1. Introduction

- Mexico is one of the countries with the highest installed geothermal capacity in the world. Los Azufres Geothermal Field (LAGF) is one of the most productive geothermal fields in Mexico with an installed capacity of 247.9 MW.

- Commercial exploitation at LAGF started in 1982. Most of the geothermal activity is concentrated in a volcanic complex consisting of Miocene andesites and covered by Quaternary dacites and rhyolites. LAGF is divided into western production zone (WZP) and northern production zone (NPZ).

2. Geological Setting and Methodological Setting

- LAGF is hosted in a 2700-m thick fractured, Upper Miocene to Pliocene basaltic andesite to dacite base complex called the Mil Cumbres andesite with ages between 18.1 – 5.9 Ma.

- Andesitic lavas and basaltic andesites of the Zinapecuaro andesite unit are included that the potential sources of mantle He and heat could be mafic melt intrusions.

3. Mixing of Atmosphere-, Crust-, and Mantle-derived Helium and Argon

- Commercial exploitation at LAGF started in 1982.
- Fluid temperatures reach values as high as 350 °C with normal range of 240 – 280 °C in the field.
- In NPZ and SPZ, re-injection of exploited brines is done at the western border of the productive zone (figures above and below) to maintain the reservoir pressure.

3.1. Mixing of Atmosphere-, Crust-, and Mantle-derived Helium and Argon

- The contributions of crustal helium are up to 53% and 18% for fluid samples in the NPZ and SPZ, respectively.
- Well AZ-2A and AZ-6B have low R/Ra values – a significant amount of air component from re-injection or air contamination.

4. Net Dichotomy in SPZ vs. NPZ Samples

- SPZ and NPZ samples fall on two distinct regression line with 40Ar*/3He ratios of 16,200 and 8,060, respectively, lower than mantle (42,000-60,000) and crust (2 x 10^19) (Figures above and below).

5. Heat Source, Timing and Transport in the Field

- The reservoir is sealed by a silicic sequence of rhyodacites, rhyolites and dacites with ages between 1.6 – 0.15 Ma.
- At least five larger volcanic episodes affected the LAGF in recent geological time: 1.6-0.84 Ma; 0.34-0.14 Ma; 0.15 Ma; 38-26 kyrs.

5.1. Heat Source, Timing and Transport in the Field

- The contributions of crustal helium are up to 53% and 18% for fluid samples in the NPZ and SPZ, respectively.
- Well AZ-2A and AZ-6B have low R/Ra values – a significant amount of air component from re-injection or air contamination.

Impact of Injectate

- Except for the Chilclard lagramite, no residual fluid result from pre-production fluid analysis. LAGF has been re-injecting water at 12°C boiling at reservoir temperatures between 200 and 300°C.

- Noble gas ratios of most samples can be explained by (1) injectate boiling at reservoir temperatures varying from 280 to 380°C or (2) the mixing of injectate and the condensate (steam phase) boiling at reservoir temperatures.

Acknowledgement and Reference

- We thank the Comisión Federal de Electricidad (CFE) de Morelia and Los Azufres for assistance during sampling. DLP is supported by a NSERC discovery grant 2008-5537. Financial support for the NPZ reconnaissance & facilities audit 0AB-019-99 is greatly appreciated. We wish to thank Max Kennedy at Berkeley Lab to access subsurface data of noble gases for geothermal energy up to the critical point from the unpublished work of the late Smith (1986).

- The mixing of noble gases and 87Sr/86Sr to identify heat sources and constrain fluid evolution at Los Azufres. Geothermal energy up to the critical point from the unpublished work of the late Smith (1986).