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JNCC Research Contribution Project Report

Geoconservation in the Overseas Territories of the UK

2009

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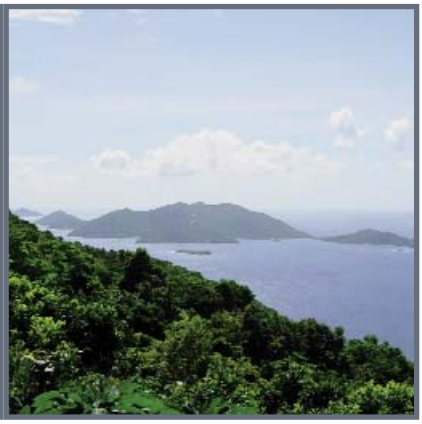
JNCC
Joint Nature Conservation Committee

Geoconservation in the Overseas Territories of the UK



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2009

Acknowledgements

This report was commisioned by the Joint Nature Conservation Committee to help improve our understanding of the geological importance and diversity of the UK Overseas Territories. A further aim was to broadly review the geoconservation activity being carried out there, and identify any particularly significant threats to important geological features. The project was managed by Neil Ellis for JNCC.

Grateful thanks is afforded to all those who provided information that helped create the present document, in particular:

British Indian Ocean Territory: Joanne Yeadon; Anguilla: Karim Hodge; Bermuda: Jack Ward; British Virgin Islands: Bertrand Lettsome; Cayman Islands: Gina Ebanks-Petrie; Gibraltar: Albert Bruzon; Montserrat: Gerard Gray; Turks and Caicos Islands: Wesley Clerveaux; Pitcairn Islands: Jay Warren; St. Helena: Isabel Peters; Tristan da Cunha: James Glass; Ascension Island: Susanna Musick; Falklands Helen Otley; South Georgia and South Sandwich Islands: Darren Christie; British Antarctic Territory, Kevin Hughes.

JNCC is also grateful tor all those who supplied photographs – each of which is individually acknowledged – which clearly demonstrate the diverse natural heritage of the Overseas Territories.

JNCC
Joint Nature Conservation Committee

Introduction

The Joint Nature Conservation Committee (JNCC) is the statutory adviser to Government on UK and international nature conservation.

JNCC has an Overseas Territories and Crown Dependencies programme which aims to give advice and support to UK, Overseas Territory and Crown Dependency governments on nature conservation.

The present desk-based study was commissioned in 2009 to provide information specifically on the geological and geomorphological features of the Overseas Territories (OTs).

Sandy Bay, St. Helena, which may be added to the World Heritage List in the future. (Photo: Ashley Leo.)

The OTs were introduced by an Act of British Parliament in 2002. They were previously known as 'British-Dependent Territories', and before that, 'Crown Colonies'. The OTs range across the globe from Anguilla in the Caribbean to British Antarctic Territory to the Pitcairn Islands in the Pacific Ocean. The territories of Jersey, Guernsey, and the Isle of Man, though under the sovereignty of the British Crown, have a slightly different constitutional relationship, they are classed as Crown Dependencies, and are not the subject of this study.

The study provides a simple summary of the **geodiversity** features that are of special conservation value. 'Geodiversity' is the abiotic parallel of biodiversity. It is the variety of rocks, minerals, fossils, landforms, sediments and soils on Earth and it encompasses the natural processes which form and alter them. **Geoconservation** is the activity concerned with protecting, and where possible, enhancing and promoting geodiversity.

For the study, contacts were made in each territory to find out what specific geoconservation activity exists; and whether there were other conservation programmes that could embrace geodiversity.

For each territory, a list of geoconservation sites (where they exist) including national and international designations, geoparks, World Heritage sites, and other protected sites that encompass geology and landscape is provided. There is also a summary of the major threats and 'environmental pressures' potentially affecting the sites and areas, and existing, or opportunities for, geotourism and relevant web links to relevant sources of information.

World Heritage Sites

In the 14 OTs there are three World Heritage sites: at the historic town of St George and its fortifications in Bermuda, Henderson Island (Pitcairn Islands), and Gough and Inaccessible Islands (Tristan de Cunha). The historic and natural environment of St. Helena may be added to the World Heritage Tentative List for inclusion in future years.

Henderson Island, part of the Pitcairn group, is a fossilized raised coral atoll sitting on a volcanic island with the nearest land mass, New Zealand, some 4 800 km away. The Pitcairn Islands are young at 0.8 to 0.9 million years old, but the weight of its volcanic material depressed the crust and lithospheric flexure uplifted Henderson Island, 200 km from Pitcairn Island itself. The 380 000 year lift has produced a dry, fossil lagoon with corals *in situ* some 33 m above sea level.

Gough and Inaccessible Islands are part of the Tristan da Cunha group in the South Atlantic. Gough Island is the summit of a Tertiary-aged volcano with dramatic, steep sea cliffs, and Inaccessible Island, a 2–3 million year old eroded remnant of an extinct shield volcano, not surprisingly (from its name) has quite inaccessible cliffs.

Geodiversity

The geodiversity seen across the OTs is spectacular with a range of superbly exposed features including the stages in the evolution of an active plate margin and marine basin with remnants of an ancient volcanic arc in South Georgia and the South Sandwich Islands.

On Montserrat the Soufrière Hills volcano killed 19 people on 25 June 1997 in a pyroclastic eruption which went on to destroy the capital Plymouth in August of that year. The eruption caused half of the island to be evacuated and much will remain uninhabitable for decades.

Soufrière Hills on Montserrat. (Photo: Tara Pelembe.)

Anegada, geologically distinct from the rest of the British Virgin Islands, is flat and composed of limestone and coral with white sand beaches and the long Horseshoe Reef, the largest in the Caribbean and the second largest in the world.

Darwin's geology

In this Darwin anniversary year (2009), his *Beagle* voyage is remembered in the OTs of the South Atlantic Ocean. He recognized that deposits filling the central depression in the Devil's Riding School on Ascension were formed in a lake suggesting that the climate was substantially wetter in the past. St. Helena boasts snail fossils of evolutionary significance; they were found at the base of Flagstaff Hill and were studied by Darwin. Darwin also collected brachiopods, crinoids and trilobites from the Fox Bay Formation sandstones in the middle of the West Falkland Group. On Falkland he also recorded the periglacial landforms where solifluction has smoothed slopes and formed stone-runs, but left rock outcrops unaffected. These stone-runs are unique, spectacular and distinctive with delicate environments occurring in valley bottoms and on slopes as alternate strips of boulders and sparse vegetation. Darwin called them 'streams of stones'.

Geodiversity controlling biodiversity and land-use

On Anguilla, in the Caribbean, there are 25 salt ponds scattered throughout the island, in the past these have supported a thriving salt industry, and now prevent the flooding of roads, farms, businesses, and homes by providing a place for excess rainfall to be absorbed and held. They also protect fragile and sensitive coral reefs and seagrass beds by catching, holding, and filtering fresh water before it can reach them.

There are no streams on the Cayman Islands because of the limestone bedrock, the absence of sediment run-off gives clear waters making the Caymans one of the most popular snorkelling and diving areas in the world.

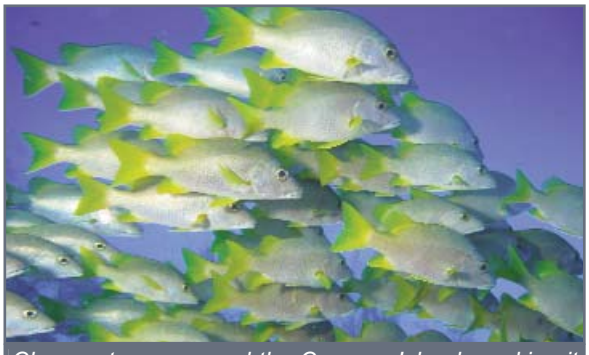
All of the islands in the Turks and Caicos Islands have caves and those on Middle Caicos form the largest cave network in the archipelago, especially Conch Bar Caves with the largest sub-aerial cave system in the Caribbean. It is a national park with significant human history from the pre-Columbian past. Grand Turk has an extensive, pristine barrier reef system 200 m from shore, shallow depressions called 'Salinas' in the limestone contain heavily-alkaline salt water that seasonally evaporates, depositing gypsum, calcium carbonate, and sea salts. These Salinas attracted seasonal salt rakers from Bermuda in the 17th century who settled and formed the basis of the salt industry which lasted into the mid-20th century.

Environmental pressure

Particular environmental pressures include coastal development. Geological features and 'type sections', benchmark reference points for geologists, which are described in technical papers dating back over 100 years are under threat from coastal protection measures, from excavations, and from shotcrete used to re-enforce rock faces.

In Bermuda, limestone quarrying, water pollution, waste dumping, littering, and vandalism of speleothems and other cave deposits continue to threaten the unique cave resources.

In Gibraltar the greatest pressure is on Quaternary sediments as urban development has been dramatic since the early 20th century and continues apace. All major reclamation projects including the extension of the dockyards between 1895–1900 and the extension of the airfield in 1942 used scree breccias, but sea-dredged sand was used to infill part of the northern harbour area and to build high-rise housing and office developments.



Clear waters surround the Cayman Islands making it a popular snorkelling and diving destination. (Photo: Nickki Chapman.)

Grand Cayman has more than 900 000 visitors a year who come for water sports and leisure, putting pressure on the cave systems, but tourists there visit Hell to see the dark-grey to black phytokarst, a landform of the limestone formations produced by boring plant filaments, with sharp, jagged surfaces and razor edges. Geotourism is not always inconsistent with geoconservation, depending on the resilience of the resource, and whether rates of erosion are accelerated by human activity.

In Antarctica the Mount Flora SSSI, designated for its rich fossil flora, was one of the first discovered in Antarctica and could be vulnerable to souvenir fossil collectors and merits protection.

Geoconservation activities

Geoconservation activities are few in number in the OTs, but worthy of mention is the multi-disciplinary Bermuda Cave and Karst Information System (BeCKIS) project, established in 2002 with professionals and volunteers working to produce a common GIS database. This includes cave maps, water quality information, potential threats, living and fossil species distributions, palaeontological excavations of the talus cone in Admiral's Cave and dating and analysis of stalagmites.

The Ascension Environmental Information Operations Utility (AEIOU) project will synthesize existing information from land jurisdiction, environmental mapping and monitoring, and geological and cultural data with new land-cover data into a single manageable framework. Resulting maps will provide the means to implement the plan for Green Mountain. This has the opportunity to promote and include geoconservation into the Green Mountain National Park.

Also in the Atlantic Ocean, St. Helena's Environment Charter's Guiding Principles and Commitments broadly supports geoconservation and within the Strategy for Action there are actions and programmes specifically related to conservation of geodiversity features and the issues surrounding that activity.

The whole of Antarctica is designated as a natural reserve devoted to peace and science by the Antarctic Treaty's Protocol on Environmental Protection. There are certain areas given even greater protection through the protocol's system of protected and managed areas with 70 Antarctic Specially Protected Areas (ASPAs, formerly SSSIs), five Antarctic Specially Managed Areas (ASMAs) and over 80 Historic Sites and Monuments (HSMs).

The OTs are geodiversity rich, perhaps surprisingly so, as they cover such a small area of the Earth's crust. They certianly do however show the link between the natural, cultural heritage and landscape of these former Crown colonies.

Indian Ocean

British Indian Ocean Territory (BIOT)

Introduction

The islands and reefs of the Chagos Archipelago form the part of the Laccadives–Chagos Ridge that runs north to south in the middle of the Indian Ocean. There are five atolls at Chagos: Bank, Peros Banhos, Salomon, Egmont and the largest atoll in the world at Diego Garcia. There are ten reefs and submerged shoals including Blenheim Reef, Speakers Bank, Pitt Bank and Centurian Bank. The islands, 1000 in total, cover an area of around 60 km^2, but the area of near-surface coral reefs is 4000 km^2 representing 1.5% of the global area of reefs. The terrain is flat and low, with most areas not more than 2 m above sea level. The climate is tropical marine, hot and humid and swept by trade winds. The only inhabitants are on Diego Garcia and the BIOT is a protected area.

Diego Garcia, British Indian Ocean Territory, the largest atoll in the world. (Photo: Serendigity, Creative Commons)

Geoconservation programmes

Existing None
Activities None

Geoconservation sites

There is one Ramsar site and seven strict nature reserves.

Environmental pressures

The main pressure is rising sea level.

Web links

http://www.chagos-trust.org/
http://www.islandvulnerability.org/otuk.html
http://www.ukotcf.org/territories/biot.htm

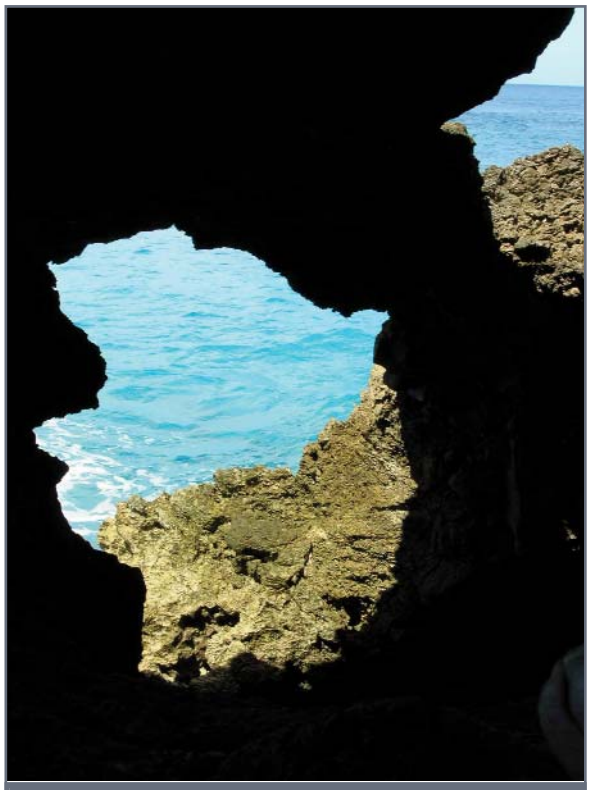
North Atlantic Ocean

Anguilla

Introduction

Anguilla is the most northerly of the Leeward Islands in the Lesser Antilles and lies 235 km east of Puerto Rico and 10 km north of St. Martin. The territory consists of the main island, approximately 26 km long by 5 km wide, together with 22 smaller islands and cays which have no permanent population. The land area of the territory is 102 km² with a population of about 13 500, most living in Anguilla's capital The Valley. The name 'Anguilla' means 'eel' and it fits the island's sinuous flat shape with the highest point of 65 m on Crocus Hill. Rainfall is low and the vegetation is mainly small trees and bush. It has a dry and hot climate with an average temperature of 28°C and the mean annual rainfall is 1 017 mm. The coastline has sandy bays in the south and cliffs in the north. There are extensive reefs off the north coast and fringing reefs along most of the south coast. The 17 km-long reef along the south-east coast is considered to be one of the most important largely unbroken reefs in the eastern Caribbean. Anguilla arguably has the best beaches in the Caribbean.

Anguilla and the islands of St. Bartholomew and St. Martin consist of andesitic tuffs and tuff-breccias of Middle and Late Eocene age with intruded basalt, andesite, and quartz diorite of a slightly later date. The tuffs were tilted and faulted by volcanic activity in the Late Eocene and during the Oligocene–Miocene periods limestone and marls were deposited unconformably on the tuffs. These limestones cover the island except for two small outcrops of tilted tuffs and basalt. Later the



Northern Anguilla cliffs. (Photo: Anguilla National Trust.)

limestones were gently folded and during Pliocene and Pleistocene times the islands were probably connected to form one large island. The area is now submerged to form the Anguilla–St. Bartholomew Platform. Beyond the island of Sombrero is a very deep channel, the only one of its kind, dissecting the Antillean chain and cutting off the sunken plateau of the Virgin Islands to the west.

Anguilla has few natural resources, but there are 25 salt ponds scattered throughout the island, which in the past supported a thriving salt industry, pictured on postage stamps of the island, but now abandoned. Salt ponds are able to prevent the flooding of roads, farms, businesses, and homes by providing a place for excess rainfall to be absorbed and held. They also protect fragile and sensitive coral reefs and seagrass beds by catching, holding, and filtering fresh water before it can reach them. The value of the flood control services ("ecosystem services") provided by Anguilla's salt ponds is estimated at almost EC$3 million annually.

The topography is characterized by limestone sinkholes or 'bottoms' scattered throughout the island and development has occurred in a few of the larger sinkholes including The Valley.

New developments being built at Barnes Bay, Anguilla contributing to environmental pressures on the island. (Photo: Anguilla National Trust.)

Fountains Cavern, a large limestone cavern located on a ridge at about 20 m above sea level, is one of 19 Amerindian sites identified and is considered to be the most important archaeological (Pre-Columbian) site on the island. Its historic significance has led the government of Anguilla to develop a national park with the cavern as the focus, and it has been nominated as a World Heritage Site. The cavern has been closed to ensure its protection and is not accessible to the public. The cave has various geological formations and a cave lake which the Amerindians used as a source of fresh water.

Geoconservation programmes

Existing Activities None

Geoconservation sites

The only site is Fountains Cavern, nominated as a World Heritage site, but there are ten nationally protected sites. None are specific for geoconservation.

Environmental pressures

Tourism is very important to the economy, and along with house building, puts pressure on natural resources, but the major pressure comes from hurricanes, tropical storms and flooding. The low-lying topography and drainage pattern of the sinkholes and salt ponds increases the risk of high-winds, flood damage, coastal erosion and landslides, all of which affect the geodiversity.

Web links

http://gov.ai/doenvironment/
http://www.axanationaltrust.org/
http://www.wdpa.org/MultiSelect.aspx
http://www.islandvulnerability.org/otuk.html
http://www.ukotcf.org/territories/anguilla.htm

Bermuda

Introduction

Bermuda lies at approximately 32° N, 64° W and 900 km (570 miles) from North Carolina, USA. It is 25 km long, 2.5 km wide with a total land area of 53 km^2 and has 65 000 inhabitants. It comprises of four main islands and more than 130 smaller reef-protected islands at the southern rim of the Bermuda Platform. Land is generally low lying with heights over 50 m at a number of locations and the highest of 76 m on Town Hill, Smiths' Parish.

The characteristic geology of sandy, limestone aeolianites interlayered with palaeosols ('fossil' soils) is a result of the cyclical submerging and emerging of the Bermuda Platform during the Pleistocene period. The 50 m of limestone rest on a truncated volcanic seamount of basaltic rocks built up in two eruptions between 45 and 33 million years ago. The topography consists of Pleistocene wind-blown sand dunes or aeolianites cemented into limestone, locally called 'Dunerock' with large-scale cross bedding indicative of dune migration. There are no rivers, but significant reserves of fresh ground water in 'lenses' in the younger limestones that have high inter-granular porosity and relatively low permeability. There are inland marshes and salt water lakes and 179 known caves, most located in the narrow strip of land separating Harrington Sound from Castle Harbour where the Walsingham limestone, the island's oldest, is exposed.

Bermuda has one of the highest concentrations of caves in the world which are significant with deep anchialine pools, extensive underwater networks, numerous and delicate speleothems, and unique fauna and flora with 21 currently listed as critically

Crystal Caves, Bermuda. (Photo: Andy Dobson.)

endangered under the Bermuda Protected Species Act.

The caves show a large amount of roof collapse, irregular chambers and fissure entrances probably caused by collapse that occurred when sea levels fell. Today's caves are only a fraction of the size of the original solutional voids dissolved by fresh-water early in Bermuda's geological history. There are a number of sinkholes, and it is not unusual to discover caves on the edges of the large collapsed areas. Many caves in Bermuda are beautiful, large and historically important and have been opened to visitors including Crystal, Island, Cathedral, Admiral's, Castle Grotto, Leamington, Wonderland, Walsingham, and Tuckers' Island Caves. The Devil's Hole, a collapse cave that was first opened for public exhibition in 1843, is utilized as a natural fishpond. Blue Grotto, another water-filled collapse cave, was recently the site of trained dolphin shows. Prospero's Cave previously known as 'Island Cave' contains an underground bar and discotheque. The caves and speleothems are thought to be at least 200 000 years old.

Geoconservation programmes

Existing Activities None

The multidisciplinary Bermuda Cave and Karst Information System (BeCKIS) project was established in 2002 with professionals and volunteers working to produce a common GIS database. This includes cave maps, water quality information, potential threats, living and fossil species distributions, paleontological excavations of the talus cone in Admiral's Cave and dating and analysis of stalagmites.

Geoconservation sites

There is one World Heritage site, the historic town of St. George and its related fortifications, seven Ramsar sites and 135 nationally protected sites listed by UNESCO and WDPA respectively. The World Heritage site has great potential for geo-conservation and along with some of the the national sites, but the caves are not listed as such. Bermuda has a well-developed system of parks that serve to protect natural features both biological and geological. For example a large section of the south shore of Bermuda including many of the signature beaches and coastal dunes are in the parks system and are protected.

Environmental pressures

Escalating development, filling for construction projects, limestone quarrying, water pollution, waste dumping, littering, and vandalism of speleothems and other cave deposits continue to threaten the unique cave resources. Geological features and 'type sections' which are described in technical papers dating back over 100 years are under threat from coastal protection measures, from excavations, and from methods (such as shotcrete) used to re-inforce rock faces. Similarly, modern geological features such as beaches and dunes are being modified by private landowners.

Paget Marsh, Bermuda, is a peat marsh covered with a cedar and palmetto forest. (Photo: Andy Dobson.)

Web links

http://www.bnt.bm/
http://www.tamug.edu/cavebiology/BeCKIS/Intro.html
http://www.wdpa.org/MultiSelect.aspx
http://www.islandvulnerability.org/otuk.html
http://whc.unesco.org/en/list/983
www.bamz.org
www.biodiversityactionplan.bm
www.bnt.bm
http://www.ukotcf.org/territories/bermuda.htm

British Virgin Islands (BVI)

Introduction

The British Virgin Islands comprise of 60 semi-tropical islands with four large islands, Tortola, Virgin Gorda, Anegada and Jost Van Dyke. The islands are part of the Virgin Islands archipelago in the Leeward Islands in the Caribbean Sea at the eastern extremity of the Greater Antilles and are topographic highs on the Puerto Rico Bank, a sub-merged platform on the Puerto Rico–Virgin Islands microplate located between the Caribbean and North American plates.

The islands are composed of Mesozoic and Lower Tertiary deformed island-arc rocks and underlain by the Virgin Gorda granite batholith intruded in

Horseshoe Reef off Anegada in the British Virgin Islands, the second largest reef in the world. (Photo: BVI National Trust.)

Mid to Late Eocene times. Weathered exposures in tonalitic rocks at the south end of Virgin Gorda gives huge boulders on beaches created as 'tors' due to the classic deep weathering of granitic rocks along joints. The removal of the weathered material has produced spectacular boulder-strewn beaches on the south-west coast of Virgin Gorda and at Fallen and Broken Jerusalem. Spring Bay National Park and The Baths National Park, two of 17 managed by the BVI National Parks Trust, are tourist sites with salt water pools at the base of the tor boulders that are up to 4 m high and 15 m in diameter. Anegada is geologically distinct from the rest of the group and is a flat island composed of limestone and coral with white sand beaches and the long Horseshoe Reef, the largest in the Caribbean and the second largest in the world. Anchoring on Horseshoe Reef is illegal.

Geoconservation programmes

Existing None
Activities None

'Tor' boulders on the beach. (Photo: BVI National Trust.)

Geoconservation sites

There are 46 protected areas and the BVI National Parks Trust currently manages 17 national parks including 16 terrestrial parks and one marine park, the wreck of the *Rhone*. None are specifically geological but geodiversity features in two:

- The Baths National Park, declared in 1990, features giant boulders forming a cave with a sand bottom pool in one area, which is one of the most photographed spots and more than 50% of the visitors to the BVI visit The Baths.

- Spring Bay National Park, declared in 1974, is to the east of The Baths and has giant boulders, but more-open beach.

Environmental pressures

The UK Overseas Territories Conservation Forum (UKOTCF) notes that development of marinas along the coastal areas has been an on-going issue in the territory. Mangroves and sea grass beds are destroyed and reefs are smothered to make way for the tourism-related infrastructure as development continues to compete with the environment on which it is based. The BVI government has made anchoring on Horseshoe Reef illegal in an attempt to protect the reef.

Web links

www.bvinationalparkstrust.org
www.bvidef.org
http://www.ukotcf.org/territories/bvi.htm
http://www.islandvulnerability.org/otuk.html

Cayman Islands

Introduction

The Cayman Islands, in the western Caribbean to the north-west of Jamaica, comprise of three islands, Grand Cayman, Cayman Brac, and Little Cayman representing uplifted fault blocks formed at the margin of the North American and Caribbean plates. The islands are part of the Cayman Ridge, stretching from south-east Cuba, through the Gulf of Honduras to the Misteriosa Bank near Belize, which forms the northern margin of the 5 000 m deep and 250 km wide Cayman Trough.

The island's bedrock is granodiorite with basalt covered by the Mid-Tertiary Bluff Group limestone and dolostones, and fringed unconformably by poorly lithified Pleistocene Ironshore formations, and recent carbonate sediments. Cayman Formation limestones from the Miocene age can be found on Grand Cayman and Cayman Brac

Phytokarst specimens at Hell on Grand Cayman. (Photo: James Nicholls, Creative Commons.)

and there are extensive cave systems at Bodden Town and Pollard Bay respectively. Many of the caves have a range of speleothems deposits, e.g. stalactites, stalagmites, pisoliths and calcite rafts, some are filled or partly filled with a banded, multi-coloured, hard, crystalline dolostone called Caymanite, which is used to make jewellery. Caves are rare in the Pliocene Pedro Castle Formation and absent from the Ironshore Formation on both main islands.

Phytokarst, dark grey to black with sharp, jagged surfaces and razor edges, produced by boring plant filaments is a landform of all of the limestone formations and is best known at Hell on Grand Cayman. Fossil mould cavities caused through the dissolution of aragonitic skeletons of corals, gastropods and bivalves, are common in the limestones which have also been dolomitized to varying degrees. The islands have narrow insular shelves supporting prolific coral reef. There are no streams due to the limestones and the absence of sediment runoff gives clear waters making the Caymans one of the most popular snorkeling and diving areas in the world.

Diving in the clear waters at Little Cayman. (Photo: Nikki Chapman, JNCC.)

Geoconservation programmes

Existing None
Activities None

Geoconservation sites

There is one Ramsar site, 48 protected areas ranging from marine parks through to grouper spawning sites to reserves, replenishment and no diving zones, and a botanic park, but no geo-diversity sites as such.

Environmental pressures

Shallow lagoon bedrock facies of the shore zone of the North Sound in the 1990s was dredged to supply marl for the reclamation of swampland. There are more than 900 000 visitors a year who come to Grand Cayman for water sports and leisure putting pressure on the cave systems. Geotourists visit Hell to see the black phytokarst.

Web links

http://www.islandvulnerability.org/otuk.html
http://www.ukotcf.org/territories/cayman.htm

Gibraltar

Introduction

The Rock of Gibraltar is a 398 m monolithic limestone klippe. This eroded remnant of a nappe is late Cenozoic in age and is part of the Gibraltar arc formed when the Betic Mountains of southern Spain and the Rif mountains of northern Morocco were created from the collision of the African and European plates. Eroded wave-cut platforms are widespread at different levels (at least eight marine abrasions), scree breccias, raised beaches and caves are apparent. Marine abrasions are prominent at the Plateau of Europa Flats at 30–40 m above sea level, and Windmill Hill at 90–130 m above sea level. This evidence and the sheer north face of the Rock and boreholes showing considerable thicknesses of marine sands and clays beneath the surface of the isthmus prove that Gibraltar once was an island separated from the Spanish mainland.

The main ridge is massive Gibraltar Limestone dipping west at high angles, and underlain by younger Catalan Bay Shale to the north-east and east and overlain with older shale to the west. The Great Main Fault zone trends north-west to south-east from the Dockyard South Gate to Hole-In-the-Wall and separates the east dipping limestone of the Southern Plateaux from the main ridge. The north face of the Rock overlooks the Isthmus and was formed during the Quaternary period along a

The Rock of Gibraltar, a 398 m monolithic limestone klippe. (Photo: Allie Caulfield, Creative Commons.)

zone of weakness. Shoreline features notch the Rock and there are 165 caves. Both the Isthmus and lower slopes of the Rock are covered by thick Quaternary sands and scree breccias, a mixture of limestone blocks, some several metres across, and beach sands.

Raised beach sands and gravels are widespread and are metres thick on the eastern side of the Southern Plateau 80 m above present sea level. The Alameda Sands are wind-blown sands, up to 16 m thick, originally spread from the Glacis and south towards North Pavilion are the remnants of a capping scree on the western side of the Rock. Recent Catalan Sands, truncated cross-bedded units occur at the foot of the east coast and lie above a raised beach at about 8 m above sea level. Isthmus aeolian sands are exposed on Western Beach the only strip of land that remains of the Isthmus as Gibraltar airport covers most of the narrow stretch of low lying land standing 3 m above sea-level, and extending from the north face northwards for 800 m beyond the British lines into Spain.

St. Michael's Cave, Upper Rock, Gibraltar. (Photo: Allie Caulfield, Creative Commons.)

Geoconservation programmes

Existing None
Activities None

Geoconservation sites

The entire area of the Upper Rock is a nature reserve, but there are no specific geoconservation sites protected.

Environmental pressures

The most pressure is on Quaternary sediments being used for building as urban development has been dramatic since the early 20th century and continues apace. All major 'land reclamation' projects including the extension of the dockyards between 1895–1900 and the extension of the air-field in 1942 used scree breccias, but sea-dredged sand was used to infill part of the northern harbour area and to build high-rise housing and office developments. Limited reclamation has taken place since 1995.

Web links

http://www.parks.it/world/UK/Eindex.html#Gibraltar#Gibraltar
http://www.islandvulnerability.org/otuk.html
http://www.ukotcf.org/territories/gibraltar.htm

Montserrat

Introduction

Montserrat, is 17 km long and 11 km wide, mountainous, with streams and waterfalls in dense tropical vegetation and situated in the northern part of the Lesser Antilles. It is one of the Leeward Islands and lies 43 km south-west of Antigua and 64 km north-west of Guadeloupe. The Antilles is a volcanic island arc formed where the Atlantic

tectonic plate is subducted beneath the Caribbean plate. Montserrat, a strato-volcano, is composed of andesitic lavas and volcaniclastic rocks produced by dome-forming eruptions; although the South Soufrière Hills are of basalt-andesite composition.

The main features are the remnants of andesite lava domes; andesitic breccias representing the talus of previous lava domes; pyroclastic flow deposits formed by the collapse of lava domes; lahar and debris avalanche deposits; and subordinate tephra fall deposits. There are three volcanic centres of differing age, from oldest (Pleistocene) to youngest (Recent) and north to south are the Silver Hills complex composed of two-pyroxene andesite lavas and agglomerates; Centre Hills Complex characterized by steep-sided peaks (remnants of Pelean domes) surrounded by aprons of block and ash flow and surge deposits, a distinctive pumice lapilli fall deposit, reworked equivalents of the pyroclastic deposits as well as mudflow/lahar deposits.

Petrographically it is composed of two-pyroxene and hornblende-hypersthene andesites; and the active andesitic volcano of the Soufrière Hills consisting of a series of lava domes emplaced along an ESE-trending zone. Block-and-ash flow and surge deposits predominate in flank deposits with hydrothermally altered rocks and active fumarole fields, known locally as soufrières. Garibaldi Hill and St. George's Hill form two smaller, isolated topographic highs. Rock exposures are limited to coastal cliffs, road cuttings, and inland cliffs.

The Soufrière Hills volcano became active for the first time in 350 years on 18 July 1995 following a three year period of seismic activity, two years later pyroclastic activity killed 19 people and two months after that the capital Plymouth was

Dense tropical vegetation on mountainous scenery on Montserrat. (Photo: C. McCauley.)

The Soufrière Hills volcano and in the foreground the capital city Plymouth, which was devestated by the eruption in 1995. (Photo: Mike Schinkel, Creative Commons.)

destroyed. Half of the island was been evacuated and much will remain uninhabitable for the next decade or more. The eruption has been characterized by the growth of an andesite lava dome with associated pyroclastic flows, vulcanian explosion and debris flows, and there have been five distinct phases to the eruption so far. Volcanic activity has declined since March 1998, but is continuously monitored. Since volcanic activity began population of the island has declined from about 11 000 to 4500.

Geoconservation programmes

Existing None
Activities None

Geoconservation sites

There is one national park and 17 other protected areas, but none specifically for geodiversity, although the Soufrière Hills volcano is a wonderful open-air laboratory.

Environmental pressures

None recognized, but the weather is degrading the newly erupted rocks and deposits on the Soufrière volcano.

Web links

http://www.volcano.si.edu/world/region.cfm?rnum=1805
http://www.mvo.ms/
http://www.islandvulnerability.org/otuk.html
http://www.uwiseismic.com/General.aspx?id=1
http://www.ukotcf.org/territories/montserrat.htm

The low lying topography of the Turks and Caicos Islands. (Photo: Tara Pelembe..)

Exploring the caves on Turks and Caicos. (Photo: Eric Salamanca.)

Turks and Caicos Islands

Introduction

The Turks and Caicos Islands, part of the Bahamian archipelago which is a large carbonate platform along the subsiding continental margin of North America, are south of the Bahamas and comprise eight islands and 32 uninhabited cays covering 430 km^2 with a population of 8100. Grand Turk, Providenciales, North, South, West, East and Middle Caicos and Salt Cay are inhabited and lie on the Caicos Bank, a plateau that rises 2400 m from the ocean floor.

The oldest rock is a Cretaceous fossil reef exposed on West Caicos. The topography is low and most of the islands are nearly flat with a maximum height of 63 m. The islands are dominated by complex ridges of aeolian calcarenite on a platform of Pleistocene marine limestones. The ridges have asymmetric cross-sections, large cross-bedded units and occasional fossil land molluscs and are interpreted as dunerocks. The older ridges are highly indurated with extensive pot holes and well-developed lapies.

All of the islands have caves and those on Middle Caicos form the largest cave network in the archipelago, especially Conch Bar Caves with the largest sub-aerial cave system. It is a national park with significant human history from the pre-Columbian past. The island of Grand Turk has an extensive, pristine barrier reef system 200 m from shore and there are also shallow depressions called 'Salinas', in the limestone which contain heavily-alkaline salt water that seasonally evaporates, depositing gypsum, calcium carbonate, and sea salts. These Salinas attracted seasonal salt rakers from Bermuda in the 17th century who settled and formed the basis of the salt industry which lasted into the mid-20th century.

Geoconservation programmes

Existing None
Activities None

Geoconservation sites

There are four national parks, three marine national parks, four land and sea national parks, and ten nature reserves, only Conch Bar Caves National Park is geological.

Environmental pressures

The area is susceptible to the usual tourism and development pressures exerted especially on beaches which are one of the most dynamic and fast changing parts of the islands' landscape.

Web links

http://www.tcmuseum.org
http://www.ukotcf.org/territories/turksCaicos.htm
http://www.islandvulnerability.org/otuk.html
http://www.environment.tc/

Pacific Ocean

Pitcairn Islands

Introduction

The Pitcairn Islands are very remote with the nearest land mass, New Zealand, some 4 800 km away. The Pitcairn Islands consisting of Pitcairn Island, the only inhabited island; Henderson Island, the largest; and the two atolls Ducie and Oeno, lie at the east end of the Tuamotu chain on the Pacific tectonic plate. Henderson Island, a World Heritage Site, is 37 km^2 of raised coral atoll sitting on a volcanic island which formed about 13 million years ago; Pitcairn is younger at 0.8 to 0.9 million years old. The weight of this volcanic

The location of Adamstown on Pitcairn Island. (Photo: Wesley Fryer, Creative Commons.)

material depressed the crust and lithospheric flexure with uplift 200 km from the load started raising Henderson Island above sea level. The 380 000 year lift has formed a fossil raised reef and a dry, fossil lagoon with corals *in situ*. The rise continues at a rate of 0.1mm/yr and has lifted the coral atoll to 33 m. Henderson Island has vertical cliffs rising to 30 m. Marine erosion at the southern end has formed arches in the sea cliffs and a 'blow-hole' 100 m inland. Several reef terraces with caves at different heights are preserved in the bays as the process of uplift is not continuous; these caves were used for shelter and habitation by the early Polynesian settlers.

Henderson Island provides a unique opportunity for documenting climate change in the second half of the Pleistocene. Fringing reefs 50–100 m offshore occur around half of the island and protect the principal beaches. There is no fringing reef between South Point and the north-west beach or around the extreme north-east point where the cliffs are severely undercut. The central plateau of the island is formed by the fossil lagoon floor and the island has eroded karst with limestone pinnacles and rugged areas of steep-sided 2–3 m deep pits.

Geoconservation programmes

Existing Activities None

Geoconservation sites

Henderson Island is a World Heritage site and it is 'a unique example of a raised coral atoll characterized by a fossil lagoon surrounded by intricately eroded karst surfaces. Corals dating back over half a million years remain in situ and provide an exceptional opportunity for exploring the relationships between tectonic uplift (caused by the loading of the Earth's crust by neighbouring Pitcairn), sea-level fluctuation, and climate change over hundreds of thousands of years.'

Environmental pressures

None of the geological materials may be removed from Henderson without a licence granted by the Pitcairn Islands. The administration of which must be sanctioned by the Management Committee.

Web links

http://www.ukotcf.org/territories/pitcairn.htm
http://www.ukotcf.org/pdf/Henderson.pdf
http://www.islandvulnerability.org/otuk.html

South Atlantic Ocean

St. Helena

Introduction

St. Helena is 122 km^2 and 700 miles south east from Ascension Island and 1200 from Tristan da Cunha, which are dependencies. It has a population of 5644 and no airport. It was discovered by the Portuguese in 1502 and settled by the East India Company in 1659. It was also home to the exiled Emperor Napoléon Bonaparte from 1815 until his death in 1821. Ascension Island and Tristan da Cunha are dependencies of St Helena where the Governor is based.

The island is the deeply eroded summit of a massive composite volcano 130 km in diameter rising from the sea floor at a depth of 4224 m; Diana's Peak is 823 m above sea level. The island is 16 km long by 10 km wide bearing north-east to south-west with a high central ridge and radiating from it are 300 m deep dry valleys. There are cliffs over 300 m high along the island's coastline, and a height of 494 m is reached at Great Stone Top. The valley sides and cliffs reveal a succession of alkali olivine basalt-trachyte-

Great Stone Top, the highest sea cliff in the Southern Hemisphere. (Photo: Ashley Leo.)

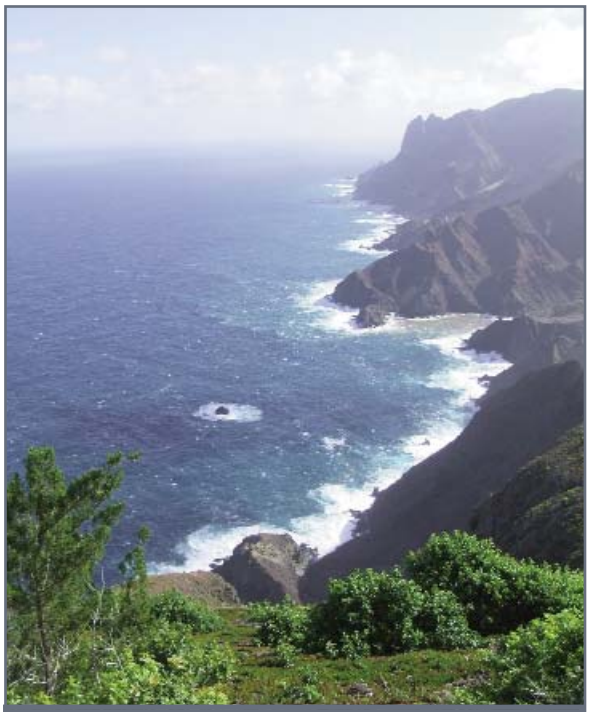
Flagstaff Hill, where Darwin studied fossilized snails. (Photo: Steve Plato.)

phonolite lava flows with interbedded ash and pyroclastic deposits. The basalts exposed on St. Helena have undergone much alteration, and are deep-weathered and friable; the clay mineral halloysite is a common alteration product. Spheroidal weathering forms, typical in basalts, are a common sight, particularly in the valleys fringing Deadwood Plain (Netley Gut, Bilberry Field Gut). These valleys are currently affected by accelerated erosion. Fresh exposures, best seen in cliff faces, reveal the basalts to be typically block-jointed. Both vesicular and amygdaloidal forms abound, the latter being infilled with zeolites and calcites.

The island was formed by two coalescing shield volcanoes with centres in the north east at Flagstaff Hill/Knotty Ridge area, and in the south west at Sandy Bay. Another more recent centre is in the east. The Sandy Bay centre is later than the north east and provides most of the volume of the rocks with eruptions along fissures, and both major centres have transgressive dyke swarms. Marine volcanic lava forms are rare and pillow lavas are not recorded. Trachytes and phonolites form plugs, domes and, more rarely, dykes, and the Asses Ears and Castle Rock are particularly fine examples of columnar phonolitic intrusions; Lot's Wife is a volcanic neck. The oldest rocks are greatly altered breccias exposed between dyke swarms, some intense with the ridge connecting Flagstaff Hill with the Barn composed of 200 dykes with no intervening tuffs or other material. The basalts and trachybasalts are 10–13 million years old and 8–8.5 million years for the later intrusions.

Geoconservation programmes

At present St. Helena's Environment Charter's Guiding Principles and Commitments broadly supports geoconservation and within the Strategy for Action there are actions and programmes specifically related to geoconservation features and issues. There is broad protection for areas of geoconservation significance under the Land Development Control Plan (LDCP), (December 2006 http://www.shda.co.sh/data/files/downloads/ldcp_vol_1.pdf) which sets out the land use planning policies. 'It's purpose is to act as a guide to residents and prospective developers as to what type of development will be encouraged or acceptable and where such development can be located.'



Coastal Zone, St. Helena. (Photo: Tara Pelembe.)

Key landscape and geological features are protected through a number of policies and strategically the LDCP recognises three very different and identifiable land zones, the Greenheartland notable for its great scenic beauty; Coastal Zone with spectacular coastal scenery, rugged, remote and unique and visible geology, and the Intermediate Zone where most development will be accommodated. Specific policy areas relevant to geoconservation include: encouraging where appropriate landscaping around new built developments; sympathetic build design including siting, materials, screening and landscaping; and policies and guidelines relating to alterations, further development and signage in conservation areas and on listed buildings.

The importance of various specific landscapes and geological features have been afforded special protection through the proposed National Protected Areas Plan which lists 14 areas that have been proposed (not yet legally designated) for special protection for among other features their 'outstanding geological, physiographical or

historic features'. The LDCP and new Land Planning and Development Control Ordinance (2008) does make provision for Environmental Impact Assessments for major developments, which will allow a full assessment (expertize and resources permitting) of geoconservation features where applicable. Provision is also made in the Ordinance for building preservation orders and conservation areas.

Geoconservation sites

The historic and natural environment of St. Helena is comparable with, and exceeds in conservation value, many of the sites presently inscribed under the World Heritage Convention, and the UK may add teh area to its Tentative List.

There are 21 protected areas on St. Helena including nine protected landscape and natural monuments. Specific geoconservation sites are:

North Easterly Protected Area

An area of outstanding natural beauty and one of the most prominent features of the island's landscape. Snail fossils of evolutionary significance have been found at the base of Flagstaff Hill and studied by (among others) Charles Darwin. The area should be managed to protect the outstanding natural features of Flagstaff and the Barn and to preserve an important fossil deposit site.

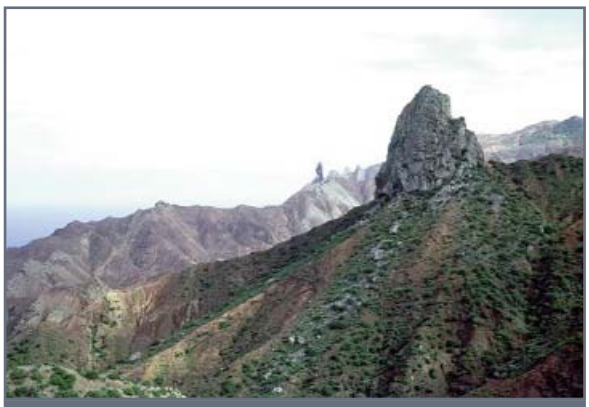
South East Protected Area

Great Stone Top boasts the highest sea cliff in the Southern Hemisphere at 494 m. There are also impressive views down the cliffs and seaward to George and Shore Islands.

South West Protected Area

This area contains some of the most dramatic and beautiful land and seascapes on St. Helena. Physical features are not only visually impressive

Heart Shaped Waterfall, St. Helena. (Photo: Steve Plato.)



Lot's Wife, St. Helena. (Photo: Ashley Leo.)

but represent scientifically important geological features. Lot is a plug of a volcano and Lot's Wife, the Gates of Chaos, Asses Ears and Speery form part of a volcanic dyke.

Heartshaped Waterfall

Heartshaped Waterfall is a natural monument in a scenically beautiful area.

Plantation Forest

This forest should be protected to enable management of this area of national forest as a public park.

Casons (including George Benjamin's Arboretum and Nature Trail Area)

George Benjamin's Arboretum provides easy access to the endemic species of flora on St. Helena, and the Casons Nature Trail guides visitors through stands of Cape Yew trees and endemic ferns.

Environmental pressures

There are no known mineral deposits on St. Helena, but it is quarried for building stone and three sites are earmarked in the Land Development Control Plan for quarrying. There are also deposits of blown white sand which was used in building, but today sand pumped from the sea is used instead. A proposal has been put forward to mine the white sands in an area that holds bird bone deposits. The issue has not yet been fully addressed due to a variety of factors, it is generally considered that this area should be preserved for its environmental value and future scientific study.

Web links

www.bweaver.nom.sh
http://www.volcano.si.edu/world/region.cfm?rnum=1805
http://www.islandvulnerability.org/otuk.html
http://www.ukotcf.org/territories/stHelena.htm

Tristan da Cunha

Introduction

Tristan da Cunha, a dependency of St. Helena, is a 2060 m shield volcano in the South Atlantic Ocean, is 1900 km from St. Helena and 2400 km west of Cape Town. It has nearby islands of Nightingale, Inaccessible and Gough, the last two are known as 'Gough and Inaccessible Islands World Heritage Site'. Inaccessible Island is 35 km south-west of Tristan da Cunha and 340 km north-northwest of Gough Island. Only Tristan da Cunha is inhabited with 284 people in 2000.

Tristan da Cunha, 13 km wide, lies about 500 km east of the Mid-Atlantic Ridge and has high cliffs on most sides. Lava flows dominate the low-angle base and the steep upper flanks and pyroclastic cones ringing the central cone are scattered around the lower flanks. Eruptions have occurred from Queen Mary's Peak, a 300 m wide summit crater, which has a small lake, and from numerous flank vents and radial fissures. Radial dyke swarms are prominently exposed on all sides of the island. Strombolian cinder cones occur on the flanks along concentric ring structures and NNW- and ENE-trending radial fissures. The only eruption since the island was settled occurred during 1961. Inaccessible Island is a 2–3 million year old eroded remnant of an extinct shield volcano, which has built up a wide submarine plateau, and has thin basaltic flows interleaved with ash and scoria overlain in places by later volcanic domes, plugs and dykes. The island is an undulating plateau rising to 500 m above steep sea cliffs cut by waterfalls.

Gough Island is the summit of a Tertiary volcano with dramatic steep sea cliffs forming, and an undulating plateau rising up 910 m. The east has deep, steep-sided valleys, known as glens, separated by narrow, serrated ridges. The west has rounded slopes running down from the central plateau to sea cliffs.

Geoconservation programmes

Existing Activities None

Geoconservation sites

Of the four islands 40% is protected nature reserve and Gough and Inaccessible islands are a World Heritage site.

Environmental pressures

There are no apparent environmental pressues.

West coast of Tristan da Cunha. (Photo: Michael Clarke, Creative Commons.)

Web links

http://www.volcano.si.edu/world/region.cfm?rnum=1805
http://www.islandvulnerability.org/otuk.html
http://www.tristandc.com/

Ascension Island

Introduction

Ascension Island, like Tristan da Cunha is a dependency of St. Helena where the Governor is based. Ascension Island, population 1250, was discovered on Ascension Day in 1501 by the Portuguese navigator Joao da Nova, and lies in the South Atlantic about 750 miles north west of St. Helena and covers an area of 98 km^2 with the highest point of 859 metres on Green Mountain.

Ascension Island is located just west of the Mid-Atlantic ridge and just south of the Ascension Fracture Zone (50 km to the north). Unusually for the mid Atlantic, the island is a not a mantle 'hotspot'; in fact the hotspot lies to the east of the Mid-Atlantic Ridge about 175 miles away. The

Ascension Island. (Photo: Anselmo Pelembe.)

Ascension Island is the summit of a massive strato-volcano that rises 3 200 m above the oceanic crust of the South American Plate. (Photo: Anselmo Pelembe.)

island is a broad emergent summit of a massive strato-volcano that rises 3200 m above the 5–6 million-year-old oceanic crust of the South American Plate. The base of the volcano is 60 km diameter, and the island represents only the top-most and youngest few per cent of the volcano's mass.

Ascension Island is unusual among oceanic islands in having a high proportion of pyroclastic deposits relative to lava flows, approximately 40:60 based on exposure. The mafic and silicic pyroclastic deposits, and trachyte lava flows and domes, predominate in the centre and east of the island. The remainder of the island comprises scoria cones and mafic lava flows, some with a thin veneer of pyroclastic deposits. There are over 50 scoria cones all with an oxidized surface layer, and most composed of cinders with minor blocks and bombs. K–Ar whole rock age dates (mostly for trachyte) suggest that the oldest exposed rocks are about 1 million years old. There have been no eruptions since the discovery of the island and the last major volcanic eruption took place about 700 to 1 000 years ago on Sisters Peak, although the island was uninhabited until 1815.

Nearly all of the mafic (basalt to benmoreite) lava flows, typically a few metres thick and scoriaceous, are flows of variable and small volume, erupted from breached scoria cones with steep flow fronts. Dykes are rare. Trachyte and rarer rhyolite flows on and around Green Mountain are 0.8 to 1 million years old and those at Weather Post and Devil's Cauldron flow domes were erupted within the last 60 000 years. Green Mountain is composed of pyroclastic deposits, both scoria and pumice, and many show evidence of reworking by water, suggesting that the climate was substantially wetter in the past. Darwin recognized that deposits filling the central depression in Devil's Riding School were formed in a lake.

Ascension is famous for xenolith suites. Granite xenoliths are the intrusive equivalents of the rhyolite flows; gabbroic xenoliths have isotopic compositions different to those of the exposed volcanic rocks and syenite xenoliths are partially melted and contain veins and small pods of glass.

Geoconservation programmes

Existing None
Activities The Ascension Environmental Information Operations Utility (AEIOU) project will synthesize existing information from land jurisdiction, environmental mapping and monitoring, geological and cultural data with new land cover data into a single manageable framework. Resulting maps will provide the means to implement the plan for Green Mountain. This has the opportunity to promote and include geoconservation into the Green Mountain National Park.

Geoconservation sites

Green Mountain National Park
Letterbox National Park
The name of the latter park comes from the habit of sailors leaving letters for collection.

Nature reserves

Sisters Nature Reserve (geology)
This reserve is the site of the youngest volcanic (Icelandic type) eruption on the island estimated at 700 to 1000 years old, with a young Hawaiite flow originating from a breach high on the flank of the cone. This flow extends 3 km to the coast and flows around Broken Tooth. There is no central crater, but the fissure is marked by a line of oval depressions caused by eruptions.

Mexican Thornbush has been reported to threaten the green turtle population on Ascension Island. (Photo: Anselmo Pelembe.)

King Penguin on South Georgia. (Photo: Wili_Hybrid, Creative Commons.)

Devil's Riding School Nature Reserve (geology)
An example of one vent producing trachyte lava and basalt forming what was the island's largest freshwater lake, but it dried up and was found to contain unique sedimentary deposits, the 'Devil's eyeballs'. The reserve also has the most recent gaseous fumarole activity.

Environmental pressures
The UKOTCF reports that the recently introduced Mexican Thorn bush threatens the green turtle population, the surviving unique desert flora and fauna and some geological features, but these are not specified.

Web links
www.ascensionconservation.org.ac
http://www.the-islander.org.ac/art_3838_59_0.html
http://www.volcano.si.edu/world/region.cfm?rnum=1805
http://www.islandvulnerability.org/otuk.html
http://www.ukotcf.org/territories/ascension.htm

Falkland Islands

Introduction
The Falkland Islands archipelago consists of two large islands, East and West Falkland and 780 smaller islands extending 250 km from east to west and 155 km north to south. The highest point is Mt. Usborne (705 m) on East Falkland, and the coastline is deeply incised forming sheltered inlets with some high cliffs of 50–100 m high. The islands lie at the western end of the Falkland Plateau, a relatively shallow water area of continental crust that extends towards South Georgia, and are surrounded by four major Mesozoic–Cenozoic sedimentary basins with considerable potential for oil and gas.

There are Precambrian gneisses and granite at Cape Meredith in the southern part of West Falkland, but rocks are mainly Silurian–Devonian sediments with the southern part of East Falkland Carboniferous–Permian. The rocks split into the West Falkland Group, underlying West Falkland, and the northern uplands of East Falkland and consist of Silurian–Devonian quartzose and sub-arkosic sandstones with siltstone and mudstone forming a rugged landscape, and the Lafonia Group underlying the low lying areas of southern East Falkland (Lafonia). The surrounding islands are also mainly Carboniferous–Permian tillites, mudstones, sandstones and siltstones. There are no Jurassic, Cretaceous or Tertiary sediments but there are three sets of dolerite dykes ranging in age from Early-Jurassic to Mid-Cretaceous period cutting across the islands and representing the break up of Gondwana. The Falklands were not covered by ice sheets or subject to extensive glaciations, but there are glacial deposits and landforms above 500 m on north-east and south-east facing slopes on East and West Falkland; corries and hollows and tarns on Mt. Usborne and Mt. Adam.

There are many periglacial landforms especially where solifluction has smoothed slopes and formed stone-runs, but has left rock outcrops unaffected. Stone runs are unique, spectacular, distinctive and delicate environments occurring in valley bottoms and on slopes as alternate strips of boulders and sparse vegetation. Darwin called them 'streams of stones'.

Brachiopods, crinoids and trilobites are found in the Fox Bay Formation sandstones in the middle of the West Falkland Group; the same assemblage of fossils is found throughout southern Brazil, South Africa and Antarctica; Darwin collected fossils from here on the *Beagle* voyage. The Fitzroy Tillite from the Permo-Carboniferous glaciation is widespread and has a distinctive dark matrix.

There are striking geological similarities between the Falklands and South Africa's Cape Fold Belt and Karoo Basin which suggests that the Falklands might contain similar mineral wealth and recent exploration has found possible diamond-indicator minerals and fresh, angular gold grains have been discovered in streams.

Geoconservation programmes

Existing	None
Activities	None

Geoconservation sites

No sites are protected under legislation, but there are 33 protected nature reserves and sanctuaries. The Falkland Islands State of the Environment 2008 report notes 'A number of sites are tentatively recognized for their geodiversity assets, due to being:

- exposed type sections of a stratigraphic unit geologically unique to the Falkland Islands;
- geologically unique to/characteristic of the Falkland Islands;
- contain important fossil beds;
- historical importance, such as sites visited by Charles Darwin.

The list is tentative only and a more-comprehensive assessment is needed. The suggested sites include: Cape Meredith complex, West Point forest beds, Pebble Island, Jenesta Point and Purvis Point, South Harbour neptunian dykes, Devonian sequence along the Port North coast, Port Louis sites visited by Charles Darwin, Princes Street stone run, tillite cliffs to the east of Hill Cove (E. Edwards and P. Stone, personal communications).

Environmental pressures

The important geological sites are known and none appear to be under threat from any incompatible activities.

Web links

http://www.ukotcf.org/territories/falkland.htm
http://www.volcano.si.edu/world/region.cfm?rnum=1805
http://www.islandvulnerability.org/otuk.html
http://www.epd.gov.fk
http://www.epd.gov.fk/wp-content/uploads/Falkland%20Islands%20State%20of%20the%20Environment%20Report%202008_final_sm.pdf
http://www.bgs.ac.uk/falklands-oil/onshore/onshore_intro.htm

South Georgia and the South Sandwich Islands

Introduction

South Georgia, an emergent part of a small block of continental crust, is connected southwards by a line of sea mounts to the volcanically and tectonically active South Sandwich Islands where there are seven strato-volcanoes, a shield volcano and a submarine volcano.

The geology of South Georgia shows the stages in the evolution of an active plate margin and marine basin with remnants of the ancient volcanic arc. The rocks are in five distinct sequences, dominated by sediment. The Cumberland Bay Formation, a thick sequence of volcaniclastic sandstones and shales, intruded by quartz and feldspar rich veins, forms half of the island and all of the high ground. A fault zone separates it from the Sandbugten Formation's Gondwana derived sandstones and shales containing fragments of continental margin granites and sediments. The Annekov Island Formation is 3 km thick and has andesite and gabbro plutons intruded into finely banded mudstones and conglomerates. The Drygalski Fjord Complex, forming part of the central Salvesen Range of peaks rising to 2000 m, is composed of gneisses and is intruded by granites and gabbros. This is separated from the Larsen Harbour complex (ocean floor lavas and rocks) by another fault zone and together was part of the original margin of Gondwana. Ammonites, bivalves and fossil wood are found on Annekov Island.

There are heavily dissected mountains of the Salvesen and Allardyce Ranges with Mt. Paget at 2 960 m. Over 50% of the island is permanent ice cover with steep sided valleys filled with glacial deposits and glaciers extend to sea level. The coastline has extensive wave-cut platforms and the north east is indented with fjords.

The Thule Islands, at the southern end of the South Sandwich island arc bordering the Scotia Sea, consist of three strato-volcanoes constructed along an E–W trending line.

Bristol Island on the South Sandwich arc lies across Forster's Passage from the Southern Thule Islands and forms one of the largest islands of the chain. It is glacier covered, and a steep-sided flank cone or lava dome, Havfruen Peak, is located on the east side, and a young crater and fissure are on the west flank. Montagu Island, largest in the group, is a massive shield volcano cut by a 6 km wide ice-filled summit caldera rising 3 000 m from the sea floor between Bristol and Saunders Islands. Around 90% of the island is ice-covered; glaciers extending to the sea typically form vertical ice cliffs.

The young 990 m Mt. Michael strato-volcano dominates glacier covered Saunders Island, and has a 700 m wide summit crater and a remnant of a somma rim to the south east. Tephra layers are visible in ice cliffs. The southern end of Candlemas Island consists of an eroded, glacier-covered basaltic strato-volcano cut by steep cliffs on the east.

Cumberland Bay: Thatcher Peninsula with King Edward Cove, the Allardyce Range and the summit Mt. Paget, South Georgia. (Photo: NASA.)

Protector Shoal seamount, located 56 km north west of Zavodovski Island, forms the northernmost volcano of the arcuate South Sandwich Islands.

Geoconservation programmes

Existing	None
Activities	None

Geoconservation sites

The only site for geoconservation specifically protected is Annekov Island SSSI.

Environmental pressures

There are none apparent.

Web links

http://www.sgisland.gs/index.php/Main_Page
http://www.volcano.si.edu/world/region.cfm?rnum=1805
http://www.islandvulnerability.org/otuk.html

British Antarctic Territory (BAT)

Introduction

Antarctica is the fifth largest continent and is divided into West Antarctica and East Antarctica separated by the mountains of the Trans-Antarctic Range. East Antarctica is a stable sedimentary platform with metamorphosed rocks overlain by younger sediments. West Antarctica, including the British Antarctic Territory, is a complex of folded and metamorphosed, mainly volcanic sediments. There is one active volcano in the Antarctic Peninsula on Deception Island. There are two microplates, the Ellsworth Mountains block, formed in the early Mesozoic, and the Antarctic Peninsula block, the most recent addition to the continent, formed by the Andean Orogeny of late mesozoic–early Cenozoic that coincided with the breakup of Gondwana; the peninsula is an extension of the Andes and is composed of igneous intrusive rocks, volcanic and metamorphosed sediments.

Geoconservation programmes

Existing None
Activities None

Geoconservation sites

The whole of Antarctica is designated as a natural reserve devoted to peace and science by the Antarctic Treaty's Protocol on Environmental Protection. There are certain areas given even greater protection through the protocol's system of protected and managed areas with 70 Antarctic Specially Protected Areas (ASPAs, formerly SSSI), five Antarctic Specially Managed Areas (ASMAs) and over 80 Historic Sites and Monuments (HSMs).

ASPA 170 Marion Nunataks, Charcot Island

This site was designated for the nunataks which are composed of turbiditic sandstones and mudstones, which are different to those on Alexander Island, and possibly the whole of the Antarctic Peninsula. The sediments were originally deposited within a deep marine trench that formed as a result of the destruction of the Pacific plate beneath the edge of the ancient continent of Gondwana. The sedimentary rocks were scraped off the Pacific plate as it was destroyed and accreted to the Gondwana continent, causing them to be folded and metamorphosed under high pressure. Charcot Island sedimentary rocks are thought to be Cretaceous.

ASPA 126 Byers Peninsula, Livingston Island, South Shetland Islands

Designated for the well-preserved sub-fossil whale bones present in raised beaches, and the lakes and their sediments are important for the study of the Holocene palaeoenvironment, and for establishing a regional Holocene tephrachronology. The peninsula is of exceptional historical interest with the greatest concentration of 19th century historical sites in Antarctica.

ASPA 140 Parts of Deception Island, South Shetland Islands

This ASPA site is designated for its volcanic activity, having had major eruptions in 1967, 1969 and 1970. It has a unique landscape of barren volcanic slopes, steaming beaches and ash-layered

British Antarctic Territory. (Picture: Lokal_Profil, Creative Commons.)

glaciers forming a horse-shoe shaped opening to the sea at Neptune's Bellows. Neptune's Bellows is one of the few places where vessels can sail directly into the centre of a restless volcano.

ASPA 147 Ablation Point–Ganymede Heights, Alexander Island

Designated as one of the largest ablation areas in West Antarctica with a complex lithology and wide range of features including raised beaches, moraine systems, and patterned ground.

ASPA 148 Mount Flora, Hope Bay, Antarctic Peninsula (previously SSSI 31)

This site is designated for its rich fossil flora, and was one of the first discovered in Antarctica.

Environmental pressures

Mount Flora ASPA is vulnerable to souvenir fossil collectors and merits protection.

Web links

http://www.volcano.si.edu/world/region.cfm?rnum=1805
http://www.islandvulnerability.org/otuk.html
http://www.ukotcf.org/territories/bat.htm
http://www.antarctica.ac.uk/about_antarctica/geopolitical/environmental_issues/mining.php