Development of slaty cleavage in a mudstone unit from the Cantabrian Mountains, northern Spain. R. J. Norris, Department of Geology, University of Otago, P.O. Box 56, Dunedin, New Zealand.

A 200 m thick mudstone unit in the Carboniferous of the Cantabrian Mountains, northern Spain, exhibits a progressive development of slaty cleavage. The increase in intensity of cleavage from top to bottom of the unit appears to be correlated with a decrease in mean grain size and an increase in proportion of matrix, leading to higher strains in the lower part. Large detrital muscovite and quartz grains have an original preferred orientation parallel to bedding.

Cleavage development occurs by the formation of spaced crenulations or strain bands, along which the detrital micas are rotated towards the cleavage. The cleavage is enhanced by pressure solution along the limbs of the crenulations, giving rise to anastomosing cleavage films within which the quartz grains become elongated. The development of the cleavage is further enhanced by growth of strongly oriented new micas within the cleavage films, which thereby increase in width. The new micas are mainly a paragonite–muscovite intergrowth and are quite distinct in composition from the large detrital micas. Pyrophyllite is also interpreted as a secondary metamorphic mineral. No clay minerals have been detected. It is suggested that metamorphism, under greenschist-facies conditions, of detrital kaolinite and illite/montmorillonite in the matrix gave rise to pyrophyllite and paragonite/muscovite, respectively. Rotation, recrystallization and enhanced growth during deformation led to the development of the mica fabric.

Bedding-parallel foliations: their nature and significance. G. Oertel, Department of Earth and Space Sciences, University of California, Los Angeles, California, 90024, U.S.A.

Like other foliations, those that are parallel to bedding are caused by the preferred orientation of grain shapes. To produce a significant effect, a large number of the rock-forming grains must have shapes far from equant. The most common grains with this property are phyllosilicates: the clays, micas and chlorites. Although bedding-parallel foliations can coincidentally be produced by tectonic deformation, their usual cause is the Earth's gravitational field, causing either a sedimentary fabric or compaction.

Detrital mica flakes with diameters of the order of a millimetre or larger tend to settle horizontally on the floor of the sea or another body of water if there are no strong currents. With bedding also horizontal, this produces a sedimentary foliation that parallels bedding. Large detrital mica grains are not rare, but they are much less common than clay-size phyllosilicate grains.

Mudstones and claystones that are tectonically undeformed also usually possess a bedding-parallel foliation. This fabric arises when the pore-water of a mud or clay is squeezed out of the sediment under the stress exerted on the grain framework by the weight of overlying, younger deposits. Fine clay or mica particles in uncompacted muds are almost always originally oriented at random. This is due either to flocculation of sedimentary particles suspended in the water column or to the passage of such particles through the digestive tracts of any of a number of planktonic or benthonic animals who mould them into faecal pellets.

The original distribution of phyllosilicate grains in the sediment is modified by the strain of compaction. The theory of homogeneous transformation explains the preferred orientation and provides a tool for the quantitative estimate of the strain, if the original orientation distribution is known or can be assumed. This is significant for the understanding of diagenetic processes and also forms the basis for factoring the compound deformation due to a tectonic strain superposed on an early compaction and causing the phenomenon of slaty cleavage.

Experimental deformation of quartz in a controlled metamorphic environment. A. Ord and B. E. Hobbs, Department of Earth Sciences, Monash University, Clayton, Victoria, Australia, 3168.

The aim of this paper is to demonstrate the dependence of the flow strength of quartz upon its chemical environment during deformation.

New experiments have been designed to test the recent development in theories which relate the flow strength of minerals to their defect chemistry. The experiments are based on traditional buffer techniques, and result in the thermodynamic activities of various chemical species being controlled during experimental deformation. This control was lacking in the early hydrolytic-weakening experiments where the source of water was dehydrating talc, and other chemical species, in particular carbon, were present, all in uncontrolled proportions.

The most recent experiments have been conducted on quartz specimens encapsulated in silver. The oxygen fugacity in this enclosed environment was controlled by the presence of chemical buffers plus water. These are, in order of decreasing oxygen fugacity (fO_2), Mn_3O_4–Mn_2O_3, Cu–Cu_2O, Ni–NiO, Mo–MoO_2 and Ta–Ta_2O_5. The middle three provide geologically relevant values for fO_2. The strength of natural single crystals of Victorian quartz deformed normal to $\{10\bar{1}0\}$, under these chemical conditions, at 1500 MPa confining pressure, 800°C, and 10^{-5} s^{-1}, after a heat treatment of 20 hours at this T and P, decreases from about 1500 MPa to 200 MPa with increasing fO_2.

Recrystallization is well developed in the specimens with low strength whereas deformation lamellae are common in the high-strength specimens. The water content of both deformed and undeformed crystals has been measured by infra-red spectroscopy.

This increased control and knowledge of chemical environment during deformation is vital to understanding the strength of rocks in geologically different terrains.

Multiple deformation of the Rischbieth megabreccial thrust complex, Willouran Ranges, South Australia. A. J. Parker, South Australian Department of Mines and Energy, P.O. Box 151, Eastwood, South Australia, 5063.

In the central Flinders Ranges and Willouran Ranges disrupted Adelaidean sediments occur in a number of tectonic structures variously described as thrust complexes, diapirs, syn-sedimentary slump breccias, and tectonic décollements. One such structure occurs at Rischbieth Well in the Willouran Ranges. Within the Rischbieth structure, intense folding and brecciation of the early Adelaidean Callanna Group has deformed it into a barely recognizable sequence of quartzites, sandy dolomites, slates and, locally, albitic monzonite–syenite–diorite plugs. The marked contrast in structural complexity between the Callanna Group and the overlying Burra Group suggests either mega-slumping within the Callanna Group, early folding preceding deposition of the Burra Group, or disharmonic folding in the cores of anticlinoria. Also, apparent thinning of Burra sediments along the margins of the Rischbieth structure can be largely attributed to stratigraphic thinning, suggesting that the Rischbieth structure was an emergent horst uplifted and deeply eroded prior to or during Burra Group deposition. Folds in the Burra Group can be traced into the core of the Rischbieth structure and overprint early formed, very tight to isoclinal folds associated with thrusts. Therefore, it is suggested that a period of folding and thrusting occurred prior to or early during deposition of the Burra Group. The early formed isoclinal folds and thrusts are analogous to steep thrust structures in the Willyama Block and suggest a W-directed thrusting leading to shallow onlap of Burra sediments from the east but deeper, more active sedimentation in front of the thrusts to the west.

Structural analysis of the Upper Ordovician turbidites near Bermagui, New South Wales. C. McA. Powell, School of Earth Sciences, Macquarie University, North Ryde, New South Wales, Australia, 2113.

Three phases of mesoscopic folding can be demonstrated by refolding relationships and overprinting of cleavages in deformed Upper Ordovician psammites and pelites near Bermagui on the south coast of New South Wales. F_1 folds are tight to isoclinal, and commonly have a differentiated axial-surface crenulation cleavage. Where not affected by F_2, F_1 is upright, or inclined steeply, facing westward. F_1 axes are generally subhorizontal and occur in domains in which orientation is constant for kilometres along axial trend. These domains, which are separated by narrow zones where the axial orientation changes, define a regionally meridional F_1 trend, even though individual F_1 domains vary in axial trend from 090 to 340°. F_1 deforms a penetrative bedding-parallel foliation defined by aligned phyllosilicates and elongate quartz grains with syntaxial overgrowths.

F_1 are open to locally tight, upright folds with a domainal axial-