Introduction

What is an asperity?

An asperity (is an area on a fault that is stuck or locked. In the Earth, tectonic earthquakes are caused by slip along a fault plane, where two rock bodies are in rigid contact. The friction along the fault plane is not uniform in strength, so overall movement involves slip on one or more asperities, or “stuck patches” where the friction is highest. Most of the energy that is released by earthquakes comes from the patches that become “unstuck.”

More About Asperities*

Total fault offset accumulates through time in an uneven fashion, primarily by movement on first one, and then another section of the fault. The portions of the fault that produce great earthquakes can remain “locked” and quiet for one hundred or more years, while the strain is building up; then, in great lurches, the strain is released, producing a great earthquake.

Asperities, which may be caused by roughness, or protrusions on the fault, act like welded contacts between the sides of the fault. Younger faults have rougher surfaces with more asperities. As a fault repeatedly ruptures, the asperities can be worn down, creating fault gouge and smoothing the fault. The gouge material often decomposes to a fine clay and forms a thin layer which “greases” the fault for easier sliding. Fluids can also facilitate slip by reducing the normal stress on the fault.

The San Andreas Fault is actually a fault system that is more than 800 miles long and the seismically active portion extends to depths of at least 10 miles within the Earth and ranges from a few hundred feet to a mile or more wide. It doesn’t slip all at once, but rather, earthquakes jump around on it as local asperities break. On some stretches of some faults, however, such as around Hollister on the Calaveras fault, date movement occurs primarily by constant repeated creep events rather than by sudden earthquake offsets. In historical times, these creeping sections have not generated earthquakes of the magnitude seen on “locked” sections.

The dynamics of fault rupture are complex, but general fault behavior can be explained with a simple model in which slip promotes fault weakening.

Fault slip occurs in three stages:

1) initiation of sliding on a small portion of the fault,
2) growth of the slip surface, and
3) termination of slip and fault healing. Earthquakes occur on preexisting faults operating in a “stick- slip” mode. Earthquakes are “slip” episodes; they are followed by periods of no slip (“stick”), during which elastic strain increases away from the fault. Although some growth of the fault may occur with each earthquake, we can generally assume that for large earthquakes (M>6) the faulting process primarily involves repeated breaking of the same fault segment rather than creation of a new fault surface.”

---

*From “Can Earthquakes be Predicted?” by Michelle Kathleen Hall-Wallace
**Vocabulary**

**Asperity**—literally “roughness. It is an area on a fault that is stuck or locked. A type of surface roughness appearing along the interface of two faults. Physics the elastically compressed region of contact between two surfaces caused by the normal force.

**Elastic strain**—Earthquakes are caused by the sudden release of energy within some limited region of the rocks of the Earth. The energy can be released by elastic strain, gravity, chemical reactions, or even the motion of massive bodies. Of all these the release of elastic strain is the most important cause, because this form of energy is the only kind...

**Fault plane**—The plane along which the break or shear of a fault occurs. It is a plane of differential movement, that can be vertical as in a strike slip fault or inclined like a subduction zone fault.

**Fault zone**—Since faults do not usually consist of a single, clean fracture, the term fault zone is used when referring to the zone of complex deformation that is associated with the fault plane.

**Strain**—Strain is defined as the amount of deformation an object experiences compared to its original size and shape. For example, if a block 10 cm on a side is deformed so that it becomes 9 cm long, the strain is (10-9)/10 or 0.1 (sometimes expressed in percent, in this case 10 percent.) Note that strain is dimensionless.


**Stress**—Stress is defined as force per unit area. It has the same units as pressure, and in fact pressure is one special variety of stress. However, stress is a much more complex quantity than pressure because it varies both with direction and with the surface it acts on.


**Tectonic earthquake**—an earthquake that is due to the movement of the tectonic plates. Tectonic earthquakes will occur anywhere within the earth where there is sufficient stored elastic strain energy to drive fracture propagation along a fault plane. Other earthquakes can be caused by blasts.