What is source rock?

H.J. STEIN[1,2] AND J.L. HANNAH[1,2]

[1] AIRIE Program, Colorado State University, Fort Collins, CO, USA
[2] Physics of Geological Processes, University of Oslo, Norway

From the perspective of a commodities expert, the likely answer will be organic-rich shales with hydrocarbon potential, or metal-bearing magmatic or sedimentary systems. You're either a petroleum geologist or an ore geologist, and the two professions typically stay on their own side of the fence. Has anyone seen a petroleum geologist regularly gobbling-up science at ore geology meetings or, even more unheard of, the reverse? And up the middle, are those studying "fluids in the crust", knowing the economic potential of their efforts but feeling uncertain how to access it – how to break into the terminology and be embraced as an outsider in resource-driven clubs. These are the statements that give us pause and discomfort.

The futures of research in both resource fields, hydrocarbons and metals, are co-dependent. The big leaps in commodity-driven science will be made by those who move unabashed between these two fields. Too many ore geologists fall back on the same tired models, never stepping outside their own sandbox to explore different ways to play. Ore deposits are formed by "deep-seated mantle-derived fluids" or by "granite-derived fluids", we are told. Who stops to consider the importance of organic complexes, or the chemical and physical consequences of hydrocarbon maturation? Similarly, how many petroleum geologists ponder the metal porphyrins that populate hydrocarbon systems, and what becomes of those metals as the organic molecules are cracked?

Modeling the mobility and concentration of both metals and hydrocarbons requires a keen understanding of fluids and volatiles in all kinds of rocks. Source rock is any rock that experiences breakdown of kerogen or undergoes oxidation thereby liberating metal from sulfide, silicate, or organic-rich material. Neither process is very interesting in the absence of water and CO_2, a pressure gradient, and space to move.

It is the fluid and volatile phases in rocks that move natural resources into place. The processes involved may be incremental to catastropic. The time scales may be instantaneous to hundreds of millions of years depending on one's perspective. But the notion that an ore deposit in the crust had a direct pipeline to the mantle should be put to rest. Rather, large scale mantle events stimulate processes in the crust over long time-scales. Source rock can be any rock implicated in the process with volatile, fluid, metal, or hydrocarbon to contribute.

Field-based examples that capture these processes are explored in this contribution. Processes that "upgrade metals" and "downgrade kerogen" are constrained in absolute time through precise Re-Os dating of sulfides and hydrocarbon.

Mantle plume chemical asymmetry - implications from geodynamic models

BERNHARD STEINBERGER[1,2*], RENÉ GASSMÖLLER[1] AND ELVIRA MULYUKOVA[1]

[1]GeoForschungsZentrum Potsdam, Potsdam, Germany, bstein@gfz-potsdam.de (* presenting author)
[2]Physics of Geological Processes, Univ. of Oslo, Oslo, Norway

Introduction

Recent results indicate that mantle plume composition systematically varies with position relative to the plume center, and that this heterogeneity could correspond to different regions where the plume material came from before rising through the plume conduit [1,2]. Here we present results of a numerical model regarding the relation of source region and location in the plume.

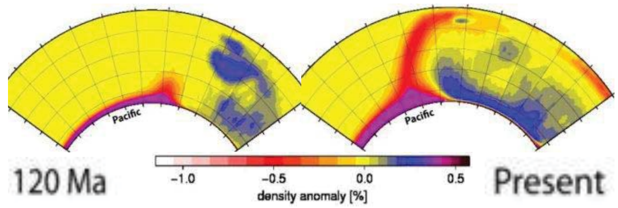

Figure 1: Cross sections for a mantle model [3]. Subducted slabs (blue) sink to the base of the mantle, and push hot material from the thermal boundary layer (red) towards the edges of thermo-chemical piles (violet) where it rises in the form of mantle plumes.

Observations and Models

Almost all Large Igneous Provinces, when reconstructed to their eruption locations, fall above the margins of either of the two Large Low Shear Velocity Provinces beneath the Pacific and Africa [4], often viewed as chemically distinct. Based on plate reconstructions since 250-300 Ma, we model a pattern of several plumes each at the edges of two thermo-chemical piles in the lowermost mantle, both with a numerical code based on spherical harmonics [5] and the finite element code CitcomS [6,7]. We develop a 2-D finite element code that allows us to accurately model entrainment of chemically distinct material in plumes.

Results and Conclusions

Model plumes often occur at locations similar to observed hotspots with conduit shapes similar to [8] where flow is based on tomography-based density models. By tracking along flow lines, both for subduction- and tomography-based flow superposed with plume influx, we map source regions onto predicted location in the plume. The mapping allows insights into the element distribution in the source region by comparing the properties of plume-related magmas. Furthermore, comparing the created models allows us to constrain under which conditions plumes entrain chemically distinct material in their source region and whether these are likely to occur on earth. Based on high-resolution 2-D results we assess entrainment and where inside the conduit chemically distinct material is expected to occur.

[1] Weis *et al.* (2011) *Nat. Geosci.* **4**, 831-838. [2] Huang, Hall & Jackson (2011) *ibid.*, 874-878. [3] Steinberger & Torsvik [2012] *G-Cubed* **13,** Q01W09. [4] Torsvik et al. [2006] *GJI* **167**, 1447-1460. [5] Hager & O'Connell [1981] *JGR* **86**, 4843-4867. [6] Zhong et al. [2000] *JGR* **105**, 11063-11082. [7] Tan et al. [2006] *G-Cubed* **7**, Q06001. [8] Steinberger & O'Connell [1998] *GJI* **132**, 412-434.