# Excursion 4 Stoer Group at Enard Bay

Maarten Krabbendam

*Purpose:* To examine the stratigraphy and sedimentology of the late Mesoproterozoic Stoer Group, and its unconformable relationships with the underlying Lewisian gneiss and overlying Torridon Group. The upper part of the Stoer Group is best examined here, whilst the lower part is best seen on the Stoer Peninsula (Excursion 3).

*Aspects covered:* Clastic sedimentology in a Mesoproterozoic rift environment, including algal limestone (the oldest life forms in Britain), putative drop stones, accretionary lapilli in the Stac Fada Member, and two well-exposed unconformities with distinct palaeo-relief.

*Maps:* OS: 1:50,000 Landranger sheet 15 Loch Assynt; 1:25,000 Explorer sheet 439 Coigach and Summer Isles. BGS: 1:50,000 101W Summer Isles.

*Terrain:* Mainly coastal outcrops with relatively easy access; a moderately good path links most of the localities. Most outcrops can be visited at any state of the tide, but some critical localities (e.g. Locality 4.6) are best seen at medium to low tide. Many boulders and bedding planes can be extremely slippery, especially below high tide mark. The excursion is not recommended during stormy conditions. Inland, recently planted forestry has created rough hummocky ground.

*Time:* Between a half and a full day.

*Access:* There are no access constraints for this excursion, but much of it is on or near crofting land and care must be taken with livestock – keep dogs on a lead at all times. Please note that the outcrops should not be hammered.

Park at the large lay-by [NC 0211 1241] at the road junction at Achnahaird Bay. Parties with several cars could leave one car near the bridge south of Loch Garvie [NC 0392 1300], as this saves a walk back along the road.

## Locality 4.1 Achnahaird Bay: Meall Dearg Formation. [NC 0221 1312]

Walk along the road to the north-east for about 500 m At a sharp bend to the right, turn left off the road and walk through heather and bog in a NNW direction to a small knoll between a lochan and the bay [NC 0221 1312]; (Figure 36).

The rocks here are part of the Meall Dearg Formation, the uppermost formation in the Stoer Group. The outcrops show west-dipping strata with well-bedded, locally cross-bedded coarse sandstone. Close to the high-water mark is a pebble bed, with rounded pebbles of quartzite and vein quartz; this is one of the few pebble beds within the Meall Dearg Formation.

Continue north along the shore, walking underneath dip slopes of sandstone. Some 50 m before the grass ends at a pebble beach, there is a small hollow on the right.

## Locality 4.2 Achnahaird Bay: Meall Dearg Formation. [NC 0215 1335] to [NC 0217 1400]

From this point northwards along the eastern shore of Achnahaird Bay there are good outcrops of trough cross-bedded sandstone. Walk north along the pebble beach and then along a path. Good three-dimensional outcrops of planar cross-bedded sandstone, with co-sets up to 2 m thick, can be seen along the high-water mark. Cross-beds dip west (steeper than normal bedding) indicating palaeocurrents to the west. Wave-rippled sandstone can be seen between the larger cross-bedded sets.

## Locality 4.3 [NC 0222 1419]

A thick set (*c*.3 m of cross-bedded sandstone is excellently exposed here (Figure 37) and appears to form a huge, 50 m wide channel or possibly barchan dune. Features such as pebble beds (Locality 4.1) and wave ripples suggest an overall fluvial origin for the Meall Dearg Formation (Gracie and Stewart, 1967; Stewart, 2002), possibly in braided rivers or alluvial fans.

Cross a stile, turn right (east) and skirt a small bay (Camas a' Bhuailte), all the time following a rough path around the headland of Rubha Beag, where the path turns east again. Pass a small bay with a pebble beach. Continue across the broad rocky promontory until you encounter a narrow, rectangular inlet on your left, and then descend steeply to the shore.

## Locality 4.4 Camas a' Bhothain: Meall Dearg Formation – Poll a' Mhuilt Member boundary. [NC 0271 1464]

The rectangular inlet is eroded into the softer mudstone of the Poll a' Mhuilt Member, the highest member of the Bay of Stoer Formation (Figure 32). On the left (west) side of the inlet is the contact between red mudstone of the Poll a' Mhuilt Member and the overlying sandstone of the Meall Dearg Formation (Figure 38). The red mudstones are locally laminated but also massive in places. The contact is sharp and locally erosive, and shows the sudden change from a calm, possibly lacustrine to a higher-energy fluviatile environment (Stewart, 2002).

The mudstone is only a few metres thick, as exposures on the east side of the inlet are of breccia and conglomerate, with large clasts of gneiss up to 1 m across, in a sandy, gritty matrix. The breccia is a couple of metres thick and directly overlies Lewisian gneiss basement, which forms a prominent ridge just east of the inlet (Figure 39). Note that the Stac Fada Member is not present here, suggesting that the basement ridge was exposed during deposition of this member.

Return to the path, and continue east, crossing the gneiss ridge into another, more rounded bay with the ruins of a salmon bothy. Walk to the west side of the bay.

## Locality 4.5 'Salmon Bothy' Bay, west side: 'drop stones' in the Clachtoll Formation. [NC 0278 1463]

Just above high-water mark, metre-sized gneiss blocks are embedded in laminated red mudstone and sandstone. These outcrops have been the source of significant controversy, with the blocks being variously interpreted as ice-rafted drop stones (Davison and Hambrey, 1996) and as mass-flow deposits (Young 1999). Bedding in the surrounding mudstone and sandstone has been deformed; generally there is more deformation on the south side, suggesting southward, lateral rather than vertical emplacement. Towards the south, at the level of the gneiss boulders, oscillation ripples and desiccation cracks occur on bedding planes; Young (1999) noted that these indicate shallow to subaerial conditions of deposition, whereas ice-rafting of dropstones >1 m across would have necessitated significant water depths. To the north and on the wave-cut platform, the mudstone passes laterally into a boulder conglomerate. Young (1999) suggested that these conglomerates were formed in debris fans along the margins of lakes, with blocks of gneiss from adjacent basement highs or scarps periodically sliding into the lakes, and a similar model was favoured by Stewart (2002).

Walk past the ruined salmon bothy to the east side of the bay, and cross a prominent C-shaped tidal inlet onto a small peninsula – this is possible at all but the highest tide.

## Locality 4.6 'Salmon Bothy' Bay, east side: basal conglomerate and algal limestone, Poll a' Mhuilt Member. [NC 0286 1462]

Most of the peninsula is developed on Lewisian gneiss basement, and the gneiss forms palaeohills which are smoothed and have asymmetrical shapes. Davison and Hambrey (1996) interpreted these palaeohills as roches moutonnées, and this was used to support their suggestion of glacial conditions during basal Stoer Group deposition.

Along the C-shaped inlet are outcrops of conglomerate with gneiss cobbles, sharply and directly overlying the gneiss. Much of the conglomerate is 'glued' together by a matrix of laminated microbial, algal limestone (note that the limestone is brick-red, presumably due to staining from the overlying red mudstones). At the east end of the peninsula, laminated algal limestone is seen to overlie the breccia, but also contains large clasts of gneiss. This limestone represents the oldest life form on the British Isles; please do not hammer it.

The algal limestone is overlain by red mudstone, belonging to the same unit (Poll a' Mhuilt Member) as at Localities 4.4 and 4.5. The C-shaped inlet has eroded most of the mudstone.

South of the inlet, the mudstone is overlain by a thick unit of boulder conglomerate, with large clasts of sandstone in a sandy matrix (Figure 40); this is interpreted as the basal conglomerate of the Diabaig Formation, forming the base of the Torridon Group.

Follow the path farther east.

## Locality 4.7 Camas a' Bhothain: Diabaig Formation. [NC 030 146]

Along the path are massive, thick-bedded red sandstone outcrops, mapped as belonging to the Diabaig Formation. Curiously, many bedding planes are steep, possibly due to large-scale slump folding.

Follow the path around until you are above a small cliff. Follow the cliff top until you can safely descend, then turn north towards the left-hand (west) side of the bay.

## Locality 4.8 Camas a' Bhothain: Poll a' Mhuilt Member. [NC 0301 1456]

At the high-water mark are outcrops of red planar laminated algal limestone,whichlocally encloseclasts ofgneiss upto10 cm. across;pleasedo not hammer these. The limestone is followed upwards by laminated mudstones (Poll a'Mhuilt Member), which are in turn overlain by boulder conglomerate with sandstone clasts up to 2 m across, forming the cliff above (Diabaig Formation, Torridon Group).

To the north, on the island of Sgeir Bhuidhe and on Rubh' a' Choin, note the sub-horizontal, thick-bedded sandstones of the Applecross Formation. Continue along the bay as far as a large wave-cut platform.

## Locality 4.9 Camas a' Bhothain: Stac Fada Member. [NC 0308 1456]

The Stac Fada Member here (stratigraphically below the Poll a' Mhuilt Member of Localities 4.6 and 4.8) consists ofsandstone beds, with pea-sized accretionary lapilli in the top part, best seen on bedding surfaces. In some cases, the insides of the lapilli are seen to be concentric. Accretionary lapilli are formed when ash particles are amalgamated in moist ash clouds (similar to hailstones); they are relatively fragile and generally have a poor preservationpotential.The unit with accretionary lapilli is thicker here than at Stoer, but the volcanic fragments seen at Stoer are absent here. Thus the Stac Fada Member changes character, over a distance of *c*.15 km, from a mass-flow deposit to an ash fall dominated unit.

The lower part of the member here consists of massive sandstone, locally with gneiss clasts. Continue along the bedding planes as far as a horizontal platform of breccia, just before a small inlet with loose cobbles. Some unsightly paleomagnetic drill holes are nearby. The platform [NC 0311 1457] consists of red breccia, with cobble-sized clasts which contain accretionary lapilli and are thus derived from the surrounding Stac Fada Member. The breccia, the lowest part of the Diabaig Formation, is lower than the surrounding outcrops of the Stac Fada Member and clearly occupied a palaeohollow.

Continue west along the path, past the little inlet, passing sandstones that form part of the lower Stoer Group. Continue to the north-west on the rough path, to a spit formed by large cobbles.

## Locality 4.10 Rubh' a' Choin: Torridon Group. [NC 0331 1469] to [NC 0339 1462]

The cliff to the south of the cobble beach consists of conglomerate with both gneiss and sandstone cobbles and mudstone intercalations. This is Diabaig Formation, which is plastered against a paleocliff of Stoer Group conglomerates. Walk over the cobbles to a low rock wall or plateau some 50 m to the north-west.

The base of this outcrop [NC 0335 1471] consists of laminated fine sandstone and red and grey siltstone and mudstone of the Diabaig Formation. This is overlain by the Applecross Formation with a sharp, locally erosive contact. The Applecross Formation here consists of thick-bedded, coarse, gritty to pebbly red sandstone, with clear east-dipping cross-bedding, suggesting palaeocurrents to the east.

The cobble-covered spit and the bay to the east have clearly been eroded out at the level of the mudstone/siltstone part of the Diabaig Formation.

Return to the cliff and follow it to the left (east) until a large corner, where the cliff is at its highest [NC 0339 1462]. Cobble conglomerate, with clasts of gneiss and sandstone, is overlain first by pebbly sandstone and higher up by fine sandstone and mudstone (Diabaig Formation). Higher up is more conglomerate.

Follow the path farther east and skirt the bay (with outcrops of Lewisian gneiss), then follow the path towards the headland north of Creag a' Choin Mhóir.

## Locality 4.11 Headland of Creag a' Choin Mhóir: conglomerate of the Stoer and Torridon groups. [NC 0360 1467]

Approaching the headland, you walk over dip slopes of conglomerate with gneiss boulders (base of the Stoer Group), which dip *c*.10° to the west. At the farthest point north along the path, there is a sloping wall some 20 m north of the path. Here there are two conglomerates apparently overlying each other, separated by a sharp unconformity (Stoer Group below; Diabaig Formation on top; (Figure 41)). Both contain gneiss clasts, up to 0.5 m across. The upper part of the Diabaig Formation conglomerate grades into stratified gritty sandstone.

From the headland follow the track south over Creag a' Choin Mhóir (keeping high where possible), passing outcrops of thick-bedded sandstone of the Applecross Formation on the way. At [NC 0365 1447] the Diabaig–Applecross formation boundary occurs down at the high-water mark. After about 1 km, the path drops down towards Garvie Bay, crossing gently dipping Applecross Formation strata. At the beach of Garvie Bay follow the path inland and skirt Loch Garvie on its west side (boggy in places). Keep following the path until you meet the road; turn right (west) and back to the car-park.

## Locality 4.12 Rubha Dunain, Achiltibuie: unconformity between the Torridon and Stoer groups. [NC 0242 0678]

To see further outcrops of the unconformity between the Torridon and Stoer groups, park at the village hall in Achiltibuie and pick up a path in a westerly direction. The path turns SSE, past Achlochan cottage, and continues to the coast.

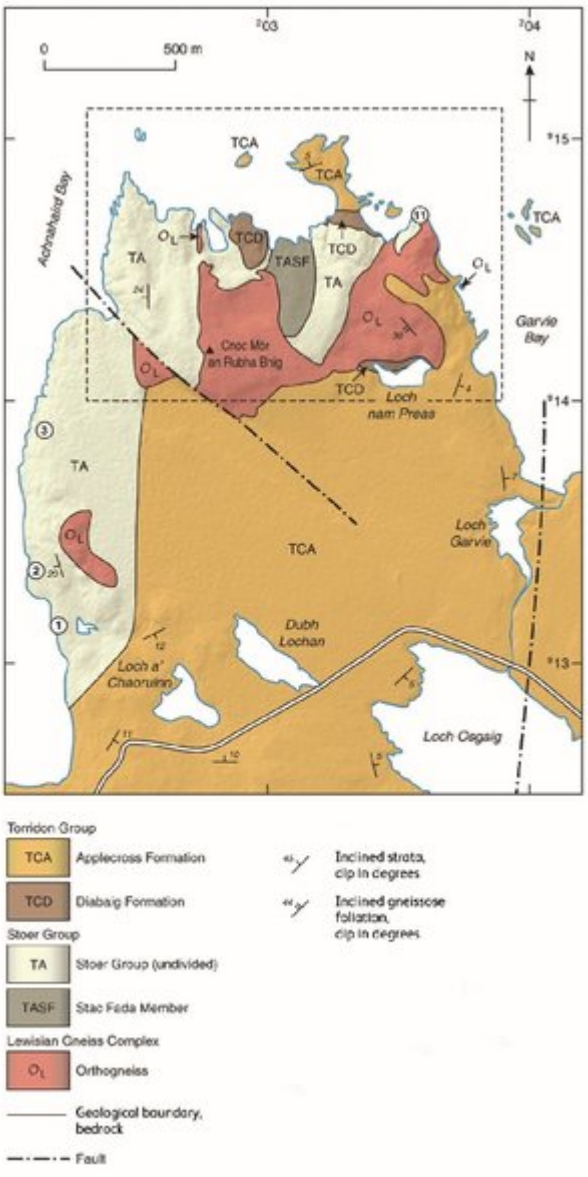
South of Achiltibuie, on the east side of the headland of Rubha Dunain at [NC 0242 0678], the Torridon Group–Stoer Group unconformity is well exposed. Below the unconformity, Stoer Group sandstones dip *c*.30° to the west. Above the unconformity, gently dipping basal Diabaig Formation conglomerates contain sandstone boulders up to 4 m across, derived from the underlying Stoer Group. The conglomerate is followed upwards by red sandstone and grey shale (Stewart, 2002).

## Locality 4.13 Reiff: Applecross Formation. [NB 962 147]

From Achiltibuie take the road to Reiff and park near the end of the road. Cross a stream and walk north-west towards Roinn a' Mhill. Excellent three-dimensional exposures of Applecross Formation sandstones can be found north-west of

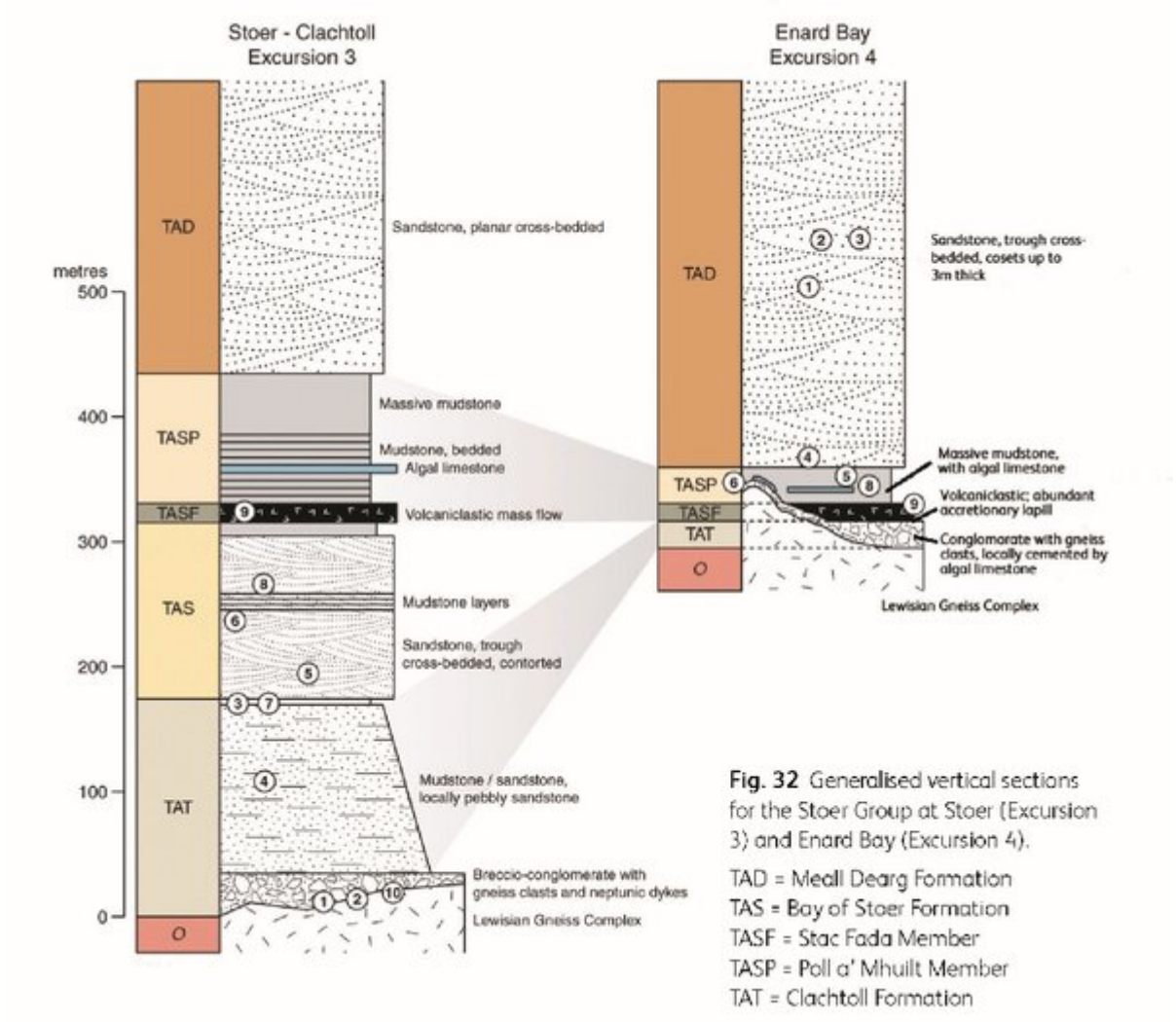
Reiff between [NB 962 147] and [NB 962 150]. Features include thick bedding, with cross-beds up to 2 m thick, commonly oversteepened and contorted. The outcrops are extensively used by rock-climbers, so please do not hammer.

## References

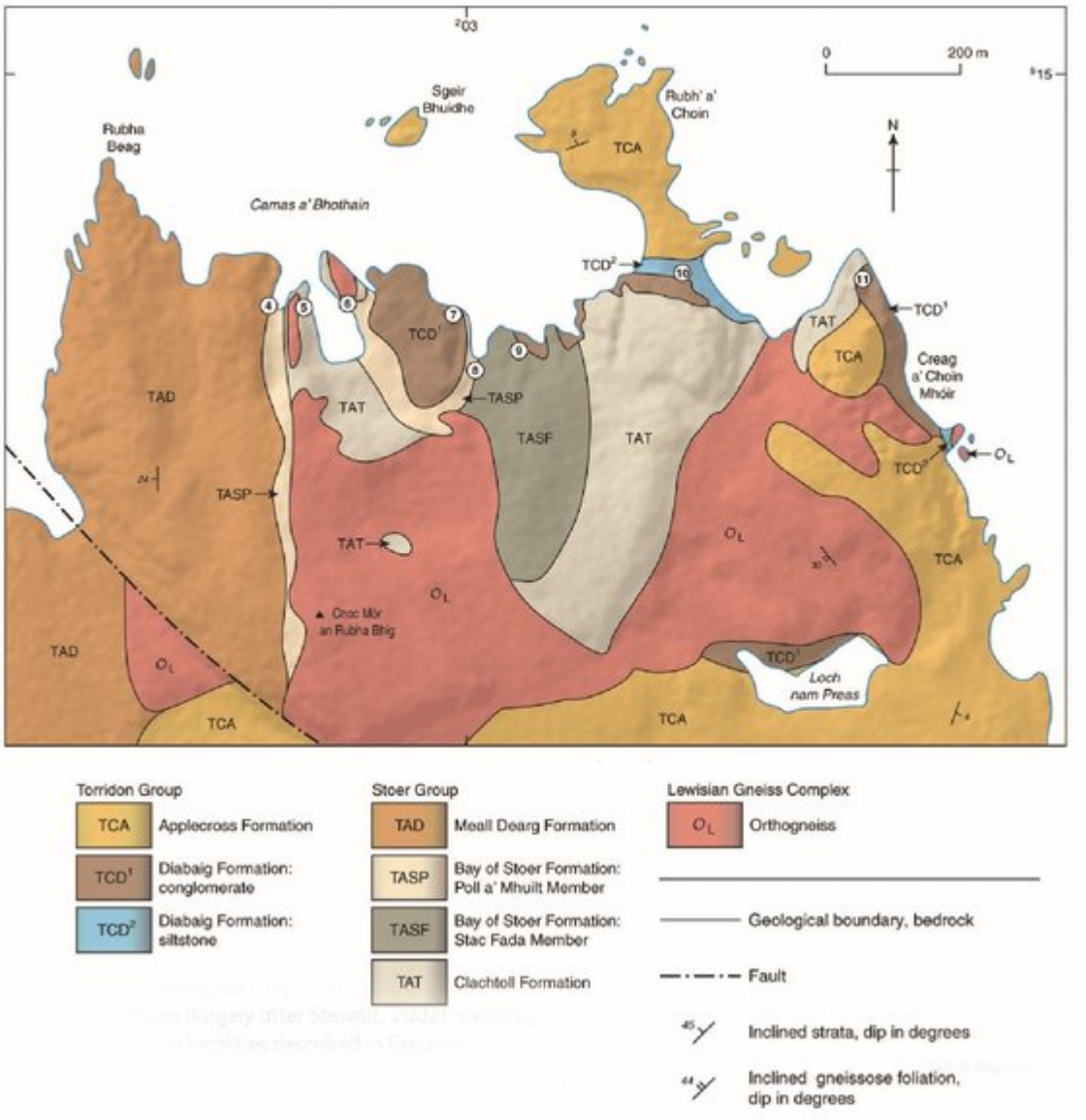



*(Figure 36) Overview geological map of the Enard Bay area (largely after Stewart, 2002), showing some of the localities described in Excursion 4. Dashed box indicates the area covered by a more detailed map (Fig. 38).*

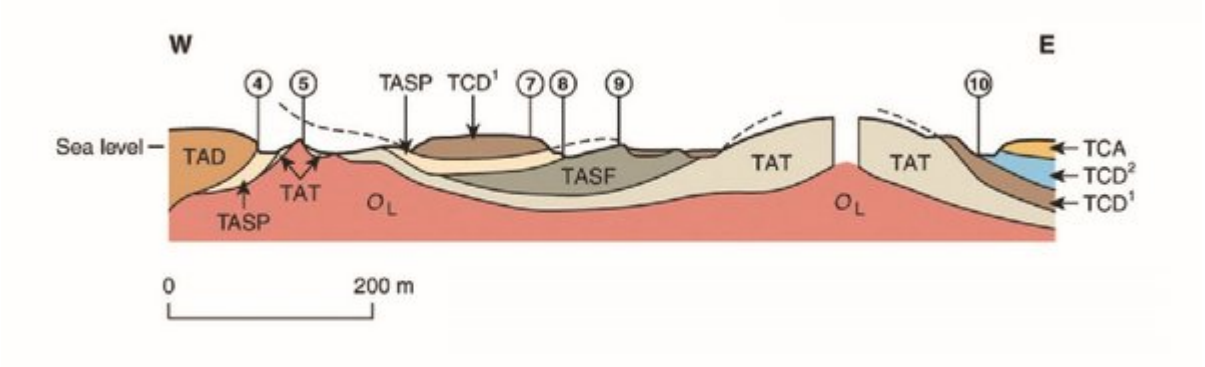
*(Figure 37) Sandstone with large-scale cross-beds, Meall Dearg Formation, Camas a' Bhuailte, just north of Locality 4.3. (BGS photograph P668334, © NERC)*




*(Figure 32) Generalised vertical sections for the Stoer Group at Stoer (Excursion 3) and Enard Bay (Excursion 4). TAD = Meall Dearg Formation TAS = Bay of Stoer Formation TASF = Stac Fada Member TASP = Poll a'Mhuilt Member TAT = Clachtoll Formation*




*(Figure 38) Geological map of the area around Camas a' Bhothain (largely after Stewart, 2002), showing some of the localities described in Excursion 4.*




*(Figure 39) Simplified cross-section through Camas a' Bhothain, from Locality 4.4 to 4.10. Key as in Fig. 38.*

*(Figure 40) Red stained algal limestone draped over Lewisian gneiss (in the foreground), overlain by red mudstone (Poll a' Mhuilt Member) largely eroded by wave action, overlain by boulder conglomerate (Diabaig Formation). Locality 4.6, east side of Salmon Bothy Bay. (BGS photograph P661241, © NERC)*

*(Figure 41) Two basal breccias: the basal breccia of the Stoer Group below, overlain via a sharp unconformity by breccia of the Diabaig Formation, Torridon Group. Locality 4.11, Creag a' Choin Mhòir. (BGS photograph P661251, © NERC)*