The style of deformation depends both on mineralogy and pre-shear fabric and on the apparent extent of shearing. In particular: phyllite and schist responded to the shear stress with asymmetric kink folds; gneiss, with proto- to ultramylonite development and fabric rotation; quartz-poor igneous rocks, cataclastically; and quartz-rich granite has a widespread flattening fabric locally overprinted by shear zones of proto- to ultramylonite, producing a *C–S* fabric, and in locations of intense shearing the ultramylonite was refolded as a layered rock.

Quartz, where present, absorbed most of the bulk strain by development of ribbon texture in the quartz-rich granites and gneiss, with feldspar deforming brittly. In the massive quartz-poor rocks there developed narrow zones of intense cataclasis in which all minerals underwent similar comminution followed by alteration; outside of these zones the feldspars experienced extensive intragranular deformation, primarily microcracking and subgrain development.

Why unconformity-related U deposits are unconformity-related. J. D. Johnston, V. J. Wall, Department of Earth Sciences, Monash University, Clayton, Victoria, Australia, 3168, and M. A. Etheridge, Bureau of Mineral Resources, P.O. Box 378, Canberra, A.C.T., Australia, 2601.

Although unconformity-related U deposits constitute a significant portion of the world's economic uranium mineralization, the role of the unconformity, until now, has been little understood. High-grade uranium mineralization in the East Alligator River uranium field is localized in reverse faults and associated zones of kinking, chevron folding and brecciation in schistose basement. The reverse faults have non-planar geometries controlled by the mechanical anisotropy of the basement schists and their contrast with the unconformably overlying, gently dipping cover of massive quartz sandstones. Preferentially following schistose basement units, the faults transform along the unconformity forming flats, and ramp steeply through the overlying massive sandstone, forming discrete narrow zones within it.

Breccia zones, initiated by hydraulic fracturing, are best developed where faults are slightly oblique to the basement foliation and in kink hinges. Chloritic alteration is most strongly developed in such zones of brittle–ductile deformation. The vast mass-transfer required to effect this alteration illustrates the vast volumes of fluid focused through these zones and hence their structurally enhanced permeability. We present geometrical and mechanical models which explain these features.

The essential role of the unconformity results from the cover/basement rheology and permeability contrasts: (a) the former controls the geometry of fault zones and related dilatant regions which enhance permeability and provide space for mineral deposition and (b) fault-focused fluid migration patterns, developed on local and regional scales, reflect the diagenetically reduced permeability of the sandstone relative to that of the hydrofractured basement.

Concentric, ellipsoidal, compositional, shell (C.E.C.S.) development around nodules associated with solution transfer during crenulation-cleavage development. P. A. Jones, Department of Geology, James Cook University P.O., Queensland, Australia, 4811.

Two outcrops of the Robertson River formation, both within 10 m of mafic intrusions contain unusual nodules. These consist of a central pre-D_1 core surrounded by several syn-D_2 concentric, ellipsoidal, compositional shells (C.E.C.S.) of varying phyllosilicate content with an albite groundmass. During the D_2 crenulation-cleavage formation event, incremental effects of the deformation were preserved as shells of modified host rock by progressive albitization outwards from the rigid core.

In the *ZY* plane of the local strain ellipsoid, coaxial and noncoaxial C.E.C.S. were developed in hinge and limb regions of folds, respectively. The geometrical relationships of noncoaxial shells to other structures indicate that no rigid-body rotation occurred during their development and that the D_2 event involved progressive, bulk, inhomogeneous shortening. The shape and orientation of each successive C.E.C.S. was controlled by the perturbation in the strain field generated by the rigid nodule. With the development of each additional shell the orientation of the whole nodule became more coincident with the local strain ellipsoid.

The D_2 event appears to have been locally episodic and the strain rate and rate of solution transfer varied with the waxing and waning of each pulse, producing three distinct types of C.E.C.S. around a central core.

Slaty cleavage generation during deformation of synthetic mica-quartz rocks in a high pore-fluid pressure environment. P. G. Lennox, Department of Earth Sciences, Monash University, Clayton, Victoria, Australia, 3168.

Specimens consisting of synthetic mica and quartz have been shortened up to 60% in a Heard gas apparatus in the presence of high pore-fluid pressures at temperatures up to 550°C, fluid and confining pressures up to 300 MPa, and at strain rates of 10^{-4} to 10^{-5} sec^{-1}. These experiments provide constraints on the deformation mechanisms operative during the generation and modification of deformation microfabrics in low-grade metamorphic rocks.

Deformation mechanisms which are important in these experiments include oriented growth and grain-rotation mechanisms in micas plus solution transfer and quartz-grain translation processes. Synthetic phlogopite–quartz mixtures yield numerous deformation microfabrics similar to those observed in rocks from low-grade metamorphic terrains. Microstructures developed experimentally during the operation of these processes include well-developed slaty cleavage, kink bands in oriented micas, scalloped quartz grains, strain shadows, mica fringe structures and conjugate shear zones (generated at >50% shortening). Vug-filling fibrous micas form when the pore-fluid pressure exceeds the confining pressure.

Experiments are proceeding in a re-designed assembly which assists the permeation of water at high fluid pressures through specimens during their deformation. The aim of these new experiments is to generate deformation microfabrics similar to those observed in low-grade metamorphic terrains in which there was a high water–rock ratio during deformation.

The relation between quartz-vein geometry and folding in a low-grade flysch sequence, Cape Liptrap, Australia. P. G. Lennox, Department of Earth Sciences, Monash University, Clayton, Victoria, 3168.

The Fold Stack area at Cape Liptrap provides an excellent exposure of a quartz-veined, simple buckle-folded sequence of low-grade metamorphosed arenites and mudstones. The quartz veins formed dominantly in hydraulic extension fractures. The quartz veins, measured from the fold-defining one-metre-thick arenite beds, form sets of consistent orientation and dimension. These quartz veins define three major quartz-vein sets; oblique, subparallel or subnormal with respect to the fold axis. They are exposed in unique, overlapping sequential patterns which change around the fold-defining arenite bed and from inner to outer arcs of this bed.

The observed sequence of quartz-vein sets from the outer hinge zone blocks is generally consistent with the theoretical pattern of quartz-vein formation derived from the finite-element model of a buckling competent bed in a thick incompetent matrix. In contrast, the limb block theoretical and observed sequence of quartz-vein sets is not consistent with this model. Derivation of the minimum principal compressive stress path in the limb blocks from the sequence of quartz-vein sets does not accord with the theoretical predictions. Both these discrepancies, for the limb block reflect in part, the effect of the mechanical anisotropy of the arenite bed on the initiation/propagation of quartz veins, the complexity of the limb-block stress history or other unknown factors.

Comparison of the observed sequence of quartz-vein sets with a simplified four-stage model of a stress-field changes during folding indicates that sets must have formed at discrete overlapping intervals within the fold-forming deformation and that some quartz-vein sets must have formed during shear failure.

Implications of the low-angle normal (evolving) crustal shear-zone model for metamorphic core complexes of Cordilleran type, and the origin of the 'accretionary wedge' of the Hellenic arc. G. S. Lister, Bureau of Mineral Resources, P.O. Box 378, Canberra, A.C.T., Australia, 2601.

The origin of the Cordilleran metamorphic core complexes is a matter of hot debate. Data in support of the evolving crustal shear-zone model are discussed. Joint work with G. A. Davis, S. J. Reynolds, and A. W. Snoke has resulted in evidence which suggests the existence of low-angle normal crustal movement zones, which evolve with increasing depth from low-angle normal 'detachment' faults, through zones of cataclasis, brecciation and/or seismic slip, into wide zones in which penetrative non-coaxial laminar flow takes place.

This model has been applied to the Southern Aegean, the Sea of Crete, and Crete. It is postulated that the Cycladic Archipelago contains metamorphic core complexes of Cordilleran type, which were drawn upward and outward from beneath the sedimentary basins now 100 km to the south, utilizing evolving crustal shear zones of the type discussed above. In the extending upper plate, extensive normal faulting took place, and subsidence was related to continental extension and the development of a sedimentary basin.

Analogous processes may have led to the rapid exhumation of the HP–LT metamorphic belt exposed in the external part of the Hellenides, in which case extensional tectonics has produced a distended paired metamorphic belt separated by an active sedimentary basin. By implication a novel hypothesis for the 'accretionary wedge' of the Hellenic arc can be made, in terms of crustal obduction, and migration of the flexure line of an unstable lithospheric slab. Gravitational spreading of the continental crust over a sinking lithospheric slab may be the mechanism driving the extensional process, although conditions imposed at the boundaries of the interacting 'microplates' must influence the situation.

Dislocation structures in naturally deformed sphalerite from Broken Hill, New South Wales. S. W. McKnight, Department of Geology, Ballarat College of Advanced Education, P.O. Box 663, Ballarat, Victoria, Australia, 3350.

The dislocation structures observed by TEM in naturally deformed polycrystalline sphalerite (17 mole % FeS), from the Broken Hill ore-body, New South Wales, show a striking similarity to those developed in deformed face-centred cubic metals of intermediate to low stacking-fault energy. Material sampled from parts of the ore-body which have undergone different deformation histories display contrasting substructures and many specimens give evidence of multiple deformation over a wide range of physical conditions.

Coarse-grained macroscopically undeformed sphalerite, typical of much of the deposit, possesses both a regular subgrain (0.4–2 mm) and considerably finer cell (3–4 μm) structure. Weak-beam and HREM have established the dissociation state of dislocations in tectonically deformed sphalerite. Cell walls are composed of high densities of *LC* dislocations and sessile faulted dipoles. The configurations are analogous to those developed in tetrahedrally coordinated elements, but this is the first report of their occurrence in a compound semiconductor. Free dislocations within cells are not common but where observed, are seen to be heavily jogged, while some jogs are constricted, others are partially extended.

Dynamically recrystallized sphalerite occurring as a sulphide mylonite within the Globe–Vauxhall Shear Zone which transects the ore-body, exhibits no cell structure, but has a very high density of widely dissociated dislocations within fine sub-grains. Stacking faults extend across sub-grains and interactions such as the formation of faulted dipoles are absent. This is ample evidence that recrystallization has taken place by sub-grain rotation.

Sphalerite deformed at high temperatures and pressures in the laboratory develops an intensely faulted and twinned structure with little evidence of dynamic recovery in original or recrystallized grains. Strain-rate and chemical environment are probably major factors in the formation of these contrasting substructures.

Macro- to microfabrics of modern convergent margins. J. Casey Moore and N. Lundberg, Earth Sciences, University of California, Santa Cruz, California, 95064, U.S.A.

Convergent plate boundaries with high sediment supply construct relatively 'ductile' prisms of accreted sediment that show distributed deformation (e.g. Barbados, E. Aleutians, S. Mexico). Fold-and-thrust-belt structural style characterizes the initial deformation of overpressured sediments in ductile forearc regions. Seismic reflection profiles reveal long décollement surfaces with intervening thrust ramps. Thickness of initial thrust packages is directly proportional to the thickness of sediment on the incoming oceanic plate. Because of their weak consolidation, continuing deformation of ductile forearcs ultimately develops a complicated, stratally disrupted structural style characteristic of onland accretionary complexes. Ductile forearcs reveal high rates of tilting or kneading of the slope–apron deposits, with an exponentially decreasing rate landward of at least one trench (S. Mexico). Available estimates suggest less than 50% of total convergence is released near the seaward deformation front of ductile forearcs. For example, only about 5% of the total convergence is taken up near the seaward edge of the northern Barbados Ridge with decreasing strain arcward. Here, deformation is partitioned into distributed deformation (small-scale faulting and fabric development) and discrete faults that separate large-scale structural units within the accretionary prism. The discrete faults constitute potential terrane boundaries where substantial strike-slip may occur.

Convergent plate boundaries with low sediment supply develop forearcs underlain by both oceanic and island-arc ophiolitic basement complexes with deformation localized near the base of the trench slope (e.g. Marianas, Tonga, Guatemala). *DSDP* penetrations of these relatively 'rigid' forearcs reveal low rate of tilting of slope–apron deposits and locally conspicuous faulting. Analysis of faults from cores in the Mariana forearc reveals conspicuous strike-slip faulting supporting transform scenarios for tectonic erosion and terrane removal.

Small-scale structures of *DSDP* cores from active margins include strata disruption, scaly and spaced foliation, kink folds, pseudo-vein structure and microfaults. Stratal disruption is associated with cataclasis of sands, perhaps with overprinting solution effects. Cataclasis occurs in sediments 200–300 m below the sea floor. Cataclastic fabrics of the *DSDP* cores are precursors to web structure or cataclastic shear networks common in accretionary complexes on land. Scaly foliation is preferentially associated with reverse faults and shows anastomosing ultramicroscopic shear surfaces. Mesoscopic to microscopic kink folds are formed by mechanical crenulation of sedimentary layers during initial layer-parallel shortening in the proto-thrust zone of the Nankai Trough. Axial surfaces of the kink folds dip at about 60° and correlate with seismically resolved thrust faults. Spaced foliation involving the development of new phyllosilicate phases occurs in Late Miocene sediments that have never been buried more than 300 m. Micro- and ultramicroscopic studies of pseudoveins show no evidence of hydrofracturing but rather suggest slow fluid expulsion following disaggregation by grain-boundary sliding and displacement in an extensional upper-slope environment.

Deformation in the contact aureole of the Wyangala Batholith, New South Wales. V. J. Morand, Department of Geology and Geophysics, University of Sydney, New South Wales, Australia, 2006.

The Siluro-Devonian Wyangala Batholith has intruded slates, phyllites, metagreywackes, quartzites and metacherts of Late Ordovician age and greenschist-facies metamorphic grade. Before granite intrusion these rocks were deformed into tight to isoclinal folds with a slaty cleavage, S_1. Adjacent to the granite they were recrystallized to varying degrees into hornfelsic rocks with cordierite + biotite and cordierite + andalusite-bearing assemblages. Contact metamorphism obliterated much of the S_1 fabric in the contact aureole producing isotropic fabrics in many rocks, with randomly oriented porphyroblasts of cordierite, muscovite and andalusite being common. A second deformation subsequent to intrusion formed a cleavage, S_2, in the country rocks and a foliation in most of the granitic rocks. The contact aureole also underwent deformation accompanied by retrogression of cordierite and much of the andalusite under greenschist-facies conditions. This has resulted in a variety of fabrics including schistose, slaty and hornfelsic textures. Whereas S_2 in pelites outside the contact zone is a crenulation cleavage, within the aureole S_2 is commonly a slaty cleavage. The role of pressure solution in producing S_2 appears to be much more important outside the contact aureole than within it. Deformed retrogressed cordierite porphyroblasts in contact metamorphosed black slates have been used to estimate strain ellipsoids for the second deformation. These ellipsoids are mostly of oblate shape with the long axis (X) parallel to the local B^2 fold axes or lineations. Boudinaged andalusite porphyroblasts in black slates are evidence of extension along the X direction.