installed and tested a new digital line-scan camera attachment for the GeoTech Multi-track logger and are now confident that this system will provide exceptionally high-resolution imagery of the cores. This is critical, since some of the cores will be essentially destroyed by sampling for radiocarbon ages. We are analyzing river system discharge along the north coast to determine which of the channel systems are likely to be active, and which have been

abandoned following long-term displacement along the San Andreas fault. We are also researching radiocarbon methods further with respect to the use of benthic and planktonic foraminifera, for radiocarbon dating. The literature offers conflicting information which we may be able to resolve to some degree with our existing Cascadia core samples prior to the cruise.

FY 2001 Results

Two piston cores and one box core from Noyo Channel, adjacent to the northern San Andreas Fault, show a cyclic record of turbidite beds, with thirty-one turbidite beds above a Holocene/Pleistocene faunal "datum".

Thus far, we have determined ages for 20 events including the uppermost 5 events from cores 49PC/TC and adjacent box core 50BC using AMS radiocarbon methods. The uppermost event returns a "modern" age, which we interpret is likely the 1906 San Andreas earthquake. The penultimate event returns an intercept age of AD 1663 (2 sigma range 1505 - 1822). The third event and fourth event are lumped together, as there is no hemipelagic sediment between them. The age of this event is AD 1524 (1445-1664), though we are not certain whether this event represents one event or two. The fifth event age is AD 1304 (1057 - 1319), and the sixth event age is AD 1049 (981-1188). These results are in relatively good agreement with the onshore work to date, which indicates an age for the penultimate event in the mid-1600's the most likely age for the third event of ~ 1500-1600, and a fourth event ~ 1300. We presently do not have the spatial sampling needed to test for synchroneity of events along the northern San Andreas, and thus cannot determine with confidence that the observed turbidite record is entirely earthquake generated. However, the good agreement in number of events between the onshore and offshore records suggests that, as in Cascadia, turbidite triggers other than earthquakes appear not to have added significantly to the turbidite record along the northernmost San Andreas margin during the last ~ 2000 years.

With 20 event ages (and no reversals), we can begin to make some observations about the turbidite event history. It is apparent that both sedimentation rate and turbidite event frequency have not been constant through the Holocene. This may be due to: 1) The behavior of the fault has changed, for example more slip shifting from other parts of the plate boundary system to the main San Andreas in the late Holocene; 2) The record includes a non-earthquake climatic or sedimentation record that has changed through the Holocene. Climatic and sedimentation changes would tend to favor a reduction in sedimentation during the Holocene as sea level rose and separated canyons from their river sources, and terrestrial erosion rates fell. We observe just the opposite, with an increase in sedimentation rate that parallels the increase in turbidite frequency with time. This observation tends to support a change in fault behavior, however this issue cannot be resolved with our single sample site.

We observe three relatively constant periods in event frequency. The youngest period, from ~ 5000 years BP to the present has an average event recurrence interval of 216-234 years (depending on whether events 3 and 4 represent one or two events). These data are quite consistent with estimates of time intervals between recurrent northern San Andreas earthquakes at Pt. Arena and Olema. At Pt Arena, Prentice (1989) estimated a 200-400 year recurrence time, and the interval was estimated to be 221 years at Olema.

We are encouraged at the close agreement with these preliminary data, and believe that this also supports our inference that the San Andreas is the principal, and perhaps only trigger for turbidites along this segment of the margin during the Holocene. Planned systematic coring in 2002 may be able to resolve the origins and event patterns through spatial and temporal correlations as it has in Cascadia (Nelson et al., 2002).

Non-Technical Summary

Cores from the Noyo Channel on the ocean floor off northern California have been examined for sand layers. These sand layers are thought to represent times when great earthquakes on the northern San Andreas fault have shaken the continental margin, resulting in landslides that transport the sand down the channels. We have determined the ages of many of these sand layers, and these ages suggest that major earthquakes have occurred about every 225 years for the past 5000 years and perhaps at slightly longer intervals before that. However, many cores must be taken in other sea-floor channels to verify this preliminary record of earthquakes. We have obtained funding from National Science Foundation for a scientific cruise in July, 2002 to collect these new cores and verify the history of earthquakes.

Published Results

Goldfinger, C., C. H. Nelson and J. E. Johnson, 2000, Holocene Seismicity of Cascadia Subduction Zone Based on the Turbidite Event Record, Proceedings Volume of the 3rd Conference on Tectonic Problems of the San Andreas Fault System Sept. 6-8, 2000, Stanford University, School of Earth Sciences, or website http://pangea.stanford.edu/GP/sanandreas 2000/index.html, 3p.

Goldfinger, C., Nelson, C.H., and Johnson, J.E., 2001a, Temporal Patterns of Turbidites Offshore the Northern San Andreas Fault and Correlation to Paleoseismic Events Onshore: EOS, Transactions of the American Geophysical Union, v. 82, F934.

Goldfinger, C., C. H. Nelson and J. E. Johnson, 2001b, Holocene Seismicity of Cascadia Subduction Zone Based on the Turbidite Event Record, Seismological Society of America, v. 72, p.

Goldfinger, C., C. H. Nelson and J. E. Johnson, 2001c, Holocene Seismicity of the Northern San Andreas Fault Based on the Turbidite Event Record, Seismological Society of America v. 72, p.

Goldfinger, C., Nelson, C.H., and Johnson, J.E., 2001d, Collaborative Research: Holocene Seismicity of the Northern San Andreas Fault Based on Precise Dating of the Turbidite Event Record. Oregon State University, Texas A&M University, and the U.S. Geological Survey, Proposal submitted to the National Science Foundation, 25p

Goldfinger, C., Nelson, C.H., Johnson, J.E., 2001e, Holocene Seismicity of the Northern San Andreas Fault Based on Precise Dating of the Turbidite Event Record, Submitted to Science.

Nelson, C.H., and Goldfinger, C., 2000, Turbidite event stratigraphy: implications for Holocene Paleoseismicity of the Cascadia Subduction Zone and northern San Andreas Faults. EOS, Transactions of the American Geophysical Union, v. 81, p. 1224.

Nelson, C.H., Goldfinger, C., and J. E. Johnson, Gita Dunhill, Tracy L. Vallier, Michaele Kashgarian,M., Mary McGann,M, 2002, Turbidite event history: methods and implications for Holocene paleoseismicity of the Cascadia subduction zone, U. S. Geological Survey Open File and Cascadia Earthquake Hazards Professional Paper, (in review) 31p, 15 figs.

Availability of Data

All processed AMS radiocarbon age data is available in excell data tables. Analogue records of core lithologic data are archived at the OSU core repository where the cores are stored. Additional interpretive data of core logs are available in Adobe Illustrator files that reside at both OSU and TAMU. The general GIS data base of swath bathymetry, seismic profiles, core locations etc. resides at OSU. The contacts for all the aforementioned data sets are Chris Goldfinger (gold@coas.oregonstate.edu) and Joel Johnson (jjohnson@coas.oregonstate.edu) at the OSU addresses listed on the first page under Chris Goldfinger (PI).