PEBBLE WATCH *explores*

A series of fact sheets on topics related to potential Pebble mine development.

About Pebble Watch

The Pebble Watch team consists of scientists and science communicators who can research and answer your questions about potential Pebble mine development—from science reports to permitting. Write staff@pebblewatch.com.

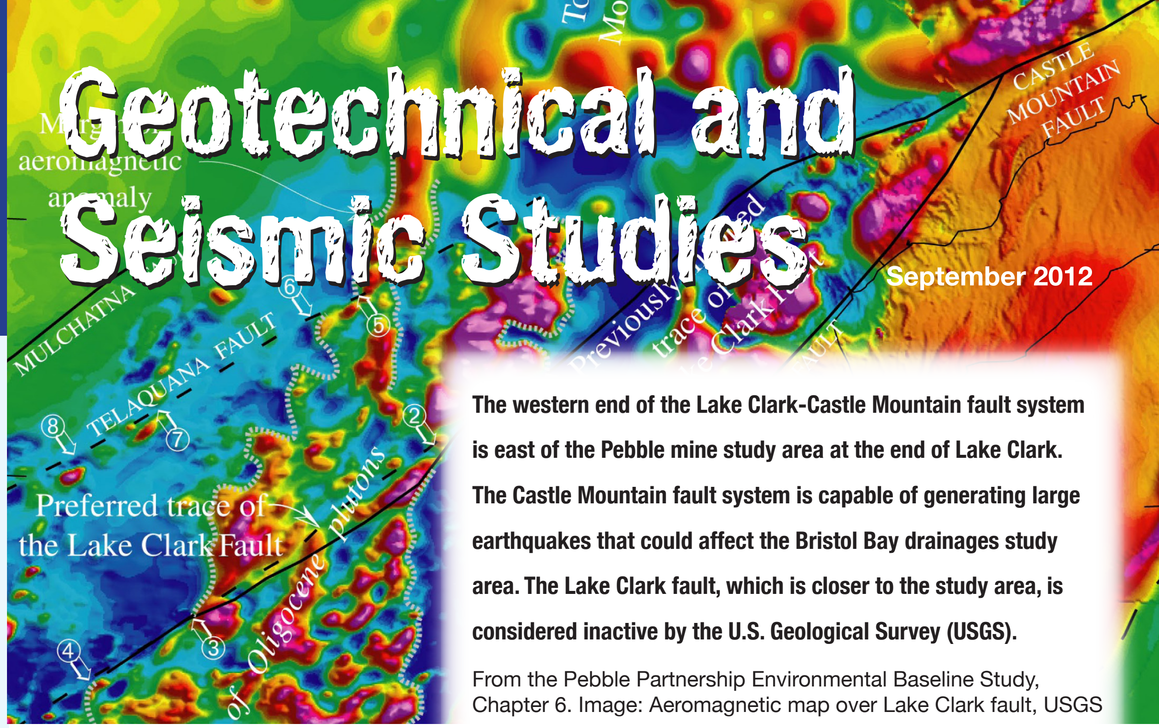
Geotechnical/seismic studies and permitting

The State of Alaska has a dam safety program requiring permits for dam construction: *A Certificate of Approval to Construct, Modify, Remove or Abandon a Dam,* and *Certificate of Approval to Operate a Dam*. Both require submission of engineering plans and reports and periodic safety inspections.

Pebble mine developers will be required to show that tailings dams will be safe. They must provide detailed calculations of how groundwater will move and fluctuate, explain how they will monitor the water levels and show detailed analyses of soil and rock stability. They must also show that they have done a thorough job of evaluating the potential for any seismic activity, and that they have designed the dam to withstand the most severe earthquake that could be possible in the dam area according to detailed evaluations by the mine company and responsible public agencies.

Geotechnical and Seismic Studies

September 2012



The western end of the Lake Clark-Castle Mountain fault system is east of the Pebble mine study area at the end of Lake Clark. The Castle Mountain fault system is capable of generating large earthquakes that could affect the Bristol Bay drainages study area. The Lake Clark fault, which is closer to the study area, is considered inactive by the U.S. Geological Survey (USGS).

From the Pebble Partnership Environmental Baseline Study, Chapter 6. Image: Aeromagnetic map over Lake Clark fault, USGS

What do geophysicists and seismologists study?

Geotechnical studies focus on the location and properties of bedrock and soils of an area and the water contained within them. They help to characterize (describe) the stability of soils and rock, as well as how groundwater may move through them. Seismic investigations describe ground motions that occur within the bedrock during an earthquake, and evaluate the likelihood of large earthquakes in the region.

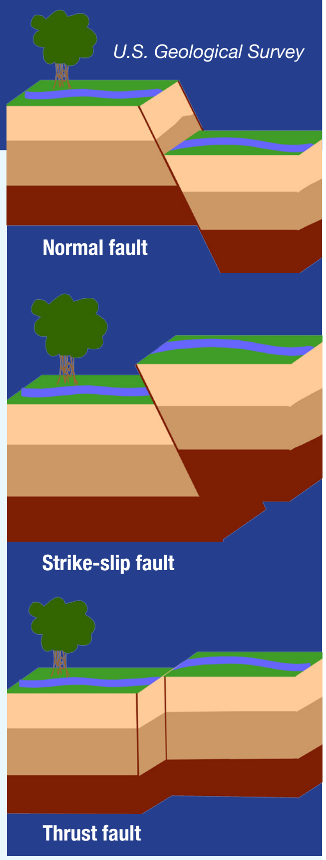
How does it relate to the Pebble mine discussion?

To design safe mine and pollution containment systems, developers must have a thorough understanding of the stability of soils and rocks in the mine area, as well as how water levels may change as water moves through the materials. Mining involves creating embankments and dams to contain waste rock—called tailings—in ponds or other holding systems. Such dams must be designed to withstand earthquakes. Mine excavation also involves the creation of steep slopes, which have potential to slide and fail, depending on the type of rock and soil material involved, and how the mine is designed. Proper design, which considers all of the geotechnical aspects of affected materials and water bodies, is crucial for preventing pollutants from escaping into the surrounding environment.

Because mining activities involve the removal of massive amounts of material, there is potential to raise or lower the water table. This can affect surrounding wetlands and water bodies, as well as how often floods occur, potentially affecting the stability of tailings dams. Therefore, mine design warrants a thorough analysis of how and where water is contained within the rocks and soils, and how mining may change these waters.

Earthquakes also can trigger slides and cause failure of containment systems. Ground movement can cause liquefaction, where water-logged soil loses its structure and becomes liquid, so that it can no longer support the weight of buildings or other structures.

What is a fault?



The Earth's crust is made up of several large pieces of rock called tectonic plates. As these plates move against each other, it can cause a fracture in the crust. If the bedrock on either side of this fracture is offset, it's called a fault. There are three main types of faults: normal, strike-slip and thrust. Stresses can build up along faults over time and eventually lead to earthquakes.

Geologists can see where faults exist by mapping the rocks and looking for offsets of geologic patterns. By studying the ages of these offsets, scientists can determine how recently movement occurred along the fault. A fault is considered active if movement has occurred within the time since the last glacial advance (the amount of time may vary depending on the region), or if there is a continuing record of very small earthquakes. However, earthquakes have occurred along faults once thought to be inactive. For example, in 1994 a magnitude 6.7 quake struck Los Angeles and in 1999 a magnitude 7 quake fractured part of the Mohave Desert. Both were located on faults considered to be inactive.

Findings from the Pebble Partnership's Environmental Baseline Document (EBD)

Between 2004 and 2008, scientists dug five 10-foot test pits and also collected cores from holes ranging in depth from 100 feet, for researching the top layers, to 500 to 5,000 feet for bedrock. They measured water pressure and conducted geophysical surveys to characterize bedrock layers deep below the earth's surface. Researchers also conducted a review of historical and scientific reports relating to regional earthquake history. They conducted site investigations only at the mine site, not the transportation corridor.

Bedrock and water – Results of the field investigations showed that bedrock lies from 10 feet to 250 feet below the surface in most of the mine area. The water table ranges from being close to the surface to about 200 feet below. Water moves slowly through most of the rocks and soils within the mine area. (More detailed analysis of groundwater appears in Chapter 8 of the EBD.)

Earthquake potential – The report presents the potential of a large earthquake (larger than magnitude 8 to 9) off the coast of Alaska due to movement of the Earth's plates. Scientists estimate the frequency of such earthquakes to be about every 650 years. But other earth movement may be more frequent along faults such as the Lake Clark-Castle Mountain fault system northeast of the mine area.

Researchers suggest the Lake Clark fault does not cross under the mine area, citing literature and 2007 research that found no surface evidence of fault activity in the mine area, and a hypothesis that the location of the fault is associated with the direction of glacial advance. In 2011, based on studies showing no movement since the last glacial period, and no earthquakes along the fault in the last 1.8 million years, the U.S. Geological Survey (USGS) classified the Lake Clark Fault as "inactive."

The Castle Mountain fault is active, however, and capable of earthquakes larger than magnitude 7 within the next 50 to 70 years. A 5.7 earthquake occurred along this fault in 1994, and another measured 4.6 in 1996. Two other smaller faults exist north of the Lake Clark fault, and the region could be affected by other faults farther from the region. However, the authors state they are not concerned with the seismic hazards from these faults because ground accelerations generated by earthquakes decrease with distance from the epicenter.

Want more detail? Find a link to the entire EBD report, as well as additional reading at www.pebblewatch.com.

Pebble Watch questions

Many federal agencies use risk analyses to evaluate earthquake risk to industrial applications. Have Pebble developers completed any risk analyses for this area?

The EBD acknowledges that an earlier mapping of the Lake Clark fault showed the fault ending because there was no bedrock exposed to study. What field investigations have confirmed that the Lake Clark fault is inactive and does not pass through the mine area?

Could movement along the Castle Mountain fault affect the connected Lake Clark fault, even though it has been classified as inactive? Has this possibility been studied?