

**SPACEWARD BOUND'S 11-YEAR HISTORY: TO EXTREME ENVIRONMENTS ON EARTH AND BEYOND.** R. Bonaccorsi<sup>1,2</sup>, C. P. McKay<sup>2</sup>, R. Mogul<sup>3,4</sup>, P. Boston<sup>5</sup>, D. Willson<sup>2,6</sup>, J. Heldmann<sup>2</sup>, L. Baker<sup>7</sup>, D. Cowan<sup>8</sup>, S. Pandey<sup>4,6</sup>, M. Sharma<sup>9</sup>, H. Sun<sup>10</sup>, J. G. Blank<sup>2,4,11</sup>, C. R. Stoker<sup>2</sup>, I. H. Mogosanu<sup>4,11</sup>, K. A. Campbell<sup>12</sup>, B. Phartiyal<sup>9</sup>, J. C. Rask<sup>2</sup>, J. Clarke<sup>6</sup>, '06-'16 SB Teams<sup>13</sup>. <sup>1</sup>SETI Institute (M. View, CA 94043, rosalba.bonaccorsi-1@nasa.gov), <sup>2</sup>NASA Ames Research Center (Moffett Field, CA 94035), <sup>3</sup>Cal Poly Pomona (Pomona, CA 91768), <sup>4</sup>Blue Marble Space Institute (Seattle, WA 98154), <sup>5</sup>NASA Astrobiology Institute (Moffett Field, CA 94035), <sup>6</sup>Mars Society Australia (Monash 2904, AU), <sup>7</sup>University of Idaho (Moscow, ID 83844), <sup>8</sup>University of Pretoria (Hatfield 0028, South Africa), <sup>9</sup>Birbal Sahni Institute of Palaeosciences (Lucknow, India), <sup>10</sup>DRI (Reno, NV 89512), <sup>11</sup>New Zealand Astrobiology Network (Wellington, 6011, NZ), <sup>12</sup>University of Auckland (Auckland, 1142, NZ), <sup>13</sup>[Ref. 1].

**Introduction:** Spaceward Bound was conceived at NASA Ames Research Center (ARC) in 2006 (Chris McKay (PI), Penny Boston and Liza Coe (Co-Is) with support from NASA HQ [1]. The first Spaceward Bound trip was to the hyper-arid core of the Atacama Desert and involved teachers from the USA and Chile.

The core concept was to involve middle and high school math and science teachers in doing real astrobiology field work: scouting and observation of unknown areas, planning experiments, collecting real samples, participating in the discussion and preliminary data analysis, and planning for the next days work. The teachers liked being in the middle of a real, and evolving, science activity. The scientists appreciated the interest and help from the teachers.



**Spaceward Bound models:** Over the past 11 years we have conducted 29 Spaceward Bound trips (600+ participants). They group into three broad categories:

1) At the Desert Studies Center Zzyzx campus in the Mojave Desert, partnering with *i*) DRI Desert Research Institute's Henry Sun (2006-2008); and *ii*) the California State University System (CSU), mostly with Cal State Pomona starting in 2009 (Rakesh Mogul Director), which runs every year [2].

2) Partnering with Space Grant States for three years of expeditions with teachers and Space Grant faculty from that state, e.g., University of Idaho. Locales have been the Badlands and glacial terrains of North Dakota, Idaho Batholith, Snake River Plain and Craters of the Moon National Monument (Idaho).

3) Partnering with a foreign University and/or Space Group: Atacama (Chile); Canadian Arctic, Namibia (2010-2012), Australia, United Arab Emirates, New Zealand (2015-2016), (Hari Mogosanu, NZAN, and Kathy Campbell, University of Auckland [3]), and Leh-Ladakh (India) [4]. The Mars Society of Australia (MSA) provided key logistics and financial support to

the Arkaroola (2007, 2009) and Pilbara (2011) expeditions and, together with the Birbal Sahni Institute of Palaeosciences, BSIP (Mukund Sharma and Binita Phartiyal), Jon Clarke co-led SB India in 2016 [4].

There is interest in continuing all three modes.

**Site selection and science topics:** Sites were chosen based on: *a*) their scientific interest and literature-based knowledge gaps; *b*) their astrobiological relevance and diversity; *c*) their planetary-like geological features - as test beds for mini-rovers/ space suits trials and planetary missions, which will help inform the exploration of Mars, the Moon, and ocean worlds; and *d*) the opportunity to connect and engage with the local communities. Scouting trips were conducted to familiarize with new and/or appropriate sites. Over the past decade, topics have included cave microbiology and thermography, microbiology of soil crust and hypolithic cyanobacteria. We also have examined the geochemistry of, icy, dry, briny, acidic, hot spring, and mineral-rich environments, as resources for microbes, and tested life detection protocols in clays, Fe-oxides, sulfates, halite minerals, and siliceous sinter deposits.

**Flowers and fruits from the collective Spaceward Bound programs:** Since its inception, the successful model of SB has bloomed into the creation of astrobiology networks in New Zealand [3] and soon in India [4]; a community of educators crafting and refining STEM programs for their classrooms; and fostered collaborative research in the fields of Astrobiology, Geology, and Geomicrobiology e.g., mapping hot springs' extremophiles in New Zealand and stromatolites in Pilbara (AU). In addition to providing teachers and students with field research experience, SB has been scientifically productive with more than a dozen published papers from various expeditions [5-6].

#### References:

- [1] [https://www.nasa.gov/offices/education/programs/descriptions/Spaceward\\_Bound.html](https://www.nasa.gov/offices/education/programs/descriptions/Spaceward_Bound.html); [2] <http://www.cpp.edu/~rmogul/spacewardbound>; [3] <http://www.science.auckland.ac.nz/en/about/news/news-2015/03/spaceward-bound-new-zealand.html>; [4] <http://spacewardbound.astrobiologyindia.in/>; [5] Williams and McKay (2015), *Intl. J. of Speleology* 44.2: 115; [6] McKay et al. (2016), *PLoS one* 11.3.