



## **Lessons Learned From the Analysis of the SAFOD Downhole Instrument Package.**

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In September of 2008 a downhole instrument package (DIP) consisting of a string of seismometers and tilt meters in isolated pressure vessels (PODs) was installed in the SAFOD main borehole. This package was designed to protect the sensors from the corrosive borehole environment and to operate for two years. The SAFOD borehole is not sealed at the bottom allowing borehole gasses and fluids infiltration. Previous short-term installations of instruments in the SAFOD main borehole had also failed as a result of corrosion of the wireline cable head. The average failure time for these installations was two weeks. The use of stainless steel tubing connected to the pressure vessels through gas tight fittings was designed to block borehole fluid and gas infiltration of the individual instruments within the PODs. Unfortunately, the DIP completely failed within a month of its installation. In October of 2010, the DIP was removed from the borehole and a failure analysis was performed. This analysis involved to following steps:

1. Analysis of data to understand timeline of failure
2. Remove instrument safely, maintaining integrity of spliced section and documenting any external clues. Test instrument at surface
3. Open PODs in a way that allows for sampling and avoids damaging instruments.
4. Chemical analysis of fluids recovered from splices and PODs.
5. Instrument failure analysis by the instrument manufacturers.

The analysis found that there were several design flaws in the DIP. This included the use of motor oil to take up air space in the individual PODs, use of a large number of gas tight seals, lack of internal seals, poorly done solder joints, use of non-temperature rated sensors, and lack of management oversight. The lessons learned from the attempts to instrument the SAFOD borehole are critical to the success of future deep borehole projects.