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Field guide to the geology of the University of the West Indies campus, Mona

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ABSTRACT. This is the first published field guide to utilise urban geology as a tool for undergraduate education in Jamaica. The campus of the University of the West Indies, Mona, is well-suited for this purpose, being situated on the Liguanea Plain, surrounded by the Port Royal, Dallas and Long Mountains, and the Hope River, and including buildings that utilise a broad range of local rock types in their construction. Five stops are discussed in detail and suggestions made for other sites on campus where further observations can be made.

INTRODUCTION

THE MONA campus of the University of the West Indies (UWI) is located on the Liguanea Plain, a broad alluvial fan that slopes gently to the south coast of Jamaica. Most buildings on the Mona campus are constructed on the Quaternary Liguanea Formation, which consists of alternating gravels, sands, loams and clays with an estimated thickness of over 185 m (Matley, 1951; Green, 1974). This picturesque campus is surrounded by the Port Royal, Dallas and Long Mountains, all formed of rocks of Tertiary age.

The purpose of this field guide is to illustrate selected aspects of the 'urban geology' of the Mona campus and the surrounding region. It is intended to provide an excursion for interested visitors to the campus and, particularly, to promote awareness of urban geological resources as an aid to teaching for students studying geology and/or physical geography at first year undergraduate level. A questionnaire for students, based on this field guide, is available from the junior author. This trip is designed to be brief, but informative, and it should be possible to visit and examine all localities in 1½ to 2 hours; a party of students can be led through this excursion, with associated practical work, in about 3 to 3½ hours. Access to Mona campus is free at all times except during special events. Most localities should be accessible for disabled and wheelchair access, apart from the upstairs verandah at Stop 1. For background reading, general introductions to Jamaican geology include Porter et al. (1982), Porter (1990), Edward Robinson (1994) and Draper (1998). Useful maps for this excursion include the 1:50,000 geological sheet 25 (Green, 1974) and 1:50,000 topographic sheet 18 (metric edition), both entitled "Kingston".

STOP 1: THE OBELISK AND DE LA BECHE BUILDING

The best place to commence a geological walking tour of the Mona campus is outside the De la Beche Building, home of the Department of Geography and Geology (Fig. 1). The building is named in honour of the British geologist Sir Henry Thomas De la Beche (1796-1855), who published the first memoir on Jamaican geology in 1827. The Geology Museum, situated on the lowest floor, is open Monday to Friday, and includes displays of rocks, fossils and minerals from Jamaica and elsewhere (S.J. Wood, 1995). A brief, descriptive guide is available free-of-charge in the museum. A geological relief map of Jamaica is mounted on the wall of the verandah on the main (middle) floor of the De la Beche Building.

The obelisk that stands outside the De la Beche Building (Fig. 2A) and adjacent to the ring road around campus was presented to the (then) Department of Geology by the Geological Society of Jamaica in 1984 (the succession is summarised in Table 1). It was erected in recognition of 21 years of the teaching of geology at UWI (1961-1982) (Porter, 1990, pp. 78-82). This structure is not only a notable landmark on campus, but is also a highly functional aid to teaching. The cladding of the obelisk, built on a reinforced concrete core, is designed to represent the lithological succession of Jamaica, on a vertical scale of one foot (about 0.3 m) equivalent to 12 million years. Jamaican rocks from the Lower Cretaceous to Pleistocene are mounted in stratigraphic order, with the Cretaceous/Tertiary and Tertiary/Quaternary boundaries being most prominently displayed (Fig. 2A). The rocks of each stratigraphic division that are delineated - Lower Cretaceous, Upper Cretaceous, Paleocene,

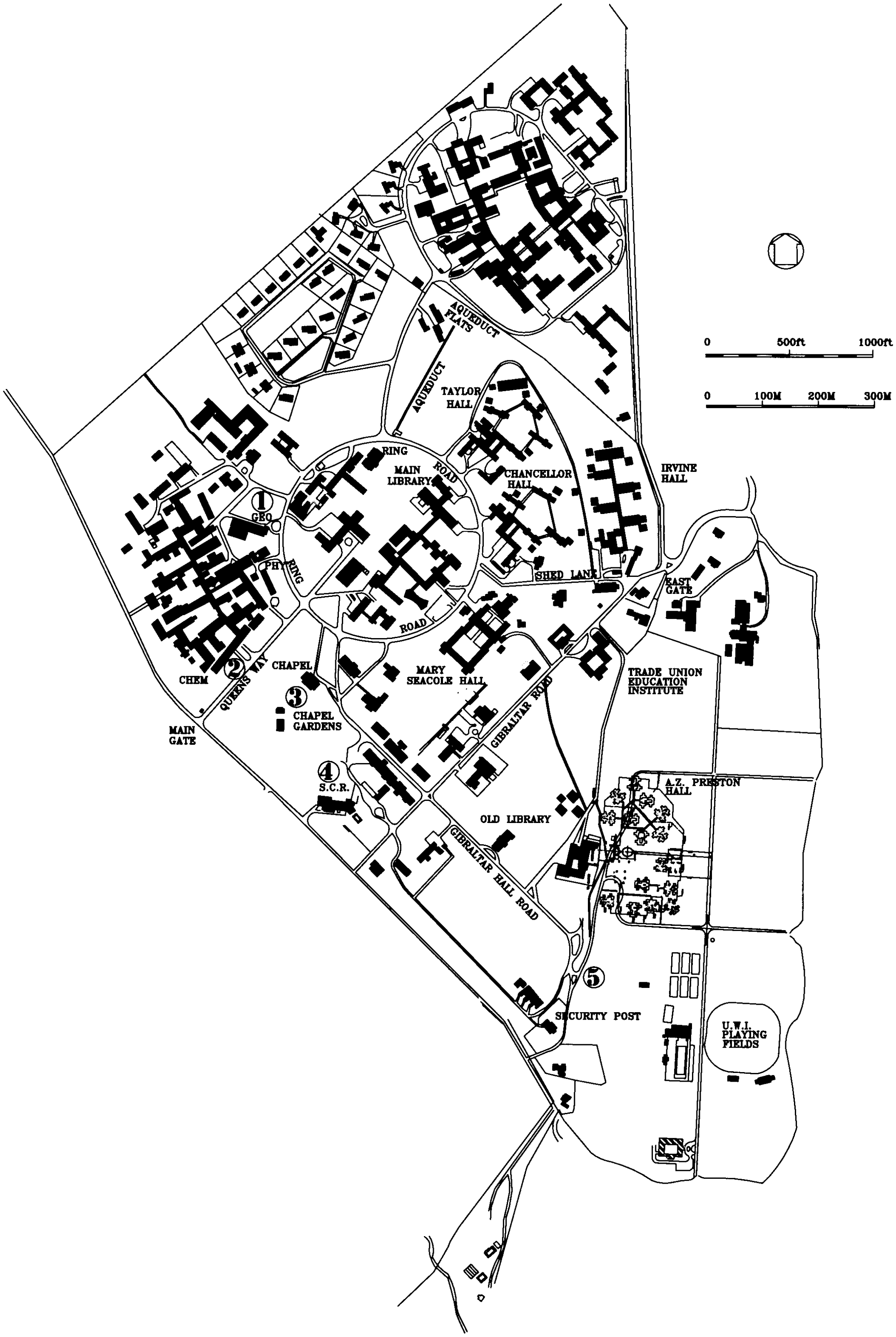

Figure 1. Map of the University of the West Indies, Mona campus, showing the positions of Stops 1 to 5 and other localities mentioned in the text.

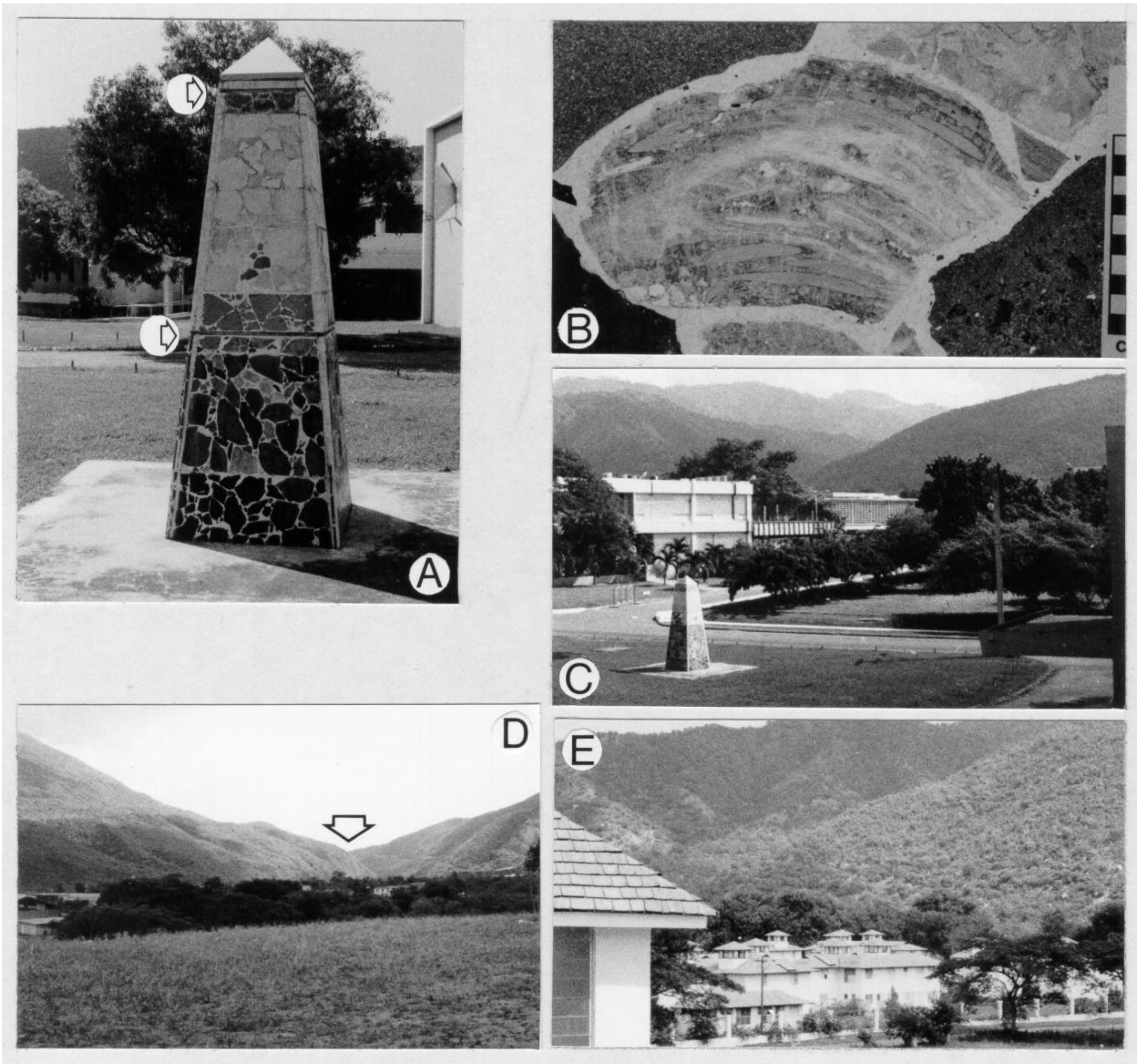

Figure 2. A-C. Stop 1. A. The obelisk, showing the cladding that represents the Jamaican lithostratigraphic succession. The Cretaceous/Tertiary (lower) and Tertiary/Quaternary (upper) boundaries are indicated by arrows. B. A longitudinal section through a fragmentary specimen of the Upper Cretaceous rudist bivalve *Titanosarcolites* sp. in the obelisk. Scale in cm. C. The view to the east-northeast from the verandah of the De la Beche Building, looking towards the Wagwater Belt (in the far distance, left), behind Dallas Mountain (middle distance, right). D, E. Stop 5. D. The view to the southeast towards the Hope River Gorge (arrowed), between Dallas Mountain (left) and Long Mountain (right). Note that Look Out is at the edge of a high river terrace, overlooking a lower river terrace. Part of the scar of August Town Quarry on Long Mountain is apparent on the far right. E. A similar, but closer, view to that of Figure 2C, with the rugged topography of the Wagwater Belt apparent behind the smoother topography of Dallas Mountain.

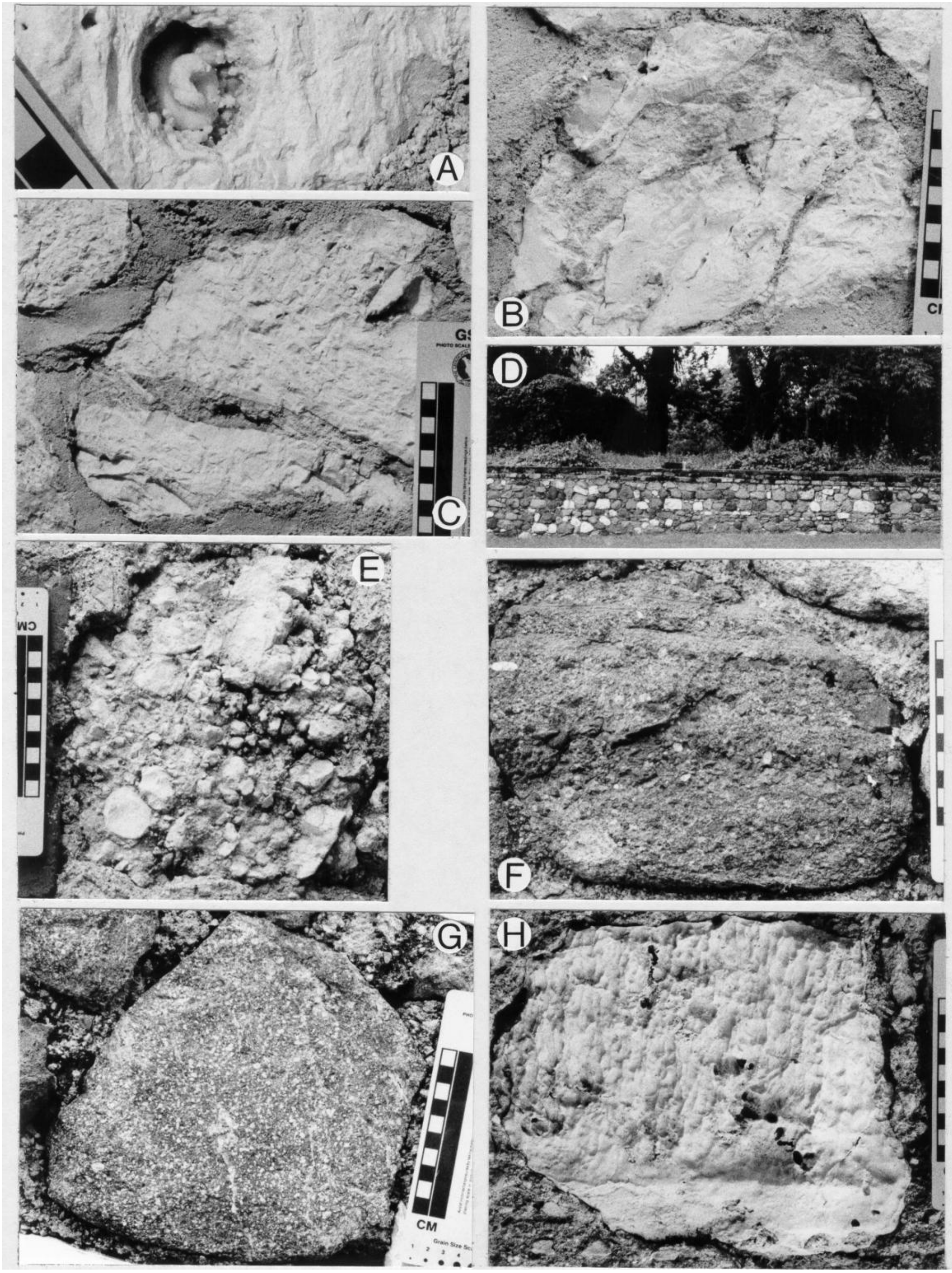

Figure 3. A-C. Stop 2, all White Limestone Group. A. Mould of an indeterminate gastropod, with infilled spherical chambers of the clionid sponge boring *Entobia* isp. B. Brecciated limestone (contrast with Figure 3E). C. Fissure with lateritic infill in limestone. D-H. Stop 4, the Mona wall game. D. General view of the wall (while other walls are also easily accessible at this stop, that illustrated is particularly well suited for this exercise, with both good access and broad lithological diversity). E. Strongly brecciated limestone with a lateritic infill (contrast with Figure 3B). F. Boulder of the Wagwater Formation with pebble conglomerates and coarse-grained sandstones. Grading suggests that this clast is mounted the 'right way up'. Some beds are offset by a small normal(?) fault (left of centre). G. Kintyre Porphyry. H. A karstified surface in White Limestone. All scale bars in cm.

Table 1. Greatly simplified geological succession of Jamaica, based on the obelisk at Stop 1. Stratigraphic divisions are those delineated on the obelisk. For more detailed explanation of the Jamaican succession, see Porter et al. (1982), Edward Robinson (1988, 1994) and Draper (1998).

Stratigraphic division	Principal Lithostratigraphic units	Main lithologies seen in obelisk
Pleistocene	Coastal Group	Reefal limestones.
Pliocene	Coastal Group	Limestones, siliciclastic rocks.
Miocene	White Limestone Group	White limestones.
Oligocene	White Limestone Group	White limestones.
Eocene	White Limestone Group	White limestones.
	Yellow Limestone Group	Impure (yellow) limestones.
Paleocene	Wagwater Group (extends into Lower Eocene)	Mixed igneous and siliciclastic rocks.
Upper Cretaceous		Andesite, basalt, ignimbrite/tuff, keratophyre, conglomerate, limestone (containing rudists such as *Titanosarcolites* and *Barrettia*), sandstone.
Lower Cretaceous		Serpentinite, marble.

Eocene, Oligocene, Miocene, Pliocene and Pleistocene - are typical of each of these divisions in Jamaica. Thus, the Cretaceous rocks are dark in colour (Fig. 2A), and mainly metamorphic and igneous in origin. Porter (1990, p. 79) listed serpentinite and marble as prominent in the Lower Cretaceous part of the obelisk, with andesite, basalt, ignimbrite/tuff and keratophyre, associated with some sedimentary rocks (conglomerates, limestones and sandstones) in the Upper Cretaceous. *Titanosarcolites* (Fig. 2B) and *Barrettia*, large individuals of two of the rudist bivalves that are typical of the Upper Cretaceous of the island, also occur in section. The Paleocene is represented by igneous and siliciclastic rocks derived from formations of the Wagwater Group. The mid-Tertiary succession is notable as being dominated by limestones of the Yellow Limestone (mid Lower to mid Middle Eocene) and White Limestone Groups (Middle Eocene to Middle/Upper Miocene) (Fig. 2A). Plio-Pleistocene rocks are a mixture of siliciclastics and limestones (particularly hermatypic corals) of the Coastal Group. The aluminium cap of the obelisk emphasises the importance of Jamaica's bauxite ore deposits.

After examining the obelisk, inspect the polished sections through rock and fossil specimens (particularly the rudist *Barrettia*) in the entrance to the De la Beche Building, before walking upstairs and examining the view to the east-northeast from the top verandah (Fig. 2C). In the near distance, the rounded outline of Dallas Mountain is apparent, composed of mid Tertiary limestones of (mainly) the White Limestone Group and lacking evidence of surface drainage, that is, there are no gullies or streams. Behind Dallas Mountain, the Port Royal Mountains have a noticeably more rugged appearance and have slopes that are strongly gullied. These hills form part of the Wagwater Belt, a Paleogene half-graben infill (Draper, 1998) dominated by silicic volcanic rocks of the Newcastle Volcanic Formation (Jackson and Smith, 1978), terrestrial 'red bed' conglomerates (Wagwater Formation) and marine near-shore to deeper-water, finer grained siliciclastics (mainly sandstones and siltstones with some mudrocks and rare coals) of the Richmond Formation (Green, 1974). A major northwest-southeast trending fault, called the Wagwater Fault, separates the Wagwater Belt and Dallas Mountain. The Port Royal Mountains represent the upthrow side of the fault and the trace of this fault can be seen by the scarp slope that rises steeply above the Liguanea Plain. Rocks derived from the Wagwater Belt may be examined in the obelisk and at Stop 4.

STOP 2: PHYSICAL CHEMISTRY LABORATORY

From Stop 1, walk anticlockwise around the ring road and turn right along the Queens Way towards the main gate. Walk past the snack kiosk and the new extension to the Department of Physics to the entrance to the Department of Chemistry. The Physical Chemistry Laboratory is adjacent to the left-hand driveway. Examine the limestone wall of this laboratory, across a grassy lawn from the Queens Way, and in the welcome shade of the ackee and mango trees.

The commonest construction materials on the UWI campus, and throughout the island, are locally produced cement and concrete whose production is largely based on local limestones. This indicates how important this rock type is to Jamaica. The most widespread of these limestone sequences is the White Limestone Group, covering about two thirds of the island's surface (Versey, 1963, p. 28). These are the very pure, mid Tertiary limestones that are well displayed on the obelisk (Stop 1, above). The pure limestones of this group were deposited in a range of sedimentary environments, in lagoonal, shelf edge and deeper water settings, between the middle Eocene and middle/late Miocene (Edward Robinson, 1988, 1994). Apart from being important for the manufacture of cement, limestones of the White Limestone Group are often used as facing stone. There are a number of examples of this on campus, but the long wall of the Physical Chemistry Laboratory is amongst the best.

The facing limestone of the Physical Chemistry Laboratory is well-cemented with a fine-grained matrix and locally fossiliferous. The fossils include foraminifers, bivalve molluscs, gastropods, at least three species of scleractinian corals and the boring *Entobia* (in gastropods), produced by clionid sponges (Fig. 3A). Fossils not preserved as moulds, such as the casts of gastropods and corals which are preserved in calcite, are more difficult to recognise. Some blocks are brecciated (Fig. 3B). Veins are infilled either with calcite, which is commonly iron-rich, or with lithified terra rosa with angular limestone clasts (Fig. 3C).

STOP 3: THE UNIVERSITY CHAPEL

Cross the Queens Way and walk eastwards to the University Chapel, adjacent to the ruins of the aqueduct. This was originally an old sugar warehouse that was reputedly built in 1799 on the Gale's Valley sugar estate in the parish of Trelawny. In 1955, Her Royal Highness the Princess Alice, then Chancellor of the University College of the West Indies, persuaded the owner of the property on which the house was located to donate the building to the University, where it would be used as a chapel. In 1956 the building was dismantled block by block and transported to the Mona campus, where reconstruction was completed three years later.

The Chapel is made of blocks of the White Limestone Group. Unlike at Stop 2, this limestone is cut into large, close-fitting blocks, although the surface has become pitted and scratched. The limestone is a calcarenite, white, cream or orange-white in colour, massive, with no evidence of obvious bedding. Calcite veins are rare and are only a few millimetres wide, at most. Very rare, globular structures appear to be nodules of a more iron-rich(?) limestone. Macrofossils are rare and are principally recrystallised shells of benthic molluscs. However, benthic foraminifers are locally common, forming accumulations that either are presumed to follow bedding or infill burrows. On the basis of these foraminfers, this limestone has been dated as Eocene and is derived from either the Bonny Gate or Montpelier formations (Edward Robinson, pers. comm. to T.A.J.).

STOP 4: RUINS AT THE SENIOR COMMON ROOM - THE MONA WALL GAME

Walk south to the ruins of the sugar works of the Mona estate, which are located between the Chapel and the Senior Common Room. The remains of several of the original buildings can be seen, such as the boiling and curing house, the overseer's house, the mill house, the bookkeeper's cottage, and the distillery and rum store. These buildings are believed to have been constructed in the 18th century using local stone and mortar (Anon, 1967). The most easily viewed of these ruins is the distillery and rum store located on the lawns of the Senior Common Room. Here, the walls of the house and floor base (Fig. 3D) are composed of boulders of limestone, siliciclastic and volcanic rocks, together with red clay bricks that also support the archways. Above one of these arches the year '1759' is inscribed.

The Mona wall game is analogous to those made popular in London by Eric Robinson (1996, 1997). Simply stated, two basic geological questions should be asked when examining the walls of these ruins; how many rock types are present and what is their provenance? Rock types first observed at the obelisk (Stop 1, above) are seen again here, permitting a degree of coarse lithostratigraphic 'correlation'. The base of the building contains rocks that show a range of lithologies, including boulders of both sedimentary and igneous rocks (Fig. 3E-H). The outer walls of the upper structure (not illustrated) are built of a mixture of mainly white and pale-grey coloured boulders. These are limestone blocks belonging to the mid-Cenozoic White Limestone Group. Several of these blocks show a variety of depositional (for example, bedding) and, particularly, post-depositional features including brecciation (Fig. 3E) and solution weathering (Fig. 3H). These are associated with some terra rosa and red brick. Limestones of the White Limestone Group and other lithologies occur as wall fill and face the inner wall.

Some particularly obvious lithologies found in the wall (Fig. 3D) are worthy of brief mention. The siliciclastic rocks show a range of textures and structures. These consist of polymict conglomerates, and of sandstones that display graded bedding and cross lamination, with grading suggesting the depositional 'way-up' (Fig. 3F). The siliciclastic rocks that have a reddish-brown colour, due to the presence of abundant haematite, belong to the Wagwater Formation, whereas those that display a dark grey to grey-green colour belong to the Richmond Formation. Both of these Paleogene formations crop out in the nearby Wagwater Belt. The igneous rocks display a greenish-grey colour due to the presence of chlorite in the groundmass. The igneous rocks are porphyritic, containing phenocrysts of white plagioclase feldspar and black hornblende in a fine-grained crystalline groundmass. These rocks also originated from the nearby Wagwater Belt, where they occur as dyke rocks and lava flows. Those igneous rocks in which plagioclase phenocrysts are prominent and appear to be more abundant than hornblende belong to the Kintyre Porphyry (Fig. 3G), whereas those in which the hornblende phenocrysts are larger and more prominent belong to the Newcastle Volcanic Formation.

The source of this lithologically diverse array of boulders was presumably local, and similar lithologies can be identified *in situ* in the surrounding Port Royal, Dallas and Long Mountains. Boulders show at least some degree of rounding and there is, at best, only limited suggestion that they may have been worked manually, unlike those that constitute the wall of the Physical Chemistry Laboratory (Stop 2, above). The lithological diversity and rounded morphology are suggestive of a river bed origin (compare Fig. 3A-C with Fig. 3E-H). These clasts were more-than-likely collected from the Hope River, which contains a coarse-grained bedload and drains the Port Royal Mountains. This river has been a source of construction material since the early European occupation of Jamaica, and continues to be a source of sand and gravel for the present-day construction industry.

Identical rocks to those seen at the ruins constitute the aqueduct that begins near the Aqueduct Flats and ends in the Chapel Gardens, and which once supplied water to the Papine and Mona estates. The columns on either side of the Irvine Hall gate may have been constructed at around the same time and probably marked the East Gate of Shed Lane (Anon, 1967). A 20th century use of the same rocks is seen in the decoration of the walls of the Trade Union Education Institute on Gibraltar Road. A plaque on the inner side of the north wall indicates that the wall was erected between 1963 and 1964.

STOP 5: LOOK OUT POINT AT PRESTON HALL

Leave the Senior Common Room and walk northeast to Gibraltar Hall Road. Travel southeast along Gibraltar Hall Road past the Old Library. At the end of this road, at the fence adjacent to A.Z. Preston Hall and the police station, admire the view at Look Out Point (Figure 2D, E).

This viewpoint is at the edge of a terrace of the Hope River and provides a panoramic view of the lower Hope River valley. It is ideally suited for studying the landscape geology (Figs. 2D, E). It is located on the Liguanea Formation and is about 600 feet (180 m) above sea level (Horsfield, 1973). Directly below the Look Out is a wide river terrace on which are located the UWI playing fields and A.Z. Preston Hall. According to Horsfield (1973), the terrace slopes gently to the southeast and is about 100 feet (30 m) above the Hope River.

A river terrace is a remnant floodplain of a river, with a bench-like form, left behind at a higher topographic level after the channel has cut down to a new, lower level. Such down cutting may be driven by a number of factors, including some that undoubtedly occurred in Jamaica during the late Cenozoic, such as tectonic uplift, drop in sea level or an increase in erosive bedload due to climatic changes (Small, 1978; Goudie, 1993, table 14.3). Thus, the high terrace (=Look Out at Stop 5) is also the oldest terrace, at least in this area (remnants of yet higher terraces are locally preserved on the valley sides between Papine and Gordon Town). Looking towards the southeast from Stop 4, the adjacent, lower (=younger) terrace is apparent (Fig. 2D). The modern Hope River flows at a lower level still, between the lower terrace and Dallas Mountain, and then into the Hope River Gorge.

The Dallas and Long Mountains are located on the east and west side of the valley, respectively. Both mountains are composed of rocks of the White Limestone Group and the Coastal Group, and both display incipient karst development, with dry gullies and solution sculpturing (D.J. Miller, personal communication, 1999). Uplift, accompanied by folding and faulting of these rocks, probably took place during the middle to late Pliocene based on the unconformity between the August Town Formation (mid-Pliocene) and the overlying Pleistocene beds (Green, 1977). Most drainage is internal in these limestones (Versey, 1963). Looking towards the northeast the smooth outline of these two hills can be contrasted with the strongly developed surface drainage of the Wagwater Belt, discussed under Stop 1 (compare Figs. 2C and 2E).

The limestone that crops out in Long Mountain is used in the local construction industry. A scar seen on the hillside of Long Mountain represents the location of the August Town Quarry where limestone aggregate is mined for construction purposes.

To the south, the Hope River flows between Dallas and Long Mountains through the Lower Hope River Gorge (Fig. 2D). The present development of the gorge is attributed to the diversion of the Hope River during the Holocene or late Pleistocene. Formerly, the Hope River drained towards the west across the alluvial fan of the Liguanea Plain (P.A. Wood, 1976). The reason for the change in direction is still unclear. Matley (1951) believed that uplift led to a rejuvenation of the river and the cutting of a channel southwards through the fan. Raw (in Matley, 1951), Goreau and Burke (1966) and P.A. Wood (1976) shared the view that the diversion resulted from river capture in the area of the gorge by denudation and erosion of the col that once joined Dallas and Long Mountains. Edward Robinson (1963) reported that Chubb considered the gorge to be in existence since the Pliocene, but was temporarily blocked by younger alluvial fan deposits. Ahmad and Robinson (1994) have suggested that such a blockage may have been caused by a large debris flow, or a series of debris flows, that emanated along the Wagwater Fault scarp during periods of heavy rainfall and flooding. Such events could account for the presence of the very large boulders of the Newcastle Volcanic Formation and Wagwater Formation that not only occur near the gorge, but are found elsewhere on the Liguanea Plain.

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