Structural geology of the Galmoy carbonate-hosted Zn-Pb orebodies, Co. Kilkenny, Ireland.

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INTRODUCTION – Over the past few decades a variety of models have been advanced for the origin and evolution of Irish Zn-Pb deposits, all of which acknowledge the important role of faults, which act as the main conduits for transporting ore fluids and form the main bounding structures to the deposits. Here we present new structural insights into the formation and evolution of the Galmoy deposit, Co. Kilkenny.

The Galmoy Zn-Pb orebodies are situated within the *'Rathdowney Trend'* of the south-central Irish Midlands: a circa 80 km long NE-SW-trending belt of Lower Carboniferous carbonate rocks noted for its abundance of mineral occurrences. The orebodies occur at the stratigraphic contact between two formations with strongly contrasting lithological and rheological properties: (1) massive Waulsortian micritic limestones, pervasively affected by fault-controlled regional dolomitisation, and (2) well-bedded argillaceous bioclastic limestones (ABL) of the Ballysteen Formation, which underlie the Waulsortian. The stratiform orebodies range from circa 1-25m in thickness and comprise massive to disseminated replacements of the lowermost 30m of the dolomitised, and to a large extent brecciated, Waulsortian.

EXTENSIONAL STRUCTURES -The Galmoy orebodies occur within the hangingwall of a regionally-extensive, ENE-trending, left-stepping segmented normal fault array that also hosts mineralisation at the Lisheen Mine, 9km to the WSW. At Galmoy, the fault segments dip towards the north and have a maximum net displacement of circa 200m. In the vicinity of the G orebody, two ENE-trending overlapping fault segments bound a 600m wide, gently (5°) E-dipping ramp, interpreted as a breached relay zone. Even these large-scale fault segments appear to have been segmented on smaller scales, with the presence of minor splays and bends, attributed to the coalescence of small-scale fault segments with strike-perpendicular dimensions of a few tens of metres.

In addition to the principal faults, minor normal faults and extensional monoclines with displacements of circa 1-10m, termed *'rolls'*, are found throughout the mined area where the ABL is exposed in the ore footwall. In the direct hangingwall of the G fault, the rolls are discontinuous along strike over circa 10-20m, but share the same trend as the principal ENE-striking fault segments. In areas more distal to the principal faults, such as the CW and G-NE orebodies, roll axes tend to strike NNE-SSW or N-S indicating a component of cross-axial extension.

CONTRACTIONAL STRUCTURES - Evidence of contractional deformation post-dating ore mineralisation is widespread throughout the orebodies. Although the ENE-WSW trending, deposit-bounding faults preserve net normal offsets of up to circa 200m, the development of contractional structures such as: (1) chevron folds with amplitudes of 5-10m within the G fault zone; (2) a tight hangingwall syncline along the G fault; (3) reverse-sense deformation fabrics in the ore directly in the fault hangingwall, indicate that considerable inversion of these normal faults has taken place. The commonly observed development of footwall reverse faults which short-cut roll structures and occasionally cause minor duplications of the ore suggest that considerable slip was focussed along the base of the sulphide during contraction. Slip directions associated with the contractional deformation indicate that the deformation was dextral-transpressional, with a NW-SE shortening direction, consistent with the established late Variscan deformation in Ireland and Britain.

Within the mine, contractional deformation appears to intensify towards the east. Contractional deformation such as an east-vergent recumbent fold system and arrays of chevron- and box-folds are particularly focussed along NNE-SSW and N-S trends. Along the southeastern margin of the R orebody, a large NE-SW trending fault with a net reverse displacement of circa 110m has been intersected by exploratory drill-holes and appears to bound the known extent of ore mineralisation to the southeast. Examination of drill-hole intercepts indicates the presence of both stratigraphic duplications due to contractional deformation and significant amounts of stratigraphic removal due to (earlier?) extensional deformation. We tentatively interpret this structure as an inverted normal fault belonging to a more NNE-trending fault element of the Rathdowney Trend.

STRUCTURAL CONTROL OF MINERALISATION - Thickening of the orebodies towards the principal ENE-WNW trending normal faults is consistent with the notion that the faults acted as the principal flow conduits for the mineralising fluids. This model is supported by the distributions of metals within the deposits with highest Pb values generally being restricted to parts of the orebodies adjacent to the main faults and with an increasing Zn:Pb ratio in the more distal orebodies; this type of trend has previously been attributed to the cooling of fluids away from the faults. The combination of elevated Pb values and extreme ore thicknesses typically occurs within the vicinity of fault irregularities on the principal normal faults, such as apparent breached relay zones and the branch-line of a splay. This spatial association suggests that highly strained volumes associated with fault segment linkage have provided the principal vertical conduits to ore fluid flow.

The presence of marked thickness changes of sulphide within the hangingwalls of roll structures suggests that they also pre-date ore deposition though they are believed to have controlled lateral flow rather than vertical flow. Given the absence of evidence either of post-ore normal faulting or of textures supporting the notion of normal fault-related fluid pressure cycling (by either a ‘seismic-pumping’ or ‘fault-valving’ mechanism), we conclude that ore mineralisation took place after the cessation of normal faulting.