Re-Os shale ages constrain onset and duration of Late Jurassic anoxia, Barents Shelf

S. GEORGIEV[1,2], H.J. STEIN[1,2,3], J.L. HANNAH[1,2,3], B. BINGEN[1], H.M. WEISS[4]

[1] Geological Survey of Norway, 7491 Trondheim, Norway, georgiev@colostate.edu (* presenting author)
[2] AIRIE Program, Colorado State University, Fort Collins, CO, USA
[3] Physics of Geological Processes, University of Oslo, Norway
[4] SINTEF Petroleum Research, 7465 Trondheim, Norway

Organic-rich marine shales with excellent oil-generation potential were deposited in abundance during the Late Jurassic. These include the Kimmeridge Clay Formation, the main source rock for North Sea oils, and areally extensive black shales in North Alaska, Arctic Canada, the Barents Shelf and Northern Siberia [1]. One of them, the Hekkingen Formation, is the most widespread, though variably mature, hydrocarbon source rock on the Barents Shelf. We report high precision Re-Os isotopic data and geochemical data for three intervals from a condensed section of Hekkingen Formation in the Nordkapp Basin, southwestern Barents Sea.

We sampled shales of the Hekkingen Formation from two shallow drillcores [2], previously subject to detailed biostratigrahpic studies [3]. Shales at the base of the lower Alge Member yield a Re-Os age of ~158 Ma with an initial $^{187}Os/^{188}Os$ ratio of ~0.45. Up section, shales of the overlying Krill Member yield a Re-Os age of ~147 Ma and initial $^{187}Os/^{188}Os$ ratio of ~0.63.

Rock-Eval pyrolysis shows that the organic matter is thermally immature (T_{max} ~400 to 410 °C) and of mixed marine-terrestrial origin (kerogen type II/III predominates). The high total organic carbon (9-19 wt%) and lack of bioturbation, combined with unusually high enrichment in redox-sensitive trace elements Re, Os, Mo, U, Se and V, indicate deposition of the Hekkingen shales under oxygen-free bottom water conditions. Extreme enrichment in Ag, Zn, Ni, Cr, Cu, Cd, Sb, As and Tl, even for black shales, may stem from a high degree of anoxia combined with slow sedimentation in a distal setting with minimal clastic input.

The Re-Os ages provide time pins for the onset (~158 Ma) and duration (at least 11 m.y.) of Late Jurassic anoxia in the Barents Shelf, and for sedimentation rates of organic-rich muds with extreme trace metal concentrations. Additionally, comparison of Re-Os ages with detailed biostratigraphy provides new radiometric constraints for the age of the Kimmeridgian-Tithonian boundary. Rising initial Os isotope ratios from the Oxfordian to the Kimmeridgian shales mirror rising seawater Sr isotope ratios throughout the latest Jurassic [4]. These parallel trends suggest that the initial $^{187}Os/^{188}Os$ of shales records the $^{187}Os/^{188}Os$ of contemporaneous Late Jurassic seawater. The trend toward more radiogenic Sr isotope ratios may reflect decreasing mid-ocean ridge production [4], rather than changes in continental weathering rates.

Funding: NFR Petromaks project 180015/S30

[1] Leith et al. (1992) *NPF Spec. Publ.* **2**, 1-25. [2] Bugge et al. (2002) *Mar. Petr. Geol.* **19**, 13-37. [3] Wierzbowski and Smelror (1993) *Acta Geol. Pol.* **43**, 229-249. [4] Jones et al. (1994) *GCA* **58**, 3061-3074.

Intrabasaltic Regoliths in the Deccan (India) and Karoo traps (Lesotho): witnesses of volcanic quiescence and environmental links.

MARTINE GERARD[1*], FREDERIC FLUTEAU[2], VINCENT COURTILLOT[2] AND MAUD MOULIN[3]

[1] IMPMC, IRD, Université Pierre et Marie Curie, Paris, France, martine.gerard@impmc.upmc.fr (* presenting author)
[2] IPGP, Université Paris Diderot, Paris, France
[3] Dpmt de Géologie, Université Jean Monnet, Saint Etienne, France

Large igneous provinces (LIP) are often synchronous with major mass extinctions. Intertrappean layers ("red boles") correspond to periods of volcanic quiescence. Their study complements other methods, and may help to quantify how volcanic activity translates into major environmental perturbations. Geomagnetic secular variation recorded by lavas can be used as a relative time proxy (1,2), providing an estimate of the time needed to generate these regoliths. We have studied a 1200m thick stack of flows in the Deccan and Karoo LIPs. In the Deccan, 22 red boles occur between volcanic flows. Most consist in 5-10cm thick red clayey material filling joints and diaclases at flow contact, located in the frontal part of flow lobes. Only 5 red boles are thicker, but their lateral extent (less than 1km) prevents a stratigraphic reconstruction. The more mature regoliths (a few meters thick) correspond to weathering profiles of massive basalts. Red compact silty clay with relics of feldspars and voids grades into orange silty clay with friable vesicular relics of blocks of basalts, overlaying brown clay jointed lava and massive altered lava. Mineralogical parageneses and micromorphological observations indicate strong hydrolysis and also (deuteric or metasomatic) hydrothermal alteration. No organic relics were found. The duration of formation is likely much less than 10000 years for the more evolved regoliths, when compared to similar paleosols affected by hydrothermalism. Most red boles we observed in the top part of the Deccan lava pile were probably formed in less than 1000 years, consistent with the magnetostratigraphic study [1].The Karoo intra-basaltic regoliths are much less developed and numerous [2]. The red weathered horizons and hydrothermalized contacts always occur within lava lobes, more easily affected by alteration and topographic irregularities. At the base of the section, more or less baked sandstone interbeds have recorded a minor mineralogical signature of weathering from the surrounding lava flows. The altered bases of the overlying lava flows and the baked sediments suggest humid lacustrine conditions. The weathering profiles in the upper part of the section are basaltic saprolites with a summital horizon of smectites-hematites. Within a few profiles, silty quartz may also suggest colluvial paleosols. As is the case for the Deccan regoliths, zeolitic parageneses suggest a strong impact of hydrothermalism. Compared to the Deccan, the Karoo intertrappean layers suggest much more arid climatic conditions that would have drastically limited the occurence of weathering.

[1] CHENET et al. (2009), *JGR,* **114**, doi:10.1029/2008JB005644.
[2] MOULIN et al. (2011), *JGR,* **116,** doi:10.1029/2011JB008210.