Brock University

Report on Concrete Samples

Descriptions & Interpretations

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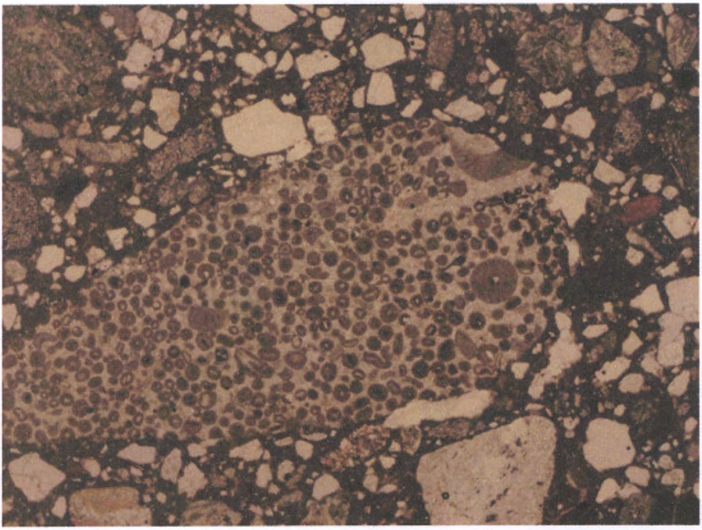
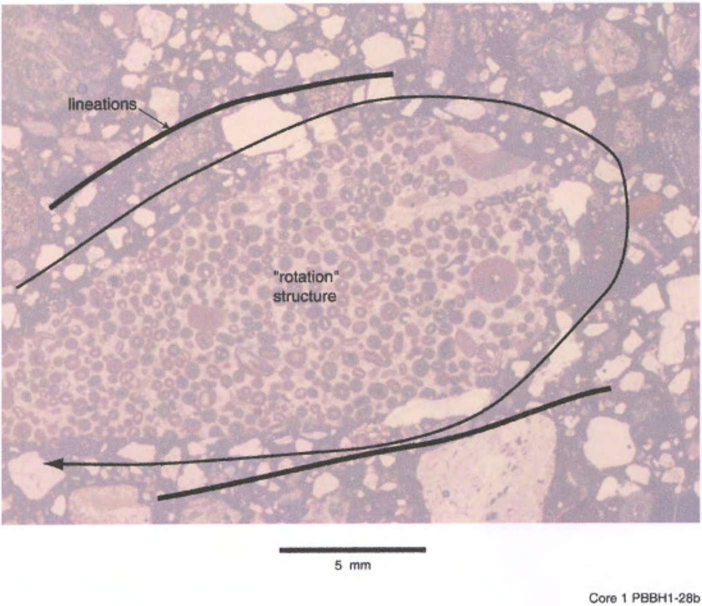
CANADA

All the samples discussed below were supplied by The core samples were shipped to the Micromorphology Lab. at Brock University where they were impregnated and thin sectioned. Each core was cut to produce both vertical (V) and horizontal (H) thin sections.

Core 1 PBBH1-28b

The thin section is dominated by a large rotation structure in its centre bounded on either side by two parallel lineations. The sample exhibits the effects of plastic deformation during mixing. The existence of these structures all indicate partial mixing or improper homogenization resulting inn brittle fracturing of the sample possibly due to 'dry' zones occurring within the concrete.

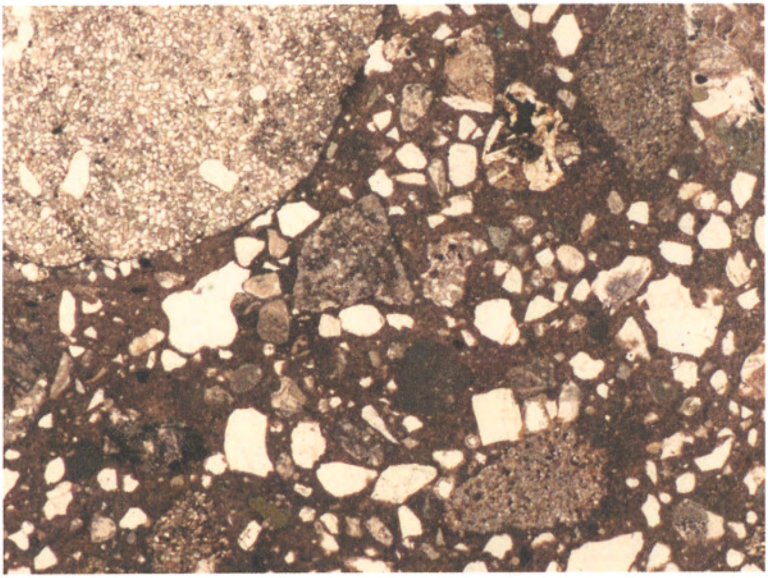


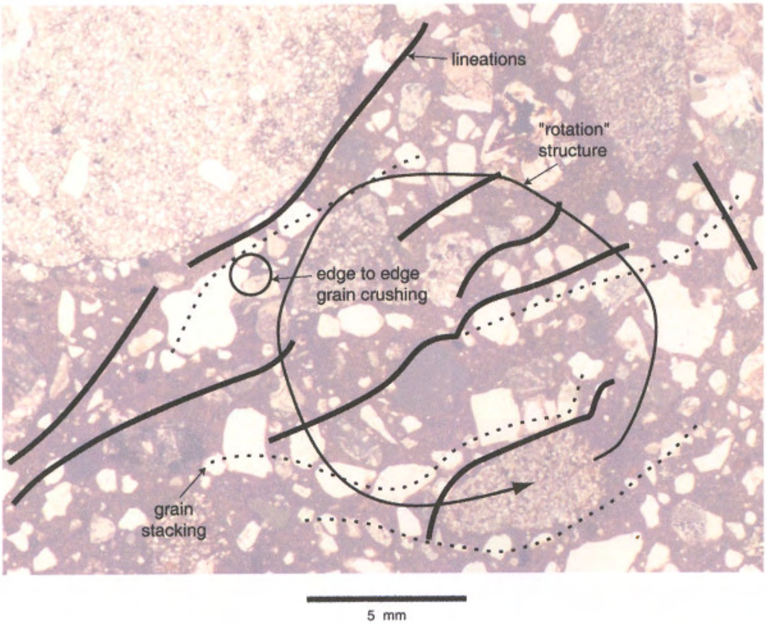


Core 1 PBBH1-28b

Core 2 PBBV2-1a

This sample contains a range of structures including grain stacks, rotation, edge to edge grain crushing and short distance lineations. All of these structures are symptomatic of improper mixing and localized brittle fracture probably due to the presence of 'dry' zones as noted in the previous thin section.

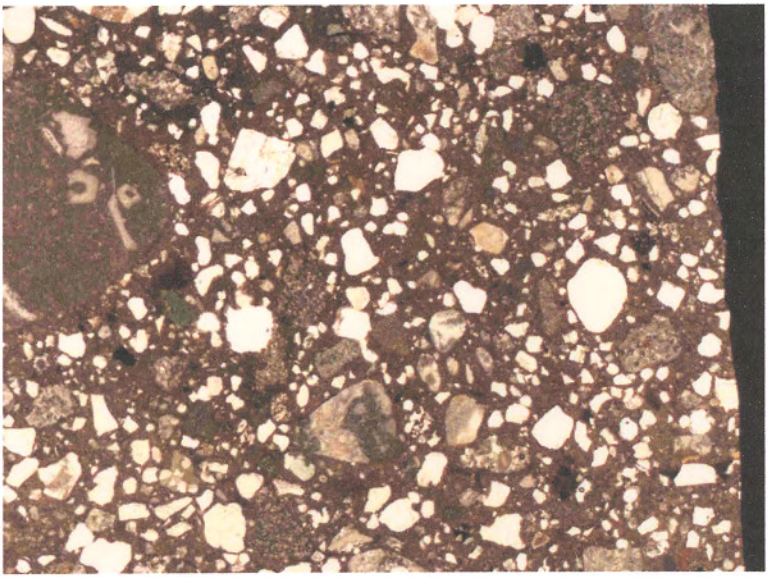


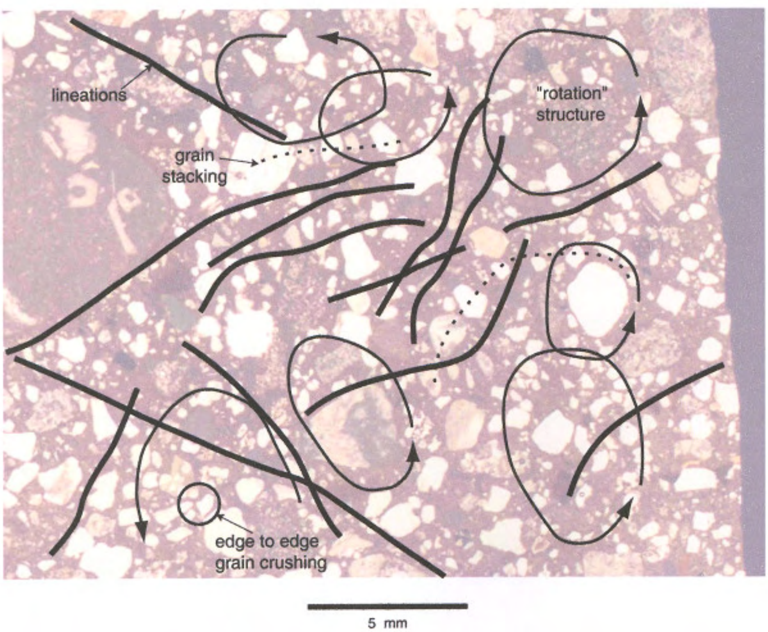


Core 2 PBBV2-1a

Core 2 PBBV2-3a

In some thin sections of which this is an excellent example a series of rotation structures are found juxtaposed one another indicative of considerable plastic deformation occurring followed subsequently by brittle fracturing leading to lineations being formed. The sequence of events can be garnered from the overlaying of lineations superimposed over the rotation structures. This set of events would indicate that the concrete first was ductile before being 'set' but prior to final 'setting' brittle fracturing occurred. Either the concrete dried out just prior to final 'setting' or the concrete was externally stressed at that stage in its formation.

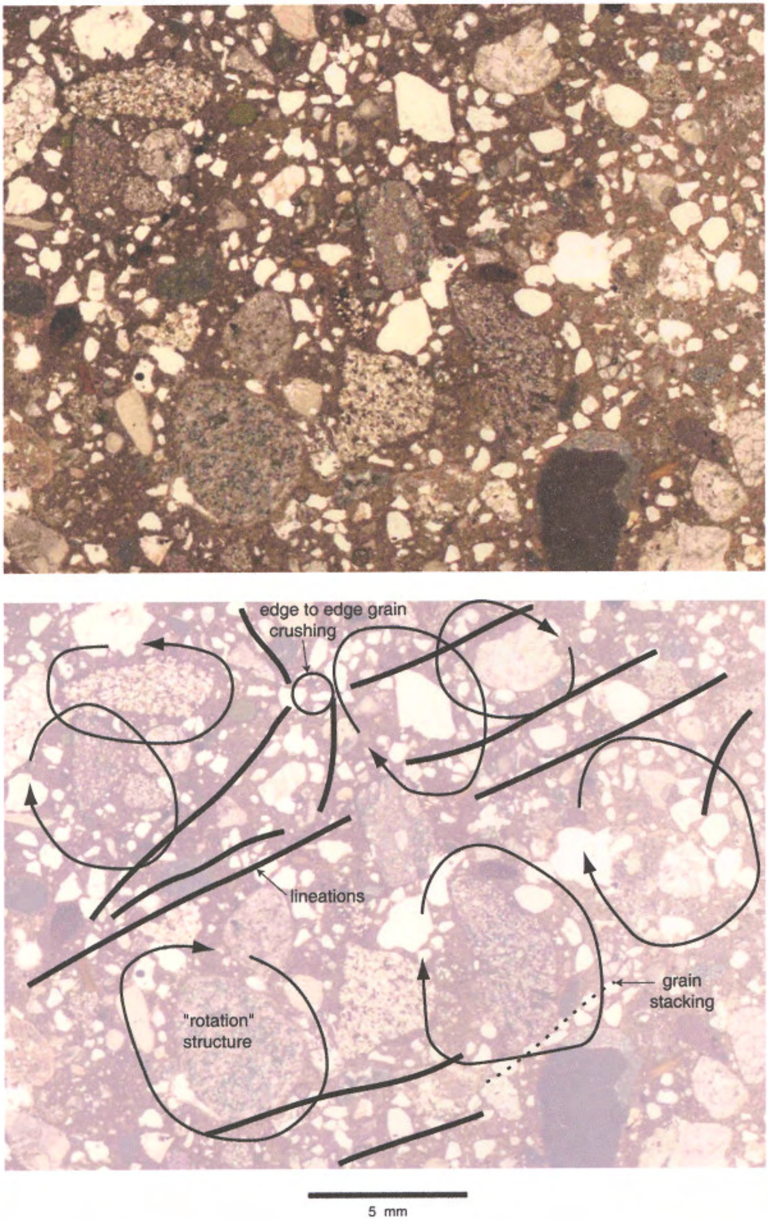




Core 2 PBBV2-3a

Core 2 PBBV2-5a

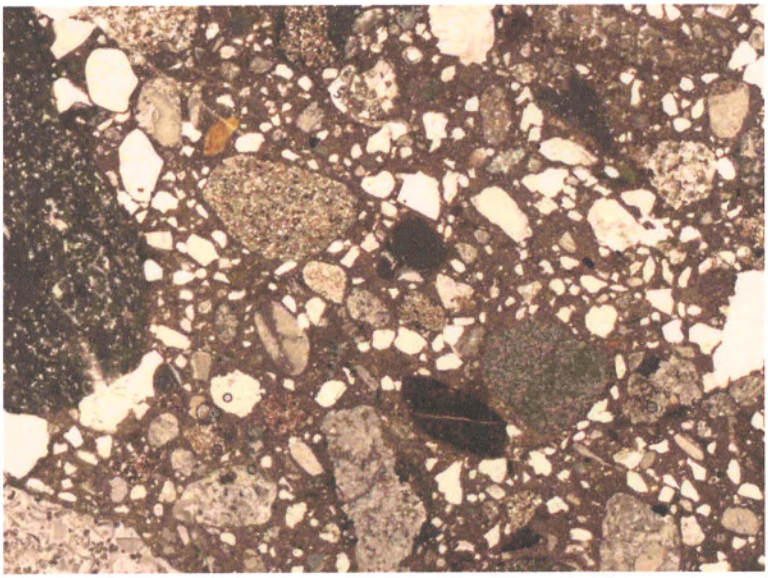
This sample is almost identical in terms of structures and interpretations the above tins section (Core 2 PBBV2-3a**).** However, the one marked difference is that it is apparent from this thin section that there are two distinctive shear directions at right angles to each other crossing the concrete. This would indicate that the concrete was externally stress in at least two 90^0 opposed directions before final 'setting'.

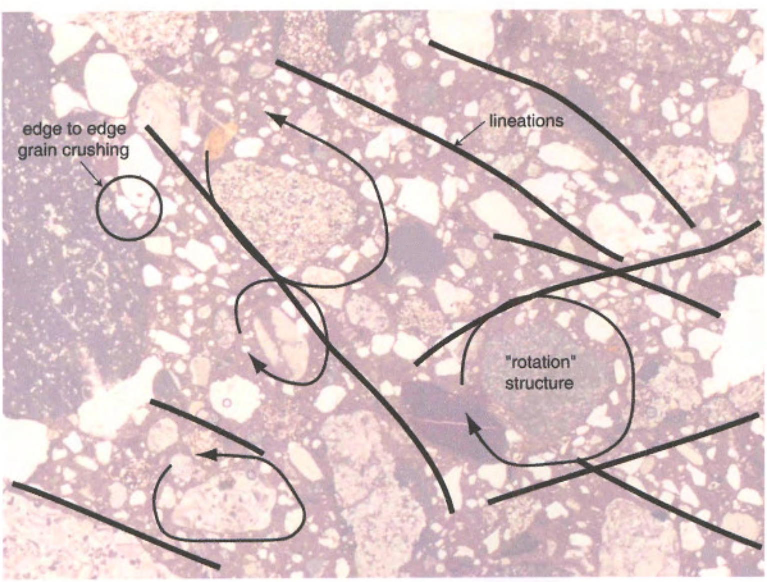


Core 2 PBBV2-5a1

Core 2 PBBV2-7a

Similar to the sample above (Core 2 PBBV2-5a), this sample carries evidence of again a two-way external stress application but at amore acute angle of around 45^0 that may be indicative of both two compressive or one single shear direction the latter being acute due to subsequent Riedel shear effects. The latter is typical of bulk non-pervasive shearing. In either case it illustrates again ductile deformation followed by brittle fracture prior to final concrete 'setting'. The edge to edge grain fracturing indicates 'dry' conditions possibly where grain stresses were so high that asperity fracturing took place following very high compressive stress application.



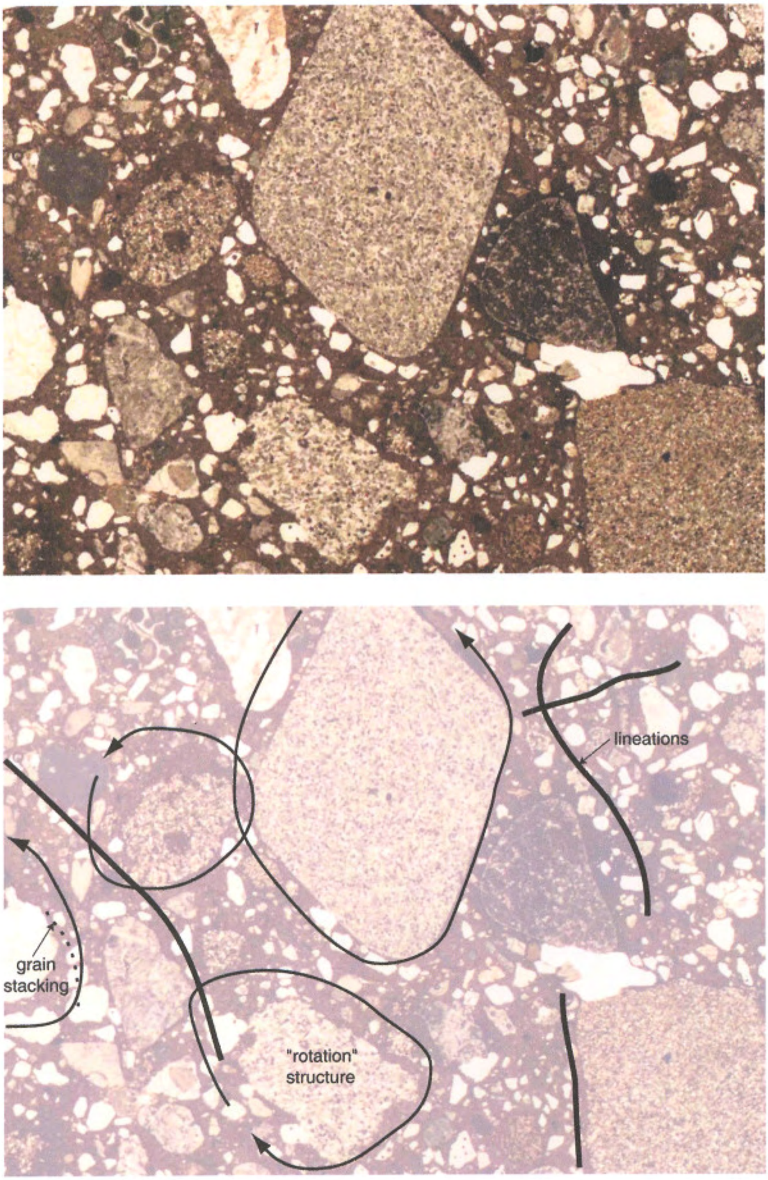


5 mm

Core 2 PBBV2-7a

Core 2 PBBV2-9a

This sample probably exhibits a narrow shear zone from top left to right bottom of the thin section containing several rotation structures products of the higher ductility within this crude shear zone. Like previous examples lineation mark the edge of the zone and in one instance cross-cut on the right indicative of subsequent external stress application.

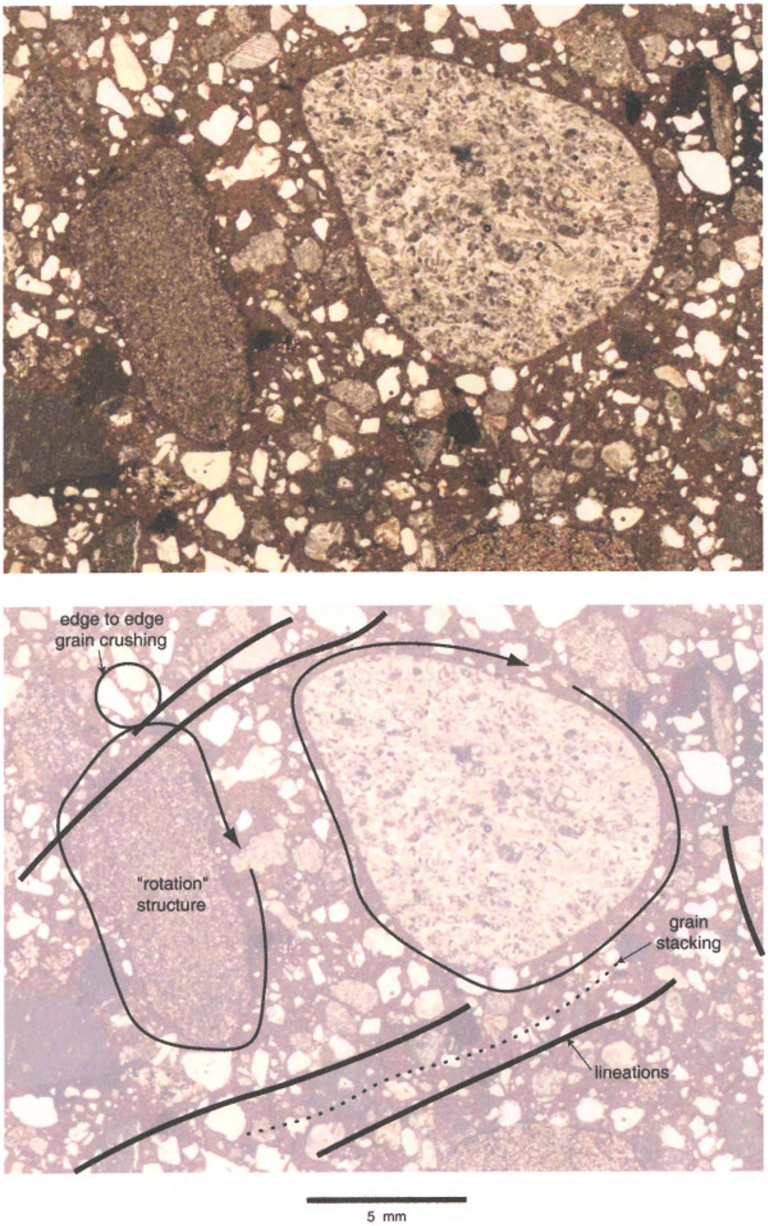


5 mm

Core 2 PBBV2-9a

Core 2 PBBV2-12a

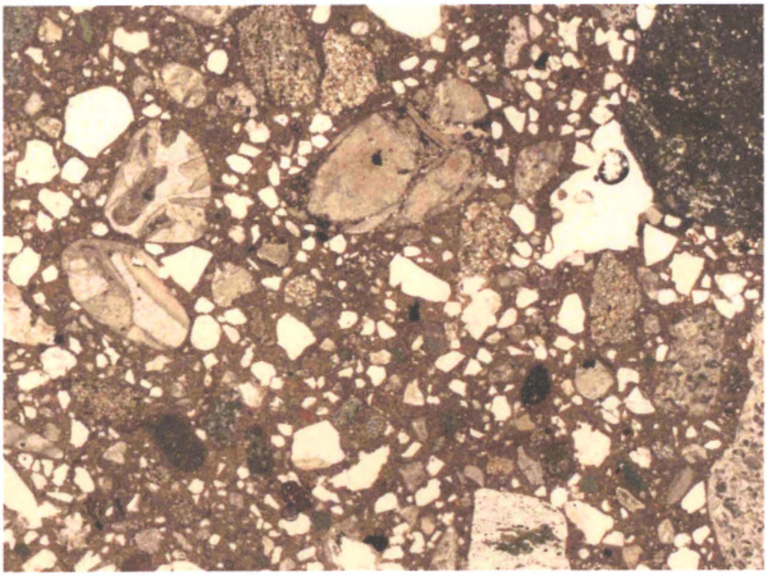
This sample as in the previous one above (Core 2 PBBV2-9a) shows a shear zone, this time from left to right across the thin section, again containing rotation structures. It seems clear that after the ductile event prior to the concrete 'setting' that a parallel external stress to the shear zone resulted in brittle fracturing of the setting concrete.

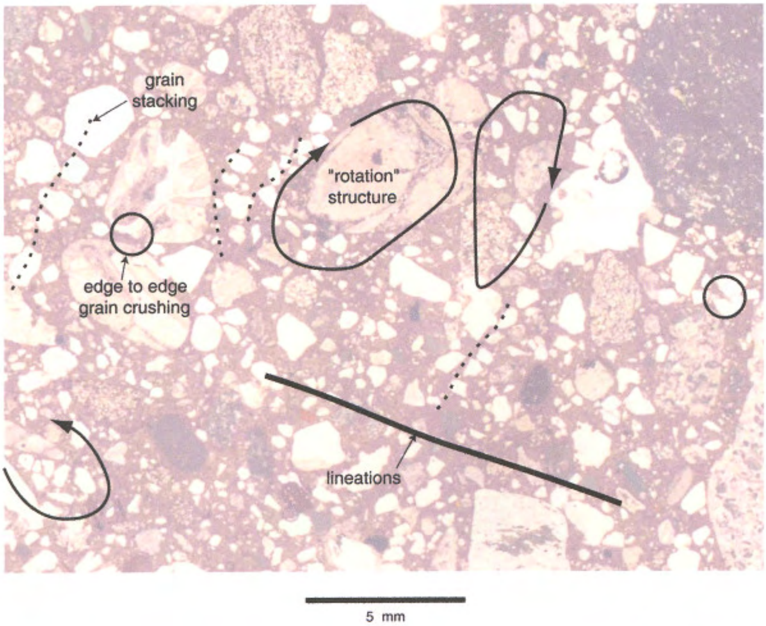


Core 2 PBBV2-12a

Core 2 PBBV2-15a

In many cases the concrete exhibits limited yet scattered microstructures throughout the material. In this instance there are a series of bent grain stacks, small rotation structures, a single long lineation and several instances of edge to edge breakage. It seems likely that this sample exhibits a fairly good level of mixing and limited ductile and brittle deformation and likewise limited external shear application. Therefore it is concluded that this zone within the core 'set' fairly quickly on being poured. If this is the case, and many of the above examples come from Core 2, it would suggest that there is a very high heterogeneity in the 'setting' time of this particular piece of concrete allowing some areas to set much slower than other thus subject to continued plastic deformation, external stresses and scattered development of 'dry' areas within this core permitting brittle fracturing typically after ductile flow has ceased.

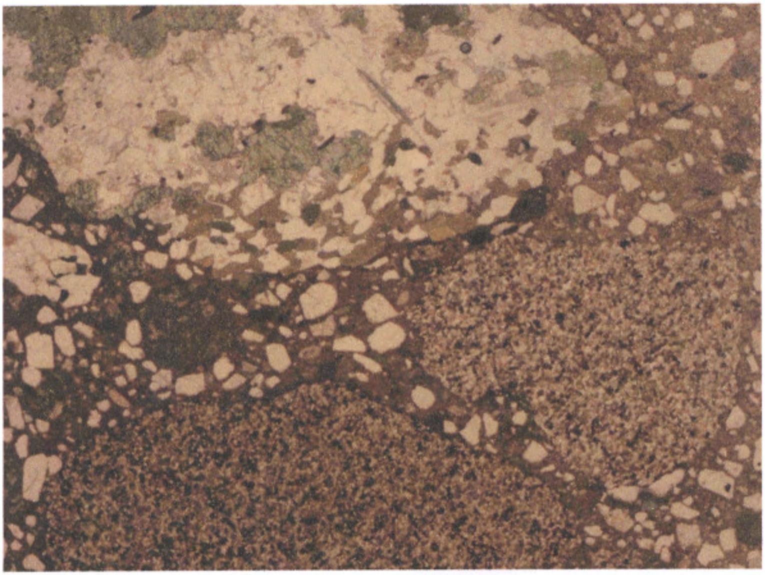


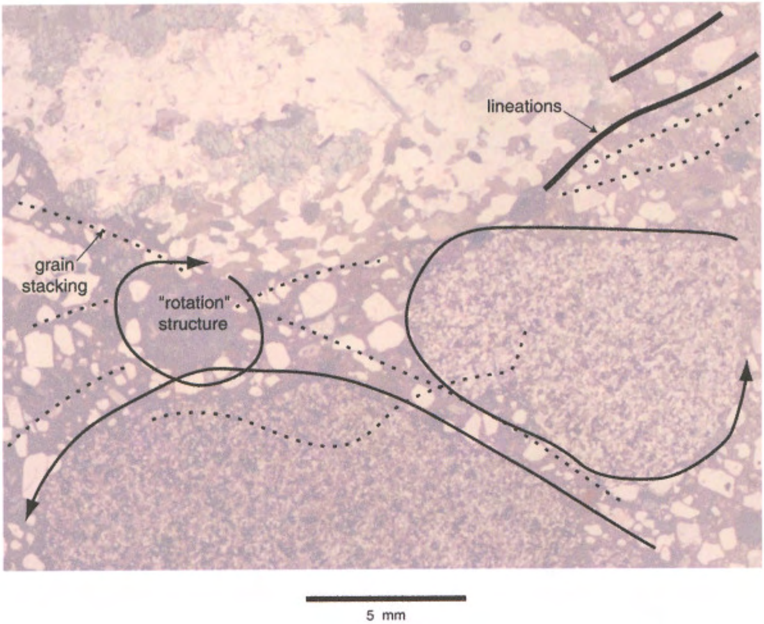


Core 2 PBBV2-15a

Core 2 PBBV2-35b

It is apparent in this thin section that a highly ductile area of fine-grained matrix has squeezed through a set of 'necks' between large clasts. The evidence in the form of a central rotation structure, grain line stacks and lineations all point to plastic flow between these clasts.

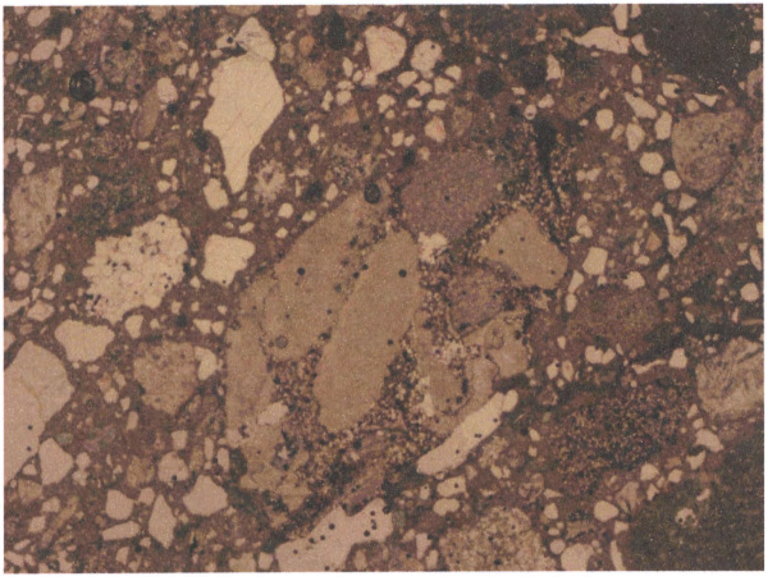


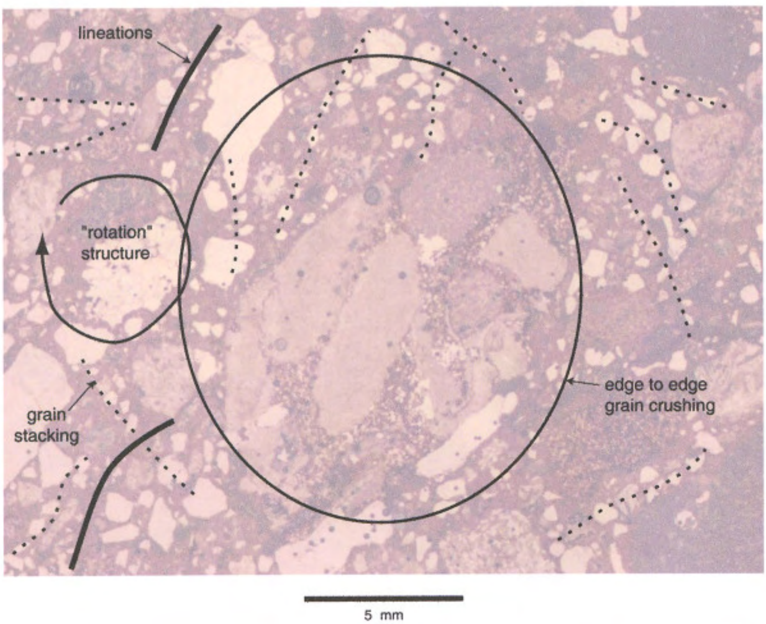


Core 2 PBBH2-35b

Core 3 PBBH3-44b

This example from Core 3 illustrates an instance of a large agglomeration of clasts that have 'stuck' together and then been rotated. The 'clot' of clasts exhibits internal edge to edge grain crushing events and would appear illustrative of localized clotting of parts of the concrete that then was subsequently rafted into 'un-set' concrete that was still exhibiting ductile plastic behaviour.





Core 3 PBBH3-44b

Summary of Thin Sections

All of the thin sections discussed above were chosen from a total of 9 large thin sections that were then subdivide into 270 individual images from all three cores. The sections shown above all contain certain features common to most of the thin sections but often of a particularly excellent example. Based upon the thin sectioned cores several fundamental points emerge:

• all examples of concrete in all the cores exhibit both ductile and brittle form of stress deformation,

• in most cases, if not all, ductile deformation seems to have occurred prior to the effects of external stress leading to brittle fracturing probably illustrative of the concrete going through various phases of 'setting',

• evidence of 'rafting' of clotted units of concrete do occur indicative of rapid 'setting' of some localized parts of the concrete followed by subsequent plastic deformation of the concrete as a whole,

• it is possible that the concrete has not been homogenized (mixed0 as much as it should be before 'setting' begins thus allowing fracturing to extensively occur just prior to 'setting'. The effect of this is perhaps to locally weaken the concrete through the development of a myriad of microfractures (lineations) that may lead to subsequent concrete failure.

References

Marchad, J. Hornain, H, Diamond, S., Pigeon, M & Guiraud, M. 1996 The microstructure of dry concrete product. Cement and Concrete Research, 26 (3) 427-438.

Meer, J. J. M. van der, Menzies, J, *in press* The Micromorphology of unconsolidated sediments. *Earth Science Reviews.*

Scrivener, Karen L. 1989 Microstructure of concrete. Materials Science of Concrete III, 127-61.