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RECONSTRUCTING FLUID FLOW EVOLUTION FROM COMPRESSIONAL TO EXTENSIONAL REGIMES. LATE CORROSIVE FLUIDS: A KEY FACTOR FOR POROSITY FORMATION AND ENLARGEMENT

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Combined petrographic and geochemical evidence from different case-studies provide a general pattern to evaluate the role of earlier fluid circulation during the compressive regime of FFTB formation vs. the contribution of later fluid circulation related to extensional regimes, as well as to migration of fluids related to organic-matter maturation. Major fluid flow stages and fluid evolution are constrained through mineral paragenesis, isotopic signatures of carbonates ($\delta^{13}C$, $\delta^{18}O$) combined with fluid inclusion microthermometry of successive cement stages, as well as to isotopic signatures of related sulphates / sulphides ($\delta^{34}S$, $\delta^{18}O$).

Common trends in cement-fluid evolution for several studied cases that, in turn, have a major role in porosity evolution are:

(1) Cements and fluids during compression are relatively minor. Vein fills show strong evidence of deformation and elevated rock:water ratios. High salinities and $\delta^{18}O$ *vs.* SMOW of interpreted parental fluids indicate cements precipitated from squeezed basinal brines during folding and thrusting in the orogenic belts.

(2) Fold and thrust belt exposure and karstification is represented by the reopening of rock discontinuities (bedding surfaces, stylolites or fractures and veins filled by calcite cements from previous compressive regime). The karstic stage is thus characterised by enlargement of porosity - permeability of the reservoir rocks, as opposite to the preceding compressive regime.

(3) Mixing of brines with different chemistries and / or temperatures is a major process in porosity generation from shallow karst to thermal karst realms. Porosity formed by mixing corrosion ranges from connected micropores within the matrix to large karstic cavities (hundreds of metres in section) that can be observed in seismic profiles.

(4) Fluid inclusion microthermometry coupled to $\delta^{18}O_{carbonate\ mineral}$ from the same crystals provide evidence of major inflow of low salinity fluids at depth during extensional episodes. These episodes have a major control in releasing overpressured fluids that focus along original rock-discontinuities (fractures, enlarged karst conduits, open stylolites). Hydraulic brecciation and major mixing corrosion may occur during extension.

(5) Migration of corrosive overpressured fluids predates / accompanies hydrocarbon migration. Porosity formed or enlarged by overpressure, together with corrosion along rock-discontinuities and precursor cement crystal boundaries generates an interconnected pore-network during late diagenesis. During this stage, arrested diagenesis after initial hydrocarbon migration is essential for the preservation of the pore-network.

(6) The mineral association related / coeval to hydrocarbon migration may include siderite, dickite, quartz, fluorite, pyrite-marcasite and celestite-barite. This association is mostly found as

cavity-fill of open stylolites and veins or as a partial fill of post-corrosion cavities, as well as replacing earlier calcite / dolomite. Corrosion / replacement fronts usually develop outwards from stylolites and veins. The volume of this post-corrosion mineral association is minor and thus there is a net increase of porosity during hydrocarbon related late diagenetic stages.

(7) Isotopic signatures of pyrite-marcasite and celestite-barite suggest sulphate reduction processes. On the other hand, $\delta^{13}C$ of late carbonate cements indicate the release of organically-derived CO_2. The most-likely source of organic matter to fuel sulphate reduction should have been the migrating hydrocarbons.

Conclusions.-

Cement stratigraphy and microsampling for geochemical analyses of cements filling veins and cavities enables the reconstruction of 1) fluid-flow history and porosity evolution with accurate detail, as well as 2) the stage at which hydrocarbon migration occurred and its relation to the structural evolution of a particular region.

During fold and thrust belt formation, porosity was mostly destroyed in most studied cases. Squeezing of interstitial brines caused host-rock recrystallization and thus the lost of host-rock porosity. Minor flow of brines to discontinuities, either depositional or newly formed during the compressional regime, causes precipitation of calcite cements in veins and cavities. Compaction and / or directional stress formed pressure-dissolution and stylolite surfaces that sourced $CO_3^{=}$, Ca^{2+} and Mg^{2+} for cement precipitation. Shearing, recrystallization and boudinage should have mostly destroyed / obliterated remaining porosity if any.

Major cavitites form after opening of already existing veins and fractures due to stress relaxation during uplift and subaerial exposure of the fold and thrust belt and / or mixed corrosion during extensional regime.

Overpressure and circulation of corrosive fluids related to hydrocarbon migration are major processes for the increase of interconnected porosity in the reservoir units at depth during late diagenesis. Corrosion of cements and microcorrosion of the host-rock is of extreme relevance for permeability increase.

Fluid-flow during oil-charge is favoured by the existence of a network of discontinuities (bedding planes, fractures and veins, stylolites) within the reservoir-rock. Fractures formed during fold and thrust belt evolution may reopen and be used for hydrocarbon migration during a later extensional regime.