

# Field Meeting in Jordan and Syria, 14–25 April, 1996

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WALTHAM, T. 1997. Field Meeting in Jordan and Syria, 14–25 April, 1996. *Proceedings of the Geologists' Association*, **108**, 71–77. An excursion of twelve days covered geological and archaeological sites scattered across much of western Syria and Jordan. The limestones, deserts and volcanics of Syria were sampled between the great historical sites of Palmyra, Krak and Bosra. More varied geology was seen in Jordan, where the Dead Sea, Petra and the sandstone mountains around Wadi Rum were the highlights.

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The concept of a geological excursion to the Middle East grew from widespread interest in the spectacular carved sandstone of Petra and the multitude of geological delights in the Dead Sea rift and the southern desert of Jordan. The itinerary was extended into Syria, which had the least of the political problems so rife among Jordan's neighbours. No visitor to this region could ignore the wealth of historical and archaeological material which begged for attention, and the excursion was planned to cover these aspects as well as the geology. Archaeological leaders or deputy leaders appear to be thin on the ground, so the meeting was geologically led with a programme designed to give the historical sites the time they so richly warranted.

Geological literature on the two countries is not widely available, and the modern geological maps of Syria are regarded as state secrets. The geology of Syria (Ponikarov, 1967) is dominated by Cretaceous and Palaeogene limestones, except for the great spreads of Neogene basalts in the south. Similar rock sequences dominate the geology of Jordan (Bender, 1975; Powell, 1989), except where Palaeozoic and Precambrian basement rocks are exposed in the southern deserts. An excursion guidebook (Waltham, 1996) has further details on the geology of all the sites visited (Fig. 1).

Airline schedules dictated that the party of 42 members and guests flew out of Heathrow on a Sunday morning, heading for a dinner break at Amman airport and a very late connection into Damascus.

## 1. MONDAY 15 APRIL: DAMASCUS AND MALOULA

The old city of Damascus provided a fascinating morning's sightseeing, though the geological interest was restricted to some splendid Cretaceous limestone, packed with *Nerinea*, used inside the Omayyad Mosque. In the afternoon, the excursion bus climbed the gorges north of the city, cut into anticlines of Cretaceous limestone exposed in the Palmyride fold belt. Maloula is an ancient Christian village spectacularly sited beneath a scarp face of Eocene limestone, with

conspicuous rockfalls as signs of its active retreat (Fig. 2). A circular walk started on the bare dip slope above the village and then descended a narrow ravine in the limestone; this is regarded as a feature of fluvial activity probably aided by seasonal snowmelt during the Pleistocene.

The route north lay across semi-desert, until greenery marked the Orontes Valley. A roadside stop was made near Rastan, to examine blocks of Tertiary limestone containing abundant large algal nodules, unfortunately surrounded by malodorous refuse. The overnight stop was in Hama, a very pleasant city distinguished by the magnificent old waterwheels (norias) along the banks of the river.

## 2. TUESDAY 16 APRIL: KRAK AND THE DESERT

A morning visit was to Krak des Chevaliers, the finest surviving Crusader castle. Blocks of both limestone and basalt were used to build the massive walls and splendid vaulted roofs of the interior galleries. The ramparts command vistas across the coastal mountains of folded limestone, but the Pliocene basalts to the east are poorly exposed.

The afternoon drive was a long haul eastwards into the deserts. Between Homs and Palmyra, the terrain is fairly flat. Broad shallow basins have floors of Quaternary sediment, while low rises are formed of Tertiary limestones with surfaces of shattered debris and discontinuous calcrete. The overly luxurious hotel beside the ruins of Palmyra was reached before dusk.

## 3. WEDNESDAY 17 APRIL: PALMYRA

Palmyra grew as a caravan stopover in the desert, and then as a great Roman city, beside an oasis of palms fringing a sabkha basin. Water came from the Efca spring at the end of a limestone ridge; this has now ceased to flow due to over-abstraction through wells to maintain farm irrigation. The ruins of the Roman city form one of the great tourist sites of the Middle East, and most of the day was spent among

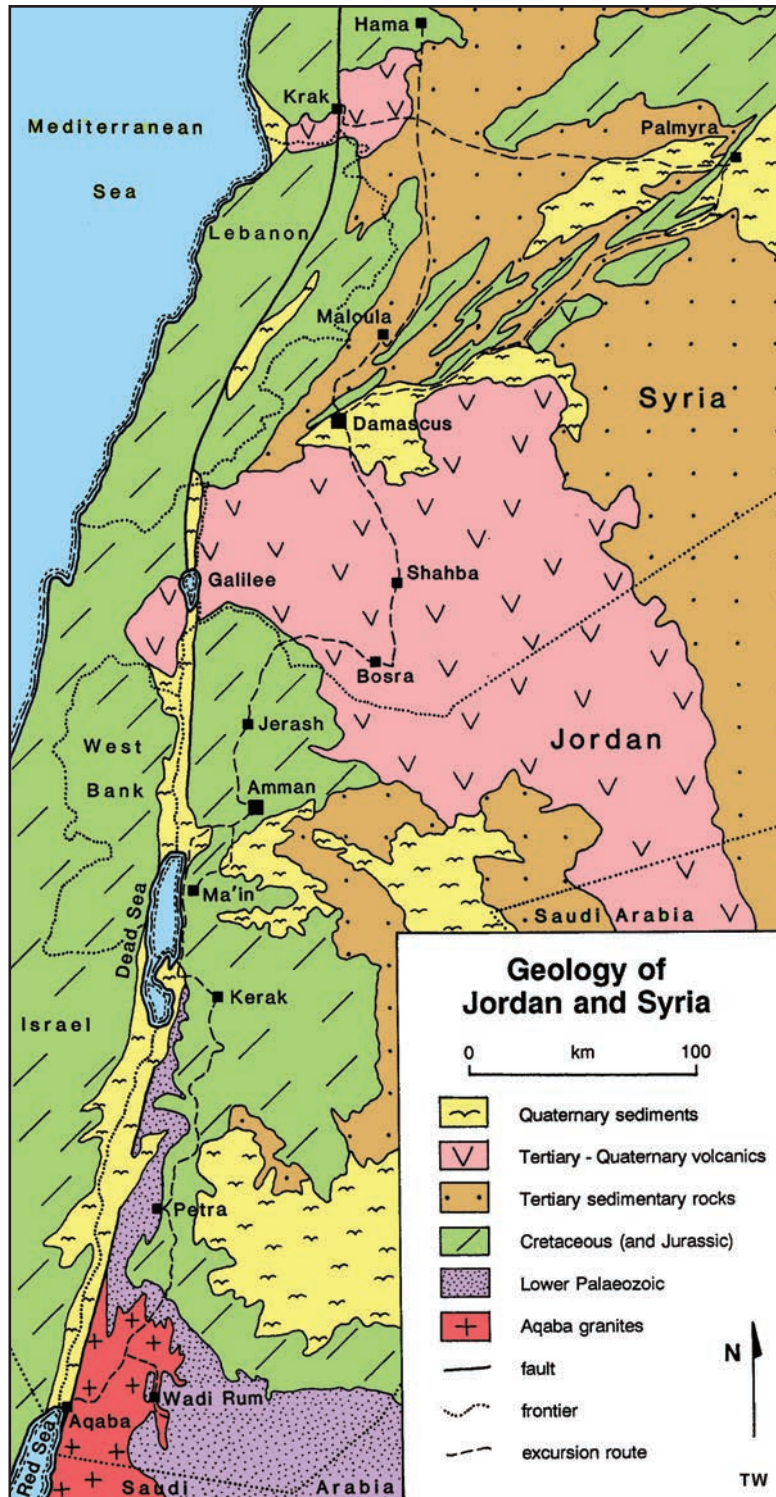


Fig. 1. Outline geological map of Jordan and Syria, with locations visited during the excursion.





Fig. 2. Rockfall debris litters the ramparts of the escarpment above Maloula village.

them. The lines of tall columns forming the Grand Colonnade along the main street and also round the Temple of Bel are perhaps the finest feature; most are of local limestone, but there are segments of granites imported from Egypt and Turkey. Some of the columns are eroded about 1–3 m above their bases due to sand blasting before the lowest section was re-excavated, and others are badly corroded where they were once buried in wet soil. Underground tombs provide access to the fractured limestone bedrock, and the descent into the Three Brothers Tomb cuts a section through the colluvium.

Late in the afternoon, the party headed out to the abandoned Roman stone quarries on Jabal at Tar, west of the oasis. This involved crossing a desert basin, and the bus trundled over rough gravel tracks until it was stopped by a tiny wadi washout in the middle of nowhere. A walk up the bahada paralleled a wadi cut through only a few metres of colluvium into the sloping pediment, and then led up cemented scree to the old quarries cut into the rim of the mesa. The Middle Eocene limestone was seen to be notably massive, with beddings and joints solutionally widened only in the metre or so below the modern surface; tool marks appear to have been removed by post-Roman rain-water dissolution. The view from the quarries across the desert basin was rather fine (Fig. 3), except when obliterated by a short-lived dust storm.

#### 4. THURSDAY 18 APRIL: JABAL AL-ARAB

Beautiful morning sunlight drew most of the party back to Palmyra for an early photo opportunity among the ruins. The bus then left to head southwest alongside the anticlinal mountains of the Palmyrides. Cretaceous phosphates are worked in large opencast mines in the desert basins, and a stop was made in a road cutting to examine the material. The phosphate was derived from animal excreta and skeletal remains in shallow shelf seas; it now forms pellets and nodules in a carbonate matrix.

South of Damascus, a wide zone of basaltic lavas centres on the massive and very gently graded shield volcano complex of Jabal al-Arab (Dubertret, 1929), where activity ceased about 3000 years ago. The town of Shahba lies beside a line of four small volcanic cones, each 50–100 m high; three of these are symmetrical cinder cones with degraded central craters, while the fourth is an incomplete cone of welded spatter. Many of the party walked up the road which spirals up the southern cone and offers fine views of the others. Two stops were also made at roadside quarries which revealed sections through the stratified structure of the cinder cones; the quarry near Risas exposed a mineralized fissure which had been the feeder to a fumarole on the cone's flank, and now contains crystalline and stalactitic sulphates.





Fig. 3. Fluvial channels meander down the bahada below the Palmyra stone quarries; some of the Roman ruins are just visible in the distance, silhouetted against the dark palm trees of the oasis; the Arab castle stands on a limestone ridge.

### 5. FRIDAY 19 APRIL: BOSRA AND JERASH

This was a day where the archaeological sites eclipsed the rather sparse local geology. The morning visit was to the Roman ruins of Bosra, notable for their construction largely by hewn blocks of black basalt and also for the well preserved theatre with tiered seating for 15 000 people. The Syria/Jordan frontier was crossed at midday, and the afternoon was spent at Jerash. These Roman ruins are built of more traditional white limestone, and are second only to Palmyra for the splendour of their colonnades, temples and theatres. The next two nights were spent in Amman, an almost completely modern city which sprawls across a group of steep limestone hills.

### 6. SATURDAY 20 APRIL: HAMMAMMAT MA'IN

West of Amman, the limestone highlands crest above a steep descent of more than 1500 m into the Dead Sea rift valley, and deep wadis cut back into the high land to expose some of the structure in the marginal fault zone. Wadi Zarqa Ma'in was filled by basalt in Neogene times, and a post-volcanic wadi was entrenched into Cretaceous sandstone beside the old lava fill; this exposed the feeder plug, which

now forms a high black cliff in the wadi wall. The vulcanicity is long dead, but younger hot springs have deposited large banks of tufa within the new wadi. The springs are fed by meteoric water which collected its carbonate content when draining through the limestone plateau and then being heated at considerable depths. Development of a tourist resort has created easy access to the site (so far only from the Madaba side), and the party inspected the active and fossil tufa cascades (Fig. 4), as well as the plug with its columnar joints and wall zone rich in xenoliths. None of the party bathed in the geothermal waters, whose very high radon content may account for the radiant complexions of regular local visitors.

Mosaics were the non-geological theme for the afternoon, with visits to the ancient mosaic map in the church at Madaba, and also to the collection of mosaics in the ruined church on Mount Nebo, overlooking the Dead Sea.

### 7. SUNDAY 21 APRIL: DEAD SEA

The descent from Amman to the Jordan Valley was on the new Friendship Highway towards Jerusalem. First stop was the small beach resort on the Dead Sea, where many of the





Fig. 4. The main tufa cascades at Hammamat Ma'in.

party went in for a swim. The water contains 32% of dissolved salts, and its density of  $1.16 \text{ g cm}^{-3}$  makes conventional swimming difficult, but it allowed some to pose for photos while reading a newspaper as they floated in the brine. Another stop further south along the coast was on a rocky foreshore close to Wadi Mujib, where a spray zone is crusted with white mineral deposits. Selective precipitation from the mineral-saturated Dead Sea water, and subsequent rainwater leaching of the more soluble chlorides, appears to leave calcite as the dominant mineral; stalactites and crystal pools are spectacular in the active zone, and dry, older crusts were recognized in a zone a few metres above the present water level. Other sights along the Dead Sea coast included the deep sandstone canyon at the bottom end of Wadi Mujib, fault blocks of Palaeozoic sandstone, more geothermal tufas, and a fine suite of terraces formed as the Dead Sea has declined in level by nearly 10 m over the last 70 years (due to both climatic change and increased abstraction from the River Jordan, which is its only significant input).

Wadi Kerak has a road which provided the route back onto the limestone highlands. The alluvial fan at its outlet

risers nearly 400 m, and provided a distant view of the salt flats which now occupy the southern sector of the Dead Sea. The bus then climbed the road up through the thick, horizontal Cretaceous succession, with views across to the massive landslide in the north wall of the wadi where the shales and limestone have failed above the stronger sandstone. From Kerak, the route south followed the King's Highway along the highland crest; the plug in Wadi Hasa would have warranted a stop, but local political unrest forced the bus onto a detour which missed the site. Wadi Musa, the modern town above Petra, was reached for the night.

## 8. MONDAY 22 APRIL: PETRA

The highlight of any visit to Jordan is Petra, whose ancient structures carved into the sandstone cliffs rank among the world's greatest spectacles. Contrary to popular account, the monuments never were a city, but are merely the tombs of the Nabataean people's ancestors. But Petra is 2400 years old, and the scale of the stonework is staggering.

Petra was an important trading city sited in a sheltered valley among the sandstone canyons which dissect the steep slopes flanking the Dead Sea rift. The Petra valley is a graben, nearly 1 km wide, with deep canyons draining into it and out of it (Waltham, 1994). Both the graben and the canyons have nearly vertical walls of sandstone. These walls have the monumental tombs and their facades cut into them; they have survived the centuries, while Petra's original homes have faded and disintegrated. The host rock of Petra is the coarse, fluvialite, Cambrian, Ram Sandstone; the red Umm Ishrin unit is soft enough to be carved with primitive tools, while the scarcity of joints within its massive structure minimizes breakdown and collapse (Jaser & Bargous, 1992).

Members of the party enjoyed a whole day's walkabout in Petra, all in small groups at their own pace. All entered via the Siq, the impressive, joint-guided, fluvial canyon just a few metres wide but up to 100 m deep; this is entrenched into a sandstone bench, and deepens as it descends against the dip towards the Petra graben. Confounding the second great Petra fallacy, the Siq is one of four entry routes, but is used by all visitors because it is uniquely spectacular. Everyone delighted at that first magical view of the Khazna monument, glimpsed between the curving canyon walls.

The cement of the Ram Sandstone has a significant iron content, in the form of brown, red, orange and yellow varieties of limonite and other oxides. Truly spectacular colour banding is created by large and complex varieties of Liesegang rings. These were formed during diagenesis by deposition in concentric zones of critical oxidation states within slowly moving porewater, and multiple phases of banding are superimposed on subtler patterns created by primary cross bedding. The colour banding is only seen in unweathered rock faces, and weathered surfaces are the uniform rose red of literary renown. Members found the finest colouring inside some of the smaller tombs just south



of the Urn Tomb, as well as on the facades of the Silk and Florentinus Tombs.

All members of the party made the long trek up to ad Dayr, the largest of Petra's monumental facades (Fig. 5). It stands high on the sandstone plateau west of the graben, and the added benefit of the long trek is the view west down the canyons towards the Dead Sea rift, where the basement porphyries and dykes are clearly seen below the Ram Sandstone.

## 9. TUESDAY 23 APRIL: SOUTH TO AQABA

A late morning start allowed many members a second chance to walk down the Siq and soak in a little more of Petra's splendour. A small group took the wilderness route into Petra, down Wadi Mudhlim. Flash floods that could render the Siq a death trap are diverted by a low dam to pass through a short tunnel (cut by the Nabataeans) northwards into this Wadi. In normal, dry conditions this route is longer, and rougher than the Siq; it is also less spectacular, except



**Fig. 5.** The massive facade of ad Dayr, carved into the Cambrian sandstone at Petra.



**Fig. 6.** The rock bridge on Jabal Burdah, high above the desert floor near Wadi Rum.

for the last section which is a dramatic and very narrow slot that suddenly emerges through the graben wall. Every first-time visitor should enter Petra down the Siq, but Wadi Mudhlim is a delight for the fluvial geomorphologist on a return visit.

Siq al Barrid was visited by all, later in the morning. Its single joint-guided canyon has tombs carved into its walls, and it leads through to a wadi in a splendid sandstone wilderness; overturned foresets were recognized on the cross bedding exposed in some of the wadi walls. The adjacent Neolithic settlement of Beida was an added attraction, as was the stop en route to appreciate the view down the length of the Petra graben.

After lunch, the bus headed south across the limestone plateau; the Cretaceous carbonates contain many echinoids, notably *Hemiaster* and *Heterodiadema*, but these were obtained more easily from trinket stalls around Petra than by scouring the outcrops. The descent of the escarpment of Ras an Naqab, took the route into Jordan's very dry and very barren southern desert. Mesas and inselbergs of the



Ram Sandstone were glimpsed to the east, but the highway was followed down a spectacular wadi towards Aqaba. This cuts through Precambrian granites (Rashdan, 1988), where great cliff exposures are laced with huge numbers of dolerite dykes; truncated by the Ram Sandstone unconformity, these are relics of Precambrian crustal tension that was a predecessor of the Red Sea rifting. A photostop at the best of the dykes was given added spice as it was beside a military post, where photography is forbidden. Aqaba was reached for a stay of two nights.

#### 10. WEDNESDAY 24 APRIL: WADI RUM AND THE RED SEA REEF

An early start soon had the party in Wadi Rum, the roadhead Bedouin village surrounded by the highest of the inselberg mountains of Ram Sandstone. A fleet of bone-shaking jeeps then took everyone out to enjoy the magnificent desert scenery. A long loop included the Barrah Canyon with sand

dunes on its floor between vertical walls of sandstone 300 m high. Some of the jeeps diverted via Jabal Burdah, where the energetic half of the party walked up to the very spectacular rock bridge which spans a deep canyon (Fig. 6); the walk to the bridge involved a little acrobatic climbing, all worthwhile for the splendid views from the heights of the sandstone mountain.

A hurried return to Aqaba left the late afternoon to appreciate the very fine coral reefs in the clear waters of the Red Sea. Fourteen members went scuba diving on the reef, while the remainder caught glimpses of the coral from glass-bottom boats.

The next morning, a long drive north on the Desert Highway gave some feeling for the great empty spaces into which the eastern parts of Jordan disappear. The flight home from Amman to London was mercifully short, but gave a chance to reflect upon the varied geology, the friendly people and the impressive archaeology which combined to make these desert lands a delight to visit.

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This paper was originally printed in black-and-white, and did not include these two photographs of Petra (of the Khazna rock carving seen in a first view down the Siq canyon, and of the unweathered rock at the Silk Tomb).

