

The uses of Electron Backscatter Diffraction in Structural Geology

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In the last 25 years EBSD has become a routine method for analysing deformed rock microstructures. It can help in many different ways, not all of them widely used, so here we discuss three.

Dislocation analysis

Wheeler, J., E. Mariani, S. Piazzolo, D. J. Prior, P. Trimby, and M. R. Drury (2009), The Weighted Burgers Vector: a new quantity ..., *Journal of Microscopy*, 233(3), 482-494, and manuscript in review

Interphase misorientation analysis

McNamara, D., M. A. Pearce, J. Wheeler, and D. J. Prior (2012), Fabrics produced mimetically during static metamorphism ..., *Journal of Structural Geology*, 44, 167-178.

Dating distorted crystals

MacDonald, J. M., J. Wheeler, S. L. Harley, E. Mariani, K. M. Goodenough, Q. G. Crowley, and D. Tatham (2013), Lattice distortion in a zircon population and its effects on trace element mobility and U-Th-Pb isotope: ... *CMP* 166, 21-41.

Dislocation analysis: Weighted Burgers Vector method

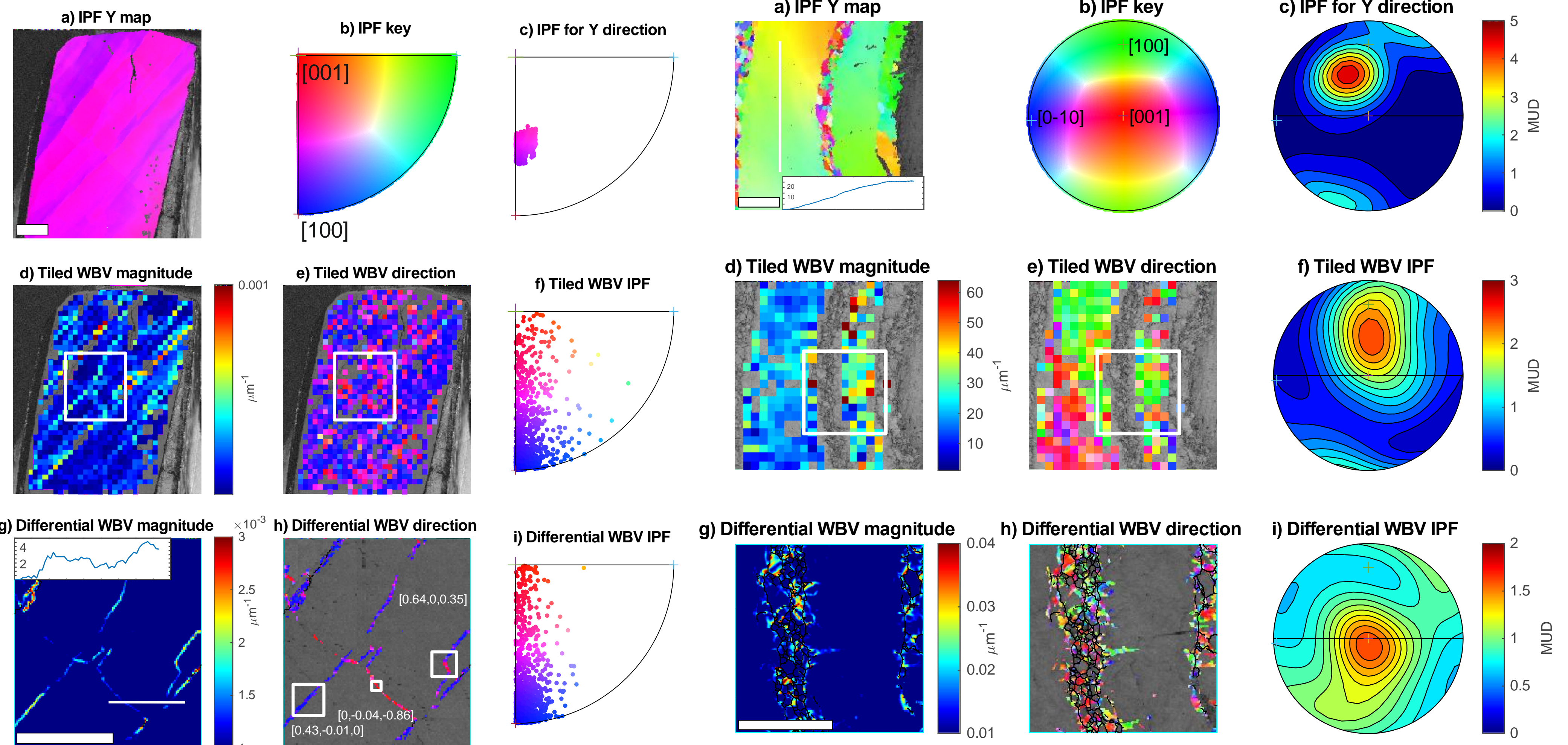
Experimentally deformed olivine
(courtesy of Jake Tielke)
Two slip systems activated, with dislocations recovered into two sets of subgrain walls – a simple example to illustrate how the method picks up the Burgers vectors of the slip systems.

Naturally deformed plagioclase from oceanic crust
(courtesy of Pat Trimby)
Smoothly distorted plagioclase ribbons run N-S. Small recrystallised plagioclase grains are dominated by [001] Burgers vectors and – surprisingly – have higher dislocation densities than the ribbons we interpret to be their parents.

“Weighted Burgers Vector” =
Sum over all dislocation types of
(dislocation density) × (Burgers vector) × sin(angle of dislocation line to map)

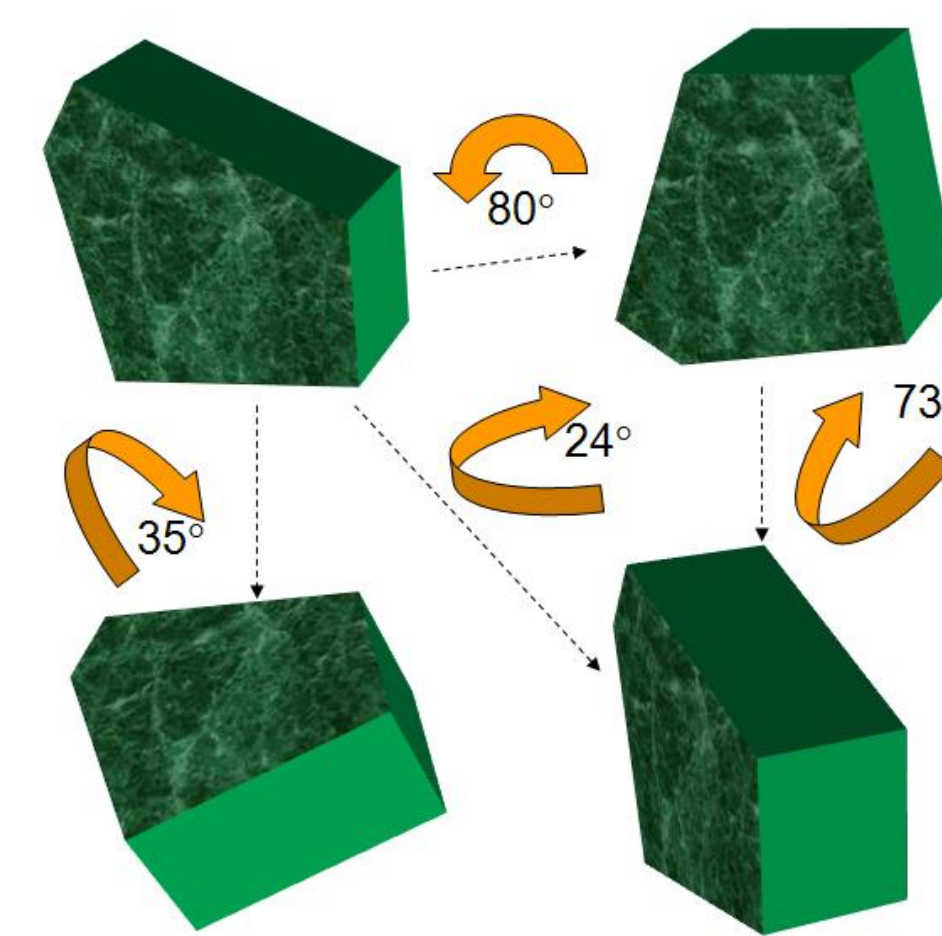
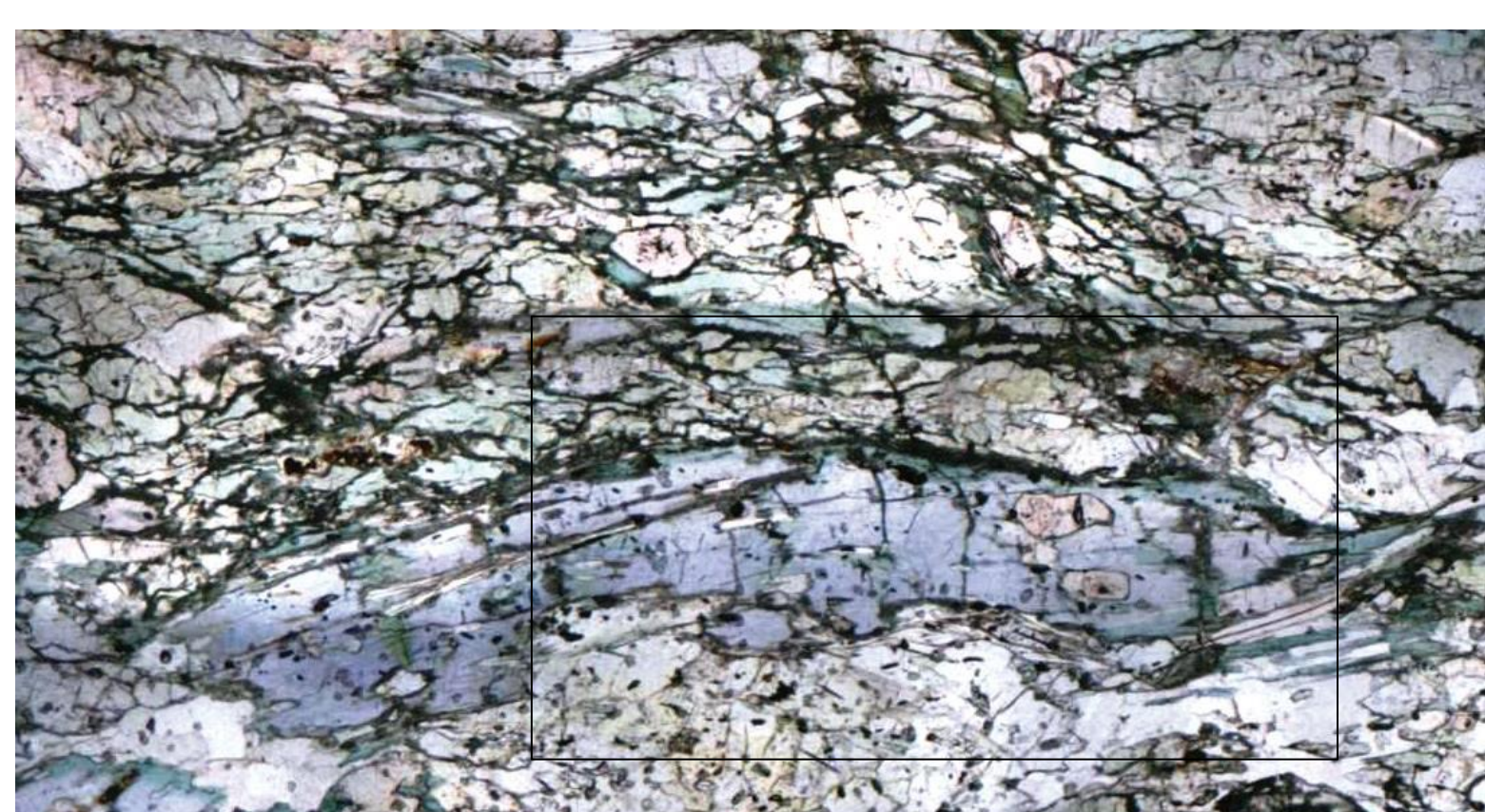
Layout of figures for both examples (insets are misorientation profiles)

a) Orientation, colour coded using Inverse Pole Figure scheme	b) IPF key for a) and other IPFs	c) IPF for map shown in a)
The method allows for direct investigation of geometrically necessary dislocations and slip systems		
d) “Tiling” (or the “integral method”) is an approach where the WBV is calculated over a finite region, here square. The magnitude is a proxy for dislocation density. Each tile has a colour.	e) Because the WBV is a vector, we can colour code its direction in crystal coordinates ...	f) ... and plot those crystal directions on an Inverse Pole Figure to test hypotheses about the Burgers vectors of dislocation slip systems
g) The “differential method” is mathematically equivalent to the integral method; numerically it has higher spatial but lower angular resolution. Each measurement point gets a colour	h) As in e) we can colour code the direction ...	i) ... and as in f) we can plot on an IPF. Angular imprecision will influence our interpretation – work is in progress to quantify accuracy.

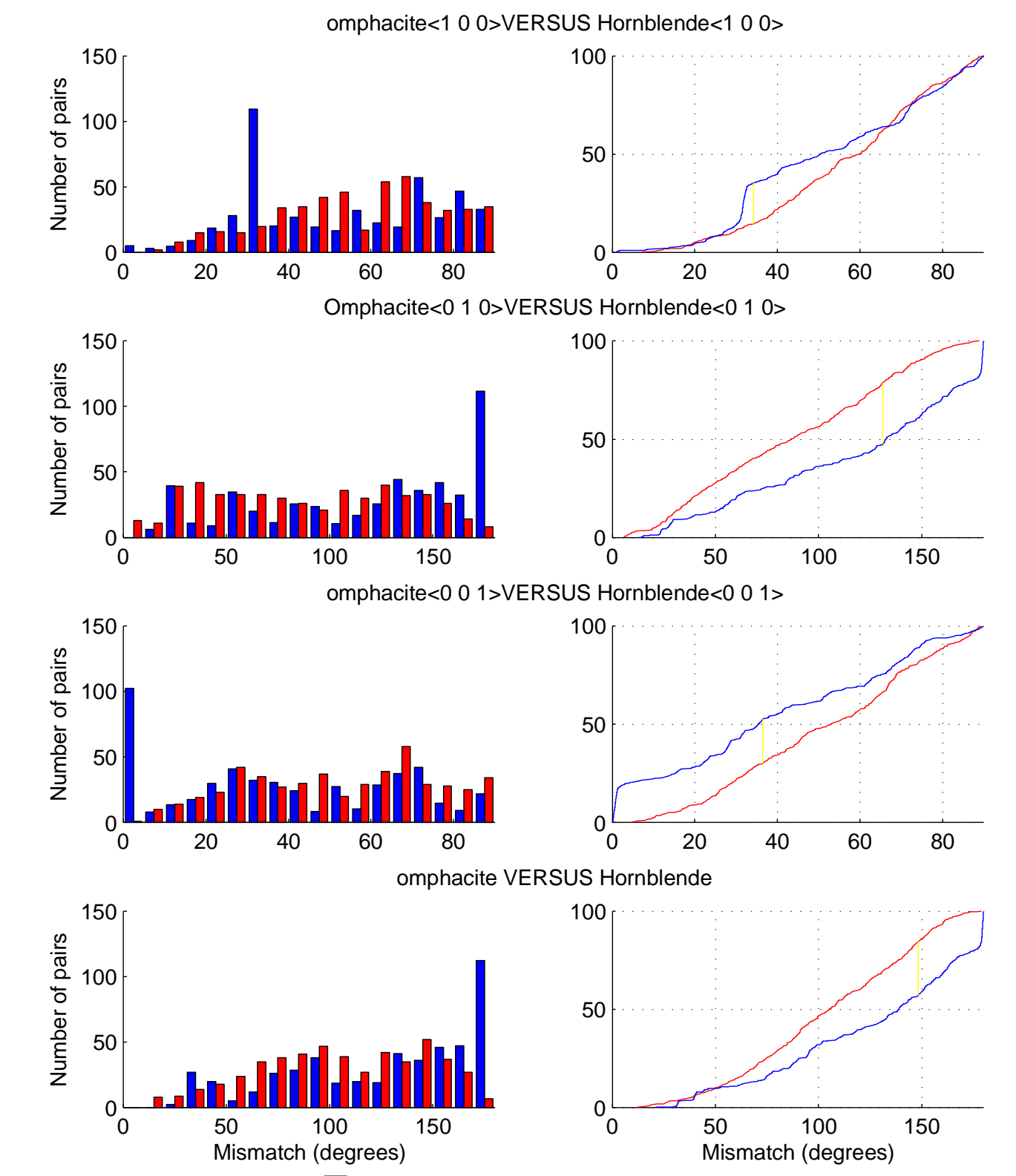


Interphase misorientation analysis

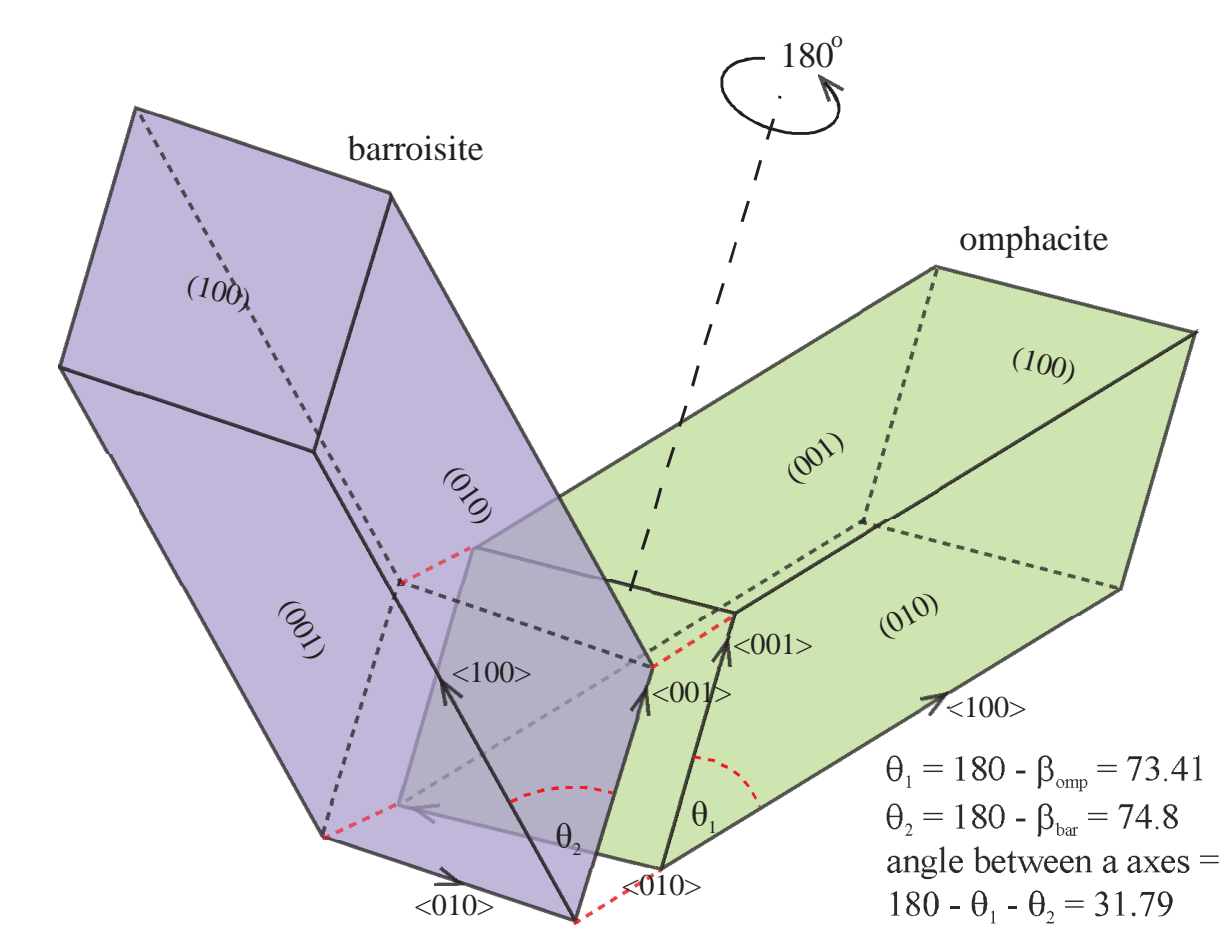
In an eclogite, CPOs (below) seem to show deformation when omphacite was stable and later when barroisite was stable. In fact we show barroisite grew mimetically on omphacite without further deformation



Intraphase misorientation analysis (left): measure the angle needed to align one crystal lattice with another. Plot histograms of angles for neighbouring pairs or for pairs selected at random. Compare the histograms to see whether adjacent crystals have influenced each other or formed from a common parent e.g. by subgrain rotation (Wheeler et al. 2001)

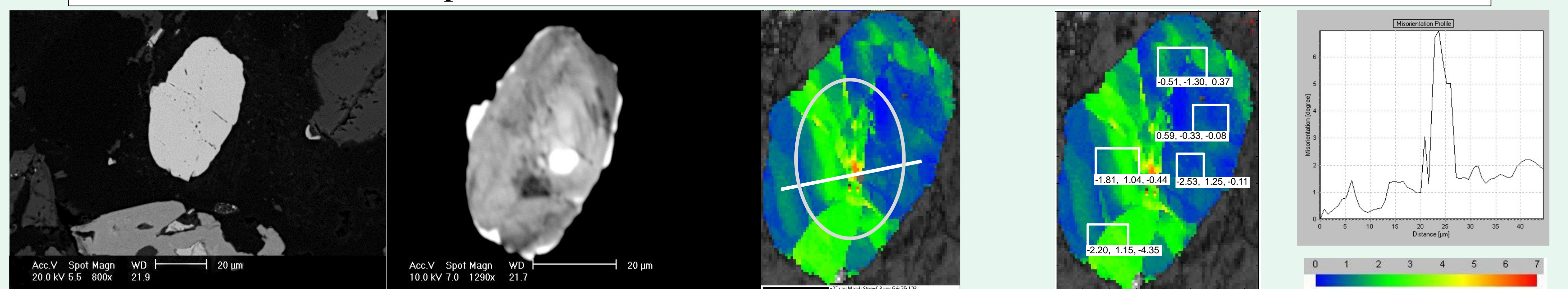
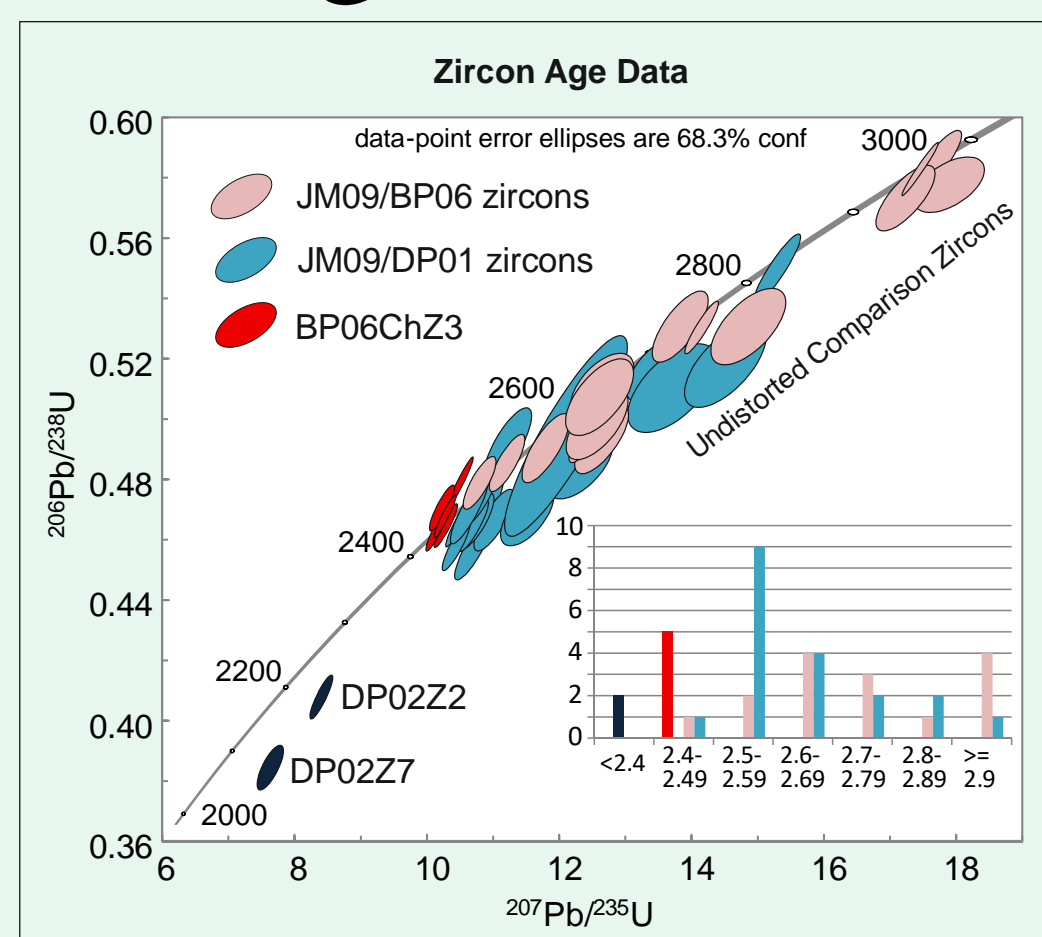


Interphase misorientation analysis (left): define a crystal direction in the two different phases to use as a reference orientation relationship (top blue versus green). Plot histograms as for intraphase misorientation analysis. Results for barroisite versus omphacite are on right. Note the a axis “spike” showing that growth orientation of barroisite is influenced by omphacite grains.

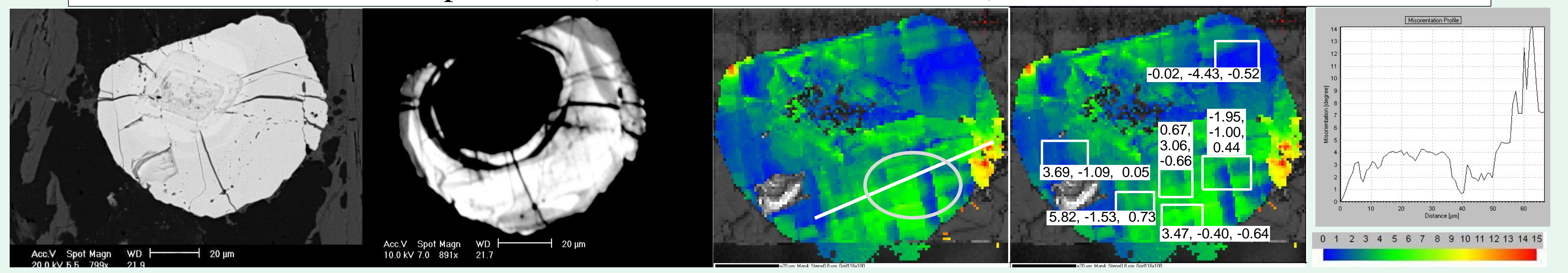
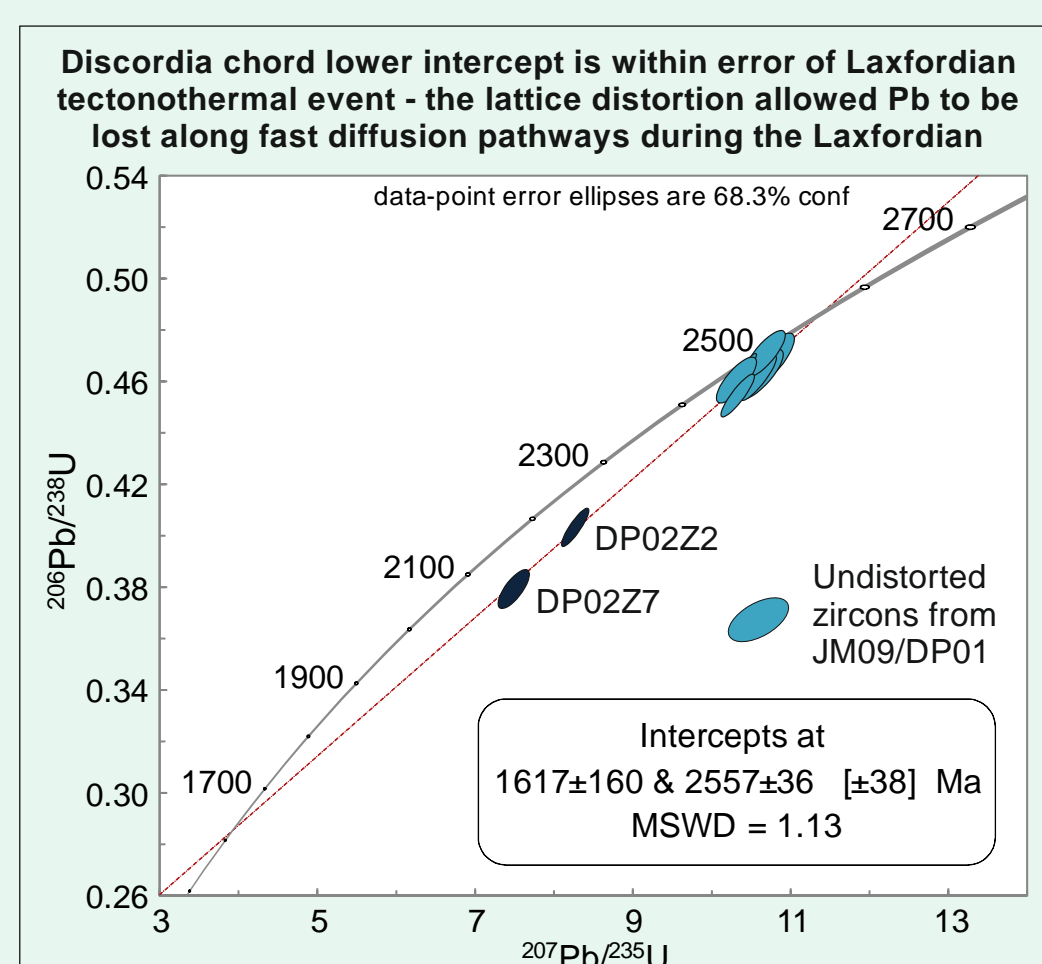


Dating distorted crystals

Zircon DP02Z2 from sample DP02 (Laxfordian shear zone core), Badcall Point



Zircon DP02Z7 from sample DP02 (Laxfordian shear zone core), Badcall Point



Zircon is reputed to be retentive of Pb unless it recrystallises. But distorted grains from the Lewisian Gneiss (shown right) give younger ages than undistorted ones suggesting Pb is lost along dislocations.

Backscatter electron image.

Cathodoluminescence image.

Orientation variation relative to a reference point (key to right): line shows profile for misorientation. Ellipse shows ion microprobe spot.

Average WBV in various rectangular areas. The three numbers indicate the WBV components parallel to a, b and c crystal axes. Units are multiples of 10¹² m⁻². The numbers are *not* the same as dislocation densities but are closely related and give an order of magnitude.

Misorientation profile along line marked on map.