LabEx OSUG@2020

Observatoire des Sciences de l'Univers de Grenoble

Ce projet est soutenu par le Laboratoire d'Excellence OSUG@2020 (ANR10 LABX56) financé par le programme d'Investissements d'Avenir lancé par l'Etat et mis en oeuvre par l'ANR.

Titre du projet : Three-Dimensional Resistivity and Magnetic Imaging of Vapor Dominated Areas in Yellowstone National Park.

Volet : Recherche

Porteur du projet : Claire Bouligand

Laboratoires impliqués : ISTerre

Bilan du projet pour l'année/la période

Bilan d'activité ***(1 page max)***

To better understand the geometry of ascending vapor plumes and their relation to geologic structures and hydrothermal alteration in vapor dominated systems, we carried a geophysical study in the Solfatara Plateau thermal area along the northern boundary of the Yellowstone caldera. This ~600 m x 600 m area consists of glacial deposits overlying a rhyolite flow. Thermal manifestations consist of a small mud pool and several small fumaroles with visible native sulfur deposits. In June 2016, we collected detailed electric resistivity, magnetic, Transient Electro-Magnetic (TEM), spontaneous potential (SP) and Nuclear Magnetic Resonance (NMR) data. Fourteen rock samples were also collected to measure the electric resistivity and magnetization properties of the altered and unaltered subsurface in the laboratory. The location of our measurements is displayed on Figure 1.

The electric resistivity survey included eleven 160 m-long profiles centered on the mud pool and also included two longer profiles (320 m and 480 m) to investigate deeper structures. The spontaneous potential was measured using two electrodes connected to a voltmeter, at about 100 locations. The 3D inversion of the electric profiles will provide us with an electric resistivity model of the upper 50 m of the subsurface. A preliminary model shows a conductive body beneath the mud-pool that may correspond to a vapor plume (Figure 2). The initial SP data shows large spatial variations suggesting a complex pattern of fluid flow.

NMR and transient electromagnetic soundings (40m x 40m or 100m x 100m) were performed at 12 different locations. The NMR soundings were hampered by too much cultural noise from the power line running through the area. Initial results from the TEM soundings suggest a shallow conductive layer (first 50 m) overlying a more resistive layer (100 m), and perhaps the water table at a depth of ~200 m.

The magnetic measurements had a spacing of ~5 m in the area that was also covered by the electric resistivity survey and a spacing of ~25 m in the rest of the study area. The magnetic data allows us to distinguish between areas where the rhyolite flow is outcropping (large amplitude anomalies due to large magnetization of the flow) and areas covered by glacial and hydrothermal deposits (lower amplitude anomalies due to the low amplitudes of anomalies). There is no magnetic low beneath the mud pool, possibly suggesting that the vapor plume is not associated with a strong degree of alteration. We also used a handheld susceptibility meter to measure the magnetic susceptibility of the ground at about 100 locations. These in-situ measurements show a low magnetic susceptibility

coinciding with the location of the electric conductor suggesting a strong degree of alteration at the surface above the vapor plume (Figure 2).

Preliminary results from this study were presented at AGU Fall Meeting 2016: Bouligand, C., S. Byrdina, A. Kass, T.P. Irons, J. Vandemeulebrouck, J.L. Ball, B.T. Ritzinger, E.G. McConville, S. Hurwitz, Geophysical imaging of a vapor dominated hydrothermal system in Yellowstone National Park, USA, AGU Fall Meeting, Abstract T43A-3021, 2016.

The field geophysical data were acquired under the research permit YELL-2016-SCI-7006 and benefited from the help of the National Park Services staff and the park rangers at Yellowstone National Park.

Illustrations - avec légende et crédit *(à envoyer également séparément)*

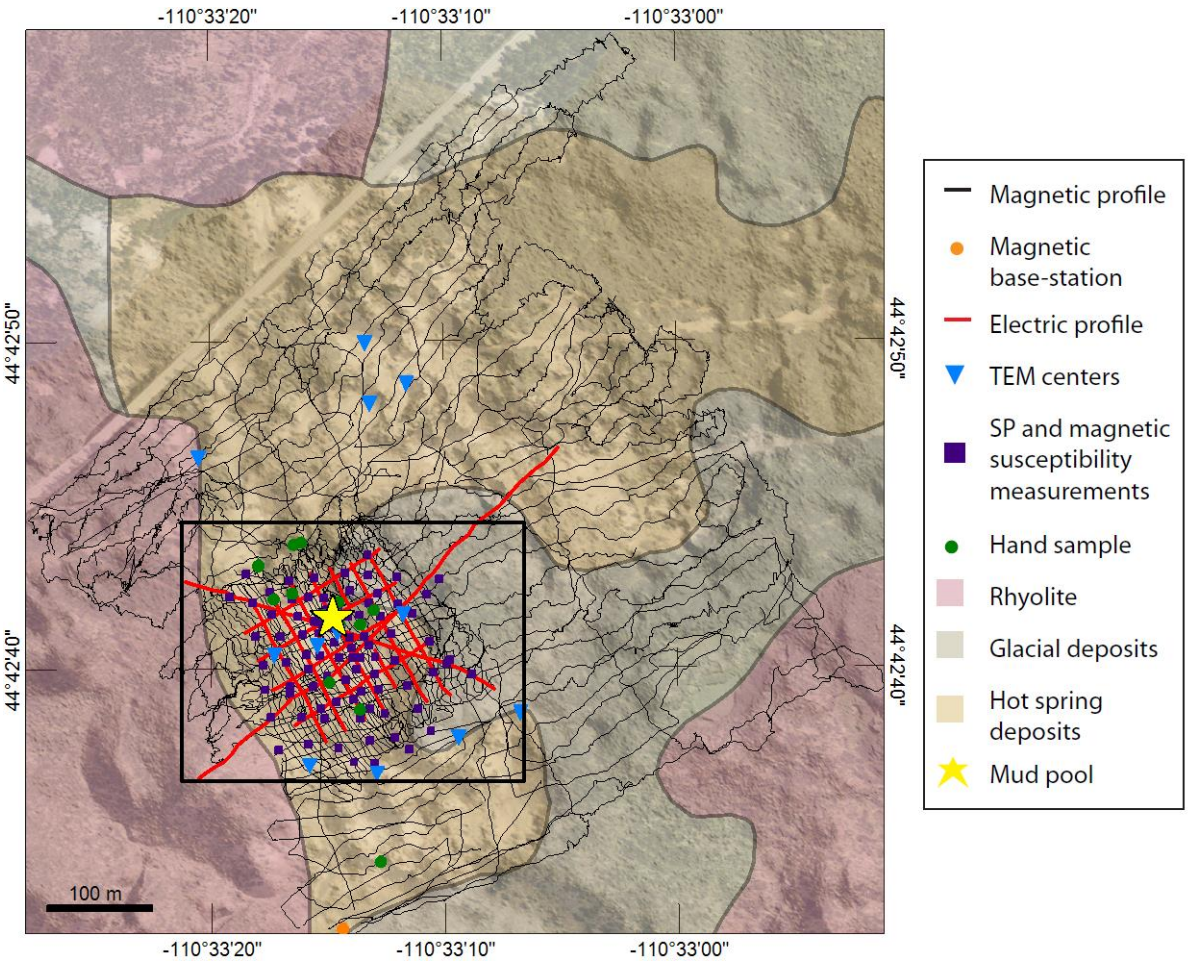

Figure 1: Geophysical data acquired at Solfatara Plateau Thermal Area during the field session in June 2016. Geological limits from Christiansen (U.S. Geological Survey Professional Paper, 729-G, 2001).

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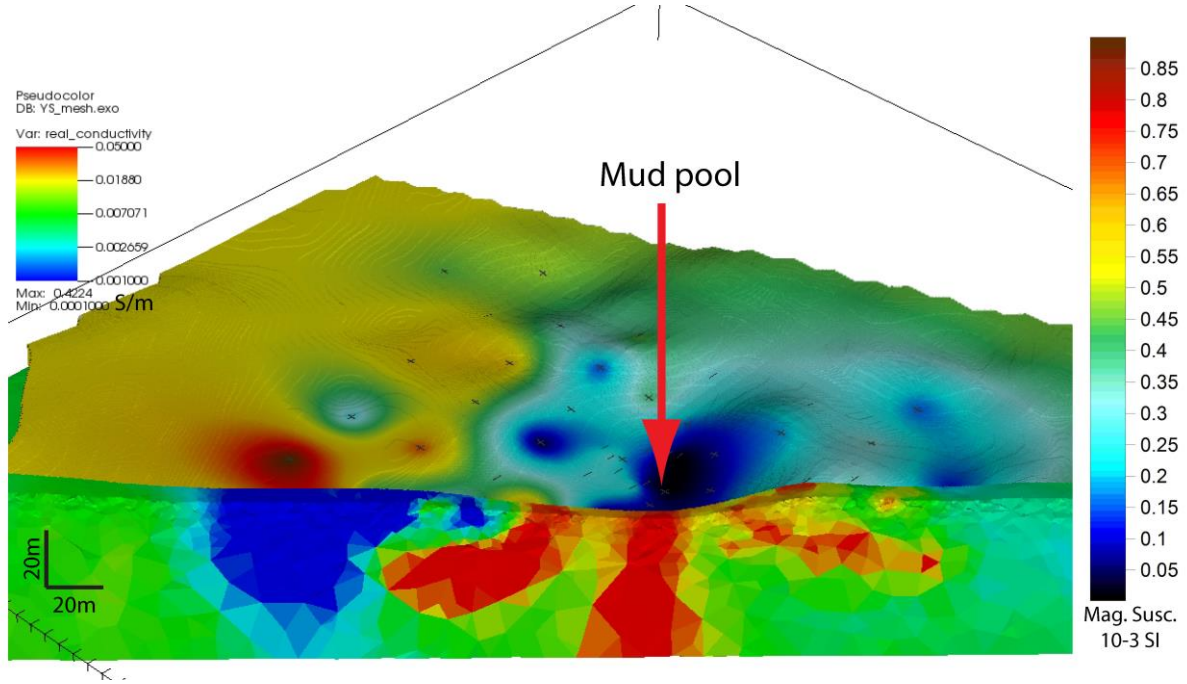

Figure 2: Cross-sections of the preliminary 3D model of electrical conductivity overlaid by the map of magnetic susceptibility deduced from in-situ measurements at the ground surface. We observe a correlation between the magnetic susceptibility low and the conductor imaged with electric resistivity tomography.

Production scientifique *(articles scientifiques, actes de congrès…)*

Bouligand, C., S. Byrdina, A. Kass, T.P. Irons, J. Vandemeulebrouck, J.L. Ball, B.T. Ritzinger, E.G. McConville, S. Hurwitz, Geophysical imaging of a vapor dominated hydrothermal system in Yellowstone National Park, USA, AGU Fall Meeting, Abstract T43A-3021, 2016.

Bilan financier succinct *(avec suivant les cas : co-financements éventuels, équipements achetés, missions, recrutements divers, fonctionnements divers…)*

Financement Labex 8000 euros

Co-financement : ISTerre AO interne 2000 euros

L'ensemble du financement a été utilisé pour la mission à Yellowstone de C. Bouligand, S. Byrdina et J. Vandemeulebrouck en juin 2016 :

Frais de transport (avion & voiture de location): 3193.29 euros

Equipement (location, transport & assurance) : 3927.61 euros

Frais sur place (nourriture & hébergement) : 2317.92 euros

Total 9438.82 euros

Annexes si besoin ou lien sur des sites existants et pérennes jusqu'à la fin du Labex (2020)