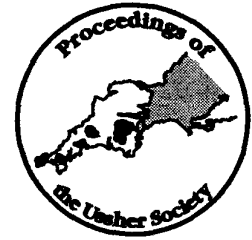


## PERMIAN BRECCIAS AND PLEISTOCENE IN TEMPORARY EXPOSURES AROUND TIVERTON, DEVON, AND THEIR STRATIGRAPHICAL CONTEXT

R. L. P. HODGSON AND D.J. C. LAMING



R.L.P. Hodgson, Earth Resources Centre, University of Exeter, North Park Road, Exeter, EX4 4QE.  
D.J. C. Laming Herrington Geoscience, The Elms, Crabb Lane, Exeter, EX2 9JD.

### INTRODUCTION

The Tiverton District was mapped geologically by W.A.E. Ussher in the late 19th Century (Edwards, 1990). Unfortunately, no memoir was produced and exposures of the Permian bedrock are rare, particularly under the town centre, commonly being masked by superficial deposits. Figure 1, based on the British Geological Survey Sheet 310, 1:50,000 series, shows the Permian outcrops in the Tiverton Basin; superficial deposits have been omitted for clarity.

Two construction projects in late 1993 created temporary exposures in the Tiverton area. The Newport Street Resewerage project entailed excavation of five shafts into the bedrock in the town centre, and excavations were also made south of the town along the old railway line during construction of the Tiverton Southern Relief Road. These exposures, with others in the district, provided useful evidence on the depositional succession of the Permian strata in the Tiverton area and the immediately surrounding country.

This note describes new information on the Permian geology of the Tiverton district, derived from these temporary exposures, and the stratigraphy is set in context from exposures mainly north and east of the town. In a correlation diagram which included the Tiverton area, Laming (1968) introduced the terms Chevithorne Breccias and Tidcombe Sands, in ascending sequence, and herein an additional higher formation, the Tiverton Breccias, is introduced. As further detailed mapping is required to define them more precisely, the stratigraphic units are presently informal.

The red-bed formations lie in a sedimentary basin eroded in a Carboniferous (Culm) sandstone-shale sequence which forms the higher ground to the south, west and north of the basin. The basin opens eastward to join the main New Red Sandstone depositional succession of Devon and west Somerset. Although no internal dating evidence has been found, the age of the formations is Permian since they lie stratigraphically beneath the Triassic pebble-bed formations and the underlying Aylesbeare Group mudstones, which outcrop to the eastward, and unconformably overlie the Culm.

### DESCRIPTIONS OF EXPOSURES

#### *Newport Street Resewerage Scheme, Tiverton*

A sketch plan and section showing Newport Street, to the north of the Pannier Market, are shown in Figure 2. The five excavations (A to E) revealed very coarse breccia beds at the western end, passing via an intermediate muddy cohesive unit to fine-grained, slightly gravelly sandstone or micro-breccia at Bampton Street. At all but location A, the Permian strata were covered by 3-4 m of dense cobbly Terrace Gravel (shown as "Valley Gravel" on the published geological map).

#### *Coarse grained breccia - St Peter's Church to Market entrance*

A red-brown, coarse-grained clast-dominated breccia was exposed at locations A, B and C (Figure 2). It consisted of densely-packed subrounded to subangular particles, in places up to 350 mm mean diameter in a muddy sand matrix. Cobbles (between 60 mm and 200 mm) were abundant grading tests on three samples gave a range of 9-24% by weight exceeding 60 mm, with 8-17% of silt fraction (smaller than 63 µm). This very coarse-grained breccia is distinguished from

the finer-grained, more angular breccias at Chevithorne (see below), and included in a new formation, herein named the Tiverton Breccias (TvB).

#### *Sandstone with fine-grained breccia - Bampton Street*

At 3 m below the surface of Bampton Street, location E, the excavation revealed a massive but weak, red, fine-to-medium-grained sandstone with thin beds and lenses of fine-grained angular gravel. This exposure appears to belong to the underlying Tidcombe Sands, suggesting that a small fault occurs between locations D and E, downthrowing the breccia to the west.

#### *Gravelly clay-silt - Castle Street*

The tunnel line passed into a less gravelly, matrix-dominated breccia near the end of Castle Street. The proportion of breccia in the pit walls at location D decreased towards the northern face, where the exposure was of a stiff red mudrock with sporadic small breccia layers dipping about 5° north. The southern face exposed about 50% coarse clasts. This exposure appeared to be gradational with the Tiverton Breccias seen at location C.

#### *Terrace gravels*

All the excavations except location A passed through superficial deposits consisting of dense sandy gravel 3-4 m thick, although the presence of infill for road and sewer constructions made the exact depth of natural ground difficult to determine. Scattered discrete lenses of silt and sandy clay were seen, but the deposit was largely unsorted and included many subrounded pebbles and cobbles, with some boulders up to 500 mm in size, mainly found near the base of the deposit. There were no Terrace Gravels at location A; it is possible that they were excavated at the time of construction of the nearby churchyard wall.

#### *Southern Relief Road*

A single-carriageway relief road (bypass) was under construction in December 1993 between Blundell's Road and Exeter Road, Tiverton, along the line of the former railway. The road crosses the southern edge of the Tiverton Basin at an oblique angle; excavations for cuttings and structures thus provided good exposures of the Permian deposits on the southern margin of the basin, where it abuts against the Culm.

The largest exposures were created during the excavation of the former bridge at the foot of Canal Hill, where a cutting 5 m high [SS 9594 1246] was made (now protected by retaining walls). As at the western end of Newport Street, a largely unsorted, clast-dominated coarse-grained breccia was present, characterised by abundant fragments of Culm sandstone plus vein quartz in a coarse gritty matrix; no volcanic fragments were found. Clasts were subrounded to subangular and many exceeded 60 mm; in an exposure measuring roughly 5 m by 2 m high, over 20 such cobbles were counted and there was also one boulder measuring 350 mm by 350 mm. The beds at this locality have shallow apparent dips around 5° south, the probable true dip direction. This exposure is attributed to the Tiverton Breccias.

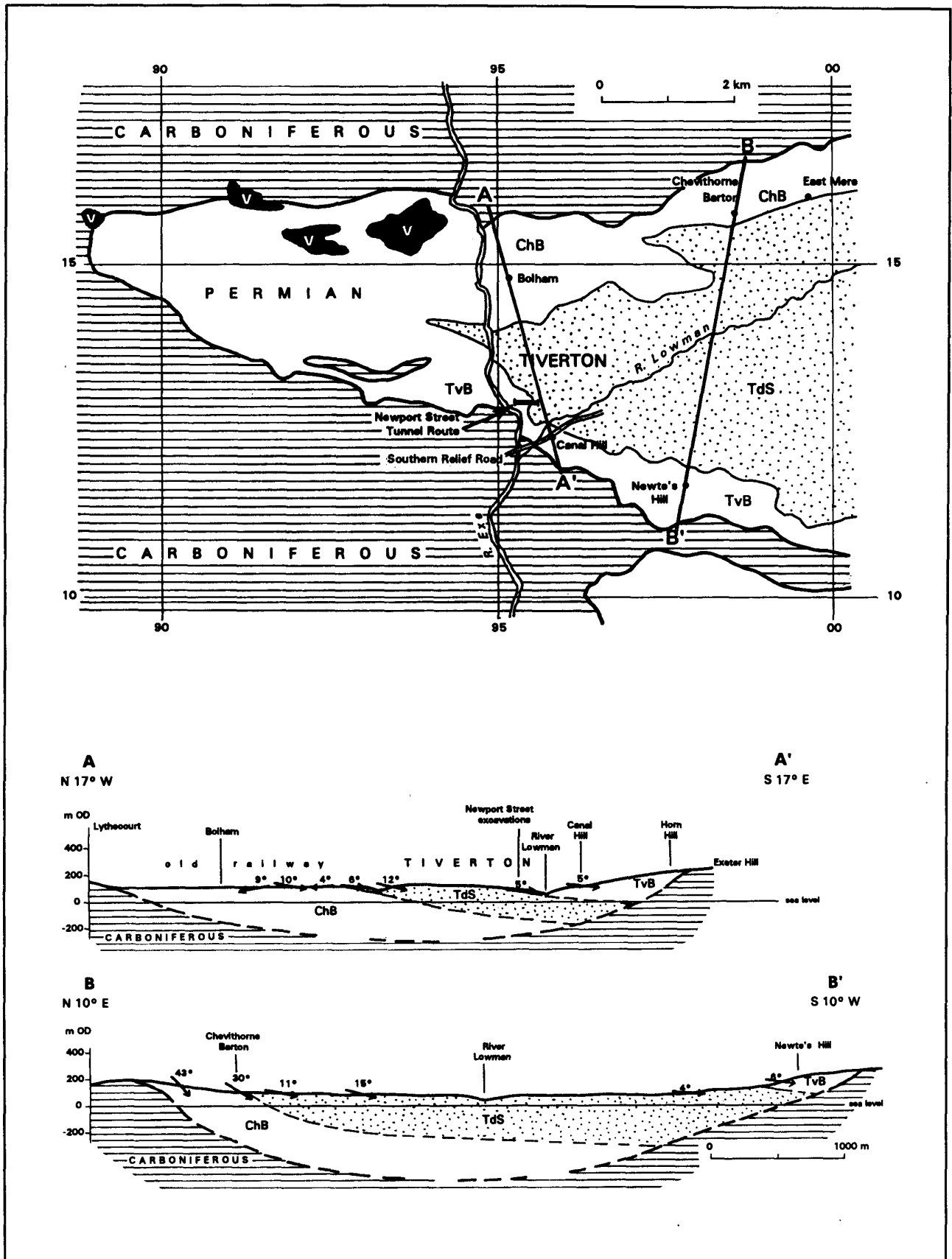


Figure 1. Permian geology of the Tiverton District, adapted from the British Geological Survey Sheet 310 (mapped by Usher 1871-97), with cross-sections to illustrate the relationships of the Permian formations to each other and to the floor of the Tiverton Basin (mainly conjectural).

Formations labelled are: ChB = Cheyithorne Breccias; TdS = Tidcombe Sands; TvB = Tiverton Breccias; V = volcanic rocks of the Exeter 'Series'.

Other exposures in adjacent road cuttings showed deposits similar to those at the Canal Hill site.

**PERMIAN STRATIGRAPHY OF THE TIVERTON AREA**

The Permian Tiverton Basin is one of several basins on the west of, and tributary to, the main Permo-Triassic red-bed depositional basin of East Devon and West Somerset. The Tiverton basin is analogous to, but not so extensive as, the Crediton Basin 15 km to the south. It broadens eastward to join the main outcrop at Sampford Peverell, which is 14 km from the westernmost end of the basin. Eastwards the strata disappear beneath younger sand, mudstone and conglomerate formations of the upper parts of the red-bed sequence.

As with other parts of the Permian succession in Devon, the breccias are interpreted as being formed as alluvial-fan deposits, resulting from rapid but very intermittent streamflood and sheetflood deposition in a desert under a semi-arid sub-tropical climate, perhaps equivalent to northern Nigeria at the present day. Sand deposition was the result of late- and post-flood stream-sorting of the coarser sediments, infilling areas between alluvial fans and concentrating in the centre of the depositional basin. No aeolian sandstones are known from the Tiverton area.

Outliers of red beds found on a high ridge of Culm rocks north of

the basin suggest a former northerly overlap, though the occurrence of fossiliferous sandstone fragments attributed to the Pilton Beds, which crop out to the north, but do not appear in the Tiverton Basin, suggests a separate intermontane valley. This is also the case to the south where breccias occupy a basin around Butterleigh separated from the Tiverton Basin by the high Culm ridge running east-south-east from Tiverton. Although the north side of this ridge is apparently fault-controlled, it was probably created before the deposition of the red beds, as there is no evidence for any movement affecting the sedimentation. However, there is a possible fault along the northern margin of the basin at Washfield Weir [SS 943 161].

Although the offset geological outcrop pattern shown in Figure 1 indicates the possibility of a transcurrent fault along the north-south valley of the River Exe, there is at present no evidence for its existence. Poor exposure makes correlation difficult across the river, between the main and western parts of the basin.

Similarly, poor exposure hinders definition of the formations in the main part of the basin east of the River Exe. Mapping at 1:25,000 scale in the 1960s outlined three red-bed formations: the Chevithorne Breccias, overlain by the Tidcombe Sands, both of which occur in the centre of the basin east of Tiverton; and the Sampford Peverell Breccias, which are found to the east around that village and are not shown in Figure 1.

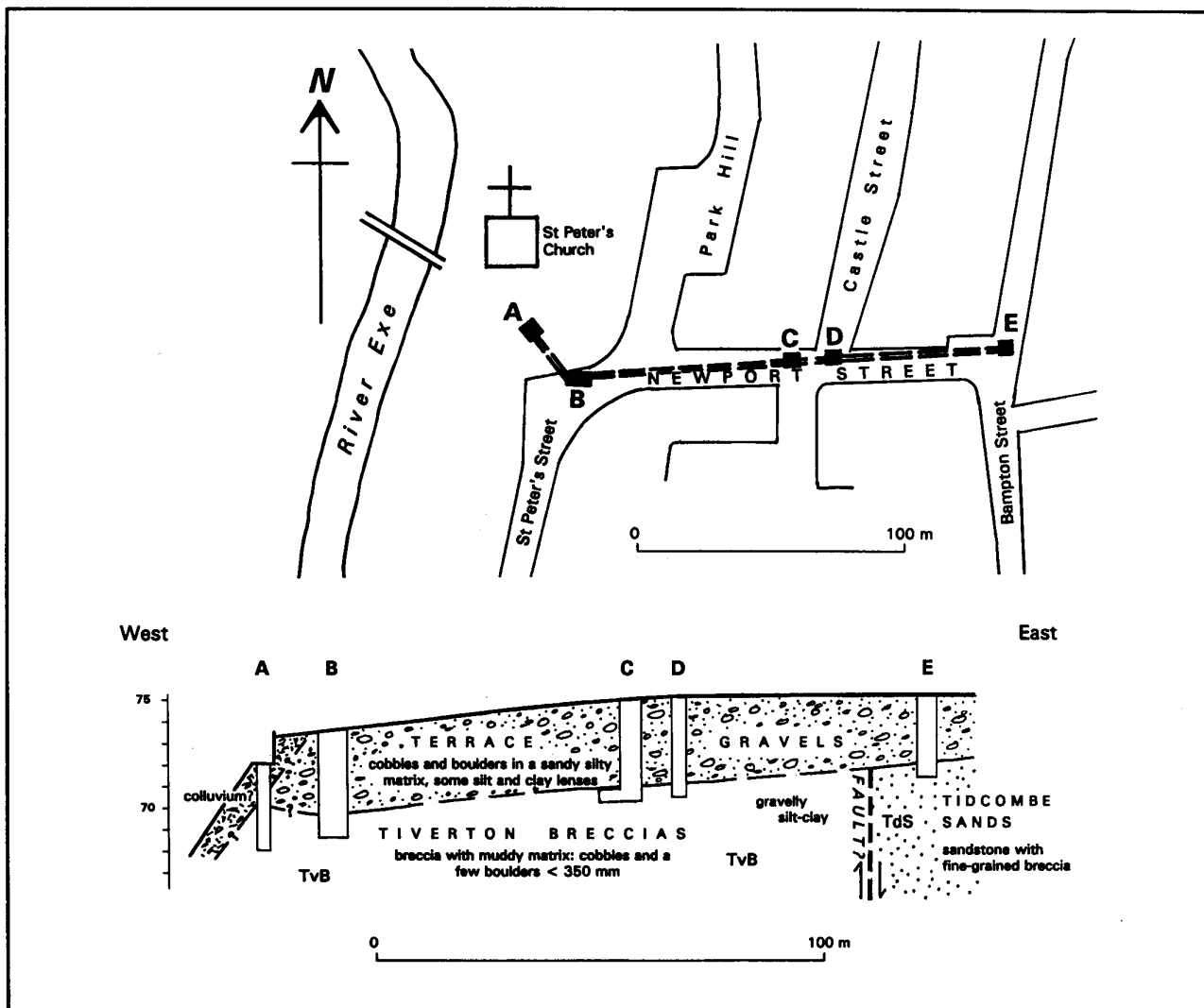


Figure 2. Plan and geological section along the excavated tunnel line in Newport Street, Tiverton. Pits from west to east are localities A-E mentioned in the text. TvB = Tiverton Breccias, TdS = Tidcombe Sands. Vertical exaggeration of section is 5 times.

The **Chevithorne Breccias (ChB)** are characterised by fragments consisting almost entirely of Culm sandstone and sparse vein quartz, in a gritty sandy matrix; the largest fragments seen are 60-100 mm in most places, exceptionally up to 300 mm. An important distinguishing characteristic is that the fragments are subangular to angular. Interbeds of medium to fine-grained sandstone, commonly with stringers of fine-grained breccia, are found in the upper parts of the formation where it grades upwards into the Tidcombe Sands (Figure 1). Imbrication of the fragments indicates derivation largely from the north, though variations in direction suggest that the sediment streams issued from a number of canyon mouths in the north side of the basin, spreading out as they reached the basin floor. The formation is named after Chevithorne Barton [SS 985 159]; in the road 300 m south of there, the top of the formation grades up into the overlying sands, though this part of the section is now overgrown.

Other exposures are visible west of the Barton itself: at one point [SS 983 160], breccia beds with fragments up to 350 mm dip 43° south.

The **Tidcombe Sands (TdS)** occupy the low-lying ground in the centre of the topographic basin east of Tiverton, and are nowhere well exposed. They are fine- to medium-grained sands, moderately well-bedded, with sparse interbeds of fine-grained breccia of Chevithorne type.

A recent re-examination of the area, undertaken to check the context of the tunnel findings, showed that a higher formation was also present, named in this article as the Tiverton Breccias (TvB) and well exposed at Newte's Hill [SS 975 118]. This formation includes fragments of Culm sandstone and vein quartz, similar to the Chevithorne material, but they are subangular to subrounded and obviously of more distant derivation. A few fragments of volcanic material were also found, suggesting derivation from the outcrops west of the River Exe, though no type correspondence was proved.

(Note: identification of breccia formations in the Permian relies heavily upon the fragment profile, including their degree of rounding: effectively, each formation represents a distinct alluvial-fan unit with generally unique source characteristics).

Other outcrops of the formation were seen in the temporary section at Canal Hill, described above, and along the old railway line south of Bolham [SS 953 147] where volcanic fragments are less sparse among the Culm sandstone clasts. Imbrication in the breccias showed derivation from the west and south-west, along the axis of the basin, and the Bolham outcrops suggest the presence of a large alluvial fan spreading out from the present day Exe gap south of Tiverton. The faulting which apparently gave rise to the north-south section of the Exe valley is probably post-Triassic, but a line of structural weakness could well have been present in Permian times.

The cross-sections A and B in Figure 1 show the general relationships across the basin. The southern margin of the basin does not, as mentioned, show any evidence of post-Permian faulting, and it is concluded that the Tiverton Breccias at that locality were banked up against a partly eroded old fault scarp, and deposited by sheetfloods flowing from the west parallel to it. A thickness of about 500 m is indicated for the Tidcombe Sands, but lack of borehole data does not permit a valid reconstruction of the deeper parts of the section so this is only an estimate.

The implications for the tectonic history of the area are that the initial basin began filling soon after its formation, with erosion probably coinciding with the growth of the Variscan mountains at the end of the Carboniferous; east-west block- and graben-type faulting may have occurred then, giving rise to several east-west valleys. The Chevithorne Breccias were deposited by local streamfloods and sheetfloods coming largely from the north, bringing in material of purely local derivation. As the topographic relief was reduced by hill erosion and basin infilling, sand deposition became more common and eventually predominated. The onset of high-energy sedimentation after this, marked by the appearance of the Tiverton Breccias, is interpreted as a response to renewed uplift of the source area, with larger-sized detritus funnelling down into the basin; this was derived from a wider source area, which included the canyonhead zone south of Tiverton and probably the western part of the present day basin and its hinterland. Although in other parts of the Permian outcrop this expansion of source area led to a greater variety of clast type being deposited, little diversification was possible here because the source area contained only Culm sedimentary and Permian volcanic rocks.

Although it is tempting to correlate this tectonic pulse with the one that initiated the sedimentation of the Crediton Breccias, to the south, and to correlate the Tidcombe Sands with the Dawlish/ Clyst Sands and Knowle Sandstones, the lack of free feldspar in any of the beds in the Tiverton area means that there are no correlatable elements to support such a relationship.

## CONCLUSIONS

The Permian strata revealed by the excavations in Newport Street and along the Southern Relief Road belong to the Tidcombe Sands and an overlying new formation named herein as the Tiverton Breccias. The Chevithorne Breccias on the north side of the basin were formed as alluvial fans of local derivation, and the overlying Tidcombe Sands were derived by stream action from adjacent fans. The Tiverton Breccias represent a return to high-energy sedimentation, probably resulting from a tectonic pulse which caused a large alluvial fan to form. The presence of large-size boulders in the Tiverton temporary exposures is attributed to the configuration of the basin at the southern margin, where the fan issued northwards and eastwards from a large canyon on the site of the present Exe valley. This configuration appears to have been re-excavated in Pleistocene times, so that the overlying Terrace Gravels are lithologically similar to the Permian breccias, although derived from the north.

## ACKNOWLEDGEMENTS

Our gratitude is due to Miller Civil Engineering Ltd and Balfour Beatty Ltd for permission to inspect the Newport Street and Southern Relief Road sites, respectively. Our thanks also go to Dr R.C. Scrivener at British Geological Survey, Exeter office, for assistance in providing background records and office reports.

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