Salt, Shale and Igneous Diapirs in and around Europe

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Salt, Shale and Igneous Diapirs in and around Europe

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Preface

Despite their differences in size and scale, shale, salt and igneous intrusions display many similarities. For example, at the time of emplacement, the material forming all three types of intrusions (viscous or not) is always much weaker than the country rocks. Units of halite, granitic magma, or overpressured shale cannot sustain large deviatoric stresses without deforming, which makes them highly mobile rocks, provided there is space available into which the intrusive material can flow. All intrusions pierce, or appear to pierce, surrounding country rocks having a wide variety of lithologies. All three types of intrusions have experienced much more internal strain and vertical movement than the country rocks. All have risen, at least partly, in the upper continental crust. Another similarity these three types of intrusion have is that their formation has traditionally been attributed to the same geological process, Rayleigh–Taylor instabilities. This is the process in which a weak, viscous, less-dense material (the intrusion) can spontaneously rise through and deform denser country rocks that are assumed to behave viscously and to have negligible yield strength. The latter assumption has been challenged by rock-mechanics data and geological observations. Apart from magmas, evaporites, and overpressured shales, most rocks in the upper continental crust exhibit a rheological behaviour controlled by elastic and frictional properties. The strength of the country rocks is typically considerably higher than (1) the strength of the intrusive rocks and (2) the deviatoric stress generated by small instabilities at the interface between the intrusion's source layer and the overlying rocks.

The three types of intrusions also differ. Evaporitic intrusions are fed typically by a laterally continuous layer, and the rheological properties of the intrusive material do not change drastically throughout the time of emplacement. In contrast, the material forming mud volcanoes and igneous intrusions does not originate from a continuous layer but is fed by more locally restricted sources, where thermal and mineralogical conditions make the source rocks weak and mobile. Both magma and overpressured shale tend to gain strength during their ascent, as the fluid pressure and temperature decrease.

Most recent literature suggests that researchers working in all three fields no longer support the traditional Rayleigh–Taylor instability mechanism and now favour a mechanism in which the weak, intrusive material rises through much stronger country rocks. Typically some amount of tectonic deformation is required to overcome the strength of the country rocks. For example, normal faulting caused by regional extension thins and weakens the country rocks and creates the accommodation space in which intrusions can rise. Regional contraction or transtension squeezes the weak, mobile intrusive material and thereby provides the additional pressure required for the intrusion to lift and deform the overlying country rocks.

Most of the articles herein illustrate how emplacement of intrusions is associated with regional or local tectonics. **Vigneresse & Clement** discuss arguments in favour of various mechanisms of granitic magma emplacement and emphasizes the role of regional tectonics in allowing igneous intrusions to rise. **Román-Berdiel *et al.*** illustrate, by means of experimental models and field observations in the Spanish Variscan belt, how transtensional tectonics can control the mode of emplacement of granitic plutons. **Merle & Donnadieu** address the combined influence of thin-skinned (gravity-driven) and thick-skinned (tectonic) deformation on the geometry and kinematics of faulting above magmatic intrusions. **Rossetti *et al.*** demonstrate how regional, post-orogenic extension has controlled the emplacement of monzogranitic intrusions in the northern Tyrrhenian region. **Rabinowitz & Mart** present seismic tomography data from the Dead Sea rift that suggest the presence of a magmatic intrusion at depth caused by transtension. **Talbot *et al.*** provide new data on the rates at which salt diapirs in the Zagros region rise and spread. **Gaullier *et al.*** illustrate the different styles of salt structures in and around the Nile deep-sea fan, where regional thick-skinned tectonics interact with thin-skinned, gravity-driven tectonics. **Stephanescu *et al.*** present seismic-reflection data from Romania, the area where the term *diapir* was first defined, and demonstrate how regional tectonics has triggered and controlled salt-diapir rise and evolution. **Miralles *et al.*** describe the internal geometry of evaporitic diapirs in the south Pyrenees. The last article, by **Kopf & Behrmann**, shows that mud diapirism in the Mediterranean Ridge was a rapid but episodic process related to tectonic-plate convergence.

We hope that the several examples provided in this publication will help future studies focus on the role of regional tectonics in controlling intrusion emplacement, a process that was previously thought to depend solely on the internal properties of source and country rocks. We also hope that the many similar characteristics of various types of intrusions illustrated herein will provide an impetus for further, multidisciplinary approaches in all three fields.

The content of this Special Publication was derived from a symposium entitled 'From the Arctic to the Mediterranean: Salt, Shale and Igneous Diapirs in and around Europe'. The symposium was convened in 1998 by Yossi Mart and Bruno Vendeville at the 23rd General Assembly of the European Geophysical Society in Nice, France.

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