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Editorial: Remagnetization and Diagenesis

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Editorial on the Research Topic
Remagnetization and Diagenesis

Remagnetization by diagenetic processes is very common in rocks. Diagenetic processes can have a profound influence on magnetic minerals and the associated magnetic characteristics of rocks and sediments. Magnetic studies can provide valuable information on timing of diagenetic events and the nature/origin of environmental alteration. Diagenesis and associated remagnetization can obscure or remove primary magnetizations. Four contributions are included in this Research Topic.

Three of the papers focus on changes in sediments caused by hydrocarbons. Abdulkarim et al. using rock magnetic analysis, investigate the effect of hydrocarbon presence on magnetic mineral diagenesis in Cenozoic Sandstones in hydrocarbon fields (1,000–1,500 m depth) in the Catcher Area Development of the United Kingdom North Sea. They compared the results with those from nearby "background" dry-well sandstones. The objective was to determine if magnetic signatures can serve as a proxy for understanding petroleum reservoir systems. Samples with hydrocarbons contained hexagonal pyrrhotite, siderite, and potentially vivianite, lepidocrocite, greigite and paramagnetic iron sulphides compared to the background samples. The samples with hydrocarbons also reduced the iron-oxide signature (nanometric and micron-sized magnetite, hematite, and titano-iron oxides) compared to background samples. Hexagonal pyrrhotite found at the oil-water transition zones was interpreted to be related to biodegradation. Siderite abundance increased at shallower depths within the reservoir, which was attributed to vertical migration of hydrocarbons and biodegradation. The results suggest that mineral magnetism can be applied to the identification of oil-water transition zones, reserve estimation, production planning, and the determination of hydrocarbon migration pathways.

A second paper by Abdulkarim et al. described a magnetic approach using high temperature susceptibility (HT-χ) measurements to determine the position and thickness of the oil-water transition zone (OWTZ) in reservoirs. HT-χ data from core samples in Paleogene reservoirs of the United Kingdom Central North Sea revealed distinct signatures around the OWTZ. There were rapid increases in susceptibilities at temperatures <250°C around the OWTZ compared to the main oil leg where susceptibility increased at significantly slower rates and at higher temperatures. The HT-χ and Mössbauer data revealed that the variation in alteration characteristics at the OWTZ is due to the increasing concentration of hexagonal pyrrhotite and/or lepidocrocite. Hexagonal pyrrhotite was identified in reservoirs existing at temperatures of <80°C and is related to biodegradation. The lepidocrocite is found at the interface in deeper reservoirs and is interpreted to be related to cessation of biogenic activities and hydrolysis of hydrocarbons at the oil water interface.

Costanzo-Álvarez et al. examines the roll of petroleum microseepage and associated chemical and microbial processes in homogeneous strata and/or with the fluid transport properties of the rocks through which oil and gas migrate. They compared numerical modelling predictions using time-dependent, one-dimensional, simulation of the advection-diffusion equation for upward methane microseepage along with some field evidence for hydrocarbon transport. They examined results from two case studies, a monitoring borehole from a landfill in southern Ontario, Canada, and an oil well from the Eastern Llanos Basin in Colombia. Synthetic methane profiles correlate with resistivity data which is considered as direct proxy for hydrocarbon accumulation. Electron paramagnetic resonance data indicates that hydrocarbon microseepage and accumulation are controlled by lithology. Extractable organic matter and magnetic susceptibility data provide evidence for hydrocarbon-mediated near-surface chemical processes. The results suggest that some near-surface magnetic and geochemical anomalies reflect deeper hydrocarbon sources, which can be useful in reconnaissance surveys to map leachate plumes or oil reservoirs.

Heij and Elmore present an integrated paleomagnetic, rock magnetic and geochemical study of the two unoriented cores (St. Chester and Krocker) in the Devonian Antrim shale in the Michigan Basin. Alternating field (AF) demagnetization isolated a lower coercivity component (LC) from 0 to ~60 mT in the Krocker core which corresponds to a Jurassic (170 Ma ± 25) magnetization based on inclination only plots. Higher coercivity components (HC) in the Krocker core are unblocked from ~60 to 120 mT and occasionally exhibit stable unblocking temperature ranges (e.g., 150°C–450°C). The HC components in the Krocker core are unique to certain members within the Antrim shale with a poorly resolved Middle Permian/Late Triassic magnetization in the Paxton member and Late Pennsylvanian (305 Ma ± 10) component in the Norwood. The St. Chester well exhibited a slightly older (205 Ma ± 10) LC component than in the Krocker core. Rock magnetic parameters indicate the magnetization resides in PSD/SD magnetite in both HC and LC components. The magnetizations are interpreted to be chemical remanent magnetizations (CRMs) with the HC component residing in SD magnetite which formed during hydrothermal activity. The LC component likely resides in PSD/MD magnetite and is interpreted to have formed in response to fluid flow associated with tectonic uplift and/or hydrocarbon migration. Petrographic observations and δ18O data indicate minerals consistent with hydrothermal mineralization. Consistent anisotropy of magnetic susceptibility lineations, interpreted to be carried in paramagnetic Fe-rich clays, indicates either a long-lived paleocurrent direction or far-field tectonic shortening originating from the neighbouring Acadian orogeny.

Author contributions

RDE wrote the first draft and the other authors commented on the draft.

Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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