Dr. Rosalba Bonaccorsi – Full Expedition Report

Dr. Rosalba Bonaccorsi (NASA Ames Research Center/ SETI Institute) leaded the search for clay minerals and biosignatures analogs of the Mars Science Laboratory 2011 Landing Sites.

This team was intentionally left open to any interaction with other teams willing to collaborate on the main theme of this investigation.

Our objectives for participating to this expedition were to identify mars analogs for MSL11 landing sites candidates (clay minerals-rich deposits), and test hypotheses on preservation of organics/ total/viable and Gram-negative biomass in clay minerals deposits vs. hematite-rich materials/ironstones. Most of samples collected during the expedition were analyzed in the field for Gram-negative biomass by using the Limulus Amebocyte Lysate assay, or LAL, a non culture-based method to detect endotoxins levels and measure, in a relatively rapid and accurate manner, the amounts of microbial's endotoxin in the environment. Basically, bacterial's endotoxin in samples catalyzes the activation of a proenzyme in the LAL. The resulting colorimetric variation (change in color) is measured by a spectrofotometer (405-410 nm) and can be translated to G-negative total biomass (cells/g).

Furthermore, during this expedition we tested the feasibility/potential of applying the assay under field conditions. Mineral and soils samples were extracted with ultrapure water using a centrifuge. Supernatant was diluted 10 to 1000 times with ultrapure LAL pyrogenic free-water and immediately assayed together with the proper positive and negative controls. David Willson, Reut Abramovich, and Stephen Joyce, assisted with sample preparation and troubleshooting in the lab.

To date, 7 out of 12 samples collected were processed at the lab set up in Arkaroola Village. Analytical efficiency was 80% (8 out of 10 assays performed passed the quality control internal test for this assay (i.e., spike recovery 50-200%, Sample and spike CV <25%). In this report raw values are provided along with the featured sampling sites.

While analyzing these materials to address the above science objectives we will also test methods, instruments and approaches to be used during the MSL11/ExoMars2016 missions

(XRD/XRF; LIBBS, microRaman, and organic analysis).

The same samples will be analyzed also for bulk organics and organic compounds in the lab. The main objective has been to test for the preservation of organics and habitability potential of clay minerals-rich vs. iron oxy(hydr)oxides-rich materials.

We will continue to address these objectives with post-expedition work to be conducted at Australian laboratories as well as at NASA Ames.
Overall, our planned activity will involve interdisciplinary investigations thru collaborations with other team members of this expedition, e.g., Elaine Bryant (Microbiology), Paulo de Sousa (Mineralogy analysis with MSL11-like instruments), Vic Gostin (Geology), David Willson, Chris McKay, and Penny Boston.

Last but not least, the dataset obtained from samples analyzed during and after the SBA09 expedition (e.g., total and viable biomass, organics and CN Elemental Analysis) will be compared to and integrated with data obtained from other desert/Mediterranean regions (Rio Tinto, Atacama, Death Valley, and the California coast).

Day 1 (07/10/09). Sampling Site 1: South of Paralana Springs

En route to the OZ Mars Analog Site Together with Vic Gostin we explored the terrains South of the Paralana Hot Springs. We sampled a meter-thick kaolinite deposits (Figure 1a-b) formed from the weathering of Precambrian (800Ma) silcrete rocks (Figure 1d). The weathered kaolinite (Sample AU09-PAR 1A: ~10^7 cells/g) is overlain by hematite-rich loose soil material (AU09-PAR 1B: ~10^8 cells/g) as shown in Figure 1c. Both intervals are at stratigraphic contact and contain ultrafine rootlets (Samples AU09-PAR 1A and AU09-PAR 1B). Vegetation cover (mainly trees) is about 50% (Figure 1c).

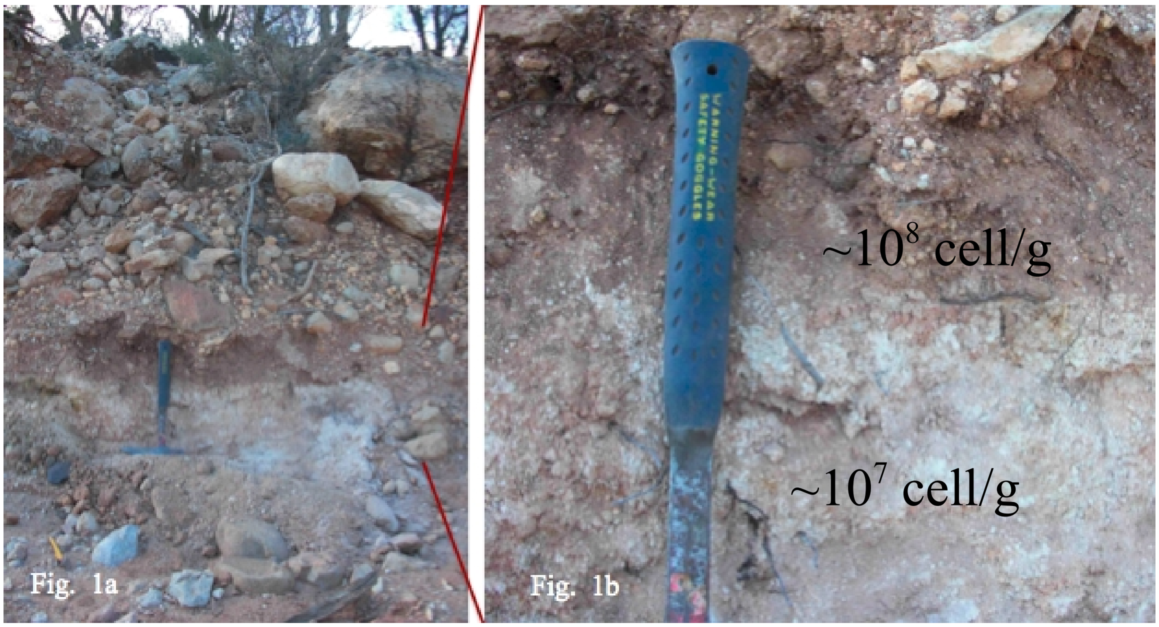


Fig. 1a
Fig. 1b


Fig. 1e


Fig. 1f

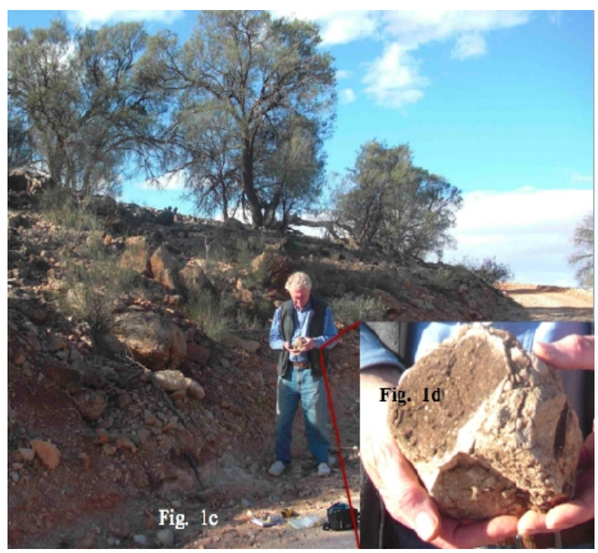


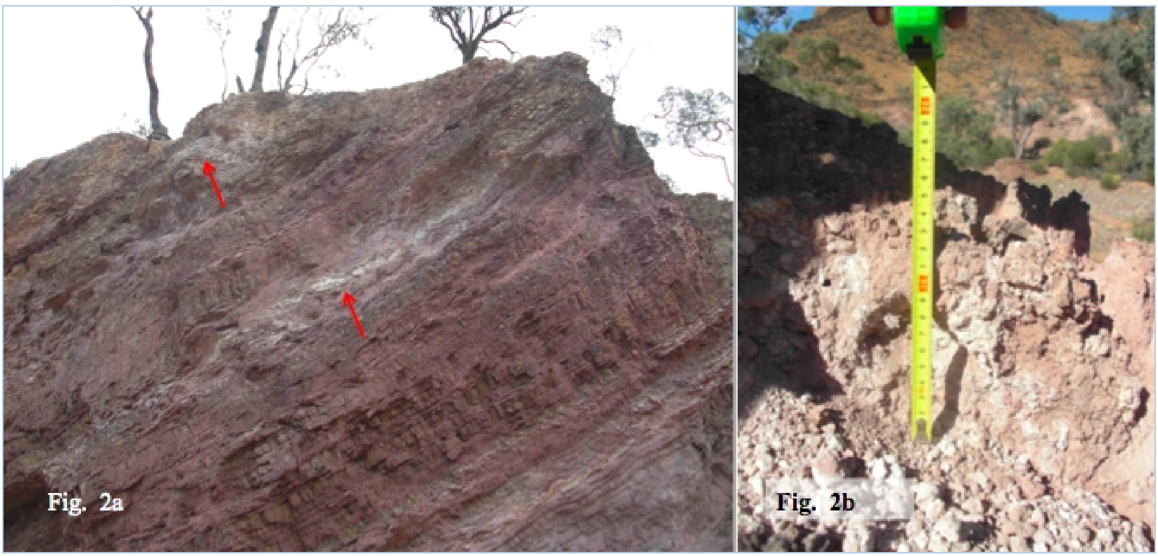
Fig. 1c
Fig. 1d

The kaolinite unit is widespread in the area (Figures 1e-f) although lacking of surface lateral contiguity owing to surface erosion.

Day 3: 07/12/09. Sampling Site 2: Nepouie Spring vicinity.

With Elaine and David Bryant, Steve, and and Joanne Berriman (Oatlands District High School, TAS) assisted with sampling at this site.

In the surrounding of Nepouie Spring we searched for clay deposits. Our survey was successful in that we identify and sampled accessible shallow nearsurface pockets of weathered material (Figure 2b).

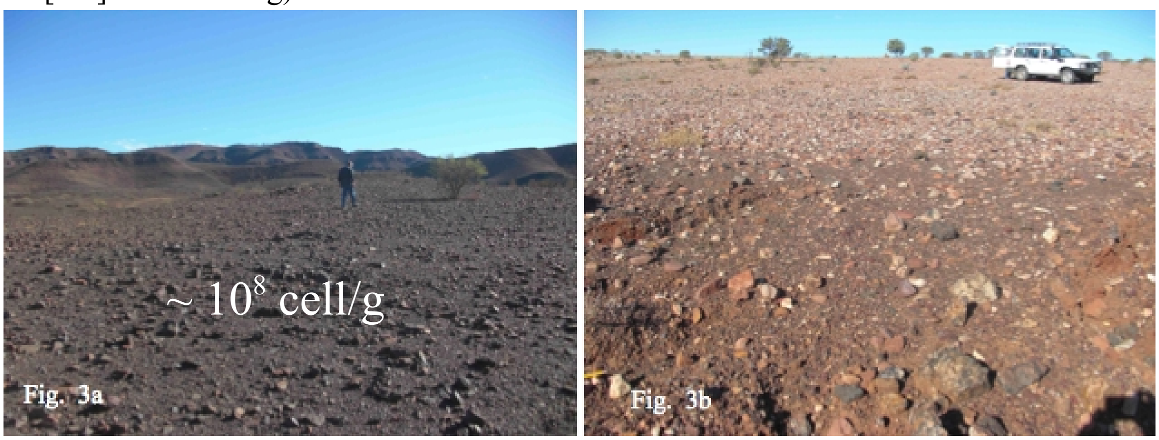


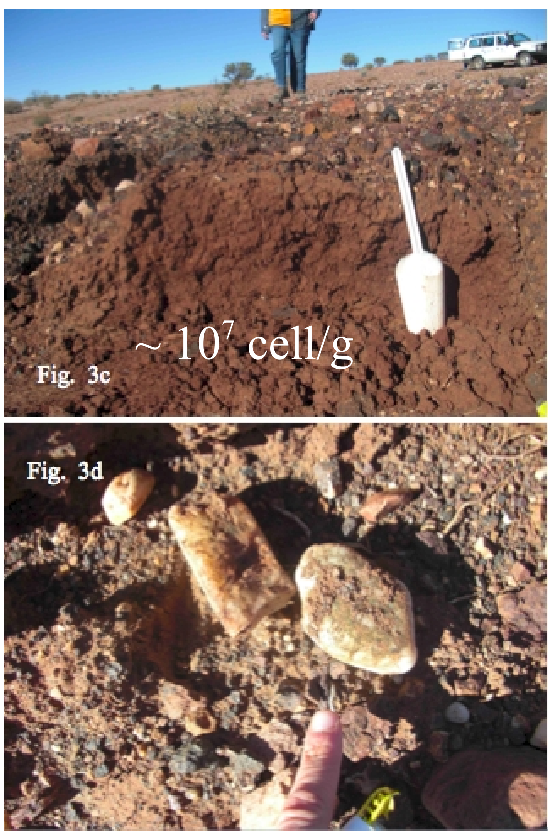
The white veins likely consist of kaolinite and illite minerals (Sample AU09-NEP 1A: ~ 6 x 10^6 cells/g) formed within the embedding Precambrian, dark pink, claystone unit (Sample AU09-NEP 1B: ~2 x 10^6 cells/g) and shown in Figure 2a. Red arrows indicate veins of weathered phyllosilicates material at statigraphic contact with the claystone unit. The weathered clays contain three fold more Gram-negative biomass than the embedding unweathered claystone unit.

Day 3. Sampling Site 3: OZ Mars Analog Site (Arkaroola Springs)

Elaine and David Bryant, Stephen Joyce, and Joanne Berriman assisted with sampling at this site.

At the OZ Mars analog site (Figure 3a-b) we sampled two sites. Soils at both sites are mostly plant barren and formed from the weathering of basaltic rocks. The first site was a 100m^2 vegetation-free area, 100% covered by basalt pavement (Figure 3a) and sampled by the Bryant's team (Sample AU09-ARK #4 [OZ]. An aliquot of the total composite surface soils was sampled for determination of the Gram-negative content (AU09-ARK #4 [OZ]: ~ 10^8 cells/g).



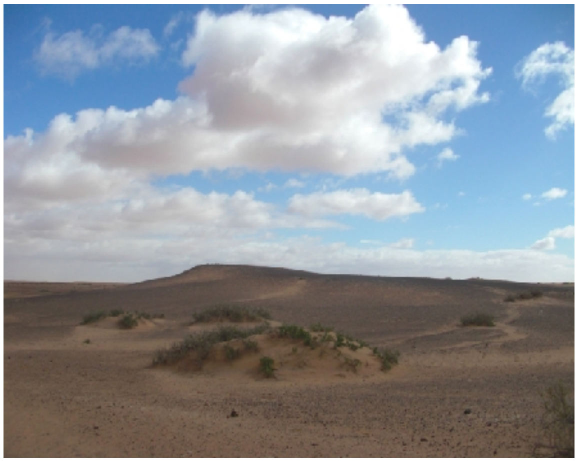


The second sample AU09-ARK[OZ], 10cm: ~10^7 cells/g) was taken from an exposed stream wall (a. 10 cm-depth) at the junction between soils covered by basalt pavement (Figure 3a) and quartz pavement (Figures 3b-c). The sampled material from the second site had a polygonal structure and a more clayey texture. Most of quarts pebbles at this site were colonized by hypolithic cyanobacteria (Figure 3d), which are gram negative-like organisms. Interestingly, the two dark brown soils (Figure 3a-b) are only a. 70-m apart and texturally similar, although material show in figure 3c, but their gram-negative biomass content differs about a factor of ten. This may be related to an existing higher concentration of cyanobacteria at the soil surface.

Surface soils from the aridest site in Arkaroola, which were sampled by Elaine Bryant (Sample AU09-ARK #2, not showed here) have total Gram-negative biomass of ~10^8 cells/g, which is comparable to the OZ Mars Site.

Day 4 (07/14/09): Sampling Site 4 (Marree/Lyndhurst (Birdsvill).

David Willson, Shannon Rupert, and Jane Dobson (Claremont College, TAS) assisted with sampling at this site.



We encountered gypsum-rich soils (plant cover ~35-40% scrubs) with very sparse dark rocks or manganese/ironstone crusts (Figure 4a). These rocks appear to be formed from chemically precipitated minerals (in association with cm-sized gypsum crystals).

The black rocks are externally weathered and with several geoid-like cavities (Figure 4C) filled with friable to indurate hematite, or ochre (dusky red) and goethite (bright yellow/orange) minerals (Figures 4b-d). We took mineral samples from some of these cavities to determine for furthers comparison of their Gram-negative like microbial biomass vs. that of the surrounding surface soils (Figure 4b).

Day 5 (07/15/09). Sampling Site 5: Reedy Springs

At Reedy Springs we sampled the blue clays outcrops, or the Cretaceous Bulldog Shale, exposed along the canyon's walls and floors within the drainage Reedy Springs system (Figure 5a).

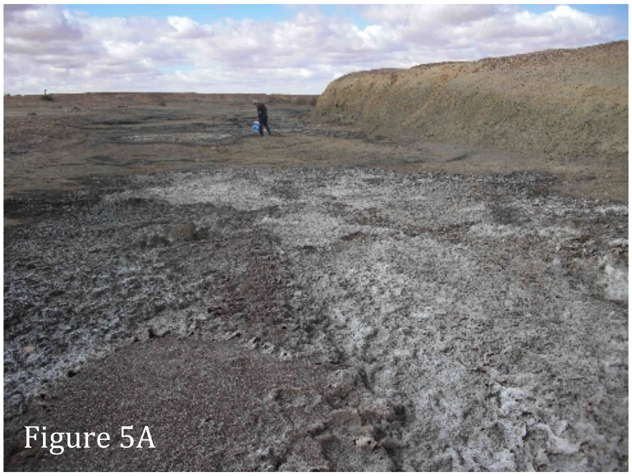


Figure 5A


Figure 5B

Overall, the main drainage valley floor (Figure 5a) is covered by soft/loose light to dark toned i.e., NaCl salts and silty-clay materials, with a vermiculated surface pattern, and sometime hosting spherical concretions of gray hematite coated with red hematite (Figure 5b). Concretions of this type were rare (D. Willson's observation) and with similar appearance to the hematite spheres "blue berries" observed by the MER rover mission at the Mars Sinus Meridiani Site.

In the above context, we took samples from both the blue clays unit and the mm-thick goethite-rich lamina (Figure 5c) at the interface with the clays levels. These thin lamina occur at stratigraphic contact with the clay levels and appear to form from the precipitation of upwelling iron oxy(hydr)oxides-rich fluids thru the spring system and diffusing thru the fractured clays unit, which are sometime oxidized at their surface (Figure 5c). The source of these iron oxy(hydr)oxides-rich fluids could be the iron sulfides component (pyrite) of the blue clays, or another sources of reduced iron deep beneath the underground system (Vic Gostin, personal communication).

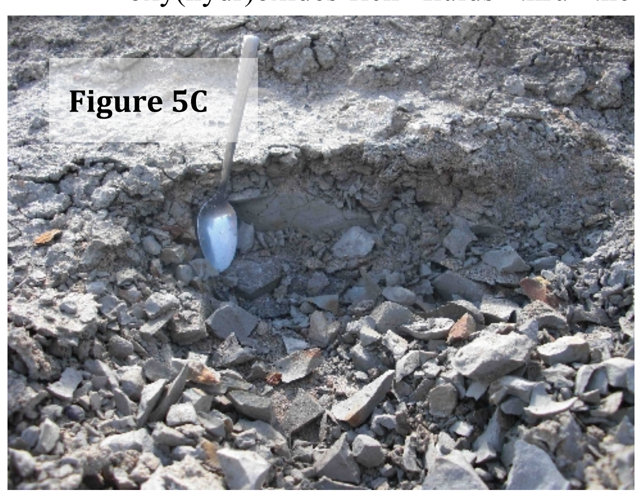


Figure 5C

Reedy Spring ponds (Figure 6b-c) and streams (Figure 6a) contain fluids rich in dissolved iron, and complex mixtures of salts including possibly Mg sulphates) and iron sulphates (Jarosite?) crystallizing surface environments surrounding the ponds and the drainage networks

(Figure 5A and Figure 6A).

The accumulation of ferric iron confers the system a reddish bright coloration (Figure 6C), which is similar in color to the typical “red vine” feature known for the Rio Tinto massive sulfide ore deposits/drainage system (Southern Spain).

David Willson (on the top left-hand side), Victor Gostin (right-hand side), and Guy Murphy assisted with sampling and background information for this site.