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# Suggested glossary of terms for hydraulically significant discontinuities in the Chalk

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INTRODUCTION.

Throughout the hydrogeological and engineering geology literature there is little or no consensus regarding the terminology to be applied to hydraulically significant discontinuities. The terms fissures, fractures and joints are commonly used either interchangeably or are used consecutively as if they are mutually exclusive terms (*eg*. "Mass permeability is controlled by joints, fractures and passages enlarged by solution" Hancock 1975, pp.507, or "The very property of the Chalk that makes it an excellent aquifer - its well-developed fractures and fissures - also renders it especially vulnerable to pollution." Foster 1993, pp 93, or " The porosity and permeability components contributed by the fissures are referred to as the fissure (or fracture) porosity and permeability." Price *et al* 1993, pp 35).

Generally, within the Chalk hydrogeological literature the term fracture appears to be used in the sense of a non-transmissive parting in the rock mass; by implication it is assumed to be an isolated parting. Whereas, the term fissure appears to be used in the sense of a parting that transmits groundwater; by implication it is assumed to be connected to a 'fissure network' (with usually unspecified geometrical or spacial characteristics). Following from the common usage of the terms fracture and fissure is the tacit assumption that fissures are fractures that have been modified (usually enlarged) by solution and precipitation processes.

Where attempts have been made to establish definitions (Price 1987) they are generic definitions of flow, controlled by assumed discontinuity structure, and not descriptive definitions of the geological structures themselves. For example in a discussion of fluid flow in the Chalk Price (1987) defined two terms; the "primary-fissure component (of flow)" and the "secondary-fissure component (of flow)". The primary-fissure component was "caused by a ... fracture system, usually consisting of three near-orthogonal sets of joints" and the secondary-fissure component was "primary fissures ... enlarged by solution ... along individual near-horizontal fractures or in discrete near-horizontal zones".

The purpose of this short note is to suggest simple but unequivocal working definitions for hydraulic discontinuities within the Chalk (excluding hydraulic discontinuities solely controlled by lithological contacts) consistent with the accepted usage of terms within the larger geological community. It is unreasonable to expect all authors presently working in the field to adopt all the following suggested definitions, however it is hoped that it will encourage hydrogeologists to be more rigorous in the definition of the terms that they use to describe dual-porosity media in general and the Chalk in particular. In addition it is hoped that this note will lead to a more critical assessment of common hydrogeological assumptions concerning fracturing within the Chalk.

It is assumed that all hydraulically significant planar or curviplanar discontinuities in the Chalk are initially due to brittle failure of the rock. Consequently, the suggested nomenclature is consistent with the structural geology literature. However, it is realized that modification of these planes by later mechanical and/or chemical processes is ubiquitous. The proposed nomenclature does not include descriptive terms for surface (ground level) or near surface weathering or periglacial processes, *eg*. solution pipes, since these processes generally do not give rise to discrete, essentially two-dimensional, structures.

Descriptive rather than generic terms have been favoured as information concerning the processes of fracturing and fracture modification in the Chalk are rarely available to the field hydrogeologist. The term fissure is not included in the glossary (Appendix 1) as no satisfactory, rigorous non-generic definition for the term could be found.

Appendix 1 contains the proposed Glossary of terms and Appendix 2 contains figures referred to in the text.

## GENERAL TERMS.

The term ***fracture*** should be used for any planar or curviplanar parting where the relative displacement of the two surface is unknown or is of no interest or consequence. This term should be used, and <u>not</u> fissure, since the former is consistent with general current geological usage (Whitten & Brookes 1972), and more specifically with structural geology usage (Bevan & Hancock 1986). If the fracture is parallel or sub-parallel to bedding then it is called a ***bedding plane fracture***. Where there is direct evidence of processes acting to modify fracture architecture these may be specified, *eg*. "solution enlarged fracture" or "fracture with clay lining".

Indications of fracture scale are encompassed by the general terms, ***macrofracture***, ***mesofracture*** and ***microfracture***. Macrofractures are taken to be partings of the order of >10m in length (*eg*. faults), mesofractures are partings of the order of <10m but >1cm in length (*eg*. joints) and microfractures are partings of <1cm in length.

The following general collective terms may be used. A group of parallel or sub-parallel fractures of a similar order of size are referred to as a ***fracture set*** and all fractures in a rock mass, regardless of orientation or size are referred to as a ***fracture system***.

Where information concerning the relative displacement of the parting surfaces is available descriptive terms may be used.

DESCRIPTIVE TERMINOLOGY.

If the relative displacement of originally adjacent points across a planar discontinuity or parting is negligible compared to the fracture length then the fracture is called a ***joint***, where the relative displacement is not negligible the fracture is called a ***fault*** (Pollard & Aydin 1988). Following from these definitions is the observation that in nature the majority of joints are opening mode (mode I) fractures and that the majority of faults are shear mode (mode II or mode III) or mixed mode fractures (Appendix 2, Figure 1).

Joints or faults parallel or sub-parallel to bedding may be referred to as ***bedding plane joints*** or ***bedding plane faults*** respectively.

The macro-, meso- and mico- prefixes are not usually applied to joints or faults (joint or fault size is usually specified directly - see below), however the term ***master joint*** may be used to identify a joint that is significantly larger than joints of a similar orientation in a given body of rock (Hobbs *et al.* 1976).

If the displacement across a fault causes local horizontal extension the fault is a ***normal fault*** and if it causes a local horizontal contraction it is either a ***reverse fault*** (for fault dips that make a large angle with the horizontal) or a ***thrust fault*** (for fault dips which make a low angle with the horizontal). The term ***wrench fault*** is used to describe faults where the displacement across the fault is predominantly parallel to the horizontal. All four types of fault are illustrated in Appendix 2, Figure 2.

Although material scientists and field geologists associate specific stress regimes with each of the modes of fracture (*ie.* with joint formation and with each class of fault) no such inferences should be made when using the terms joint or fault as defined above as they are purely descriptive terms.

Various parameters can be identified associated with fractures (joints or faults), the following are those most commonly used. ***Fracture orientation*** is the attitude of the discontinuity in space. Fracture orientation is usually defined by the dip direction (azimuth) and dip (line of steepest declination of the discontinuity). An example of dip direction and dip is as follows (015°/35°). ***Fracture aperture*** is the perpendicular distance between the two fracture surfaces. ***Fracture size*** is fracture trace length on a two-dimensional section such as a quarry face or thin section (it is <u>not</u> necessarily the true maximum fracture dimension). ***Fracture spacing*** is the perpendicular distance between adjacent discontinuities and normally refers to the mean or modal spacing of a number of observations (the type of average used should be specified, *eg.* the arithmetic mean spacing). Where joints or faults have specifically been identified these terms may be modified, *eg.* joint orientation or fault spacing.

The following collective terms for joints and faults are suggested. A group of parallel or sub-parallel joints is referred to as a ***joint set*** and all joint sets within a rock mass may be collectively referred to as a ***joint system***. Similarly, a group of parallel or sub-parallel faults may be referred to as a ***fault zone*** and all faults within a given rock mass called a ***fault system***. Where appropriate these terms may be modified to include fracture parameter terms, *eg*. joint set orientation or fault zone size.

Angular relationships between joint sets can be described as follows. Where two or three joint sets are mutually perpendicular they are referred to as ***orthogonal joint sets*** and where two joint sets intersect at a consistently oblique angle they are referred to as ***conjugate joint sets***.

Joints may be ***dilational joints*** or ***non-dilational joints***. Dilational joints are joints where there is direct evidence of a significant increase in rock mass volume during or subsequent to jointing and non-dilational joints are where there is no evidence of an increase in rock mass volume.

Where there is direct evidence of processes acting to modify fracture architecture then these may be specified, *eg*. "solution enlarged joint", "solution enlarged fault" or "clay lined fault".

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Appendix 1 - GLOSSARY OF TERMS.

**Bedding plane fault** - A fault that is parallel or sub-parallel to bedding.

**Bedding plane fracture** - A fracture that is parallel or sub-parallel to bedding.

**Bedding plane joint** - A joint that is parallel or sub-parallel to bedding.

**Conjugate joint sets** - Two joint sets that have a consistent oblique angular relationship.

**Dilational joint** - A joint across which there has been significant opening perpendicular to the joint surfaces.

**Fault** - A fracture where displacement of originally adjacent points across the discontinuity is not negligible compared to the fracture length.

**Fault system** - Term used to denote all faults within a given rock mass.

**Fault zone** - Collective term for a group of parallel or sub-parallel faults.

**Fracture** - Any planar or curviplanar parting where the relative displacement of the two surfaces is unknown or is of no interest or consequence.

**Fracture set** - Collective term for a group of parallel or sub-parallel fractures of the same scale.

**Fracture system** - Term used to denote all fractures within a given rock mass regardless of orientation or scale.

**Joint** - A fracture where displacement of originally adjacent points across the discontinuity is negligible compared to the fracture length.

**Joint set** - Collective term for a group of parallel or sub-parallel joints.

**Joint system** - Term used to denote all faults within a given rock mass.

**Macrofracture** - A relatively large fracture (nominally a fracture > 10m in length).

**Master joint** - A joint substantially larger than associated joints of the same orientation.

**Mesofracture** - A fracture intermediate in size between a macrofracture and a microfracture.

**Microfracture** - A relatively small fracture (nominally a fracture < 1cm in length).

**Non-dilational joint** - A joint across which there has been no significant opening perpendicular to the joint surfaces.

**Normal fault** - A fault that accommodates local horizontal extension (Figure 1).

**Orthogonal joint sets** - Two or three joint sets that are mutually perpendicular.

**Reverse fault** - A high angle fault that accommodates local horizontal contraction (Figure 1).

**Thrust fault** - A low angle fault that accommodates local horizontal contraction (Figure 1).

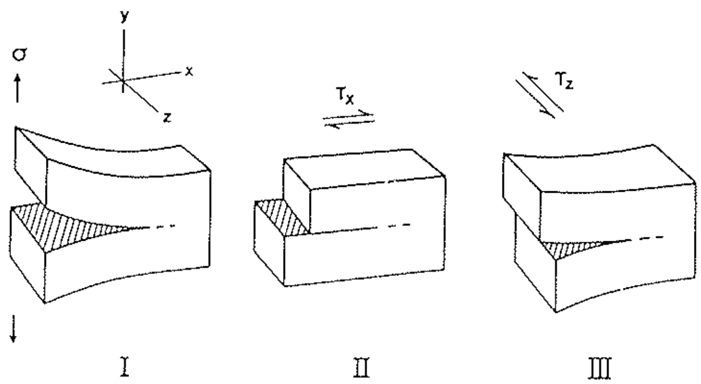
**Wrench fault** - A fault that accommodates predominantly horizontal displacement (Figure 1).

Appendix 2 - FIGURES.

Figure 1. Three basic modes of displacement at crack tips. Mode I, displacement normal to crack plane. Mode II. displacement parallel to crack plane and normal to crack edge. Mode III, displacement parallel to crack plane and to crack edge (from Paterson 1978).

Figure 2. Illustration of fault geometries. **a** normal faults, **b** reverse faults, **c** thrust fault (full arrows indicate younging direction of rocks, half arrows relative direction of movement on fault) and **d** wrench faults (from Whitten & Brooks, 1972).

Appendix 2 - FIGURES.

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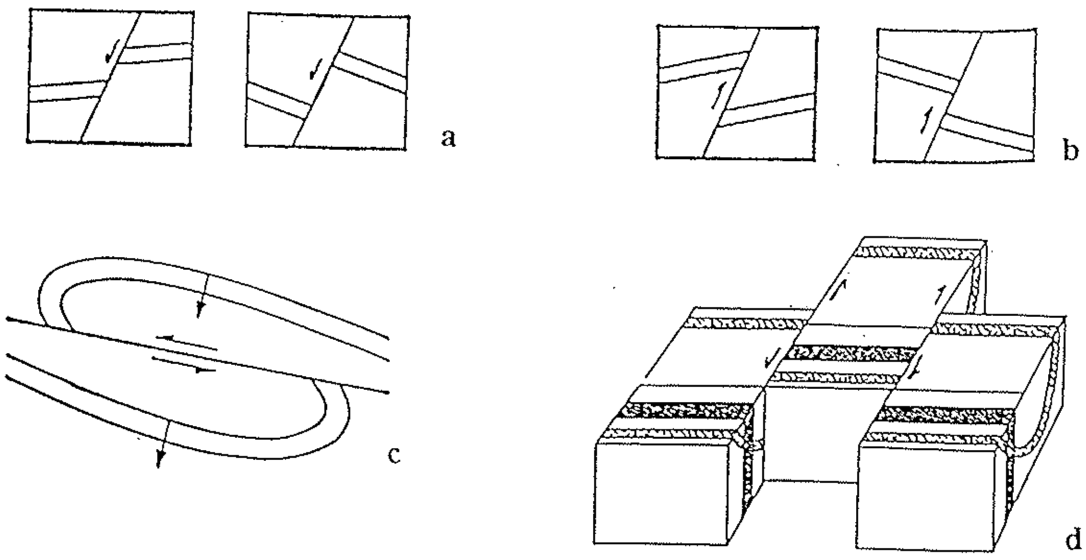


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