



# THE UNIVERSITY OF THE WEST INDIES

ST. AUGUSTINE, TRINIDAD AND TOBAGO, WEST INDIES

## THE SEISMIC RESEARCH CENTRE

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### **THE UWI SEISMIC RESEARCH CENTRE**

#### **ANNUAL REPORT JULY 1, 2016 – AUGUST 31, 2017**

##### ***DIRECTOR'S SUMMARY***

The UWI Seismic Research Centre (SRC) is the regional institution responsible for surveillance of and fundamental research into volcanoes and earthquakes for the English-speaking islands of the Eastern Caribbean. The SRC provides the governments of 9 contributing territories with accurate and up-to-date information about earthquake, volcanic and other geologic activity, including 19 live volcanoes, in the Eastern Caribbean.

The research undertaken by the SRC is focussed on developing a better understanding of the geologic processes at work in the region so as to reduce risk and promote sustainable development. To this end, the SRC play an active role in promoting geologic hazard awareness and collaborates with local, regional and international agencies on research and outreach projects. The Centre operates the largest geophysical monitoring network in the Caribbean region. It provides a national seismological service for all of its contributing territories and a national volcanological service for five of them. Its mission spans the wide areas of monitoring, research, warnings and outreach and postgraduate teaching.

During the past year the region maintained the high level of seismicity, with which the previous reporting period ended. The seismograph network recorded at least 7,982 earthquakes occurring in our area of responsibility, which represents an approximate 60% increase over the last reporting period. Locations for those of magnitude greater than 2.0 were determined for 2,357 of those recorded. At least 41 of these events were felt and there were six events of magnitude 5.0 and larger. The elevated state of earthquake activity noted in the region in

recent reports appears to be intensifying with a general increase in activity along the arc, especially in the Antigua-Barbuda area.

The strongest earthquake for the period occurred, on 2016/12/06, near the south-west of Tobago area. It was strongly felt throughout Tobago, across Trinidad and as far north as Saint Lucia. There were more than 500 associated aftershocks up to the end of December. The area north of Dominica that generated a magnitude 6.0 earthquake in 2004 reactivated in recent years and continued to manifest a significant level of low magnitude earthquakes.

Aside from the aftershock zone of the 2016/12/06 magnitude 6.1 event, the densest concentration of epicentres for the year was seen in the Antigua/Barbuda area. The Paria Peninsula area is also maintaining its dense pattern of seismicity.

The Kick-'em-Jenny volcano erupted on 2017/04/29. The eruption was preceded by low level, low magnitude earthquakes, which began on 8th April and was followed by a short period of relatively high-level seismicity. The eruption was felt in northern Grenada and Martinique as an extended period of shaking. There was no surface evidence of the occurrence of the eruption.

Activity at the Soufrière Hills Volcano in Montserrat, which is now at a low level, continues to be closely monitored by the Montserrat Volcano Observatory, a facility managed by the SRC under contract with the Government of Montserrat. Other volcanoes in the region exhibited background levels of activity except for the Boiling Lake in Dominica which experienced another episode of rapid reduction and refilling of the lake.

Our region has not seen its largest earthquake for well over 150 years and background seismicity in the region appears to be intensifying. It is for this reason that we seek to foster collaborations that allow us to enhance our monitoring and seismic hazard and risk capability, take an active role in promoting the development and legislation of Building Codes and our Education and Outreach thrust is maintained at a high level. To this end several workshops were held at secondary and tertiary level institutions that focuses on earthquake science and safety. There were weeklong outreach campaigns in Saint Lucia, Barbados and St. Vincent and the Grenadines.

## **STAFF**

### OVERVIEW OF RECRUITMENT AND RETENTION

Funding was provided for **24** members of staff through the recurrent budget of the SRC that is contributed to by the nine countries and approved by F&GP. Due to budgetary restrictions only 19 of the budgeted posts funded by our recurrent budget have been filled. However, an additional 22 persons are employed on short-term contracts specifically to assist with various grant and consultancy funded projects. One of the objectives of the SRCs' active search for extra-budgetary funding is to enable recruitment of staff on short-term contracts in order to fulfil the requirements of our full operations - these are not adequately covered by our reduced recurrent budget. Retention rates at SRC are generally high with >90% of all staff recruited opting to remain employed at the Centre.

### LIST OF APPOINTED AND PROMOTED ACADEMIC STAFF

Mr Daniel Reuppel was appointed as IT Officer II (Software Engineer).

### STAFF RETIRED OR RESIGNED IN THE REPORTING YEAR.

Associate Professional Ms. Valini Kissoon completed her stay at the SRC in December 2016. She had been with the SRC from February 2016 working with Dr. Graham Ryan on the ground deformation programme. She came to the SRC after completing an MSc in Petroleum Geoscience at the Royal Holloway University in London.

Mr. Elliot Jiwani-Brown, Honorary Research Fellow ended his attachment to the SRC in March 2017. He had been with the SRC from June 2016 working with Dr. Graham Ryan on the project "Tomographically constrained Montserrat reservoir model using TOUGH2". He sought a position at the SRC after completing an MSc in Geophysics at the University of Leeds in order to deepen his research experience.

Ms Caroline Burkart of The Dresden University of Applied Sciences (HTWD), Germany ended a six-month internship at the Centre in June 2017. She worked on both assessing GPS data from GPS campaigns in the Eastern Caribbean and the application of LANDSAT thermal infrared remote sensing data to monitoring the Sulphur Springs geothermal area in St. Lucia.

### MAJOR AWARDS AND SPECIAL HONOURS/DISTINCTIONS TO STAFF.

Research Student Michal Camejo who is also employed as a Research Assistant at the Centre obtained a Commonwealth Split-site (PhD) Scholarship and spent one year attached to the University of Bristol from September 2016-2017.

### SIGNIFICANT TRAINING INITIATIVES

The Centre was able to support the participation of several staff member in various training courses including courses in Project Management, Supervisory Management, First Aid and Media Skills.

## **STUDENTS**

### ***Continuing students***

Deborah Robertson - registered for a PhD in Volcanology working on 'Dynamics of Geothermal Systems in the Eastern Caribbean – modelling of the geophysical conditions of the Boiling Lake, Dominica'.

Michal Camejo - registered for a PhD in Volcanology working on 'Deciphering the genesis of Soufriere magmas, St Vincent'

Omari Graham - registered for an M.Phil.in Volcanology working on 'Assessment of the communication protocols used in Volcanic Emergency Management in the Eastern Caribbean'

Ms. Racine Basant - registered for an MPhil in Volcanology working on the topic 'Improved well-targeting for Caribbean geothermal exploitation: An improved seismic velocity geothermometer' under the supervision of Dr. Graham Ryan.

### GRADUATION

Mr. Viveka Jackson successfully completed his MPhil (Volcanology) during the period under review and was expected to join graduates in November 2017 Graduation ceremony.

## **STRATEGY APPRAISAL**

### STAKEHOLDERS & PARTNERS

The SRC main stakeholders are vulnerable island communities, including disaster management and other government officials, civil society and the private sector. Our operational focus is stakeholder-centred and during the period in review we engaged in a range of activities, including the provision of scientific advisories and reports, educational lectures, student and public outreach, and workshops designed to disseminate scientific information derived from our monitoring and research.

### TEACHING, LEARNING & STUDENT DEVELOPMENT

The primary objective of our post graduate programme is to build a cadre of regional experts in volcanology and seismology who can have practical and direct bearing on sustainable Caribbean development. To this end, all students enrolled in programmes at the SRC are provided with in-house training on all monitoring techniques and assist routinely with at least one aspect of SRC's core operations (including brief attachments to the Montserrat Volcano Observatory). They are therefore provided with practical and ongoing job experience in the fields in which their research are being undertaken and may be applied. Students are also encouraged and assisted to attend regional and international scientific conferences to present their research finding and interact with their peers.

### RESEARCH & INNOVATION

The SRC research agenda is dictated by its broad responsibility for monitoring, warnings and outreach to vulnerable island communities in the Eastern Caribbean. Our research is largely applied but we strive to maintain an appropriate balance and exchange between applied and basic research into the processes influencing the occurrence of earthquakes, tsunamis and volcanic unrest. In addition to our core disciplines of volcanology, seismology and tsunami science we also have a strong public education and outreach programme, with the objective of building knowledgeable stakeholders, at all levels of society. We are constantly seeking and developing new ways to achieve our objective of building knowledgeable stakeholders, at all levels of society.

## ***Research completed<sup>1</sup>***

**Title:** STREVA: Strengthening Resilience in Volcanic Areas

**Description:** This project is a collaborative project with UK colleagues at the Universities of Bristol, Oxford and East Anglia along with the British Geological Survey and the Overseas Development Institute. It is an innovative interdisciplinary project that aims to work collaboratively across different disciplines to develop and apply a risk assessment framework. It involves looking at ways in which communities respond to volcanic emergencies, and developing protocols for response. It brings together diverse researchers from universities and research institutes from within the UK and from those areas affected directly by volcanic activity.

**Funding:** Natural Environment Research Council, UK

**Principal staff involved:** Dr. Richard Robertson, Ms. Stacey Edwards, Dr. Joan Latchman, Dr. Patrick Smith and Mr. Roderick Stewart

## ***Research in progress***

**Title:** Management of the Montserrat Volcano Observatory

**Description:** Negotiations for a new management contract to run the Montserrat Volcano Observatory was significantly completed in 2016 with a new contract being signed to cover the period 1 October 2016 to 30 September 2021. Unlike the previous contract which was done jointly with the Institut de Physique du Globe de Paris of France, the new contract will be solely executed by the SRC. It enables the Centre to continue to be involved in monitoring and research on the ongoing eruption of the Soufriere Hills Volcano.

**Funding:** Government of Montserrat contract for a fixed sum of EC\$17.9

**Principal staff involved:** Prof. Richard Robertson, Mr. Roderick Stewart, Dr. Erouscilla Joseph, Dr. Graham Ryan, Dr. Thomas Christopher, Dr. Adam Stinton, Dr. Patrick Smith, Dr. Karen Pascal

**Title:** Seismic Microzonation Studies in Trinidad and Tobago

**Description:** This is a project funded by the Ministry of Planning and Sustainable Development, Government of Trinidad and Tobago to pursue the microzonation of ten cities and major population centres in Trinidad and Tobago over the next 10 years. The data collected will be

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<sup>1</sup> Only five projects listed as requested in the guidelines.

used by planners and engineers to guide future building construction in Trinidad and Tobago. In 2017 the TTMP continued its fieldwork operations in four fields: Port of Spain, San Fernando, Southern Tobago and Diego Martin. The acquisition team gathered more than 800 single-site recordings in these four areas. Processing of the data collected continues and thematic maps with regards to the resonance frequency of the sediments are being produced. Furthermore, Microtremor Array Measurements have been acquired in all fields to assist in the determination of the shear wave velocity of the sediments. These data are also being processed to produce velocity profiles in these areas. In addition to the experimental methods mentioned above, simulation of each basin has been performed in an effort to produce synthetic seismograms and determine the transfer function of sediments in these areas. The team has a new addition, Ms. Celeste Sobion, MSc. Geophysicist who is working on the strong motion network currently being installed in Port of Spain. Technical reports for the first three areas are in preparation for submission to the MoPD in the first months of 2018. Additional monthly and quarterly reports have been submitted to MoPD all through 2017

**Funding:** Grant from Ministry of Planning; a total of TT\$1.2M will be received in grant funding during the course of this project which ends in 2020

**Principal staff involved:** Dr. Ilias Papadoupoulos, Dr. Joan Latchman, Mr. Kafele Reddock, Mr. Lloyd Lynch, Ms. Stacey Edwards, Prof. Richard Robertson, Mr. Clevon Ash

**Title:** Disaster risk management in the Caribbean, support for the Seismic Research Centre, University of the West Indies [2015-2018]

**Description:** This is project funded by the Government of New Zealand through its Ministry of Foreign Affairs and Trade that involves GNS Science of New Zealand providing assistance to the SRC in building capacity in continuous monitoring of volcano-hydrothermal systems using remote techniques, ground deformation monitoring using remotes sensing and improved alerting systems for volcanic emergencies.

**Funding:** Ministry of Foreign Affairs & Trade, New Zealand, NZ\$730K

**Principal staff involved:** Dr. Graham Ryan, Dr. Erouscilla Joseph, Ms. Stacey Edwards, Mr. Roderick Stewart, Prof. Richard Robertson

**Title:** Monitoring volcano-deformation in the Eastern Caribbean combining the existing GPS network with ALOS/ALOS-2 data [2016-2018]

**Description:** This is research project funded by the Japan Aerospace Exploration Agency that seeks to develop an effective means of monitoring volcanic ground deformation in the Lesser Antilles using satellite data.

**Funding:** Japan Aerospace Exploration Agency (JAXA), US\$270K [Value of the data]

**Principal staff involved:** Dr. Graham Ryan, Dr. Karen Pascal

**Title:** Improved well-targeting for Caribbean geothermal exploitation

**Description:** This project uses geophysical and petrological data to among other things, determine drilling targets in Caribbean geothermal system.

**Funding:** Campus Research & Publication Fund, US\$11,261

**Principal staff involved:** Dr. Graham Ryan, Ms Racine Basant

**Title:** Investigation of mineralogical and chemical reactions and associated metal enrichments in the Sulphur Springs geothermal system through quantification of chemical alteration associated with acidic hydrothermal systems in volcanic rocks.

**Description:** Chemical and mineralogical quantification of alteration reactions associated with hydrothermal systems, as well as the composition of the parental rocks can provide valuable information on both island-arc volcanism and subsequent geothermal systems that form within the volcanic sequence. High-temperature geothermal systems such as Sulphur Springs can be enriched in a variety of precious- and base-metals and other elements that are also enriched in certain hydrothermal gold-silver systems and in porphyry copper systems. Hence, chemical data on the extent and intensity of rock alteration, including precious metal distribution patterns, is of significant scientific and economic interest.

**Funding:** Campus Research & Publication Fund, TT\$57,524.00

**Principal staff involved:** Dr. Erouscilla Joseph

**Title:** UKGCRF: "Harnessing 'citizen science' to reinforce resilience to environmental disasters: creating an evidence base and community of practice."

**Description:** The broad aim of this project is to understand how citizen science is currently applied to disaster risk reduction (DRR) objectives in the face of natural hazards, and how it might be more effectively applied in the future. One of the major outcomes of the workshop is the design of a project to be employed in St. Vincent, which utilises the concept of Citizen Science to help improve resilience to disasters.

**Funding:** NERC - Global Challenges Research Fund, : £157,815.00

**Principal staff involved:** Dr. Erouscilla Joseph, Prof. Richard Robertson



## OUTREACH

Despite the fact that the SRC's core mandate has historically revolved around monitoring and research, these pursuits have never been perceived as an end in themselves. While monitoring and research feed into and support each other, their products are intended for educating stakeholders and informing development. In this regard, the Education and Outreach programme of the SRC aims to bridge the gap between the science of the geological hazards monitored by the SRC and public understanding and knowledge of these phenomena in the region. The programme consists of student outreach, stakeholder sessions, special projects and collaborations throughout the islands with the aim of raising awareness to the geological hazards and helping to reduce the risk via preparedness and mitigation messages.

### ***Student Outreach***

With the move to a new building completed during the previous year our focus shifted to developing a new tour route and an area for hosting tours. However due to unforeseen circumstances, tours to the Centre were indefinitely postponed until the upcoming academic year. Instead schools were visited and presentations given to various schools and camps in Trinidad and Tobago. The E&O team also participated with booths at certain school events. These activities covered a multitude of topics (see Appendix 1).

### ***Science and Safety Sessions***

Science and safety presentations on earthquakes, volcanoes, tsunamis or all three hazards are given to private firms, government offices and other entities in Trinidad and Tobago upon request. For the reporting period, fourteen sessions were conducted with staff or members of various agencies.

### ***Collaborations/Special Events***

#### **CARIBBEAN SCIENCE YOUTH FORUM**

The SRC was invited to participate in The National Institute of Higher Education, Research, Science and Technology (NIHERST) annual Youth Forum. The Caribbean Youth Science Forum (CYSF) is a regional event that brings together Sixth Form Science students from all over the Caribbean for a full week of educational, social and cultural activities. The students

participate in lectures & discussions, workshops, field trips, projects, sports and social activities and interact with scientists. The SRC hosted a session with the students with a focus on generating interest in various geoscience careers.

### **VISIT BY THE NEW PRO VICE CHANCELLOR (PVC) FOR GRADUATE STUDIES**

In October 2016, the SRC hosted the new Pro Vice Chancellor for Graduate Studies, Professor Dale Webber for a short visit. The PVC met with staff and had discussions with the Director and Research Fellows regarding the research undertaken at the SRC.

### **WORLD TSUNAMI DAY**

On November 5, 2016, the SRC's staff joined the international disaster risk reduction community in commemorating World Tsunami Day with a photo and key safety messages. The photo was shared on the SRC's social media platforms and the international online campaign.

### **EARTH SCIENCE WEEK, SAINT LUCIA**

The SRC ended 2016 with the annual commemoration of Earth Science Week. The theme for this year was, "Our Shared Geo heritage." As such, it was decided that the island of Saint Lucia would be ideal to commemorate this theme as there are many geo heritage sites on the island. To this end, the Centre collaborated with the National Emergency Management Organization (NEMO and the Soufriere Regional Development Foundation (SRDF) to plan and execute various activities throughout the island. The SRC's main objectives for Earth Science Week 2016 were to sensitize the public to Saint Lucia's and the region's vulnerability to geological hazards and to increase awareness of the potential impact of these phenomena. The theme chosen for the week was "Let's preserve our geo heritage for future generations. The week of activities included primary school workshops, specific stakeholder training sessions, a community meeting, a media campaign and the launching of an art competition in the Soufriere region.

### **Launch of MVO 'Volcano Stories'**

2017 began with the launch of '*Volcano Stories*' in *Montserrat*'. The Centre in partnership with the Montserrat Volcano Observatory (MVO) published twenty-six winning entries from the 2013 MVO creative writing competition where, teenagers and children were invited to submit stories

under the theme: '*A Volcano's Touch*'. Various Caribbean authors illustrated these stories and the book was officially launched at the Governor's residence with several of the young authors in attendance.

#### SHELL SacodaServ Limited STEM (Science, Technology, Engineering, Math) Fair

At the request of SacodaServ, SHELL Trinidad Marketing Partner, the Centre participated in the company's STEM fair and prize giving ceremony event. This project seeks to enhance the impact of local STEM education through innovative techniques and experiential learning. Students from the participating schools were invited to the fair and visited the Centre's booth where they obtained information on the hazards monitored by the SRC and also participated in games.

#### SHELL SacodaServ Limited STEM (Science, Technology, Engineering, Math) School Sessions

Following on from the SHELL STEM Fair, the SRC was requested by SacodaServ to participate in school sessions with the aim of boosting STEM interest among secondary school students. A team participated in a workshop session at the Trinity School, Moka, Trinidad where students were given science and safety information but also information on various careers in Earth Sciences.

#### Earthquake and Tsunami Smart Week Barbados

The Disaster Emergency Management (DEM), Barbados once again invited the SRC to conduct a week of outreach activities throughout the island. The theme of this year's month was: '*Be aware, prepare, know what to do: Don't let earthquakes and tsunamis catch you unaware*'. For the 2017 campaign, the DEM sought to connect with the disabled community as March is also Disability Awareness Month. The SRC's primary objective for this week was to continue to raise the awareness of both the earthquake and tsunami hazard with respect to Barbados and provide the necessary safety messages via different methods for both the student and specific stakeholders. It is hoped that the outreach work conducted will motivate the younger generations to adopt the relevant safety measures and share the information learnt with fellow students, family members and relatives. As part of our awareness campaign, Barbados centric posts were designed and posted on our social media pages. These posts sought to provide interesting information regarding these hazards and Barbados and also engage the followers in a conversation on these hazards and the safety messages.

### Volcano Awareness Week, St Vincent and the Grenadines

This year Volcano Awareness Week (VAW) was commemorated in April 2017 in partnership with the National Emergency Management Organisation (NEMO) and the Soufriere Monitoring Unit (SMU). VAW activities included the customary school workshops with a new activity based on role play during a volcanic eruption scenario introduced to sensitize secondary to volcanic hazard management. Stakeholder sessions and media interview were also done and the week ended with an educational field tour of La Soufriere.

### Prize giving Ceremony for Earth Science Week (ESW) Saint Lucia Art Competition

In 2016, an art completion was launched during ESW in Saint Lucia. The art competition sought to encourage primary school students in the town of Soufrière and environs to go on a journey to explore and better understand their natural surroundings through artistic expression. The competition theme “*My Volcano, My Home*” was selected to motivate students to capture the influence of their vibrant natural surroundings on their daily lives. Entries were required to focus on one of four designated categories (Benefits of living with a volcano, Our Geo-heritage, Volcanic Hazards and Be Prepared) and to reflect an informed visual expression of the artists’ ideas. This competition formed part of the SRC’s ongoing drive to promote an improved understanding of geological hazards via the educational system within the Eastern Caribbean. Fourteen pieces were submitted and after being judged by a team from both SRC and Saint Lucia, the winners were announced and prizes distributed at an event in Soufriere in April 2017. The SRC’s Director, Professor Richard Robertson and Thais Henry-Ramos represented the SRC at the event.

### National Gas Company (NGC) Bocas Lit Fest

Following the launch of ‘*Volcano Stories*’, the SRC put forward the storybook for consideration at the Trinidad and Tobago NGC Bocas Lit Fest in April 2017. The proposal was accepted and Natalie Edgecombe from the MVO and the Education & Outreach team attended two events where stories from the book were read to students of various age groups. The exposure of the book to young minds and also the Caribbean literary circle helped raised the profile of the SRC and served as a new technique to deliver information about the hazards the SRC monitors.

### Seismology in Schools (SIS) Student Internship

As part of an effort to invigorate the SIS programme in Trinidad and Tobago, a week-long internship at the SRC was offered as part of the winning prize for the competition held among the eight pilot schools. Students of the Couva East Secondary school joined the Centre for one week in April 2017. They got a chance to experience work in the different departments and also produce an earthquake safety video that would be used by the Centre in outreach events. At the end of the internship, the video was shown to staff and the interns were presented with certificates.

### Creating Opportunity from Research Experience (C.O.R.E)

There were no CORE interns at the SRC in 2016. The SRC offered its seventh, eight (8) week summer internship programme for tertiary level students interested in pursuing geoscience careers at the end of the 2017 academic year (June-August). Projects were available in the Education & Outreach, Geophysics and Electronics at the SRC in Trinidad and Seismology at the Montserrat Volcano Observatory in Montserrat. Four interns were selected and had an opportunity to work closely with a supervisor on a specific project as well as gain experience within each department at the SRC. The aim was to provide a full understanding of the how the SRC operates. At the culmination of the time period, the interns were required to make oral presentations on their project.

## ***Partnerships & Collaborations***

### INTER & INTRA-FACULTY

- Disaster Risk Reduction Centre, Mona Campus [Dr Barbara Carby]
- Department of Geomatics Engineering & Land Management, St. Augustine Campus [Dr Keith Miller]
- Institute of Sustainable Development [Dr. David Smith]
- Department of Chemistry, St. Augustine Campus [Dr. Denise Beckles]
- Department of Chemical Engineering, St. Augustine Campus [Dr. Oshaine Blake]
- Department of Geography, St. Augustine Campus [Dr. Matthew Wilson]

### ***Academic Institutions***

- University of Southampton, UK [Dr. Paul Cole]
- University of Leeds, UK [Professor J. Neuberg]
- University of Oxford, UK [Professor D. Pyle]
- University of Bristol, Department of Earth Sciences, United Kingdom [Professor J. Blundy, Dr. Elena Melekhova, Professor R.S.J. Sparks]
- Université des Antilles, Département de géologie, Guadeloupe [Professor Jean-Frédéric Lebrun]
- University of East Anglia, School of Environmental Sciences, United Kingdom [Professor Jenni Barclay, Professor Roger Few & Dr Peter Simmons]
- Department of Oceanography, University of Rhodes Island, United States [Professor Steve Carey]
- Incorporated Research Institutions for Seismology [Dr Bruce Presgrave]
- British Geological Survey, United Kingdom [Drs Sue Louglin, Katy Mee, Melanie Duncan]
- Grand Valley State University, USA [Dr John Weber]
- University College, London [Professor Steve Hailes, Dr. Chris Kilburn]

### ***Monitoring & Disaster Management***

- Istituto Nazionale di Geofisica e Vulcanologia, Italy
- Institut de Physique du Globe de Paris, France
- Instituto Geofisico de la Escuela Politecnica Nacional, Ecuador
- Montserrat Volcano Observatory, Montserrat
- Puerto Rico Seismic Network, University of Puerto Rico
- Fundacion Venezolana de Investigaciones Sismologicas (FUNVISIS), Venezuela
- Coastal Zone Unit, Barbados
- Earthquake Unit, Mona Campus, UWI, Jamaica
- Caribbean Disaster Emergency Management Agency
- National Disaster Coordinators in the Eastern Caribbean
- GNS Science, New Zealand

### ***Research and Grant Funding***

- World Bank

- Caribbean Development Bank
- Natural Environment Research Council, UK
- European Commission Seventh Framework Programme (FP7)
- US Agency for International Development
- National Science Foundation, USA
- Caribbean Catastrophic Insurance Facility
- Ocean Exploration Trust
- Ministry of Foreign Affairs, New Zealand

## **FINANCIAL**

Contributions made by territories in the Eastern Caribbean for which the Centre provides a service improved significantly during the reporting period resulting in the significant reduction in our 2013-2014 budget being partly alleviated. We have continued to lobby vigorously for payment of outstanding debts at the same time that we raise additional income from external grants and contracts for projects. Staff members continue to provide 100% of any proceeds from individual consultancies into the SRC Departmental Consultancy Fund (DCF). Funding from the SRC Departmental Consultancy Fund along with various grants from external sources currently provides for 17-20 members of SRC staff being employed on short-term contracts. One of the objectives of our active search for extra-budgetary funding is to enable recruitment of staff on such short-term contracts to enable the fulfilment of our complete mandate. Funding obtained from grants and consultancy for the reporting is estimated to have been about TT\$1.5M/year.

## **DISTINGUISHED VISITORS**

**Dr. Salman Ashraff**

Remote Sensing Scientist

GNS Science, New Zealand

## **PROJECTED ACTIVITIES FOR THE 2017/2018 ACADEMIC YEAR**

### ACCESS

**Develop and improve existing facilities for post-graduate students including:** new offices, improvements in library services, support and encouragement to attend on overseas conference per year, training in monitoring techniques, attachment to the Montserrat Volcano Observatory and accessing funds for attachments to collaborating Universities for specialized training.

### ALIGNMENT

**VIOLA (Volatile recycling at the Lesser Antilles):** This is a collaborative project with several UK institutions (including Bristol, Durham & Imperial College). It involves deployment of Ocean Bottom Seismometers and the conduct of active source experiments to collect a series of seismic profiles across the plate boundary.

**Revised web site for the SRC & more effective use of social media and developing video products:** The current web site is now out-of-date and needs to be revised to be current with the needs of our stakeholders. Attention will continue to be focused on enhancing the education and outreach work of the Centre to vulnerable island communities using social media but also developing short videos.

**Volcano-Ready Communities in St. Vincent:** This is a project funded by a grant of US\$618,700 from the Community Disaster Risk Reduction Fund administered by the Caribbean Development Bank that is being done in St. Vincent in collaboration with the National Emergency Management Organisation of St. Vincent and the Grenadines. It involves the provision of scientific information and its downscaling to support community level volcano contingency planning, community-led multi-hazard mapping and capacity building for disaster risk reduction.

### AGILITY

**Explore options for developing and expanding work in terms of geothermal consultancy services:** This will involve an investigation of the demand for and requirements of providing professional services to geothermal production companies in the Eastern Caribbean.



**Finalize the outfitting and occupation of the entire new SRC building:** This includes: a) provision of space for postgraduate students and the Education and Outreach section; b) provision of space for lectures and c) transferral of our existing IT server room to the new building. We anticipate that there are sufficient funds set aside in our DCF to enable these activities to be undertaken.

**Re-location of computer servers to new building and expansion of the SRC IT infrastructure:** This will be done to satisfy the demands of increased monitoring in response to the projects being currently pursued or coming on stream (TSUAREG, VSAT, strong motion - local & CRIFF, etc.).

**APPENDIX 1: LIST OF STUDENT OUTREACH ACTIVITIES FOR THE PERIOD JULY 31ST 2016- AUGUST  
1ST 2017 IN ORDER OF OCCURRENCE**

<b>SCHOOL/Institution</b>	<b>EVENT</b>	<b>TOPIC</b>
Summer Starz Creative Camp, Valsayn	Educational Talk and Activity	Earthquake Science & Safety
Barrackpore East Secondary, Barrackpore	Workshop	All hazards science and safety
ASJA Girls College Tunapuna	Workshop	All hazards science and safety
College of Science, Technology and Applied Arts of Trinidad and Tobago (COSTATT), Port of Spain	Workshop	All hazards science and safety
The University School, St. Augustine	Workshop	Earthquake science and safety
Penal Secondary, Penal	Workshop and Career Session	Earthquake Science & Safety and Geoscience Careers
Bishop's High School, Tobago	Career Day	Booth with career and safety information
St. Mary's College, Port of Spain	Workshop	All hazards science and safety
UWI Preschool, St. Augustine	Workshop	Earthquake science and safety
Siparia East Secondary, Siparia	Workshop and Career Session	Earthquake Science & Safety and Geoscience Careers
Department of Creative and Festival Arts, UWI, St. Augustine Camp	Educational Talk and Activity	Earthquake Science & Safety
UWI Farm Road Collaborative Camp, SPEC, St. Augustine	Educational Talk and Activity	Earthquake Science & Safety

## APPENDIX 2: CONFERENCE PRESENTATIONS & PUBLICATIONS

### **Refereed Publications**

#### BOOK CHAPTERS

Rouwet, D., Hidalgo, S., **Joseph, E.P.**, González-llama, G. *Fluid Geochemistry and Volcanic Unrest: Dissolving the Haze in Time and Space*. July 2017. Book Chapter 12, In: *Advances in Volcanology*; ed. K. Nemeth. Springer Nature. Series ID 11157. doi: [10.1007/11157\\_2017\\_12](https://doi.org/10.1007/11157_2017_12). 1 Citation.

**Robertson R. E. A.** (2017): St. Kitts and Nevis. In: Casey D. Allen *Landscapes and Landforms of the Lesser Antilles*. *Geomorphological Landscapes of the World Series*. Springer International Publishing AG, Cham, ISBN: 978-3-319-55785-4, XVI, 317p.

#### JOURNAL MANUSCRIPTS

Schlaphorst, D., J-M. Kendall, B. Baptie, **J.L. Latchman**, and S. Taitt. (2017): Gaps, tears and seismic anisotropy around subducting slabs in the Antilles. *Tectonophysics* 698: 65-78. DOI: 10.1016/j.tecto.2017.01.002.

Salazar, W., **Mannette, G., Reddock, K., & Ash, C.** (2017): High-resolution grid of H/V spectral ratios and spatial variability on microtremors at Port of Spain, Trinidad. *Journal of Seismology*, 21(6), 1541-1557, <https://doi.org/10.1007/s10950-017-9681-1>

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**Dondin, Frederic Jean-Yves**, Heap, Michael J., **Robertson, Richard E.A.**, Dorville, Jean-François M., Carey, Steven (2017): Flank Instability Assessment at Kick-'em-Jenny Submarine

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**Robert Constantinescu, Richard Robertson**, Jan M. Lindsay, Roberto Tonini, Laura Sandri, Dmitri Rouwet, **Patrick Smith** and **Roderick Stewart** (2016). Application of the probabilistic model BET\_UNREST during a volcanic unrest simulation exercise in Dominica, Lesser Antilles. *Geochem. Geophys. Geosyst.*, 17, doi:10.1002/2016GC006485.

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### ***Non – Refereed Publications and Related Works***

#### CONFERENCE PRESENTATIONS

**Michal Camejo**, Jon Blundy, Elena Melekhova, **Richard Robertson**, Thomas Christopher  
*Petrology of plutonic and volcanic rocks from Bequia, Lesser Antilles arc.*

IAVCEI 2017 Scientific Assembly, Fostering Integrative Studies of Volcanism, Portland, U.S.A., August 2017.

Melanie Duncan, Katy Mee, Samantha Engwell, Anna Hicks, Sue Loughlin, **Richard Robertson**, Michelle Forbes, Idelia Ferdinand

*Increasing resilience to multiple natural hazards through citizen science: piloting the myVolcano app in St Vincent and the Grenadines.*

IAVCEI 2017 Scientific Assembly, Fostering Integrative Studies of Volcanism, Portland, U.S.A., August 2017.

Anna Hicks, Teresa Armijos, Jenni Barclay, Jonathan Stone, **Richard Robertson**, Gloria Patricia Cortes

*Risk Communication Films: Process, product and potential for improving preparedness & adaptation.*

IAVCEI 2017 Scientific Assembly, Fostering Integrative Studies of Volcanism, Portland, U.S.A., August 2017.

Sarah Brown, Steve Sparks, Anna Stewart, Jenni Barclay, Carolyn Driedger, John Pallister, Elizabeth Westby, Gill Jolly, Julian Thomson, Katcho Karume, Mony Murongani, Jean-Christophe Komorowski, Iain Stewart, Patricia Mothes, **Richie Robertson**, **Stacey Selman-Edwards**, Gokhan Atici, Bilge Karaman, Micol Todesco, Daniele Andronico, Augusto Neri, Esline Garaebiti

*VolFilm: educational films to increase resilience to risks from volcanic hazards.*

IAVCEI 2017 Scientific Assembly, Fostering Integrative Studies of Volcanism, Portland, U.S.A., August 2017.

Susan Loughlin, Anna Hicks, Jenni Barclay, Roger Few, Emily Wilkinson, **Richard Robertson**  
*Integrating diverse datasets and applying new knowledge: the use of scenario exercises in the STREVA project.*

IAVCEI 2017 Scientific Assembly, Fostering Integrative Studies of Volcanism, Portland, U.S.A., August 2017.

H. Geirsson Halldór Geirsson, John Weber, Peter La Femina, Joan L Latchman, **Richard Robertson**, **Machel Higgins**, Keith Miller, Chris Churches, Kenton Shaw

*Fault creep and strain partitioning in Trinidad-Tobago: Geodetic measurements, models, and origin of creep.*

EGU General Assembly Conference Abstracts.

**Erouscilla Joseph**, Denise M. Beckles, Viveka Jackson, Leonette Cox, and **Stacey Edwards**  
*Community-Based Volcano Monitoring Approach at Sulphur Springs, Saint Lucia: A Lesson in Good Stakeholder Engagement*

IAVCEI General Assembly, 14 – 18 August 2017: Portland, Oregon, USA.

**Papadopoulos, I**

*The Trinidad and Tobago Microzonation Project: Towards Understanding and Quantifying Risk.*  
Geological Society of Trinidad & Tobago Conference, May 2017.

**Ash C., S. Edwards, R. Robertson**

*Fostering a new Generation of Geo-Scientists: Lessons learned from the C.O.R.E. Internship Programme.*

CARIUSA 2017 Working Group Meeting, Kingston, Jamaica, March 2017.

**Richard Robertson, Lloyd Lynch, Joan Latchman, Roderick Stewart, Stacey Edwards, Omari Graham**

*Procedures for early warning of volcanic activity utilised in the English-speaking Eastern Caribbean.*

Cities on Volcanoes 9 Understanding volcanoes and society: the key for risk mitigation, Puerto Varas, Chile, November 2016.

**Richard Robertson, Lloyd Lynch, Joan Latchman, Chandradath Ramsingh**

*Keeping people safe from volcanoes in the Eastern Caribbean: lessons from 60 years of operations.*

Cities on Volcanoes 9 Understanding volcanoes and society: the key for risk mitigation, Puerto Varas, Chile, November 2016.

Paul, D. Cole, **R. Robertson**, C. Scarpeti, L. Fedele

*Explosive volcanism in the last 1000 years of Soufriere, St. Vincent, West Indies.*

Cities on Volcanoes 9 Understanding volcanoes and society: the key for risk mitigation, Puerto Varas, Chile, November 2016.

**Richard Robertson**, Rodica Tannis & Andrew Wilson.

*La Soufriere Volcano National Park – management and protection of an important Heritage site.*

Cities on Volcanoes 9 Understanding volcanoes and society: the key for risk mitigation, Puerto Varas, Chile, November 2016

**Omari Graham, Stacey Edwards, Richard Robertson, Clevon Ash & Alia Juman**

*Engaging youth in raising hazard awareness in the Eastern Caribbean.*

Cities on Volcanoes 9 Understanding volcanoes and society: the key for risk mitigation, Puerto Varas, Chile, November 2016.

Anna Hicks, Teresa Amijos, Jenni Barclay, Jonathan Stone, **Richard Robertson**, Gloria Patricia Cortes

*Using films as intervention strategies for volcanic risk reduction.*

Cities on Volcanoes 9 Understanding volcanoes and society: the key for risk mitigation, Puerto Varas, Chile, November 2016.

**Clevon Ash**, Natalie Edgecombe, Stacey Edwards, **Monique Johnson, Richard Robertson**

*Volcano Hazard Education in the Eastern Caribbean – Learning through the Arts.*

Cities on Volcanoes 9 Understanding volcanoes and society: the key for risk mitigation, Puerto Varas, Chile, November 2016.

Anna Hicks, Jenni Barclay, Emily Wilkinson, Roger Few, Sue Loughlin, Paul Cole, **Richard Robertson**, Patty Mothes & STREVA Team

*Forensic Analyses of Volcanic Eruptions.*

Cities on Volcanoes 9 Understanding volcanoes and society: the key for risk mitigation, Puerto Varas, Chile, November 2016.

Alex Poulidis, Jeremy Phillips, Jenni Barclay, Ian Renfrew, Susanna Jenkins, **Richie Robertson**, David Pyle

*Meteorological controls on local and regional ash dispersal revealed using high-resolution dispersion modelling: The eruptions of Soufriere St Vincent.*

Cities on Volcanoes 9 Understanding volcanoes and society: the key for risk mitigation  
Puerto Varas, Chile, November 2016.

**Christopher T. E., Constantinescu, R. Lindsay J., Dondin, F. & Robertson R.**

*Geochemistry of Kick ‘em Jack and Kick ‘em Jenny submarine volcanoes, Lesser Antilles.*

Cities on Volcanoes 9 Understanding volcanoes and society: the key for risk mitigation  
Puerto Varas, Chile, November 2016.

#### INVITED TALKS/REVIEWS

**Richard Robertson** (2017): OMSI Science Museum Event “Nature’s Fury: Living with Active Volcanoes”, Portland, U.S.A., 15 August, 2017.

#### JOURNALISM/PUBLIC COMMENTARY

**Ryan, G.A.** (2017): Montserrat geothermal development project, *SEG wiki*,  
[https://wiki.seg.org/wiki/Montserrat\\_geothermal\\_development\\_project](https://wiki.seg.org/wiki/Montserrat_geothermal_development_project) (invited contribution)

Johnson, M. (2017): A New Thrust for Caribbean Coastal Capital Natural Capital Blog, Inter-American Development Bank Publication, Washington DC. Available from:  
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**Q95FM (Dominica)**, 18/11/2016: Drs Erouscilla Joseph and Graham Ryan were guests on the Dominican call-in radio programme “Hot seat” to give members of the public information about the activity at the Boiling Lake.

**ZJB (Montserrat)**, 29/12/2016: Dr Graham Ryan participated as a guest scientist on the Radio Programme “Volcano Vibes” to explain the use of geophysical methods to locate drilling targets in the Montserrat geothermal system  
(<https://montserratradioecho.wordpress.com/2016/12/29/tuesday-december-29-2016-volcano-vibes-with-winston-kafu-cabey/>)



TECHNICAL REPORTS

**Joan L. Latchman, Richard E.A. Robertson, Lloyd L. Lynch, Frédéric Dondin, Chandradath Ramsingh, Roderick Stewart, Patrick Smith, Adam Stinton, Stacey Edwards, Clewon Ash, Alia Juman, Erouscilla P. Joseph, Nisha Nath, Ian Juman, Hannah Ramsingh, Farrah Madoo** (2017): 2017/04/29 Eruption of Kick-'em-Jenny Submarine Volcano: Report on the 2017/04/08-05/02 Kick-'em-Jenny unrest and eruption episode. SRC Open File Report Kick-'em-Jenny, Grenada 201706\_VOLC1.

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**Stinton, A., Bass, V., Christopher, T., Edgecombe, N., Fergus, M., Pascal, K., Smith, P., Stewart, R.,** and Syers, R. (2017): MVO Scientific Report for Volcanic Activity between 1 April and 30 September 2017. Open-file Report 17/02, Montserrat Volcano Observatory.

**Stinton, A., Bass, V., Christopher, T., Fergus, M., Pascal, K., Smith, P., Stewart, R.,** Syers, R., and Williams, P. (2017): MVO Scientific Report for Volcanic Activity between 1 October 2016 and 31 March 2017. Open-file Report 17/01, Montserrat Volcano Observatory.

**Latchman, J.L., R.E.A. Robertson, C. Ramsingh, E.P. Joseph, L.L. Lynch, N. Nath, I. Juman** (2016): Status of seismic activity in the vicinity of Tobago: As it relates to association with strong earthquakes within the Vema Fracture Transform. The University of the West Indies, Seismic Research Centre, St. Augustine, 26 December 2016, 14p.

**Latchman, J.L., R.E.A. Robertson, C. Ramsingh, E.P. Joseph, L.L. Lynch, N. Nath, I. Juman** (2016): Update on seismic activity in the Trinidad area. The University of the West Indies, Seismic Research Centre, St. Augustine, 16 December 2016, 16p.

**A Stinton, V Bass, T Christopher, M Fergus, K Pascal, P Smith, R Stewart, R Syers, P Williams** (2016): MVO Scientific Report for Volcanic Activity between 1 May and 30 September 2016. Open-file Report OFR 16-03, 83p.

**Ryan, G.A.** (2016): Possible structural target for MON-3 (rough draft), Seismic Research Centre University of the West Indies, St. Augustine, Trinidad and Tobago (Montserrat geothermal project assistance), pp. 9.

**Ryan, G.A.** (2016): Reservoir model development based on geophysical information and petrological analysis, Seismic Research Centre, University of the West Indies, St. Augustine, Trinidad & Tobago (under contract for Government of Montserrat), pp. 104.

**Stinton, A.**, Bass, V; **Christopher, T.**, Edgecombe, N., Fergus, M., **Pascal, K.**, **Smith, P.**, **Stewart, R.**, Syers, R; Williams, C., (2016): MVO Scientific Report for Volcanic Activity between 1 October 2015 and 30 April 2016. Technical Report16-02, Montserrat Volcano Observatory.