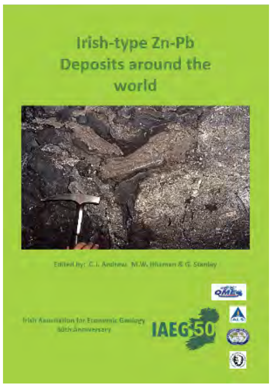

Irish Association for Economic Geology

(founded 1973)

Home Page: https://www.iaeg.ie

A new look at the Gortdrum copper deposit, Co. Tipperary, Ireland

Eoin Dunlevy[1,2], Koen Torremans[2], Mark Holdstock[3] & Murray Hitzman[2]

[1]Terranta GmbH, Rathausstraße 37a | 52072 Aachen, Germany
[2]SFI Research Centre in Applied Geoscience (iCRAG), University College, Dublin, Belfield, Co. Dublin, Ireland
[3]Group Eleven Resources, 22 Northumberland Road, Ballsbridge, Dublin 4, Ireland

Corresponding Author: Eoin Dunlevy e.dunlevy@terranta.de

To cite this article: Dunlevy, E., Torremans, K., Holdstock, M. & Hitzman, M. (2023) A new look at the Gortdrum copper deposit, Co. Tipperary, Ireland. *In:* Andrew, C.J., Hitzman, M.W. & Stanley, G. '*Irish-type Deposits around the world*', Irish Association for Economic Geology, Dublin. 363-370.
DOI: https://doi.org/10.61153/JLTX1259

To link to this article: https://doi.org/10.61153/JLTX1259

A new look at the Gortdrum copper deposit, Co. Tipperary, Ireland

Eoin Dunlevy[1,2], Koen Torremans[2], Mark Holdstock[3] & Murray Hitzman[2]

[1]*Terranta GmbH, Rathausstraße 37a | 52072 Aachen, Germany*
[2]*SFI Research Centre in Applied Geoscience (iCRAG), University College, Dublin, Belfield, Co. Dublin, Ireland*
[3]*Group Eleven Resources, 22 Northumberland Road, Ballsbridge, Dublin 4, Ireland*

Abstract The Gortdrum Cu-Ag-(Hg) mine located on the eastern edge of the Limerick Syncline represents an apparent anomaly in the Irish Orefield and has escaped attention over the past few decades. Construction of a three-dimensional geological model from historical drillhole data from the deposit area indicates that the previously recognized Gortdrum "fault" is actually a ramp-relay normal fault system similar to those at known Irish zinc-lead deposits with particularly striking parallels to the Killoran fault system at Lisheen. The Gortdrum area lies between what was a generally shelf limestone environment to the west and a more basinal environment to the east during the Chadian-Arundian. The Gortdrum fault system with downthrow to the northwest, however, cannot be the controlling structure for these regional facies change. The mineralogy and geometry of Gortdrum suggests it could have been a "feeder" zone for a zinc-lead deposit in the now eroded overlying Waulsortian Limestone. The small footprint of the Gortdrum deposit implies that similar, potentially economic copper mineralized zones could be present in other Irish type systems, especially the Pallas Green and Stonepark systems to the west and other prospects in the Limerick Syncline.

Keywords: Gortdrum, 3D structural interpretation, controlling structure, Cu-Ag-Hg mineralization, deep feeder zones.

Introduction

The Gortdrum mine which operated between 1967 to 1975 has been Ireland's only modern copper mine within the Lower Carboniferous carbonates. Ore reserves for the deposit were 3.6Mt of 1.19% Cu and 25.1 g/t Ag of which approximately 76% was extracted (Steed, 1986). The mine also produced mercury.

The deposit is hosted in Carboniferous marine sedimentary rocks. However, unlike the zinc-lead deposits of the southern Irish Orefield which are hosted in the Waulsortian Limestone and equivalents, Gortdrum is hosted in rocks forming the basal portion of the Carboniferous sequence. There is a relatively sparse literature concerning the deposit with the most detailed descriptions coming from a PhD thesis by Steed (1975) and a paper by the same author (Steed, 1986). This study places the deposit in an updated stratigraphic framework and examines the structure of the deposit as well as the implications of the known deposit geology for further exploration for similar copper deposits in the Irish Orefield.

Geological Setting

The Gortdrum deposit is located in a northeast-trending structural saddle between the southern end of the Slieve Felim inlier and the northeast trending Emly Inlier, cored by Devonian Old Red Sandstone and the lowermost portion of the Carboniferous marine sedimentary succession (Figures 1 & 2). This northeast-trending zone broadly forms an extension of the structural zone hosting the Galmoy and Lisheen deposits along the Rathdowney Trend (Figure 1).

This northeast-trending zone in the Gortdrum area separates rocks of the Limerick Syncline from those to the east in an area known informally as the Golden Gulf. The basal Carboniferous succession in the Limerick Syncline, Gortdrum area, and the Golden Gulf is designated the Lower Limestone Shale Formation and contains a mixed sequence of calcareous sandstone, argillaceous limestones, and shales which maintains a relatively similar thickness across the area (Dunlevy, 2023). The Lower Limestone Shale Formation is overlain by the

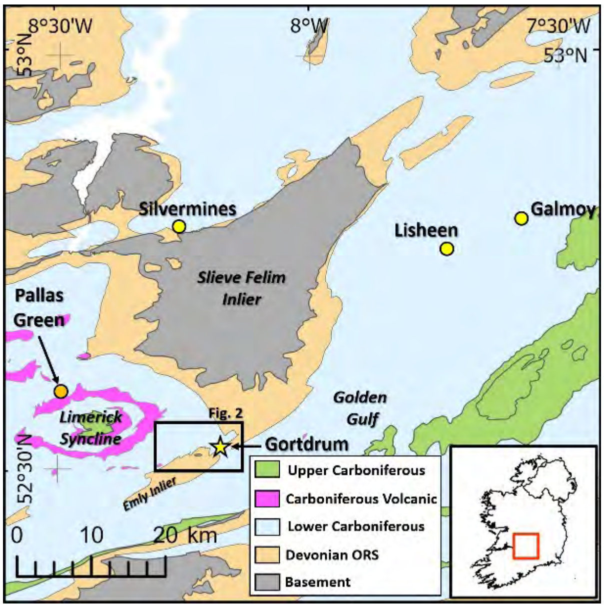

Figure 1: Geological map illustrating the location of the Gortdrum Cu deposit relative to the Rathdowney Trend running through the Galmoy and Lisheen zinc-lead deposits to the Golden Gulf, the Limerick Syncline containing the Tobermallug and Stonepark (Pallas Green) zinc-lead deposits, and the Silvermines zinc-lead deposit. The map illustrates the areas where Palaeozoic basement rocks, the Devonian Old Red Sandstone, and Carboniferous rocks crop out.

Ballysteen Formation, a sequence of argillaceous, generally highly bioclastic limestones, which is in turn overlain by the Waulsortian Limestone, a sub-wave base carbonate mud mound build-up (Lees & Miller, 1995).

There are distinct changes in the Carboniferous stratigraphic succession between the Limerick Syncline and the Golden Gulf area. Although the thickness of the Lower Limestone Shale Formation appears to be near equivalent in the two areas and the thickness of the Ballysteen Formation cannot be estimated accurately due to absence of drill hole control (Figure 3), the Waulsortian Limestone in the Limerick Syncline exceeds 500m in some places whilst in the Golden Gulf the Waulsortian Limestone is represented by 40m of "off-reef" argillaceous wackestones. The supra-Waulsortian succession in the Limerick Syncline is comprised of several hundred metres of limestones (mostly wackestones, packstones and micrites) interbedded with volcanic rocks of the Knockroe and Knockseefin Formations (Figure 3). Overall, this succession shallows upward and represents an inner-ramp environment. In the Golden Gulf area, the age equivalent Carboniferous sequence consists of several hundred meters of limestones and interbedded volcanics (Figure 3). Contrasting with the Limerick Syncline however, the Golden Gulf succession was interpreted as representing a deeper water environment (Carruthers, 1985; Archer *et al*., 1996). This contrasting stratigraphic evolution is indicative of a major facies change during the Chadian-Arundian. It is likely that this facies change was structurally controlled with the structural zone somewhere in the Gortdrum region. The age of this rapid facies change is the

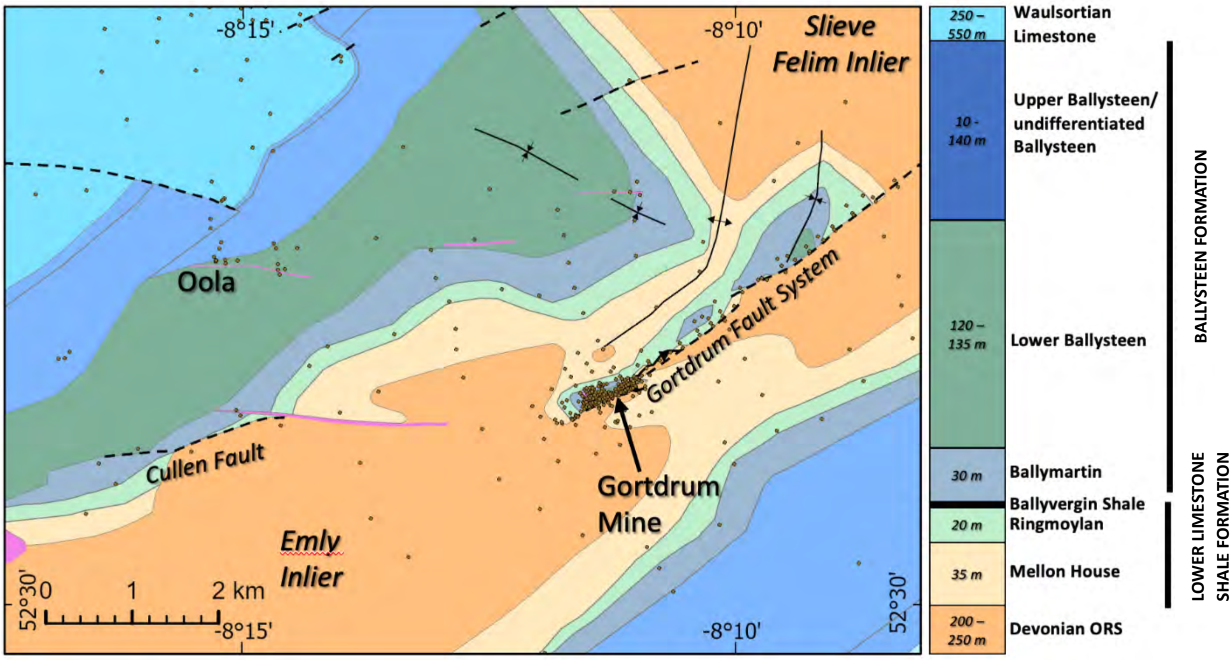

Figure 2: Plan geological map of the Gortdrum – Oola area showing the location of drill holes utilized for geological interpretation. The Gortdrum copper deposit occurs at the southwest end of the Gortdrum fault system before it appears to undergo dextral relay into the poorly known Cullen fault system to the southwest. The Oola mineralized zone occurs to the north of the apparent termination of the Cullen fault and contains a series of high angle veins adjacent to a generally east-trending mafic dike swarm.

same as similar rapid facies changes observed throughout the Irish Orefield (Hitzman & Beaty, 1996).

The Limerick Syncline area is distinctive in an Irish context because of the presence of locally voluminous igneous rocks termed the Limerick Igneous Suite (Slezak *et al.*, 2023). The Limerick Igneous Suite contains two distinct basaltic igneous units: the Knockroe and Knockseefin, which are expressed as hypabyssal intrusions, porphyritic dykes, diatremes, lava flows, agglomerates and tuffs. The lower Knockroe unit contains apatite which U-Pb dating indicates has a primary crystallization age of *c.* 350Ma (Chadian) (Slezak et al., 2023) while the Knockseefin is thought to be Asbian in age (Strogen, 1983).

In the Gortdrum area igneous rocks occur as dykes and intrusive breccia bodies (Steed 1975, 1986). Unfortunately, no intersections of these breccia bodies exist today but descriptions bear strong resemblance to polymict breccia bodies (*i.e.* igneous and Waulsortian Limestone clasts) described in the Limerick Syncline by McCusker & Reed (2013) and Blaney & Redmond (2015).

Deposit Geology

The Gortdrum orebody formed an irregular zone along the trend of the Gortdrum fault within rocks of the Lower Limestone Shale and Ballysteen Formations, though sulphides are known to extend into the underlying Old Red Sandstone (Steed 1975, 1986). Mineralization also affected some of the igneous dikes present in the area. Alteration associated with the mineralization event is described as relatively minor and consisted of alteration of limestones to dolomite and ferroan dolomite and development of some limited zones of silicification. The upper portion of the orebody contained chalcopyrite, mercurian tennantite (Hg substituting for some of the Cu in the mineral) and minor pyrite with calcite and ferroan dolomite in veinlets within shattered, massive bioclastic limestones. This gave way at depth to a sulphide assemblage dominated by bornite and chalcocite with minor pyrite. Accessory minerals

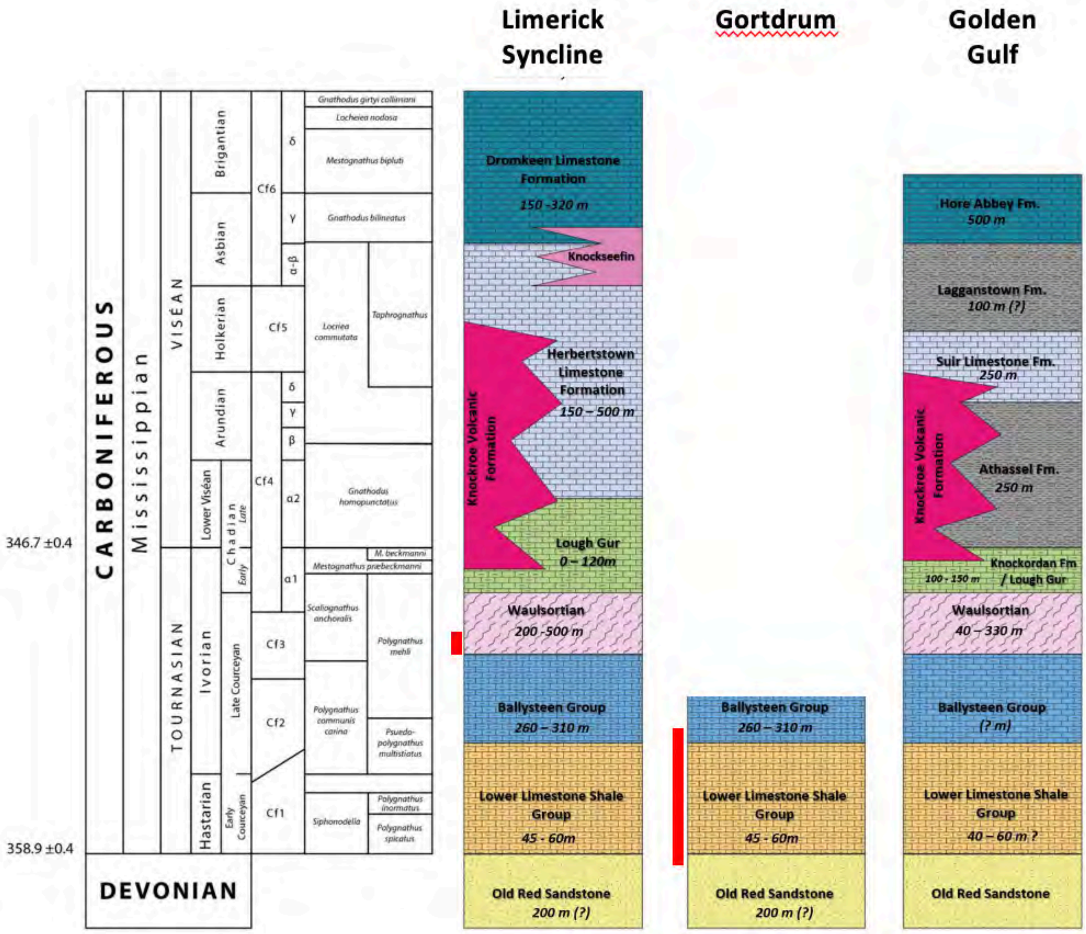

Figure 3: *Stratigraphy of the Limerick Syncline, Gortdrum and Golden Gulf areas (locations displayed on Figure 1). The generalized stratigraphic columns for the Limerick Syncline and Golden Gulf areas indicate a significant facies change at the level of the Chadian-Arundian (Lough Gur and Herbertstown Limestone Formations). The Gortdrum deposit occurs between the two areas, regionally astride this zone of facies change, in an area where erosion has removed most of the Carboniferous succession. The position of mineralized zones in the Pallas Green deposits (Limerick Syncline) and at Gortdrum are indicated by the red bars adjacent to the stratigraphic columns.*

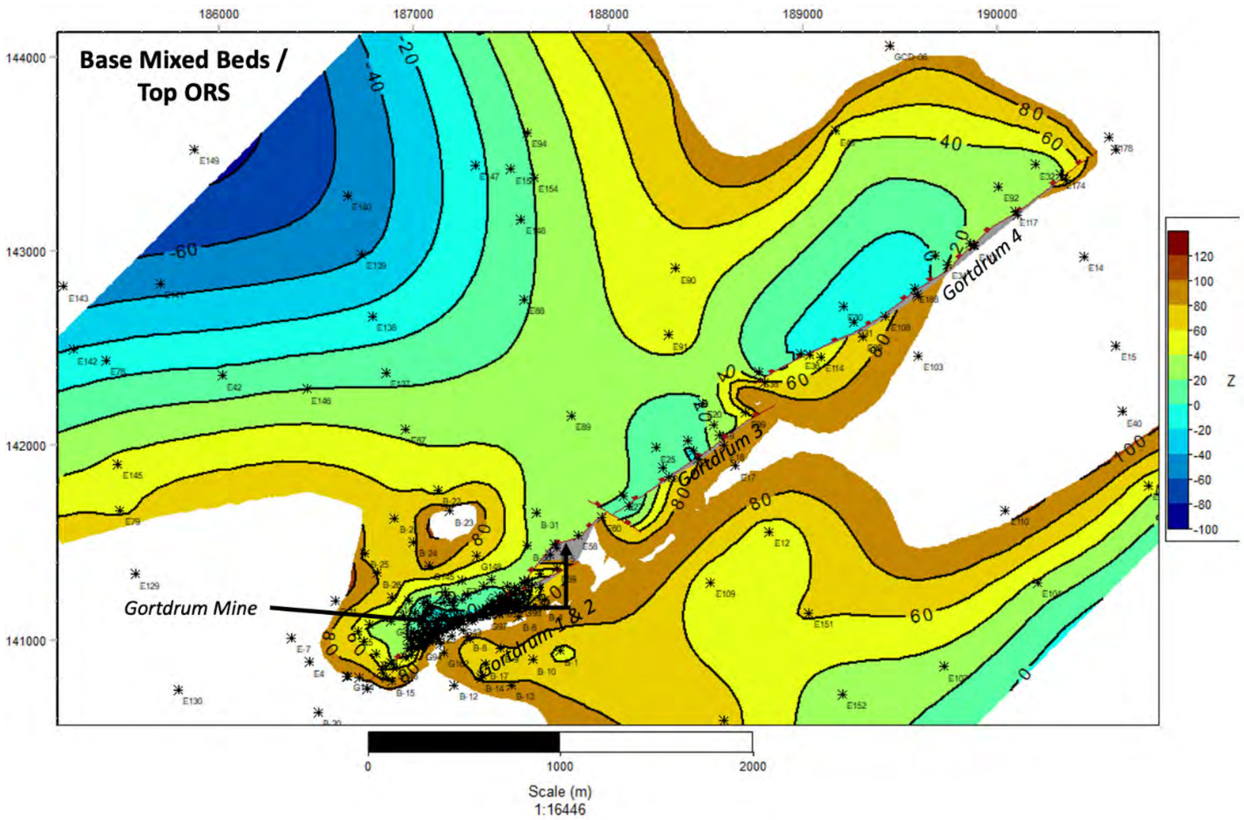

***Figure 4**: Plan view illustrating the position and offsets along the Gortdrum fault zone and the data control points (drill holes). The map displays the surface of the contact between the base of the Carboniferous marine sequence (Mellon House Formation) and the top of the Devonian Old Red Sandstone (ORS). The Gortdrum fault zone forms a classic normal fault ramp relay system (Walsh et al., 2003). The Gortdrum fault system appears to undergo a major step to the southwest near the termination of the Gortdrum 1 fault and continues across a broad anticlinal area along the Cullen fault zone (Figure 2). Note view on Figure 6 is from the lower left corner of the figure to the upper right (to the northeast) along the Gortdrum fault zone.*

in the ore included cinnabar, cobaltite (CoAsS), arsenopyrite, native amalgam, stromeyerite (AgCuS), wittichenite (Cu_3BiS_3), and a Cu-Hg-S phase now known as gortdrumite; whilst sphalerite and galena were extremely rare. While copper sulphides and arsenian sulphides (tennantite, arsenopyrite) are recognized in a number of Irish type deposits, commonly adjacent to "feeder" faults or in mineralized zones beneath the main orebodies (e.g., Silvermines, Andrew, 1986; Lisheen, Hitzman *et al.*, 2002), Gortdrum is the only Irish orebody to contain significant mercury.

Methodology

This study utilized data from approximately 430 historic diamond drill holes in the wider Gortdrum area (Figure 2). Data was captured from original drill log scans, maps and cross sections available on the GSI open file system and updated to conform with the modern stratigraphic nomenclature for the region (see Dunlevy, 2023 for further details). Data was quality controlled using QC tools in Leapfrog and a 3D structural & stratigraphic model was generated in SKUA GoCAD. No modelling of the thrusted Old Red Sandstone wedge was undertaken. The ore body outline (Figure 6) was generated using 3D georeferenced cross sections available from the GSI. Displacements across individual faults were then calculated based on measurements from this 3D model. The data presented in this paper form a portion of a much larger 3D model for the Limerick Syncline area.

Structural geology of Gortdrum

The three-dimensional geological model created from the historic drill hole data allowed evaluation of the area's structural geology. The analysis demonstrates that rather than being a through-going single structure, the Gortdrum "fault" is a system of interlinked normal faults. These normal faults (designated Gortdrum 1, Gortdrum 2, Gortdrum 3, and Gortdrum 4 from southwest to northeast; Figure 4) form a kinematically linked ramp-relay system (Walsh *et al*., 2003). An analysis of displacement along individual fault strands (Figure 5) utilizing the method of Walsh & Watterson (1989) indicates that the maximum throws of individual faults is approximately 100m and that total displacement along the entire fault zone maintains this overall maximum displacement.

This new understanding of the geometry of the Gortdrum fault system highlights its similarity to the normal fault systems at Silvermines and Lisheen (Kyne *et al.*, 2019). The maximum displacement along the Gortdrum fault system is approximately 100m, less than that of the Killoran fault system at Lisheen (160-220m) and the Silvermines faults (>200m) (Kyne *et al*., 2019). As at Lisheen, where the Killoran fault system

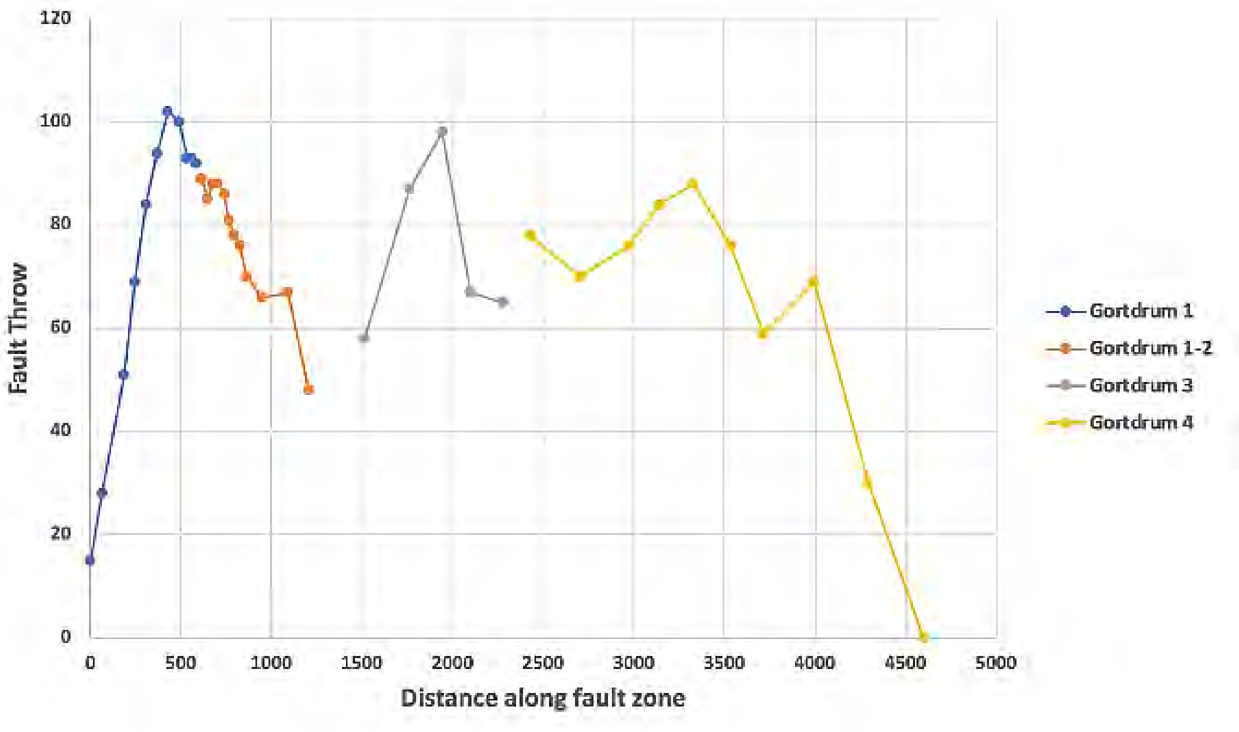

Figure 5: *Graph showing displacement along the Gortdrum fault zone calculated by offsets of the top of the Old Red Sandstone determined from drill hole data. Maximum displacement along the fault is approximately 100m. Note the regular increases and decreases in displacement along individual strands of the Gortdrum fault as expected in a linked normal fault relay-ramp system.*

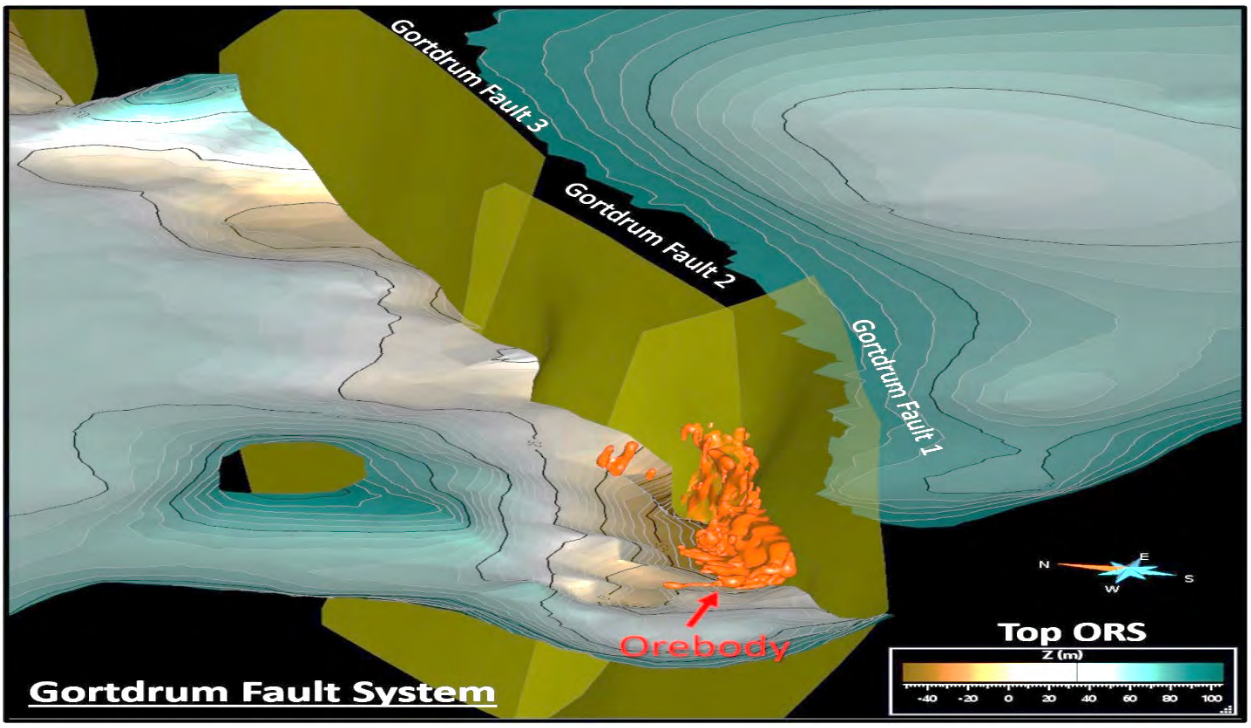

Figure 6: *3D model of the Gortdrum fault zone showing the position of the orebody (red wireframe) constructed in Leapfrog software. The surface illustrated is the top of the Old Red Sandstone. Note that the deposit forms an essentially near vertical tube adjacent to the Gortdrum 1 and 2 faults.*

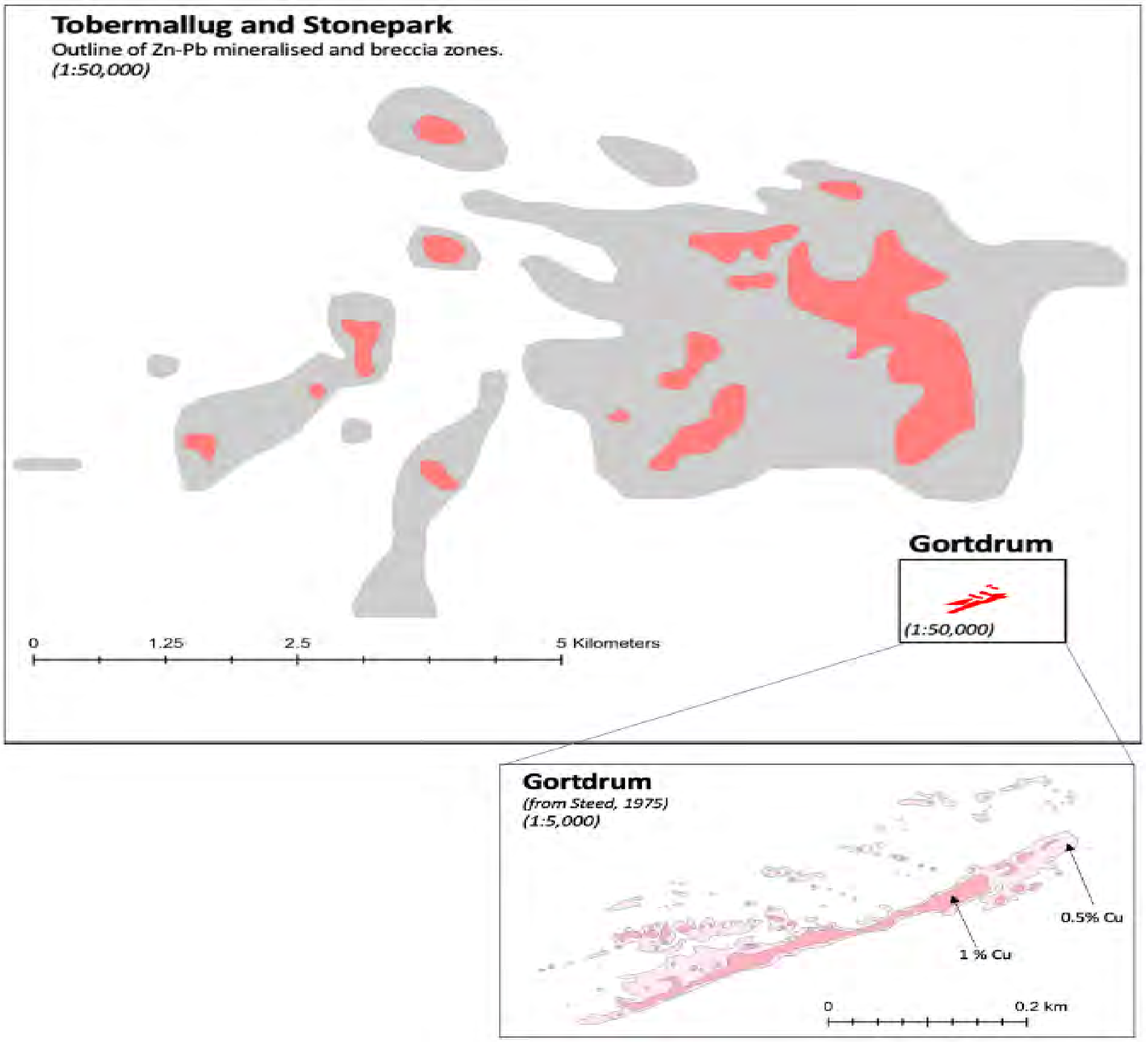

***Figure 7**: Comparison of the footprint of the Gortdrum copper mineralized zone with the zinc-lead mineralized zones and areas of breccia formation at the Tobermallug-Stonepark (Pallas Green) deposit (from Redmond & Blaney, 2015). Note that a feeder type Gortdrum zone could easily be present within the large area of the Pallas Green deposit where the stratigraphy potentially hosting a Gortdrum-type system has not been tested. The enlargement of the Gortdrum deposit displays copper grade distribution (from Steed, 1986).*

terminates to the west of the Main Zone and displacement is transferred to another normal fault several kilometers to the west across a broad uplifted ramp zone (Hitzman *et al*., 2002), drill hole data suggest the Gortdrum1/2 fault terminates to the southwest of the deposit. It is likely that displacement was taken up within a broad ramp as the fault system stepped dextrally to the west onto the more poorly known Cullen fault, likely also a ramp-relay system (Figure 2).

The Gortdrum fault system displays north side down normal movement. The regional stratigraphic relationships indicate that the Golden Gulf area underwent subsidence relative to the Limerick Syncline, thus the Gortdrum fault system cannot have been responsible for the facies change noted between the Limerick Syncline Carboniferous sequence and that known in the Golden Gulf (Figure 2). Therefore, it is probable that another normal fault system is present to the east of Gortdrum with normal movement down to the south. This normal fault system likely controls the southern edge of the Emly Inlier and the Slieve Felim Inlier and could be the extension of the Rathdowney Trend fault system (Figure 1).

As at Silvermines and Lisheen, mineralized zones at Gortdrum occur near the points of maximum throw along the normal fault system. The economic orebody was located adjacent to the Gortdrum 1/2 fault at the southwest end of the system (corresponding to the Main Zone at Lisheen) and formed a pipelike body raking down the fault (Figure 6). Interestingly, a plan map of the mineralized zones at Gortdrum (Figure 7 inset) shows that while the primary mineralized zone extends along the normal faults, secondary zones of weakly mineralized rock extend west-northwest from the hangingwall of the fault zone. The orientation of these zones is eerily similar to the Island Pod zone at Lisheen (Doran *et al*., 2022) and the K Zone at Galmoy (Doyle & Bowden, 1995) and suggests a component of oblique displacement during the extensional event that resulted in the formation of the Gortdrum normal fault array.

As noted in Steed (1986), the Gortdrum normal fault zone was reactivated following its formation as indicated by the presence of local folds and reverse faults in and immediately adjacent to the delineated faults. This is unsurprising as most of the late Courceyan-Chadian-Arundian fault systems that have been investigated in detail display features indicative of Variscan deformation (Andrew, 1986; Ashton *et al.*, 1986, 2015; Hitzman, 1999; Kyne *et al.*, 2019).

Implications for exploration

The recognition that the structural framework for the Gortdrum copper deposit is the same as the Irish-type zinc-lead deposits and has clear implications for exploration in the Limerick Syncline and beyond. The sulphide mineral assemblage at Gortdrum is similar to that in the "feeder" zones of several other Irish-type orebodies, namely Lisheen and Silvermines. The location of Gortdrum suggests it could have represented a structural "feeder" zone for a zinc-lead body in the overlying Waulsortian Limestone that was subsequently eroded.

Examining the footprint of the Gortdrum orebody relative to the currently known footprint of the mineralized zones and area occupied by hydrothermally related breccias in the Tobermallug-Stonepark (Pallas Green) system to the west in the Limerick Syncline demonstrates that it forms a very small drill target. To date no significant normal faults have been reported from the Pallas Green mineralized system. However, faults with 100m or less displacement could be relatively easily overlooked, especially given the likelihood of Variscan fault inversion. In addition, few if any holes have tested the level of stratigraphy mineralized at Gortdrum beneath the Pallas Green system. It is quite possible that a Gortdrum-type zone, or multiple zones, are present within or adjacent to the mineralized area currently known at Pallas Green. Given our current knowledge, such zones should be sought using detailed geological reconstructions and perhaps geochemical vectoring focusing on arsenic and mercury.

Acknowledgements

The work for this study was undertaken as part of a larger research project investigating the geology of the Limerick Syncline area supported by SFI research grant number 16/RP/384. We would like to acknowledge discussions with Evie Burton and Dr Paul Slezak who were also involved in the larger project and thank the reviewers whose comments greatly improved the manuscript.

References

Andrew, C.J., (1986) The tectono-stratigraphic controls to mineralization in the Silvermines area, County Tipperary, Ireland, in Andrew, C.J., Crowe, R.W.A, Finlay, S., and Payne, J.F., eds., Geology and genesis of mineral deposits in Ireland: Dublin, I*rish Association of Economic Geology, Special Publication*, p. 377–407.

Archer, J.B., Sleeman, A.G., & Smith, D.C., (1996) A geological description of Tipperary and adjoining parts of Laois, Kilkenny, Offaly, Clare and Limerick, to accompany the bedrock geology 1:100,000 scale map series, Sheet 18, Tipperary. *Geological Survey of Ireland, Dublin.*

Ashton, J.H., Downing, D.T. & Finlay, S., (1986) The geology of the Navan Zn-Pb orebody. *In:* Andrew, C.J., Crowe, R.W.A., Finlay, S., Pennell, W.M. and Pyne, J.F. (eds.). Geology and Genesis of Mineral Deposits in Ireland. *Irish Association for Economic Geology, Dublin.* 243-280.

Ashton, J.H., Blakeman, R.J, Geraghty, J.F., Beach, A., Coller, D. & Philcox, M.E. (2015) The Giant Navan carbonate-hosted Zn-Pb deposit – a review. *In:* Archibald, S.M., and Piercey, S.J. (eds.). Current perspectives on zinc deposits. *Irish Association of Economic Geology, Special Publication, Dublin.* 85-122.

Blaney, D., & Redmond, P.B. (2015) Zinc-Lead Deposits of the Limerick Basin, Ireland, in: Archibald, S.M., Piercey, S.J. (Eds.), Current Perspectives on Zinc Deposits. *Irish Association for Economic Geology, Dublin* pp. 73–84.

Carruthers, R.A. (1985) The Upper Palaeozoic geology of the Glen of Aherlow and the Galtee Mountains, Counties Limerick and Tipperary. Unpub PhD thesis, University of Dublin, Trinity College.

Doran, A.L., Hollis, S.P., Menuge, J.F., Piercey, J.L., Boyce, A.J., Johnson, S., Güven, J & Turner, O. (2022) A Distal, High-Grade Irish-Type Orebody: Petrographic, Sulphur Isotope, and Sulphide Chemistry of the Island Pod Zn-Pb Orebody, Lisheen, Ireland. *Economic Geology*, v.117, no. 2, 305–326.

Doyle, E. & Bowden, A.A. (1995) Field guid to the Galmoy zinc-lead deposits, Co. Kilkenny. *In:* Anderson, I.K., Ashton, J.H., Earls, G., Hitzman, M. & Tear, S. (Eds.). *Irish carbonate-hosted Zn-Pb deposits: Society of Economic Geologists Guidebook Series*, 21, 139-145.

Dunlevy, E. (2023) *in press*, Lower Carboniferous lithostratigraphy of Limerick, North Cork and Tipperary, *Geological Survey Ireland*, 85p.

Hitzman, M.W. (1999) Extensional faults that localize Irish syndiagenetic Zn-Pb deposits and their reactivation during Variscan Compression. *In:* McCaffrey, K. J. W., Lonergan, L. and Wilkinson, J. J. (Eds), *Fractures, Fluid Flow and Mineralization.* Geological Society, London, Special Publications 1999; v. 155; p. 233-245.

Hitzman, M.W. & Beaty, D.W. (1996) The Irish Zn-Pb-(Ba) orefield, in Sangster, D.F. (ed.). Carbonate-hosted lead-zinc deposits: *Society of Economic Geologists Special Publication* 4, 112–143.

Hitzman, M.W., Redmond, P.B. & Beaty, D.W., (2002) The carbonate-hosted Lisheen Zn-Pb-Ag deposit, County Tipperary, Ireland. Economic Geology, v.97, p. 1627-1655.

Kyne, R., Torremans, K., Güven, J., Doyle, R. & Walsh, J.J., (2019) 3-D Modeling of the Lisheen and Silvermines Deposits, County Tipperary, Ireland: Insights into Structural Controls on the Formation of Irish Zn-Pb Deposits. *Economic Geology,* v.114, no. 1, 93–116.

Lees, A. & Miller, J., (1995) Waulsortian banks. In Monty, C.L.V., Bosence, D.W.J., Bridges, P.H. and Pratt, B.R. (Eds.), *Carbonate Mud-Mounds. Int Assoc Sediment Spec Pub 23, Blackwell Science, Oxford*, 191-271.

McCusker, J., & Reed, C , (2013) The role of intrusions in the formation of Irish-type mineralisation. *Miner. Depos*. 48, 687–695. https://doi.org/10.1007/s00126-013-0474-3

Slezak, P., Hitzman, M.W., van Acken, D., Dunlevy, E., Chew, D, Drakou, F. & Holdstock. M. (2023) Petrogenesis of the Limerick Igneous Suite: insights into the causes of post-eruptive alteration and the magmatic sources underlying the Iapetus Suture in SW Ireland. *Quarterly Journal Geological Society*. v.180, 16p.

Steed, G. M. (1975) The geology and mineralization of the Gortdrum district, Ireland. Unpub. Ph.D. thesis, University of London.

Steed, G.M. (1986) The geology and genesis of the Gortdrum Cu-Ag-Hg orebody. *In:* Andrew, C.J., Crowe, R.W.A., Finlay, S., Pennell, W.M. and Pyne, J.F. (Eds.*). Geology and Genesis of Mineral Deposits in Ireland: Dublin, Irish Association for Economic Geology*, 481-499.

Strogen, P. (1983) The Geology of the Volcanic Rocks of Southeast County Limerick, Unpub. PhD thesis, Faculty of Science. University College Dublin, 609.

Walsh, J.J., & Watterson, J. (1989) Displacement gradients on fault surfaces: *Journal of Structural Geology*, v. 11, p. 307–316.

Walsh, J.J., Bailey, W.R., Childs, C., Nicol, A., & Bonson, C.G. (2003) Formation of segmented normal faults: A 3–D perspective: *Journal of Structural Geology*, v. 25, p. 1251–1261.