Mega-kink folds and related structures in the Upper Devonian Merrimbula Group, south coast of New South Wales. M. J. Rickard, Department of Geology, Australian National University, P.O. Box 4, Canberra, A.C.T., Australia, 2601.

Interbedded sandstones and red mudstones of the Upper Devonian Merrimbula Group were mildly deformed during the Carboniferous in a 'transitional' tectonic regime. A remarkable variety of structures was developed. Tectonic shortening of about 10% was accommodated by the development of kink-like monoclines and box folds with a very wide-spaced (few cm) cleavage in sandstones, spaced (few mm) 'reticulate' cleavage in siltstones, and a penetrative slaty cleavage in mudstones. Solution transfer played an important role in cleavage formation. Faults and conjugate shear zones succeeded by regional joints were developed in competent beds. Abundant quartz veins occur along bedding planes, faults and shear zones. The low strain allows certain kinematic and dynamic conclusions; the structures are geometrically congruent and were developed under high fluid pressures at a high level in the crust and are related to a single, long deformational episode under essentially horizontal E–W compression possibly accompanied by shearing along bedding planes associated with local décollement. The stress configuration contrasts with that necessary for the extensional rifting postulated for the period immediately prior to the deposition of the Merrimbula Group.

The structure of the coastal Ordovician rocks south of Bermagui, New South Wales, Australia. M. J. Rickard, Department of Geology, Australian National University, P.O. Box 4, Canberra, A.C.T., Australia, 2601.

Meridional upright F_1 folds with wavelengths of a few tens of metres are uniformly developed throughout the coastal strip. There are no consistent vergence zones related to a major structure so that the gross enveloping surface is approximately horizontal. The folds have well developed 'slaty' cleavage or 'stripy' spaced cleavage, and in places both fan about the hinge planes. The 'slaty' cleavage is the earlier surface but no evidence for associated early folds can be found and, although the spaced cleavage fans asymmetrically on one limb, there is no evidence that it transects the folds. It is argued that both slaty and spaced cleavage form successively during the same phase of folding.

F_2 folds with crenulation cleavage locally distort the F_1 folds, and the steep F_3 crenulations, minor folds and kinks are developed in wide-spaced SE-trending zones. The latter are parallel to folds in the Bunga Beds, which lie unconformably above the Ordovician turbidites, and therefore F_3 may be younger than Late Devonian.

Mechanisms of crystal growth in relation to deformation in the aureole of the Tinaroo Batholith, North Queensland. M. J. Rubenach, Department of Geology, James Cook University, Townsville, Queensland, Australia, 4811.

Following a mylonitic event (D_m) the earlier-phase muscovite–biotite adamellite of the Tinaroo Batholith was emplaced synchronously with a regional deformation event which produced F_2 folds and tight crenulations. The syn-D_2 metamorphism produced a biotite zone, an andalusite–staurolite zone, and a narrow inner sillimanite–K-feldspar–muscovite zone.

Where they have not suffered hornfelsic overprinting or retrogression during subsequent biotite adamellite emplacement, well-preserved microstructures in the andalusite–staurolite zone provide timing criteria for the reaction and growth sequence and elucidate porphyroblast-growth mechanisms. Large skeletal porphyroblasts of andalusite grew from the dissolution of staurolite, the reaction involving matrix micas and quartz and exchange of ions (including Al) between sites of dissolution and growth. Quartz dissolved from domal-shaped solution seams, now marked by graphite accumulations, in front of advancing andalusite faces, and replaced strained muscovite to form a muscovite-depleted halo 2–7 mm wide around andalusite porphyroblasts. The dissolved muscovites supplied Al for the growing andalusite grains, and components both for the growth of unstrained muscovite and biotite in the matrix and replacement of staurolite by these minerals. The preferential growth of skeletal andalusite arms along graphite/muscovite-rich layers is interpreted as being due to the ease of dissolution of strained muscovite grains and/or more rapid diffusion in such layers relative to adjacent polygonal quartz–muscovite layers.

Although the growing porphyroblasts form the domal patterns adjacent to crystal faces because of a growth/strain effect, they do not in any way deflect the pre-existing mylonitic foliation. The axial planes of the D_2 crenulations deflect around the porphyroblasts, demonstrating that they grew syn-D_2. These observations also confirm the hypothesis that deflection of foliations is due to flattening of the matrix around relatively rigid porphyroblasts rather than the latter shouldering the foliation aside by 'force of crystallization'.

Strain history and the development of transecting cleavage, with examples from the Caledonides of the British Isles. D. J. Sanderson, T. B. Anderson and D. Cameron, Department of Geology, Queen's University, Belfast, U.K.

Many models for the development of transecting (or non-axial planar) cleavage consider the two-dimensional finite strain within a plane through a three-dimensional strain ellipsoid. By assuming that cleavage approximates to the XY-plane and that fold axes develop normal to the minimum stretch within layering, it can be easily demonstrated that fold axes need not be parallel to cleavage. Such models do not consider the strain history. Even in an irrotational three-dimensional strain (i.e. principal axes do not rotate through the material) the two-dimensional strain history of the layer may be rotational. Clearly in a rotational three-dimensional strain a wide variety of strain histories is possible.

Various simple strain models are used to illustrate the potential development and geometry of transecting cleavage. Transection is shown to be fairly common in models involving wrench-type strain, due mainly to the large component of rotation within an initially sub-horizontal layer. The geometry of transection can be related to the strain history in many cases.

The inverse problem of using transection to deduce strain history is considered in the Lower Palaeozoic rocks of Ireland and South Scotland. Regions of transected folds show a consistent pattern of steep cleavage trending clockwise of steep fold axial planes, with an associated sub-horizontal stretching lineation. In regions of non-transecting folds the stretching direction pitches steeply in cleavage. These features, combined with evidence from other minor structures and the regional setting of the deformation, are used to argue for a strong component of left-lateral strike-slip movement during the Caledonian orogeny.

Microfabric development in Proterozoic schists, North Mt. Painter Block, South Australia. G. P. Scales and P. R. James, Department of Geology and Mineralogy, The University of Adelaide, Adelaide, South Australia, Australia, 5000.

In the Lower to Middle Proterozoic schists and gneisses from the North Mt. Painter Block, a mylonite-forming event has been superimposed on a multiply-folded layer-parallel foliation, S_1, which formed during amphibolite-facies metamorphism.

The development of the mylonitic foliation and associated elongation or stretching lineation, and consequent modification of S_1 can be observed in a number of different lithologies ranging from competent garnet–quartz rocks through 'granitic' augen and layered gneisses to biotite–chlorite–quartz schists and amphibolites.

The well-documented processes leading to grain refinement with increasing strain rate followed by the progressive development of the mylonitic foliation, S_m, and lineation, L_m, can be compared in these lithologies using the nature and intensity of the quartz petrofabrics and the formation and dimensions of subgrains and new grains.

By measurement of the location, area and aspect ratios of subgrains and new grains of quartz through zones showing different grain size and morphology, it is apparent that there is a common subgrain size in all specimens indicating that subgrain formation may be independent of strain rate, temperature and presence of impurities. However, new grains do show a direct relationship between their dimensions and the mineralogy and strain rate. Thus, the processes leading to subgrain formation must be of a different nature from those of new grain formation, at least until the subgrain reaches a critical size.

Subsequent to the development of the mylonitic fabric, S_m, a weaker foliation developed at 15–20° to S_m, followed by the development of crenulations with axes at low angles to L_m. Finally, a pervasive set of kink bands occurs on small scales with axes at approximately 90° to S_m. This sequence of events appears to be consistent over the whole mapped area.

Development of fabrics in multiply-deformed rocks, Eastern Harts Range, Northern Territory. G. P. Scales, A. R. Martin and P. R. James, Department of Geology and Mineralogy, The University of Adelaide, Adelaide, South Australia, Australia, 5000.

Mid- to Lower Proterozoic Arunta Complex schists and gneisses of the Irindina Supracrustals—the Irindina gneiss, Harts Range metaigneous complex and Brady gneiss, are underlain by the crystalline basement of the Entia gneiss complex. In this area, at the basement-cover boundary, which has behaved at various times as a décollement surface, the Bruna gneiss lies as a semi-concordant sheet.

The regional foliations BS_1 and CS_1 in the basement and cover, were both formed by high-grade tectonothermal events and have not been substantially overprinted by any subsequent regional tectonite fabrics. There is some evidence that metamorphism continued for a considerable time after the peak of tectonic activity in each event, thus allowing continued recrystallization to more granoblastic microstructures. BD_1 and CD_1 fabrics are very coarse-grained polygonal assemblages which have been recrystallized in most rocks to finer-grained, but still granoblastic polygonal BD_4 and CD_4 microstructures of similar mineralogy. Early mylonites, clearly recognizable in hand specimen, also have often been recrystallized to coarse-grained aggregates. The most strongly preserved tectonite fabrics occur in the late mylonites which are very fine-grained assemblages of elongate quartz ribbons and layer silicates anastomosing around a few relict megacrysts of plagioclase, garnet and hornblende. The existence of these mylonite zones suggests structural boundaries (thrusts) occur between each major unit, and in some cases within units.

Strain studies on the mylonites and associated rocks using deformed feldspar megacrysts show strong flattening strains were produced in most mylonite zones. Late movements along some of these zones have resulted in a stronger plane-strain component forming triaxial ellipsoids suggestive of simple-shear processes. This is supported by magnetic fabric results, while shortening values obtained from deformed megacrysts, magnetic fabrics and class 1C buckle-fold profiles show consistent correlation between methods, with shortening values ranging from 40 to 70%.

Foliation development in the Redbank Deformed Zone, central Australia. R. D. Shaw, Bureau of Mineral Resources, P.O. Box 378, Canberra, A.C.T., Australia, 2601.

The Redbank Zone is an E–W complex zone of deformation within the Arunta Complex, central Australia. It separates upthrust granulites to the north from amphibolite-facies rocks in the south. The granulites are divisible into (1) a southern zone comprising a metamorphosed granitoid suite showing extensive retrograde metamorphism under amphibolite-facies conditions and (2) a northern terrain made up of felsic, intermediate and mafic granulites. The amphibolite-facies terrain south of the Redbank Zone consists mainly of granite, gneissic granite and migmatite. Numerous, narrow, intensely foliated zones form a braided and anastomosing network within the Redbank Deformed Zone. These high-strain zones have a wide variation in structural style reflecting a range of rock types and physical conditions of formation. Within these zones two broad categories of highly strained rock are recognized. (1) Gneisses dominated by amphibolite-facies assemblages and having an intense foliation and lineation occur throughout the retrogressed granulite terrains. These gneissic zones are folded and cut by pegmatites, and are commonly migmatitic. (2) Zones of greenschist-facies schist and phyllonite grading into mylonite and ultramylonite cut granulites, gneisses and the southern migmatite terrain. The boundary between the southern granulite terrain and the amphibolite-facies terrain is generally marked by such a zone. Consideration of the differing metamorphic and structural styles of the two categories of high-strain zone, and the available geochronological framework, suggests that the Redbank Zone has a long and complex history of reactivation. The zone may have been established as early as about 1700 Ma, and the greenschist-facies zones represent the root zone of the nappe structures of the Alice Springs Orogeny (400–300 Ma).

The Palmerville Fault Zone: a major imbricate thrust system in the northern Tasmanides, northeast Queensland. R. D. Shaw, Bureau of Mineral Resources, P.O. Box 378, Canberra, A.C.T., Australia, 2601, and J. Fawckner, formerly of the Department of Geology, James Cook University, Townsville, Queensland, Australia, 4811.

At the Precambrian–Palaeozoic contact in northern Queensland adjacent flysch sequences are (1) separated by major reverse strike faults, (2) differ markedly in sedimentary characteristics and (3) have anomalous stratigraphic relations suggesting that they were originally deposited far apart. The sequences young progressively to the west towards the basement. These relationships suggest a tectonic model in which the Palmerville Fault is the principal fault in a complex imbricate thrust system that has resulted in the basement rocks overriding sediments of the Hodgkinson Province. The Palmerville Fault.has been steepened by later movements on the underlying faults and by regional folding and shortening. The fault is localized along a pre-existing (?)Precambrian mylonite zone. A minimum age of Late Carboniferous (300 Ma) has been obtained for the main fault movement by K–Ar dating of granitoids intruding the fault.

Progressive folding in the Davenport Province, Northern Territory. A. J. Stewart, Division of Petrology and Geochemistry, Bureau of Mineral Resources, P.O. Box 378, Canberra, A.C.T., Australia, 2601.

The Davenport Province comprises a 10 km thick sequence of sandstone and volcanic rocks resting unconformably on low-grade metasediments. The volcanic rocks are mainly basalt and rhyolite, and are most abundant in the lower part of the sequence. Tight folding produced domes and upright anticlines and synclines with sinuous but overall NW trend. Plunges range from gentle to steep. Doubly plunging anticlines and domes are localized over thick sequences of volcanics. Exceptions to the NW trend are concentrated in two fault-bounded domains, one in the northeast of the province, the other in the southeast. The doubly plunging folds produce a pattern which resembles an imperfect 'egg-carton' interference pattern, that is, interlocking domes and basins. The synclines, however, show no narrowing where they cross the anticlines, and the domes and synclines show no systematic net-like pattern. Deformation was, instead, a progressive inhomogeneous process controlled by the relative rigidity of the thick discrete piles of volcanics. As deformation began, the poorly to non-bedded volcanics shortened by cleaving, forming domes. As strain increased, the domes tightened and the enveloping sedimentary rocks were squashed into the space between, forming the sinuous anticlines and synclines. NE-striking folds in the northeast of the province formed in response to westerly movement of a large thrust sheet. Where the sheet collided with a major NW-trending fold, second-phase folds and cleavage formed. The other area of NE-striking folds in the southeast of the province is as yet unexplained.

Cleavage and syntectonic vein development in the very low-grade dolomitic Urquhart shale, Mount Isa. C. P. Swager, Department of Geology, James Cook University, Townsville, Queensland, Australia, 4811.

Three phases of deformation were recognized in dolomitic metasediments of the Urquhart Shale at Mt. Isa Mine, Queensland. Mesoscopic fold zones developed only during D_3. The type of S_3 cleavage depends largely on the nature of the pre-existing, bedding-parallel S_2 foliation. In highly micaceous black shales, S_3 crenulation of continuous S_2 occurred. In intermediate dolomitic shales, S_3 slaty cleavage overprinted S_2 slaty cleavage without microfolding, whereas in mica-poor siltstones the main D_3 fabric element is formed by D_3 extension veins. Renewed dissolution ± shear along S_2 during D_3 increased in intensity in areas with more continuous S_2 cleavage. Two D_3 vein groups can be distinguished: fibrous extension veins and 'breccia veins'. Some evidence, including shape, environment, composition, texture and relation with wallrock, suggests that these two groups represent separate 'flow systems', with larger scales of transfer (>100 m?) in the breccia veins.