1. Irish Zn-Pb Ores: Background

- Since the 1960s, Ireland has seen 5 carbonate-hosted Zn-Pb orebodies mined and over 20 sub-economic prospects discovered (Fig. 1). After the closure of Lisheen mine in 2015, only 1 operational mine remains: Tara mines in Navan.
- Ireland is in a position to become a leader in Zn production, but for more targeted Zn exploration, our current understanding of ore formation needs to be improved.
- EMPA trace element analysis can be used to understand hydrothermal fluid processes. This will help identify geochemical haloes around orebodies and thereby enhance exploration strategy.

2. The Lisheen deposit: Background

- The Lisheen deposit (Fig. 2; 33 Mt at 13.3 % Zn and 2.3 % Pb) in the southern Irish ore field formed by the replacement of Lower Carboniferous limestone, triggered primarily by fluid mixing (Wilkinson et al., 2005).
- Lisheen mine was active for over 15 years, leaving a wealth of deposit understanding. It offers an excellent testing ground for potential geochemical vectors.
- This poster presents work on the high-grade Island Pod orebody in the northern part of the mine.

3. Electron microprobe analysis (EMPA): Results

- Several generations of sphalerite, galena and pyrite were analysed by EMPA from the Island Pod orebody and its sub-economic halo (n = 574).
- EMPA data for Fe, Mn, Co, Ni, Zn, As, Pb, Bi, Mo, Ag, Cd, Tl, S, Sb, Se, Cu, Au and Sb were collected at Memorial University Newfoundland and the Natural History Museum, London.
- Sphalerite Fe content was the most variable, with a maximum value of 6.09 wt. % (Fig. 3a). Elevated Fe correlates with low 5 isotope ratio (not shown), interpreted to be derived from bacteriogenic reduction of seawater sulfate.
- Pyrite, commonly growth-zoned, showed most variation with significant values of Co (maximum 15.1 wt. %), As (maximum 9.6 wt. %), Ni (maximum 11.2 wt. %), and Tl (maximum 1.0 wt. %) (Fig. 3b). Concentrations of Co, As, Pb and Tl are distinctly higher in main ore stage pyrite than in pre-ore stage (diagenetic) pyrite.
- Galena was relatively clean, with Zn and Fe being the most common trace elements, likely due to inclusions of sphalerite and Fe sulfides.

4. Pyrite trace element variation: Orebody vs halo

- Mean concentrations of As, Tl, Ni and Co are about 40-80% lower in the sub-economic halo than in the orebody (Fig. 4a, Table 1).  

<table>
<thead>
<tr>
<th>Element</th>
<th>Orebody mean (wt.%)</th>
<th>Halo mean (wt.%)</th>
<th>n above detection limit</th>
<th>As vs Ti (%</th>
<th>wt.%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Co</td>
<td>0.34</td>
<td>0.12</td>
<td>111</td>
<td>0.12</td>
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<td>1.25</td>
<td>104</td>
<td>1.25</td>
<td>4</td>
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<tr>
<td>Tl</td>
<td>0.54</td>
<td>0.34</td>
<td>111</td>
<td>0.34</td>
<td>51</td>
</tr>
<tr>
<td>Ni</td>
<td>1.45</td>
<td>0.39</td>
<td>111</td>
<td>0.39</td>
<td>51</td>
</tr>
</tbody>
</table>

5. Pyrite trace element variation: Intra-grain scale

- Pyrite mineral chemistry can record the hydrothermal evolution of a mineralizing system.
- Island Pod pyrite preserves oscillatory zoning (Fig. 5a-b), indicating episodic flow of hydrothermal fluids.
- Intra-grain and other small scale (<250 μm) variation suggests a continuously evolving mineralizing system, which received fresh pulses of trace element-bearing fluids (Fig. 5a-c).
- Commonly, As and Co concentrations systematically increase from pyrite cores to rims. Changes in As from one band to another of up to 3 wt. % are characteristic of precipitation from distinct pulses (Caruso et al., 2018).

6. Applications: Exploration and Sustainable Development Goals

**Exploration applications**

- Pyrites offer a useful tool for understanding the genesis of ore deposits, with a single grain potentially recording the entire fluid history of a system.
- Pyrite trace element differences between the Island Pod orebody and its sub-economic halo suggest a potential application of pyrite mineral chemistry as a vector towards mineralization.

**Sustainable Development Goals (SDGs) applications**

- Zn has a role to play in several of the SDGs (Fig. 6). From its use as a fertiliser in agriculture (SDGs 2, 3) to its potential use in long term energy storage (SDGs 7, 11, 12, 13), Zn demand will increase with sustainable development.
- Ireland has an opportunity to be a world leader in Zn production, and significantly contribute towards achieving several of the SDGs.

References:

