Eliminating Quartz Pressure Sensor Drift Using A-0-A

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Abstract:

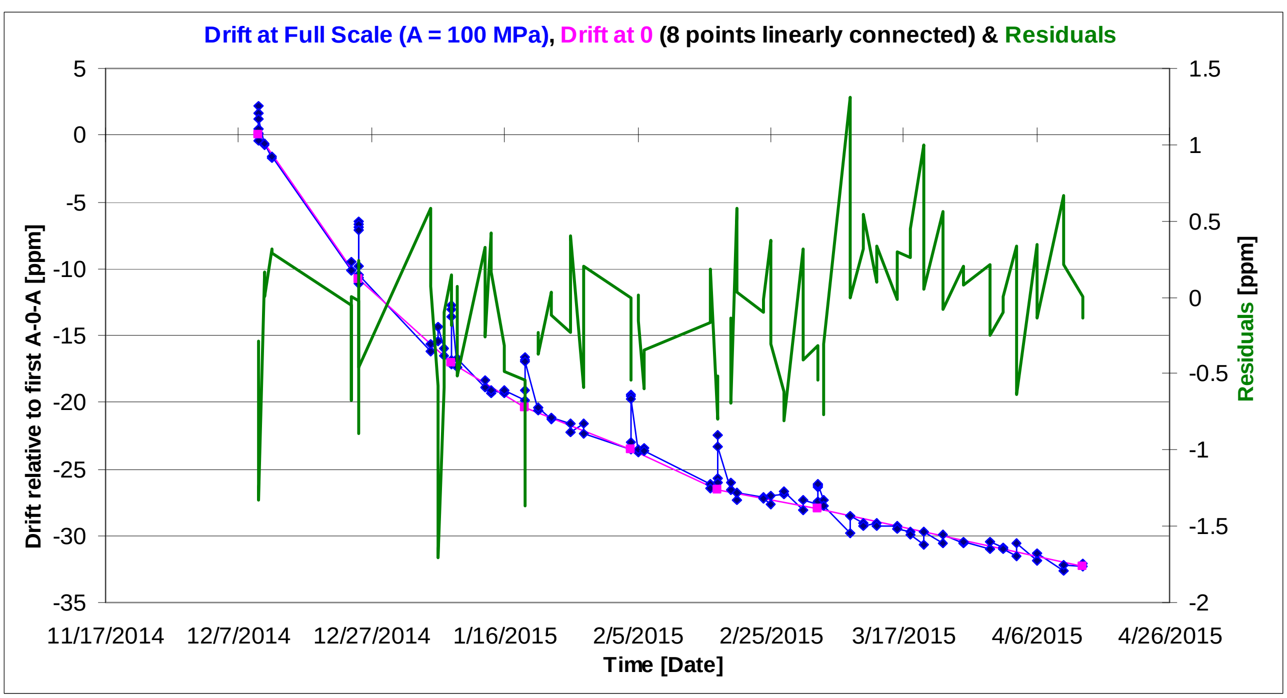
Digiquartz® Pressure Sensors can be recalibrated in-situ by periodically venting from ocean pressures (A) to the ambient pressure (0) within the system housing. Simply subtracting the drift at 0 from the measured ocean depth readings, A, eliminates sensor drift to a few parts-per-million (ppm) of full scale with a standard deviation less than 1 ppm. The new in-situ calibration method, A-0-A, is a precise means of distinguishing real seafloor movements from sensor drift.

Background:

Hundreds of thousands of pressure sensors, accelerometers, tiltmeters, temperature sensors, scales, etc. have been produced with our Resonant Quartz Crystal Technology. Thousands of the pressure sensors have been stability tested at atmospheric pressure, 0, in our laboratory. It is possible to make accurate laboratory measurements of sensor drift at atmospheric pressure to 1 part-per-million of full-scale by comparing the outputs to our barometers. However, making accurate laboratory measurements of drift under high pressure, A, is challenging and has only recently been done to 1 ppm precision at the National Metrology Laboratory of Japan-AIST. The work on their 0-A-0 metrology calibration methods has led to improved mathematical models of stability and the development of the new A-0-A in-situ seafloor calibration methods.

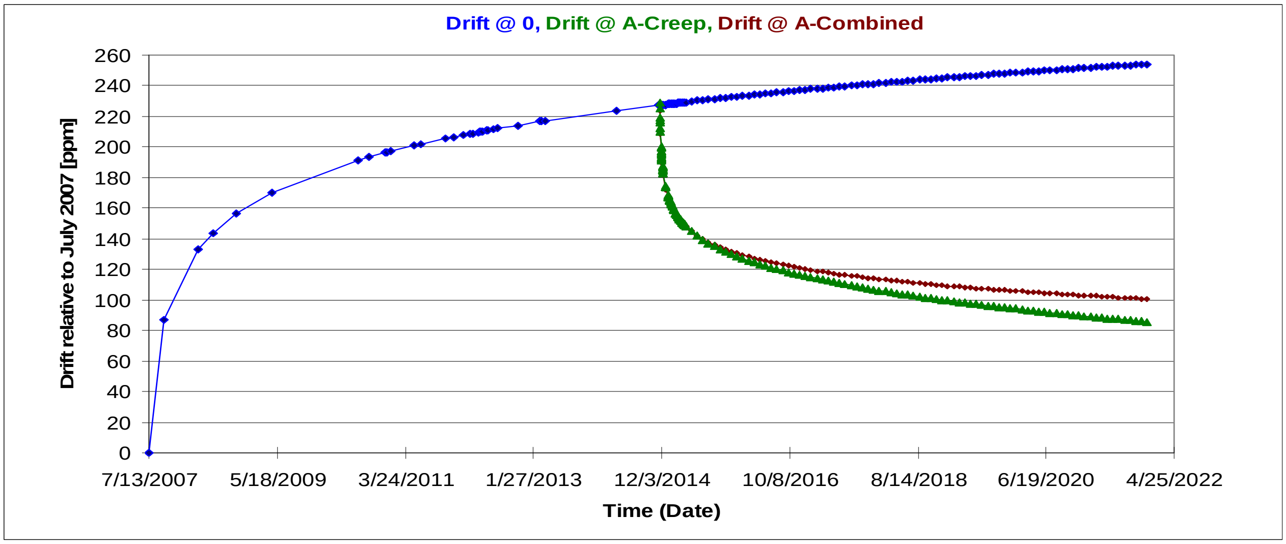
Calibration Method Results:

Full scale pressure was applied at a constant 100 MPa for over 4 months except for 8 brief A-0-A sequences. The 8 points of drift at atmospheric pressure, 0, were linearly connected and subtracted from the full scale measurement readings at A. The plot below shows that drift has been eliminated within a standard deviation of 0.5 ppm. Data are courtesy of Dr. Hiroaki Kajikawa (AIST-Japan).

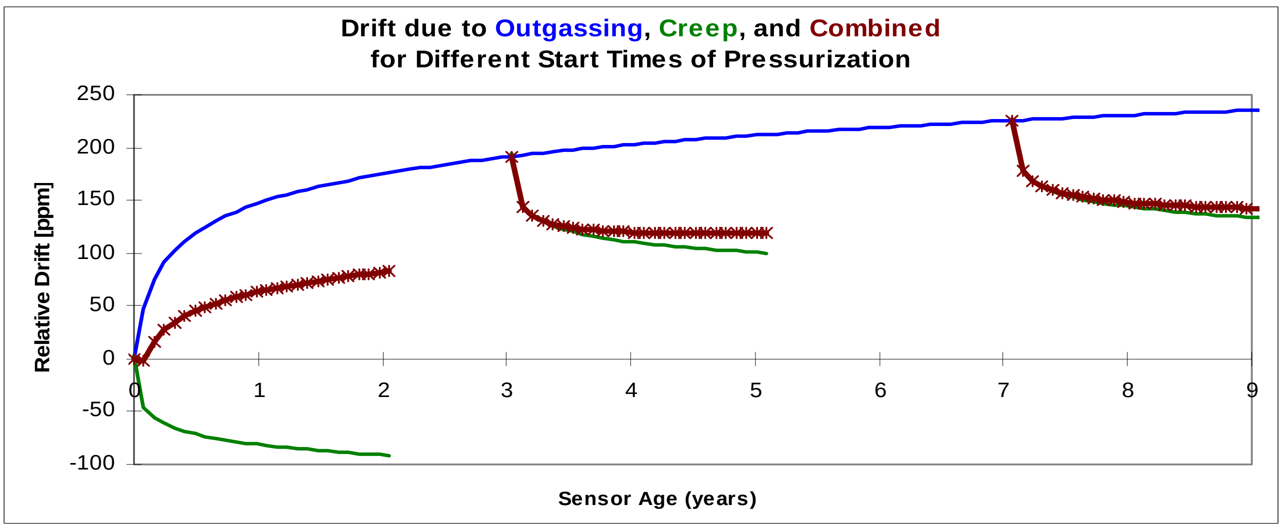


Root Causes of Drift:

The A-0-A method eliminates drift regardless of the root causes. There are at least 2 causes of drift that are related to whether the sensor is mostly at zero pressure, 0, or mostly at high pressure, A. Tests with the sensor mostly at 0 show that the frequency (and pressure) outputs at both zero and full-scale increase with time. One mechanism that can cause increasing outputs is quartz crystal aging or "outgassing" whereby the resonator mass decreases with time. When the sensor is mostly at high pressure (e.g. full-scale pressure), the outputs at zero and full-scale both decrease with time. This can be due to attachment joint or mechanism "creep". Testing for drift under pressure, A, combines the drift effects of outgassing and creep. In order to distinguish the outgassing effect from the creep effect alone, the fit to the 7 years of typical drift data at 0 was extrapolated and subtracted from 4 months of drift data held mostly at pressure A = 100 MPa. The resulting drift curves are shown for Drift @ 0 (outgassing), Drift @ A (creep), and Drift @ A combined.



The A-0-A method works regardless of the pressure profile and deployed depth. As illustrated below, the combined drift can look quite different depending on the pressure profile.



Conclusion:

Precise geodetic measurements with parts-per-million precision are possible using the A-0-A in-situ calibration method with Digiquartz® Pressure Sensors.