

Notes on Sediment Traps Methods

K.L. Maier – July 2017

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Design and Deployment

Anderson sediment traps consist of three main components, including (1) a funnel (~ 95 – 110 cm long) at the top, (2) a PVC tube screwed into the base of the funnel, and (3) a clear plastic liner tube inside the PVC tube (up to ~110 cm long). The funnel is open at the top with a baffle (plastic grid with openings smaller than intervalometer discs).

Sediment falls through the funnel and accumulates in the liner tube, which is plugged at its base. Two types of Anderson sediment traps with slightly different dimensions and materials were used in the CCE, and are referred to as USGS traps (on MS1, MS2, MS3, MS4, MS7) and OUC traps (on MS5).

When available, intervalometers were placed in the Anderson sediment trap funnels. Intervalometers in the USGS traps dropped up to 20 discs into the liner tube at 8-day intervals from a start date. Intervalometers in the OUC traps on MS5@11MAB dropped up to 20 discs into the liner tube with an initial delay time. During phase I, discs were dropped at 8-day intervals starting on October 25, 2015. During Phase III (October 2016 – April 2017) discs were dropped at 6-day intervals starting on October 13, 2013. (See graphic correlation on CT panel also.) Anderson sediment traps with intervalometers included:

Phase I (October 2015 – April 2016):

MS1@10m, MS1@35m, MS2@9m, MS3@9m, MS4@10m, MS5@11m, MS5@74m, MS7@10m

[Note that intervalometers malfunctioned, likely owing to depth, in MS4@10m, and MS5@74m; MS5@11m contained a pressure compensator with the intervalometer. MS1@10m trap with intervalometer was ripped off the mooring strongback during the Jan. 15 event.]

Phase II (April 2016 – October 2016):

MS1@10m, MS2@10m, MS3@10m

[Note that intervalometer in MS1@10m had a mechanical malfunction.]

Phase III (October 2016 – April 2017):

MS1@10m, MS1@35m, MS2@10m, MS3@10m, MS3@35m, MS5@11m

[Note that MS2@10m sediment trap and MS1@10m funnel were ripped off the moorings during deployment period; MS1@35m funnel and tube were broken (detached from each other but remained attached to the mooring) during the deployment period; MS3@35m contained a new intervalometer design that malfunctioned.]

A dilute solution of sodium azide was added to Anderson sediment traps on MS1, MS2, MS3, MS4, and MS7 to deter bioturbation in the sample. A bottle with two layers of solid sodium azide crystals sandwiched between three layers of table salt was attached (taped) to the outside of the funnels. This bottle was prepared in a fume hood, and topped with a

dual-filter-paper cap attached to a tube that ran from the bottle, through the funnel, and into the liner tube. The solids in the bottle were designed to dissolve into a super saline sodium azide mixture that filled the liner tube with a <5% sodium azide solution.

Recovery

Every attempt was made to keep the Anderson sediment traps vertical during recovery and preserve all the sediment samples.

For MS1, MS2, MS3, and MS5, the entire sediment trap + strongback was kept upright (funnel up) upon recovery until the combined PVC+liner tube was removed. This involved the upper part of the sediment trap + strongback being hooked to the crane and the lower connected to a hold-back. The bottom of strongback frame rested on the deck for stability, without any weight on the tube. Water was drained from the Anderson sediment trap funnel through a plug on the funnel. The lower connection of the sediment trap tube to the strongback was removed so that the PVC+liner tube could be unscrewed from the base of the funnel. These tubes were kept upright and cooled in a bucket with ice until the ship returned to the dock. When the tube was overfilled with muddy sediment into the funnel, the mud ran out of the funnel, was caught in a bucket, and later sub-sampled. Where the tube was overfilled with sandy sediment into the funnel, the base of the funnel was plugged with a PVC cap, and sediment was later removed from the funnel in stages from the top or the base of the funnel and labeled in plastic bags. Pushcores (PsC) were taken from funnels where tens of centimeters of sediment had accumulated and there appeared to be more than one layer.

When recovering MS4 and MS7 dual-mounted IRS-Anderson traps, the entire strongback with side-by-side Anderson and IRS sediment traps was kept upright and tied down on deck. Removal of the tube and funnel sediment followed a similar procedure to the upper canyon moorings.

Liner tubes were removed from the base of the PVC tube. First, the bottom PVC cap was unscrewed, and the base of the liner tube inside was capped as quickly as possible to prevent the base plug (o-ring stopper) from falling out of the liner tube. We found that liner tubes filled with muddy sediment slid out of the PVC tubes quickly and easily. Conversely, we found that liner tubes filled with sand had sand grains between the PVC and liner tubes that made extracting the liner tubes extremely difficult. Such liner tubes had to be carefully hammered, cut, or otherwise forced out of the base of the PVC tube. Tops of the liner tubes were capped and stored upright in MBARI cold storage for ~1 month or more prior to additional “whole tube” geophysical data collection.

Geophysical Data Collection (whole tubes)

Whole Anderson sediment trap liner tubes were photographed and logged with a GEOTEK continuous digital line-scanning camera on a multi-sensor core logger (MSCL) at the U.S. Geological Survey Pacific Coastal and Marine Science Center Laboratories in Menlo Park and Santa Cruz, California. *[For Phase I tubes, the instrument and lab were located in Menlo Park, California, and for Phase II and III data collection, they were*

located in Santa Cruz, California.] Two copies of each photo are available, one each with and without a ruler scale in centimeters. Tubes were photographed two or more times with different orientations (side facing up towards camera) if there was variation around the tube.

Whole Anderson sediment trap liner tubes were logged at 1-cm interval for P-wave velocity, gamma-ray density, and magnetic susceptibility. Calibration was conducted during logging using a standard of the same core liner. [*Two standards were used, one each for the USGS tubes and OUC tubes.*] Data available in the .out files are calibrated. These .out files can be opened as Excel spreadsheets. Depth is measured from the top of the liner tube and presented in meters. Date and time of logging is given in month/day/year hour (24 hour):minute. Core thickness is measured for each 1-cm increment and given in centimeters. P-wave amplitude is a percentage between 0 and 100, and P-wave velocities associated with amplitudes of zero should be flagged. P-wave velocity is given in meters per second. Gamma-ray density is given in grams per cc. Magnetic Susceptibility is given in SI units ($\times 10^{-5}$). Acoustic impedance is given in units $\times 10^3/(\text{kilograms} \cdot \text{meters}^3)$. Fractional Porosity (FP) is a dimensionless term calculated from the gamma-ray density. Calibration (processing) parameters are presented for each core in the header information at the top of each tabbed sheet. Typically, only three columns are plotted – PWVel (p-wave velocity in m/s), Den1 (gamma-ray density in g/cc) and MS1 (magnetic susceptibility). All three are plotted versus the first column – SB DEPTH (core depth in m). Typically, depth is presented as the y-axis with 0 in the upper left corner (see panels).

All of the Anderson sediment trap liner tubes were scanned with x-ray computed tomography (CT). CT scanning of Phase I samples (October 2015 – April 2016) was conducted using a GE LightSpeed Ultra instrument at a Stanford University Petroleum Research Institute (SUPRI-A) Enhanced Oil Recovery and Unconventional Resources laboratory facility in Stanford, California, at 120 kV and 140 mA with 1.25 mm axial slices. CT scanning of Phase II (April 2016 – October 2016) and Phase III samples (October 2016 – April 2017) samples was conducted using General Electric LightSpeed 16 CT scanner at the Lawrence Berkeley National Laboratory Rock Dynamic and Imaging Lab in Berkeley, California, at 120 kV and 160 mA reconstructed to 0.625 mm axial slices. CT scan data are presented as coronal slice images generated with RadiAnt Software, and full data are available as DICOM files. These files are in folders labeled for each trap via the CCE naming scheme. Profiles were extracted using ImageJ software from the coronal slice images where indicated with the yellow box. All quantitative data in CT files is in Hounsfield units.

Extrusion and Sub-sampling

Each Anderson sediment trap tube was extruded in 1-cm intervals at the U.S. Geological Survey Pacific Coastal and Marine Science Center Laboratories in Menlo Park (Phase I) and Santa Cruz (Phases II & III), California. Extrusion involved pushing a piston on a calibrated screw up from the base of the sediment trap liner tube such that the sediment inside the liner tube was pushed out of the top of the tube, where it was held in a 1-cm thick ring and sliced off with a metal plate. Each 1-cm slice was photographed and sub-

sampled. Approximately one half to one third of each 1-cm slice was reserved in a plastic whirlpak bag for grain size analyses. If a slice contained a segregated sample of sand and mud (e.g., sand on one side and mud on the opposite side because contacts between units were not flat), then the sand portion was preferentially reserved for grain size analyses. The remaining sub-sample from each 1-cm slice was reserved in a Miscellaneous plastic whirlpak bag labeled with the 1-cm interval to be later sub-sampled for additional analyses. Remaining Anderson sediment trap sub-samples are temporarily stored in MBARI cold storage; long-term storage of CCE samples will be discussed at the July 2017 meeting.

During extrusion of Phase I samples, sand units at the top of Anderson sediment trap liner tubes displayed deformation during extrusion. This is likely because: (1) sand above watery mud is gravitationally unstable (see loading structures imaged in CT scans); and (2) extrusion of tubes with sand was very difficult (i.e., lots of friction and resistance to the piston), such that tubes needed to be pushed or hammered with a rubber mallet onto the piston. This was remedied in Phases II & III extrusion by cutting tubes with sand a few cm below the sand unit. Each portion of the cut tube was then extruded separately, which improved extrusion and reduced friction/resistance. 1-cm slices were numbered continuously from the top of each Anderson sediment trap liner tube, regardless of whether the tube was cut.

Grain Size Analyses – J. Gales

Grain size sub-samples were shipped to the University of Southampton for laser particle grain size analyses. These were conducted by Jenny Gales using a Malvern II Mastersizer instrument measuring in quarter phi bins.

Grain-size samples were processed by (1) sub-sampling the samples into measurement pots using ~1 cm³ of each sample; (2) samples with grain sizes >2 mm were sieved to remove the fraction >2 mm; (3) 10% sodiumhexametaphosphate solution was added to make up to 20 ml solution in each sample pot; (4) samples were agitated on a mechanical shaker overnight (>12 hours); (5) the Malvern II autosampler was used to conduct the sampling; (5) random samples were selected and measured manually using Mastersizer II for comparison.

Laser-particle grain-analytical results are presented in a series of tables. Sample ID is given in the CCE naming scheme, and each sample was run three times and averaged. Samples followed by ‘_M’ were measured manually.

Grain size data are plotted on Anderson sediment trap data panels as D[4,3] (volume mean diameter), D1 and D9. For Phase I (October 2015 – April 2016) samples, each extruded cm sub-sample was analyzed. For Phase II (April 2016 – October 2016) and Phase III (October III – April 2017) samples, one sample each 5 cm (e.g., 0-1 cm, 5-6 cm, etc.) was analyzed along with additional samples in sandy intervals.

Other Notes

Additional sub-sampling from the Miscellaneous 1-cm slice bags occurred on August 11, 2017. Sub-samples for organic carbon were taken approximately every 10 cm in fine (muddy) sediment throughout the 1-cm slices and where fine material was available in the funnel samples. Sub-samples for ^{210}Pb were taken from fine material in 3 cm slices at:
Phase I: the base of MS1 @35MAB and MS7@10MAB
Phase II: from the base of MS1@10MAB and tops of MS7@10MAB and MS7@300MAB
Phase III: from the base of MS1@10MAB and MS7@10MAB
Sub-samples for ^{14}C were taken from near the base of each trap (adjacent to ^{210}Pb samples where also taken) for a total of 23 samples.

Sediment in the Anderson sediment trap liner tubes compacts over time, following recovery. When sediment compacts, water accumulates at the top of the tubes. This water was removed using syringes, and was sent to OUC (Phase I) or discarded (Phases II & III). Empty space in the tops of the liner tubes was packed with sponges or Styrofoam to minimize movement and mixture of sediment.

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