Scanning-Electron-Microscope Petrographic Evidence for Distinguishing Organic-Matter Pores Associated with Depositional Organic Matter versus Migrated Organic Matter in Mudrocks

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ABSTRACT

Organic-matter (OM) pores are an important constituent of mudrocks and comprise the dominant or subsidiary pore network of many shale-gas and shale-oil systems. New research suggests that OM pores form not only in kerogen, as originally proposed, but also in solid bitumen and pyrobitumen. Identifying the type of nanometer- to micrometer-sized organic matter that is present in mudrocks is extremely difficult, if not impossible, using a scanning electron microscope (SEM). However, distinguishing whether the OM-pore hosted organic material exists in place or has migrated would allow the determination to be made whether the original organic material was kerogen or bitumen. Through the analysis of an extensive collection of SEM photomicrographs, we have determined that there are several petrographic criteria that can be used to separate depositional versus migrated organic matter. These criteria include: (1) organic matter occurring after cementation in mineral pores, (2) fossil body-cavity voids filled with organic matter, (3) dense, spongy pore texture of the organic matter, (4) abundant contiguous pores filled with organic matter having a spongy pore network, (5) no alignment of pores in organic matter (aligned OM pores are present in kerogen), (6) cracks in organic matter related to devolatilization, and (7) anomalously larger bubbles associated with development of two hydrocarbon phases.

To help understand the concept of depositional and migrated organic matter and associated OM-pore development, we present an idealized history of OM-pore development and evolution with increasing thermal maturation. Original depositional organic material is composed of kerogen, which can be transformed to bitumen and then oil, gas, solid bitumen, and pyrobitumen (char) during thermal maturation. When bitumen is produced from the kerogen, it can migrate into the mineral pore network and later transform to solid bitumen or pyrobitumen.

The final pore network within the mudrock may be dominated by OM pores. It is important to distinguish depositional organic-matter–hosted OM pores versus migrated organic-matter–hosted OM pores because the final OM-pore network and connectivity pathways are dependent on the proportions of the distribution of these two organic matter states. Migrated organic-matter–hosted pores mimic the three-dimensional distribution of the original mudrock mineral pore network and provide more extensive contiguous permeability pathways than isolated organic matter.