Mechanical-chemical coupling and self-organization in mudstones

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Shales and other mudstones are the most abundant rock types in sedimentary basins, yet have received comparatively little attention. Common as hydrocarbon seals, these are increasingly being targeted as unconventional gas reservoirs, caprocks for CO_2 sequestration, and storage repositories for waste. The small pore and grain size, large specific surface areas, and clay mineral structures lend themselves to rapid reaction rates accompanying changes in stress, pressure, temperature and chemical conditions. Under far from equilibrium conditions, mudrocks display a variety of spatio-temporal self-organized phenomena arising from the nonlinear coupling of mechanics with chemistry.

Beginning with a detailed examination of nano-scale pore network structures in mudstones, we discuss the dynamics behind such self-organized phenomena as pressure solitons, chemically-induced flow self focusing and permeability transients, localized compaction, time dependent well-bore failure, and oscillatory osmotic fluxes as they occur in clay-bearing sediments. Examples are draw from experiments, numerical simulation, and the field. These phenomena bear on the ability of these rocks to serve as containment barriers.

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Style of late Archaean crust formation as evidenced from geochemical and Nd isotopic composition of granitoids from NW part of the Dharwar craton, southern India

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Late Archaean granitoids in the NW part of the eastern Dharwar Craton (EDC) are divided into three suites viz. TTG gneisses, biotite monzogranites and porphyritic biotite granodiorites. The TTG gneisses are pre- to syn-tectonic and show variable SiO_2 and Al_2O_3, enriched LREE and depleted HREE. They exhibit unusual chemistry in having conspicuously higher FeO (T), K_2O, Ba, Cr and Ni compared to the typical TTGs.

The biotite monzogranites are mostly post-tectonic, and display evolved calc-alkaline compositions with high SiO_2, K_2O, LILE and LREE, depleted to undepleted HREE and strongly negative to no Eu anomalies. The porphyritic granodiorites exhibit post-tectonic calc-alkaline, sanukitoid-like character with expanded SiO_2, higher TiO_2, P_2O_5, Sr, Ba, Cr and Ni, and lower Rb. Compared to typical sanukitoids they, however, uniquely display distinctly higher K_2O, ΣREE and Th.

The granitoids probably evolved in a subduction environment characterized by a slab (oceanic plate) dipping westerly below a middle Archaean continent i. e. the western Dharwar craton. The TTG magmas were produced by melting of slab basalts followed by slight contamination from the overlying metasomatized mantle wedge, and then accreted into the crust. Subsequent slab break-off due to terrane accretion and resultant upwelling of hot mantle asthenosphere triggered melting of the extremely metasomatized mantle wedge. Thus the porphyritic granodiorites were formed and intruded into the crust. This resulted in melting of the TTG gneisses accreted earlier and generated the evolved monzogranites.

Monzogranites occurring east of the N-S Hungund-Kushtagi schist belt of the area show higher εNd but lower T_{DM} ages than those occurring west. This indicates that along the schist belt terranes of different histories were juxtaposed by horizontal plate-tectonic process (accretion). The terrain on the eastern side of the schist belt had only a juvenile late Archaean component, whereas that on the west had mixed juvenile and middle Archaean components.