# INFERRING EARTHQUAKE MAGNITUDE AND EFFECTS FROM GEOLOGICAL EVIDENCE

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Geological data can be used to extend the instrumented record of earthquakes in an area in order to obtain improved estimates of seismic risk. These data are particularly useful in regions where instrumental and written records are short, for example western North America.

Types of geological evidence left by past earthquakes include: (1) displacement and deformation of near-surface Earth materials, with accompanying surface rupture; (2) sudden land-level change; (3) tsunami deposits in coastal areas; (4) liquefaction features; and (5) coseismic landslides. Two or more types of evidence, as well as good chronological control, are generally required to make a convincing case for a prehistoric earthquake.

Geological archives of earthquakes are necessarily incomplete and consequently may be misleading. Typically, only the largest earthquakes that occur in an area are well preserved in the geological record. Most earthquakes do not displace the surface and do not produce tsunamis. And only large earthquakes produce significant coseismic land-level change and landslides large enough to remain in the landscape for more than a few thousand years. As a consequence, the geological record is strongly biased towards rare, large earthquakes with return periods of hundreds to thousands of years. Smaller earthquakes that are difficult to detect geologically may be more important from a seismic risk perspective than these large earthquakes.

The geological record of earthquakes, although incomplete, provides important insights into the likely effects of future moderate and large seismic events. For example, geological data may help identify areas that are vulnerable to liquefaction and tsunamis, and areas and critical infrastructure where ground motion amplification is likely to occur. Appropriate engineering design and emergency preparedness measures in areas of high seismic risk should thus consider geological data.

The magnitude of a prehistoric earthquake can be estimated, at least semi-quantitatively, from good geological data. Empirical relationships relate earthquake magnitude to the size and distribution of seismically formed clastic dykes. The amount and extent of coseismic uplift and subsidence are also closely related to earthquake magnitude. Geological data may permit a rough estimate to be made of the length and amount of slip along a fault plane during an earthquake, thus moment magnitude.