

Fifty years of shear zones

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We are here, of course, because 1967 saw the publication of John Ramsay's famous book. Two years later a memorable field trip from Imperial College to the Outer Hebrides saw John on a bleak headland on the coast of North Uist where a relatively undeformed metadolerite within Lewisian (Precambrian) gneisses contained ductile shear zones with metamorphic fabrics in amphibolite facies. One particular outcrop was very special – a shear zone cutting otherwise completely isotropic, undeformed metadolerite, with an incremental foliation starting to develop at 45° to the deformation zone, and increasing in intensity as it approached the shear direction. Here was proof of the process of simple shear under ductile metamorphic conditions - the principles of simple shear outlined in John Ramsay's 1967 book clearly visible in nature, and verified by Ramsay's mathematical proofs in the eventual paper (Ramsay and Graham, 1970).

Later work on the Lewisian on the mainland of Scotland, in South Harris, in Africa, and elsewhere applied Ramsay's simple shear principles more liberally, more imprecisely and on larger scale than at Caisteal Odair, but in retrospect it documented what seems now to be the generality of mid and lower crustal deformation. Deep seismic reflection data show us that on passive margins hyper-stretched continental crust (whether or not cloaked by Seaward Dipping Reflectors) seems to have collapsed onto the mantle. Crustal faults mostly sole out at or above the mantle – so the Moho is a detachment- an 'outer marginal detachment', if you like, and, of course, it must be a ductile shear.

On non-volcanic margins this shear zone forms the first formed ocean floor before true sea floor spreading gets going to create real oceanic crust. Gianreto Manatschal, Marcel Lemoine and others realised that the serpentinites described in parts of the Alps are exposed remnants of this ductile shear zone. Associated ophicalcite breccias tell of sea floor exposure, while high temperature shear zones with flaser gabbro and amphibolitization must have been developed at deeper levels in the shear zone and 'dragged upwards'.

An attempt to justify these assertions will made using outcrop exsmples and some deep Seismic data
John Ramsay was always cautious about up-scaling and indulging in large scale tectonic speculations, but without his geometric acumen the big scale picture would have been even less clear.

Ramsay, J.G. and Graham, R.H., 1970. Strain variation in shear belts. Canadian Journal of Earth Sciences, 7(3), pp.786-813.