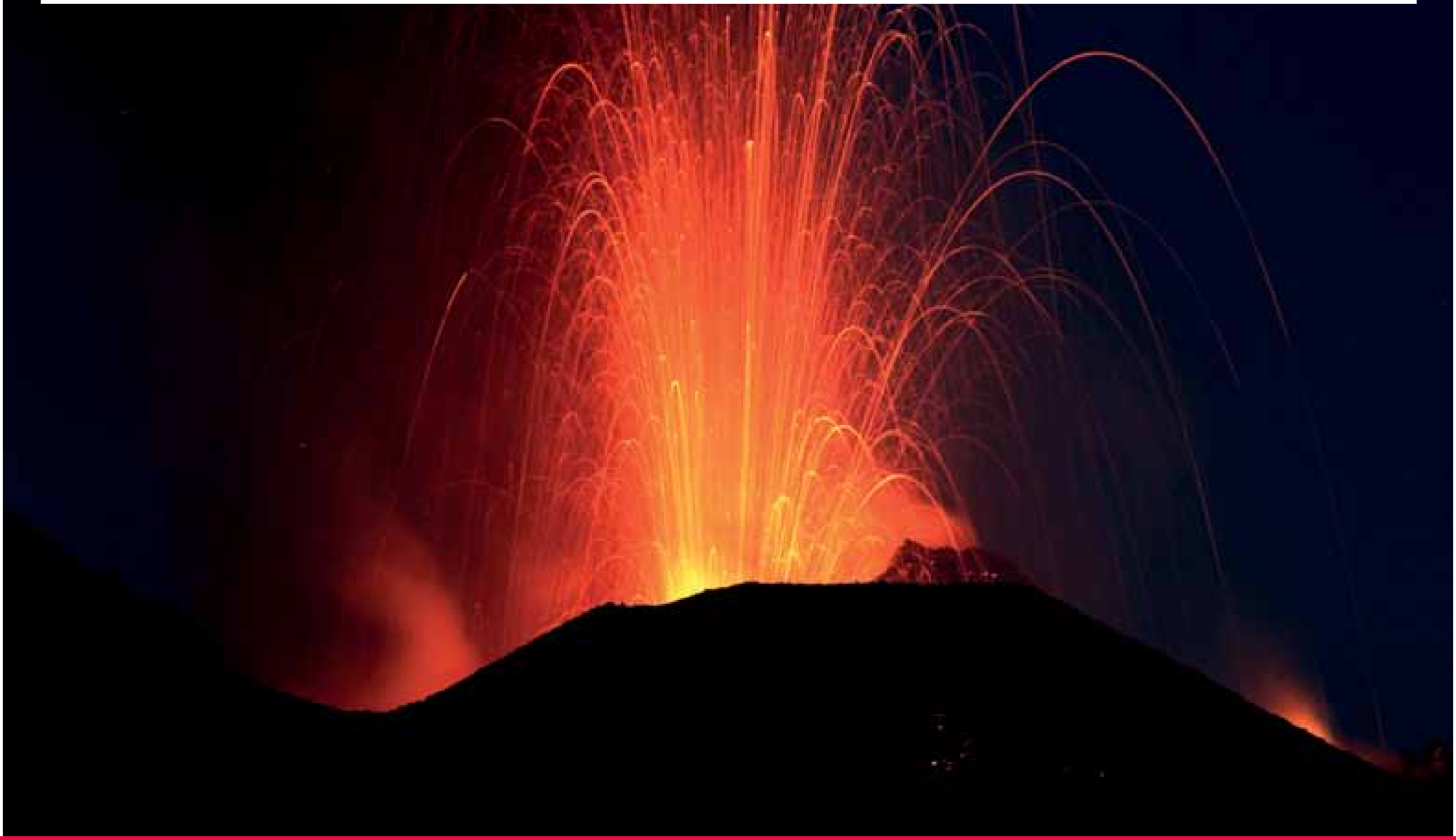

INVESTIGATING THE HISTORY OF THE EARTH

Noble gas mass spectrometer in use for earth sciences

Understanding the history of the Earth and its various inhabitants has been foremost in mankind´s pursuit of knowledge for centuries. Scientists from many disciplines constantly endeavor to make new discoveries that elucidate how our planet has evolved. Isotope Geochronology has become an important tool for Earth scientists who do their research on these topics.

Isotopes are forms of the same element. They differ only in the composition of the atomic nucleus. Elemental isotopes always have the same number of positively charged particles (protons) in the nucleus but will have a different number of neutral particles (neutrons). Some isotopes are not stable and will tend to change (decay) to a more stable state. These isotopes are called radioactive. Radioactive isotopes decay step by step or even convert into other elements. How long this conversion takes is determined by measuring the half-life of an isotope. The half-life is the period of time in which the total amount of atoms in an isotope has halved. If the half-life of an isotope is known, the age of a mineral containing that element can be derived from the relationship between stable and radioactive isotopes of that same element.

Geochronology takes advantage of the isotopic measurement. With this research method, the percentage of decay products that result from the radioactive decay of isotopes with a known half-time is determined. By the aid of this data, the absolute age of geologic material can be detected.

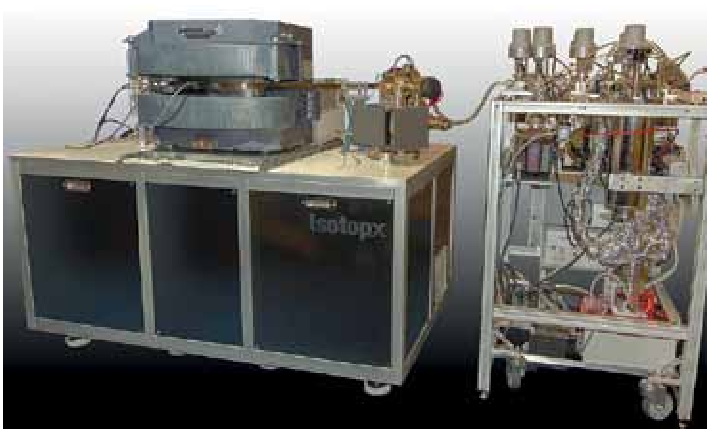

Figure 1: Noble gas mass spectrometer with attached ultra high vacuum sample preparation system using the Pfeiffer Vacuum HiCube pumping system

The Berkeley Geochronology Center (BGC) in California has specialized in geochronological research for more than three decades. The most advanced technologies available are used in the laboratory.

Advances in vacuum, laser and computer technology have resulted in experiments yielding more accurate data with higher precision. By applying results of these experiments, key insights are obtained into processes such as continental drift, volcanism, mountain building, mass extinctions, climate change, and the evolution of humankind itself. Geochronology is critical not only to establishing the time axis along where these various phenomena occur, but also to determine the temporal relationships among them.

One of the many scientific instruments in use at the research institute is a Noble gas mass spectrometer system. This system includes a mass spectrometer, a heating device – often a laser – and a sample preparation system.

Noble gas mass spectrometers are high sensitivity instruments designed for the analysis of noble gases such as Helium and Argon. An ideal use for noble gas mass spectrometry is $^{40}Ar/^{39}Ar$ geochronology. This method relies on high precision measurement of Argon isotopes to determine the product (or „daughter") of the natural radioactive decay of ^{40}K (parent). From this ratio value, the age of minerals and rock samples can be derived if the half-life is also known. Neutron bombardment of the sample is used to induce the transformation of ^{39}K into ^{39}Ar. Analyzing the sample for both the parent element (K as ^{39}Ar) and daughter element (^{40}Ar) in the noble gas mass spectrometer at the same time greatly increases the precision and accuracy of measurement.

Isotopic analysis of Argon and other noble gases is used for dating rock forming minerals and for associating important events in geological and biological history. The method can also be used for establishing the thermal history of rocks, as well as meteorites.

Noble gas mass spectrometers require special conditioning of the gas samples which are introduced for analysis. This process is performed by a sample preparation subsystem which is equipped with a pipetting arrangement and ports for the addition of sample heating systems (e.g. laser, furnace, chemical dissolution) for the generation of sample gas. After a sample gas is liberated from a geologic sample, it is cleaned with cryo-traps and getters so that all that remains in significant amount are noble gasses. The sample preparation line operates at ultra high vacuum. These vacuum levels can only be achieved with pumps that perform at the highest levels of efficiency and reliability.

The challenge

Due to its high quality demands, the BGC has chosen Pfeiffer Vacuum as its partner for the vacuum generating equipment of its noble gas mass spectrometer preparation lines. These systems placed high demands on the needed vacuum solution as they are technically sophisticated and characterized by a small footprint and portability. Most important was to accomplish the needed UHV with an ultimate base pressure requirement in the low $1 \cdot 10^{-9}$ to mid $1 \cdot 10^{-10}$ hPa range. Occasionally, the pumping system must also be capable of handling much greater gas loads that are encountered during loading of samples. Since the BGC and Pfeiffer Vacuum look back to a close and long-term collaboration, Pfeiffer Vacuum has an excellent knowledge of the demands and fields of research of the BGC. This condition and the close cooperation with the institute allowed for the development of a customized, individual vacuum solution.

The solution by Pfeiffer Vacuum

For this application, UHV systems were needed in both the rare gas sample preparation line and the noble gas mass spectrometer. This vacuum level has been obtained by using turbo molecular pumping systems, ion and non-evaporable getter pumps as well as by applying cryogenic separation techniques.

To perfectly meet the customer´s requirements for the sample preparation line, a Pfeiffer Vacuum HiCube Eco system was chosen as primary pumping system.

The decisive arguments for this solution were:
- Compact size
- Simplified cabling and control
- Ability to remotely mount the controls
- Capability to operate a cold cathode gauge
- Unrivaled low energy consumption (20 W in high vacuum mode)
- Convincing price performance ratio

The integration of the Pfeiffer Vacuum HiCube Eco into the sample preparation line chassis was especially convenient. The display control unit could be easily removed from the pumping station and mounted near the top of the sample preparation chassis so that the controls were positioned in a more ergonomic, operator friendly location for this system.

Furthermore, the MVP 015-2 diaphragm pump, with which the HiCube Eco is standardly equipped, holds additional benefits for the customer and its application. As soon as the HiPace 80 turbopump in the HiCube Eco is in a low-power mood, the diaphragm pump will enter a sleep mode wherein the diaphragm pump automatically switches off. Thus, the pump is effectively not operating and logging hours on the components. This improves the membrane life and saves electrical power – both of which lower the system operating costs. This function also reduces the overall noise and vibration generated by the system. Although the turbopump system is often in standby mode, it is capable of responding rapidly and reliably to an increased demand.

With this solution, Pfeiffer Vacuum completely satisfied the high demands of the Berkeley Geochronology Center and succeeded in confirming the close and reliable cooperation.

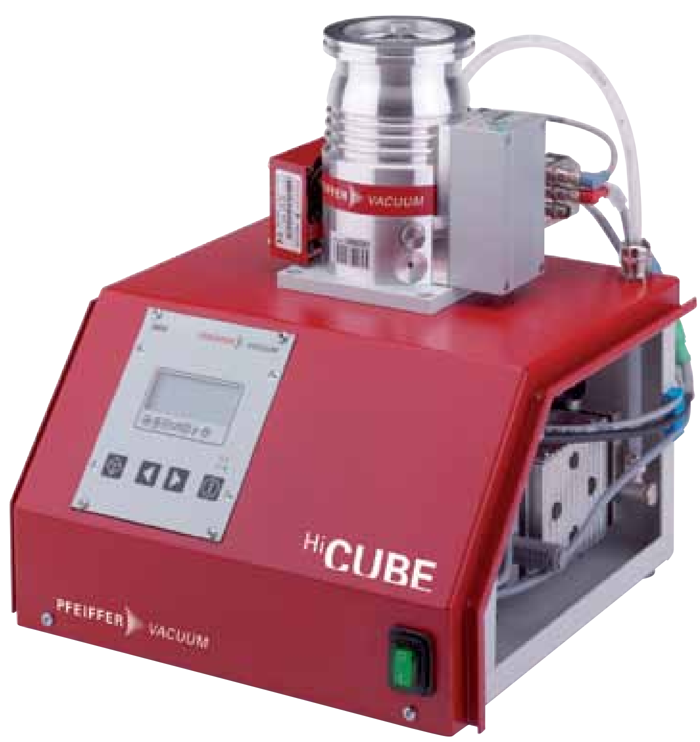

Figure 2: The HiCube Eco by Pfeiffer Vacuum

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