

Hydrothermal ore genesis: the role of carbon

M. Zentilli

Department of Geology, Dalhousie University, Halifax, Nova Scotia B3H 3J5, Canada
and

M.C. Graves

Cuesta Research Limited, Dartmouth, Nova Scotia B3A 1V8, Canada

Organic matter and its derivatives have long been recognized as essential participants in the formation of a variety of sedimentary and diagenetic ore deposits and as empirical components in higher temperature ore environments. Advances in the understanding of hydrocarbon migration and ore fluids allows an evaluation of interactions between them. The sequential consideration of source, mobilization, migration, trapping, and preservation provides a powerful framework for analysis of the interactions.

Source: Exhalations of methane or metal-bearing hydrothermal fluids both can provide nutrients that can lead to high productivity of not only metal and sulphur-fixing bacteria but bulk carbon in the form of increased biomass. Sedimentary and diagenetic concentrations of metals in reducing environments are preserved in rocks which are often also potential source rocks for hydrocarbons. As such these rocks are long term repositories of metals, sulphur, and carbon compounds. The oxidation of carbon in the diagenetic environment can result in the fixing of carbonate in rocks that otherwise would not become as potently reactive to any later fluids. Carbonate cementation imposes important constraints on the permeability history of any rock.

Mobilization: Maturation of hydrocarbons can be an agent in generating high fluid potentials aiding mechanically fluid expulsion and affecting the physical properties of the rocks. Further prograde metamorphic reactions continue to produce fluids which in the presence of carbon are restricted in their chemical properties. Overpressures thus generated often lead to hydraulic (brittle) fracturing in otherwise ductile rocks.

Migration: Migration of hydrocarbons is a process that moves reduced carbon and sulphur from a restricted source rock to reduced reservoir rocks, which may have had little reduced carbon before the process took place. The transport pathways can be hundreds of kilometres in lateral extent and can be used later by basinal fluids with metal carrying capacity. The transported carbon and sulphur are also available at these new sites for metal-carrying fluids of significantly different sources and later ages.

Trapping: Mechanically, hydrocarbons have the ability to keep pores open by preventing cementation. Chemically, both autochthonous and transported hydrocarbons can act as reductants and conveniently they reside in a porous reservoir. The trapped hydrocarbons prepare the reservoir for physical and/or chemical entrapment of metal-carrying fluid. Little evidence of this hydrocarbon may remain.

Preservation: The same reducing conditions necessary to preserve hydrocarbons from oxidation and destruction are required to preserve sulphides, hence the common association of bitumen or graphite with sulphides.

This framework is also useful in considering magmatogenic ore models. The presence of reduced (source-rock, migrating or trapped) carbon at the magma source, along the magma conduit or at the site of its final crystallization may dramatically alter magma chemistry (e.g., magnetite to ilmenite series) and ore-forming capacity. The interaction of magmas with carbon may have been an important factor in the genesis of many economic tin, tungsten, uranium, copper, gold, and even some nickel and PGE deposits.