Edge of chaos domain of Zhabotinskii CNN: Implications in hydrothermal ore-forming processes

D. XU[1,4,*], C. YU[2,4] AND Q. CHENG[3,4]

[1]School of Economics and Management, China University of Geosciences, Wuhan 430074, China (*correspondence: xdy@cug.edu.cn)
[2]Faculty of Geosciences, China University of Geosciences, Wuhan 430074, China
[3]Faculty of Science and Engineering, York University, Toronto, M3J 1P3, Canada
[4]State Key Laboratory of Geological Processes and Mineral Resources, China University of Geosciences, Wuhan 430074, China

In describing the dynamics of the complicated Belousov-Zhabotinsky reaction, Zhabotinskii proposed an axiomatic model [1]:

$$\frac{\partial\theta}{\partial t}=D_1\Delta\theta\{1-\eta[2+(\theta-1)^2]\}+B$$

$$\frac{\partial\eta}{\partial t}=D_2\Delta\eta-A\eta-\theta(\eta-1)$$

where θ and η are concentrations of the components, A and B are constant coefficients, D_1 and D_2 are diffusion coefficients. In this paper, the model was mapped into a cellular nonlinear network (CNN) named as Zhabotinskii CNN and the local activity and edge of chaos domains were calculated according to the theory and method described in [2]. The complete procedure and detailed conclusions can be found in [3].

Given practical initial and boundary conditions, choosing the system parameters A and B in the edge of chaos domain, we simulated meaningful patterns, some of which can be found in [3]. These patterns formed in the self-organization processes could be good supports to the idea that the onset of large hydrothermal deposits are at the edge of chaos [4]. The calculated edge of chaos domain could also be valuable for exploring many other complex phenomena in similar reaction-diffusion processes such as those involved in hydrothermal ore-formation.

This work was financially supported by NSFC (Nos. 40972205, 40872195, 40525009 and 40638041).

[1] Zhabotinskii *et al.* (1974) *J. Theor. Biol.* **40**, 45–61.
[2] Chua (1997) *Int. J. Bifurcation & Chaos* **7**, 2219–1425.
[3] Xu *et al.* (2003) *Earth Science Frontiers* **10**, 487–492.
[4] Yu (1999) *Earth Science Frontiers* **6**, 85–102.

Sampling challenges in Re-Os geochronology of black shale

G. XU[1,2*], J. HANNAH[1,2], H. STEIN[1,2], A. ZIMMERMAN[1], G. YANG[1], S. GEORGEIV[1,2] AND B. BINGEN[2]

[1]AIRIE Program, Department of Geosciences, Colorado State University, Fort Collins, CO 80523-1482 USA (*correspondence: Guangping.Xu@colostate.edu)
[2]Geological Survey of Norway, 7491 Trondheim, Norway

Re-Os geochronology for black shales is successful for documenting depositional ages and paleoenvironemental changes. Re and Os are susceptible to post-depositional processes; thus, a sampling strategy grounded in geologic understanding is essential. Here we present Re-Os analyses of Triassic black shales from Svalbard outcrops and Svalis Dome (Barents shelf) drill core [1] to evaluate the effects of water leaching and spatial heterogeneity on Re-Os systematics.

Svalbard shales were leached 3 times, 30 min each, with MQ-H_2O in an ultrasonic bath. Each leachate was collected and dried. For these well-indurated, carbonate-cemented shales, leaching removed only 0.2-0.4 wt%. The unleached shales, leached shales, and leachate, however, all have different $^{187}Re/^{188}Os$ and $^{187}Os/^{188}Os$. Svalis Dome shales are poorly indurated, and leaching removed a significant amount of material. Again, the leached and unleached shales have different Re-Os compositions. These tests indicate that water leaching in natural settings (e.g. groundwater flushing or subaqueous outcrops) can disturb the Re-Os system.

It has been proposed that large homogenized samples of black shale (>20g [2]) are necessary to avoid any small scale Re-Os decoupling. For indurated Svalbard shale, <1g samples yield only minor differences in isochron statistics. Re-Os analyses of <1g samples from Svalis Dome, in contrast, fall off the isochron defined by large samples (>20g). Other Re-Os studies using 5g to <0.5g samples lead to excellent isochrons (e.g. Late Permian shale from the Mid-Norwegian Shelf [3], Archean shale from the Superior Province [4]). Homogenizing large samples (~100g [5]) can unnecessarily limit $^{187}Re/^{188}Os$ variations, producing large age uncertainties.

Our results suggest that black shales exposed to surface waters or groundwater flushing should be avoided [6]. The best sample size to secure ‘closed system’ isochrons depends on the age and induration of the black shale, and must be determined independently for each geologic environment.

Funding: NFR Petromaks 180015/S30, Statoil, Eni Norge.

[1] Xu *et al.* (2009) *EPSL* **288**, 581–587. [2] Kendall *et al.* (2009) *Geol. Soc. London, Special Publications* **326**, 85–107. [3] Georgiev *et al.* (2009) *Eos, AGU* GP23B-0795. [4] Yang *et al.* (2009) *EPSL* **280**, 83–92. [5] Selby *et al.* (2009) *Chem. Geol.* **265**, 394–409. [6] Hannah *et al.* (2008) *GCA* **73**, A491.