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Slow and Steady or Episodically Catastrophic? Timescales and Processes for Hydrocarbon and Metallic Resource Development

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A range of geochemical data has been used to navigate the complexity of systems that build critical energy resources. Society's need for hydrocarbons and metals are among these resources. However, petroleum and ore deposits are traditionally studied as two completely different disciplines in geoscience. We argue that they share a common heritage, or at a minimum an intersection in that the source rocks for oil also present source rocks for metals in sedimentary basins.

In this presentation, we demonstrate the value of merging the study and teaching of these two disciplines: petroleum geology and ore deposit geology associated with sedimentary basins. We present several possibilities, for example, **(1)** the hydrothermal fluid may be the hydrocarbon-carrying fluid, and **(2)** mixing of a hydrocarbon-bearing fluid with a metalliferous brine may precipitate sulfide intermingled with oil. The end locations for the two resulting resources, however, may be spatially displaced from one another.

Using a petroleum discovery from the Barents Sea as an example, we will illustrate the intimacy between metal and hydrocarbon deposition, and we will show petrographically the episodic, locally catastrophic events that formed the two resources in the same space. We will show critical relationships between replacement textures and explosive overpressure textures, the latter leading to capture of chalcedony-oil and barite-oil emulsions. We will show sulfide veins with visible oil inclusions. Sphalerite-galena-fluorite are all critical players. Our results highlight poorly understood infusions of sphalerite, co-mingled with oil, residing in biogenic carbonate rocks.

Further, from the perspective of ore geology, our interpretations challenge classic replacement textures in some ore-forming environments. Seemingly abrupt changes in sulfide mineralogy, or the switch to oxide minerals, may be violent rupture of earlier sulfides by catastrophic fluid ingress and infilling with a new mineralogy – rather than passive replacement as is the common interpretation.

Designing strategic sampling in these complex environments often requires many analyses to build a forest of persuasive evidence to inform exploration models. Reliance on small or isolated data sets may lead to highly erroneous interpretations. Application of Re-Os geochronology and

trace element geochemistry places fluid compositions in a time context, useful in both petroleum and sulfide settings. At the same time, this information distinguishes slow continuous deposition from small catastrophic events during construction of petroleum and ore systems. Long-term investment of industry in resource-related research rewards all parties, with the common goal of meeting the needs of society and expanding the technologies that will give humanity a more sustainable future. Cross-disciplinary approaches, marrying metals and hydrocarbons, will be essential for efficient exploration and advancement of resource knowledge.

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