Computers & Geosciences 37 (2011) 1450–1459

Contents lists available at ScienceDirect

Computers & Geosciences

journal homepage: www.elsevier.com/locate/cageo

"SIGMELTS": A web portal for electrical conductivity calculations in geosciences☆

A. Pommier[a,]*, E. Le-Trong[b]

[a] Massachusetts Institute of Technology, Department of Earth, Atmospheric, and Planetary Sciences, 77 Massachusetts Avenue, Cambridge, MA 02139, USA
[b] CNRS/INSU, Université d'Orléans, Université François Rabelais-Tours, Institut des Sciences de la Terre d'Orléans (ISTO), UMR 6113, Campus Géosciences, 1A rue de la Férollerie, 45071 Orléans Cedex 2, France

ARTICLE INFO

Article history:
Received 13 April 2010
Received in revised form
10 November 2010
Accepted 11 January 2011
Available online 5 February 2011

Keywords:
Electrical conductivity
Database
Laboratory measurements
Geoelectrics
Magnetotellurics

ABSTRACT

Electrical conductivity measurements in the laboratory are critical for interpreting geoelectric and magnetotelluric profiles of the Earth's crust and mantle. In order to facilitate access to the current database on electrical conductivity of geomaterials, we have developed a freely available web application (SIGMELTS) dedicated to the calculation of electrical properties. Based on a compilation of previous studies, SIGMELTS computes the electrical conductivity of silicate melts, carbonatites, minerals, fluids, and mantle materials as a function of different parameters, such as composition, temperature, pressure, water content, and oxygen fugacity. Calculations on two-phase mixtures are also implemented using existing mixing models for different geometries. An illustration of the use of SIGMELTS is provided, in which calculations are applied to the subduction zone-related volcanic zone in the Central Andes. Along with petrological considerations, field and laboratory electrical data allow discrimination between the different hypotheses regarding the formation and rise from depth of melts and fluids and quantification of their storage conditions.

1. Introduction

In the past 20 years, substantial improvements in the magnetotelluric (MT) method have allowed detection of numerous conductivity anomalies in the Earth's crust and mantle. These anomalies have been typically attributed to the presence of partial melt and fluids (e.g., Ingham, 1988; Jödicke et al., 2006; Baba et al., 2006; Wannamaker et al., 2008). Deep geoelectrical soundings are a robust tool for investigating the mechanisms of melt and fluid formation at depth (e.g., Evans et al., 2002; Brasse and Eydam, 2008). The distinction among silicate melts, carbonatites, and aqueous fluids as well as the determination of their storage conditions (*P*, *T*, composition, melt, or fluid fraction) requires the use of electrical measurements in a laboratory (Pommier et al., 2010c). Several laboratory studies have investigated the dependence of the electrical properties of magmas and mantle materials as a function of different parameters, such as composition, temperature, pressure, water content, and oxygen fugacity (e.g., Tyburczy and Waff, 1983, 1985; Satherley and Smedley, 1985; Gaillard, 2004; Huang et al., 2005; Pommier et al., 2008, 2010a, 2010b; Wang et al., 2006; Yoshino et al., 2008). Although there are examples where the laboratory data have been used to interpret field data (e.g., Tarits et al., 2004; Evans et al., 2005; Jödicke et al., 2006; Brasse and Eydam, 2008; Wannamaker et al., 2008; Jones et al., 2009; Pommier et al., 2010c), there are also many instances where there are disconnects between those interpreting field MT data and the laboratory results. A solution to compensate for this problem is to make these laboratory data more accessible for the geophysical community. In this contribution, we present a freely available and easy-to-use web application (SIGMELTS), allowing the calculation of the electrical conductivity of geomaterials under relevant conditions for the Earth's crust and mantle. By compiling previous results of electrical measurements in the laboratory, this software enables the discrimination between the effects of different parameters on the bulk conductivity of silicate melts, carbonatites, fluids, minerals, and mantle materials, such as the temperature (*T*), the pressure (*P*), the composition, the water content, the oxygen fugacity (fO_2), and the crystal content. Different existing geometrical models are implemented to calculate the bulk conductivity of two-phase mixtures. Based on the electrical resistivity (=1/electrical conductivity) value of a mantle anomaly, an application has been developed that determines the corresponding melt fraction under defined conditions (*T*, *P*, composition). Calculations using SIGMELTS are finally applied to a subduction context, this illustration underlining the importance of coupling laboratory measurements and petrological considerations to interpret field data.

☆ Code available from server at http://www.calcul.isto.cnrs-orleans.fr/sigmelts/

* Corresponding author. Tel: +1 617 253 6398; fax: +1 617 253 7102.
E-mail address: apommier@mit.edu (A. Pommier).

0098-3004/$ - see front matter © 2011 Elsevier Ltd. All rights reserved.
doi:10.1016/j.cageo.2011.01.002

2. Software elaboration and computing details

SIGMELTS is a client-side-only web application written in JavaScript. As such all the computations and plotting are done within the browser. It relies on the jQuery framework for the interface (http://jquery.com/) and the Flotr library for the plots (http://solutoire.com/flotr/). The interface is articulated around several tabs for each type of computation and enforces the limitations of the models implemented (e.g., bound checking and mandatory parameters dynamically depend on the composition of the material considered). This allows an immediate, without a-priori learning, use of the software. The application is implemented as a template-instantiating engine: the complete data and logic of each tab are stored in a structure that is fed to a generic function generating the HTML tree and the Javascript functions needed. Adding a new tab boils down to adding a new data structure to the main Javascript file. The source code is released under the MIT license.

Seven tabs currently compose SIGMELTS. Five of them are dedicated to the computing of the electrical conductivities of silicate melts, carbonatites, common minerals, crustal fluids, and mantle materials under defined conditions. Two examples of these tabs are presented in Fig. 1A and B. The user can change the values of the input parameters (e.g., T, P, composition) in a

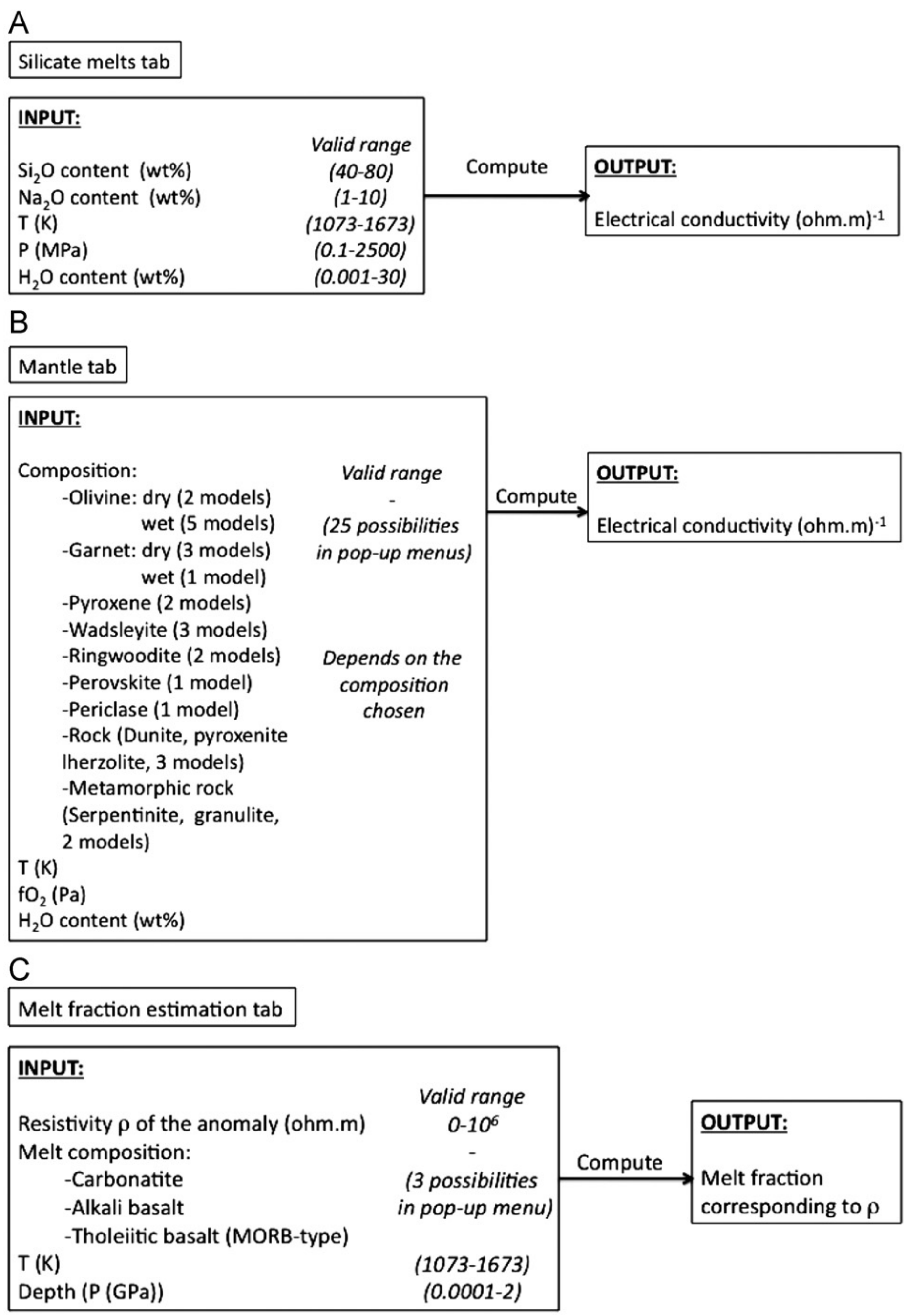

Fig. 1. Presentation of the use of SIGMELTS: examples of (A) "silicate melts," (B) "mantle," and (C) "MT anomaly interpretation tabs." Input parameters are entered by the user and consist in either a numerical value or a choice in a pop-up menu. The output value consists in the corresponding electrical conductivity value (A and B) or the melt fraction (C). Melt fraction in C is determined using the Hashin–Shtrikman upper bound (Hashin and Shtrikman, 1962).