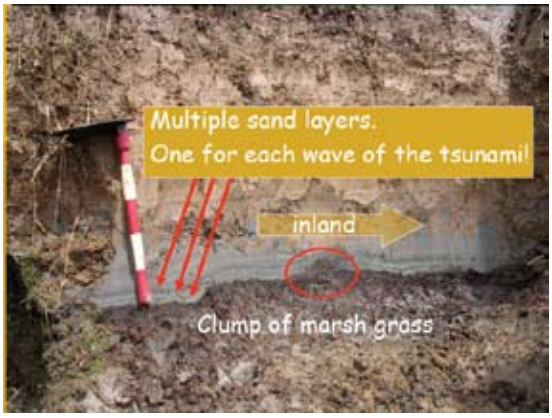
Activity— Cascadia Tsunami Geology Photo

In North America, the remains of sunken marshes and forests tell of Pacific Northwest earthquakes that lowered coasts by a meter or more. Sheets of sand (exposed outcrop in images below and described on next page) on the buried marsh and forest soils testify to associated tsunamis that ran across the freshly lowered landscape. In Japan, too far from North America for its parent earthquake to be felt, an orphan tsunami three centuries ago registered in the writings of samurai, merchants, and peasants. Their precisely dated accounts provide evidence that the most recent of the Northwest's great earthquakes occurred on January 26, 1700 at about 9:00 PM, and that this earthquake attained magnitude 9. Thanks to these and other discoveries, great earthquakes and their tsunamis can no longer take the Pacific Northwest by complete surprise.

Not just a dirt-layer outcrop..... but clues to a remarkable geologic story!

LEFT: *Poster-size photo from CEETEP Workshop of a cut bank where there is evidence of tsunamis, revealed by Brian Atwater..*

RIGHT*: Brief descriptions of what is visible in the layers as keys to processes (see next page). A Word document with labels is in this folder for students.*



The Orphan Tsunami *(Atwater and others, 2005) is reviewed by G.Pararas-Carayannis*: "A section of the book summarizes and interprets the significance of extensive geological findings and purported paleotsunami deposits (sand layers covering peaty soils) found by geological investigations along the shores of northern California, Oregon, Washington and British Columbia, as evidence that tsunamigenic earthquakes have occurred throughout geologic time along the Cascade Subduction Zone."* *(* From: Science of Tsunami Hazards, Vol. 24, No. 1, page 51 (2006))*

Background

For a "Who done it?" story of the field research behind discovering the M9 earthquake & tsunami of 1700, read the first 25 pages of Orphan Tsunami (page 18 on next page; link to book below.

Procedure:

Students observe large photo and try to decipher what the photo is showing. They need prerequisite knowledge of the mechanics of tsunamis with the down drop and incoming waves. After discussion, students then place pre-cut pieces from **Tsunami Cutbank Photo Cutouts.doc** (in this folder) and place on large tsunami photo to indicate the different things that the photo is showing.

Science Standards (NGSS; pg. 287)

- From Molecules to Organisms—Structures and Processes: MS-LS1-8
- Motion and Stability—Forces and Interactions: MS-PS2-2
- Energy: MS-PS3-5
- Waves and Their Applications in Technologies for Information Transfer: HS-PS4-1
- Earth's Systems: HS-ESS2-1, MS-ESS2-2, HS-ESS2-2, MS-ESS2-3
- Earth and Human Activity: HS-ESS3-1, MS-ESS3-2

Resources on this DVD for the tsunami of 1700

ANIMATION relevant to this topic are in the folders:

3. Cascadia Earthquakes & Tsunami >

2. ANIMATIONS Cascadia Earthquakes & Tsunami > ElasticRebound_Subduction.mov

BOOK: **3. Cascadia Earthquakes & Tsunami > 5. OTHER > Orphan Tsunami-Atwater**

Or on the internet: **http://pubs.usgs.gov/pp/pp1707/**

VIDEO: 9-minute OPB special about evidence for Cascadia tsunami:

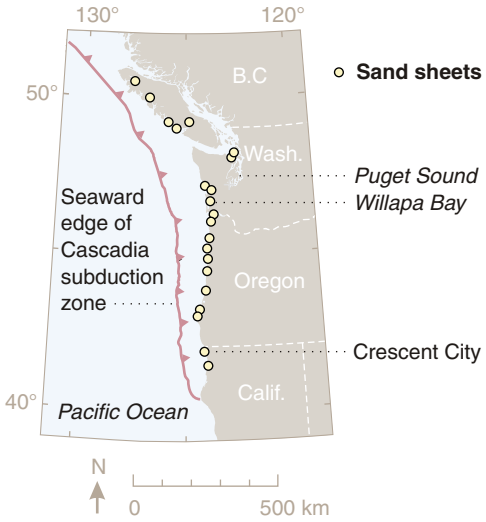
3. VIDEOS Cascadia Earthquakes & Tsunami > TsunamiUpdate_OregonFieldGuide_OPB.mov

Or on the internet: **http://www.opb.org/programs/ofg/segments/view/1715?q=tsunami**

Sand sheets 地層中の砂層

Tsunamis overran newly dropped land along Cascadia's Pacific coast.

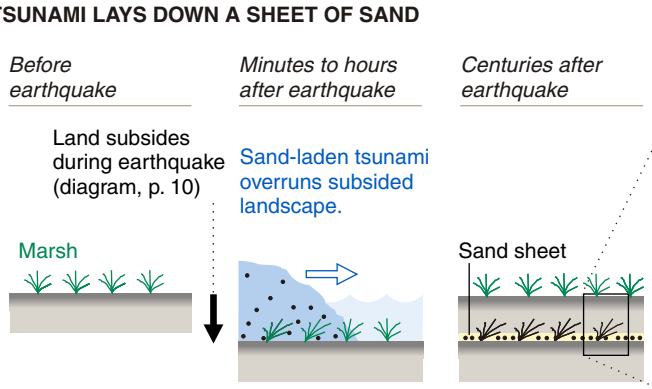
SIGNS OF CASCADIA TSUNAMIS

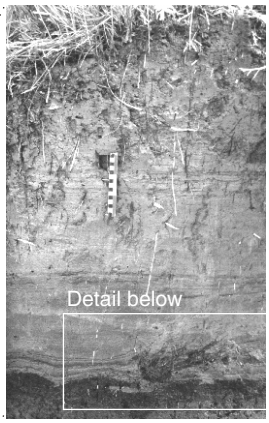


WHILE MAPPING Cascadia's signs of sudden subsidence, geologists in the 1980s and 1990s found associated evidence for tsunamis. That evidence consists of sand sheets beside bays and river mouths (dots on map, left). The sand came from the sea; it tapers inland and contains the microscopic siliceous shells of marine diatoms. Beside muddy bays the sand alternates with layers of mud (photos below) that probably settled out in lulls between individual waves in a tsunami wave train (modern example, opposite).

At most sites, the sand arrived just before tidal mud began covering a freshly subsided soil (cartoons below). Neither a storm nor a tsunami of remote origin explains this coincidence with subsidence. The simplest explanation is a tsunami from an earthquake in which a tectonic plate, in a seismic shift, abruptly displaces the sea while lowering the adjoining coast. The resulting tsunami then overruns the lowered land (cartoon, p. 10).

A TSUNAMI LAYS DOWN A SHEET OF SAND



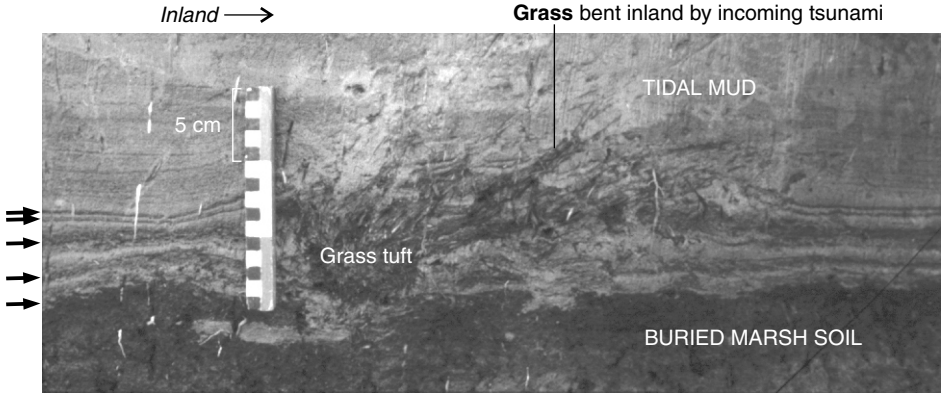


Mud deposited by tides since 1700. Contains coarse silt but lacks sand except just above a subsided, buried soil. Mud thickness, 80 cm

Buried soil of marsh that subsided in 1700

SAND SHEETS from tsunamis of great Cascadia earthquakes have been identified along Cascadia's Pacific coast (compilation by Peters and others, 2003) and at northern Puget Sound (Williams and others, 2005). Some cover archaeological sites (p. 20-21) and the floors of coastal lakes (Hutchinson and others, 1997). Constituents include microscopic marine fossils (Hemphill-Haley, 1996). Sand sheets in British Columbia record Alaskan waves of 1964 in addition to the 1700 Cascadia event (Clague and others, 2000).

A SMALL TSUNAMI on April 25-26, 1992, in northern California, provides further evidence that the Cascadia subduction zone generates tsunamis of its own. The parent earthquake, of magnitude 7.1, probably broke the Cascadia plate boundary near its southern end. The tsunami crested 0.5 m above tides at Crescent City, where it lasted eight hours (Oppenheimer and others, 1993).



Sandy layer, each the likely record of an onrushing wave in the tsunami train that began the evening of January 26, 1700 (inferred timing, p. 42-43). The sandy layers alternate with mud that probably records the slack water of crested waves.

Niawiakum River, Willapa Bay (Oyster locality of Atwater and Hemphill-Haley, 1997)

VIDEO: One-hour talk by Brian Atwater about the quest for tsunami answers in the Pacific NW:
http://www.iris.edu/hq/programs/education_and_outreach/distinguished_lectureship/past_speakers/atwater/video