UNITED STATES
DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY

Technical Letter
Saudi Arabian Mineral
Exploration - 35
December 22, 1965

Dr. Fadil K. Kabbani
Deputy Minister for Mineral Resources
Directorate General for Mineral Resources
Ministry of Petroleum and Mineral Resources
Jiddah, Saudi Arabia

Dear Dr. Kabbani:

Transmitted herewith are 10 copies of:

TECHNICAL LETTER NUMBER 35
MERCURY VAPOR DETECTOR
U.S.G.S. MODEL I

by

William W. Vaughn*

Sincerely,

Glen F. Brown

Glen F. Brown, Chief
Saudi Arabian Mineral Exploration Project

* U. S. Geological Survey, Denver, Colorado, U. S. A.

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General information

The U.S.G.S. Model I mercury vapor detector is an instrumental technique for the determination of submicrogram concentrations of mercury in soils, rocks, and gas. The equipment consists of an radio-frequency (r-f) induction heater to vaporize the mercury from the crushed rock, a mercury thermo-amalgamator to selectively trap and release mercury in the presence of interfering gas, and a meter indicating atomic absorption type vapor detector.

The crushed rock sample, usually from .25 to 1 gram, is heated to approximately 400°C in an uncontaminated environment. The gas released from the rock is conveyed directly to the amalgamator where the mercury is extracted by amalgamation with a noble metal. The noble metal is then heated in place inside the amalgamator and the mercury released and transmported through tygon tubing into the absorption chamber of the vapor detector. As the mercury vapor passes through the light path in the single-beam absorption chamber it absorbs its own energy at resonance and creates a meter signal proportional to the mercury concentration.

Instructions for operation

A. Induction heater (radio frequency)
   1. Adjust water flow thru R-f coils to "trickle."
   2. Turn ON-OFF switch (green light) on induction heater to ON. Allow 45 seconds warm-up. The high voltage power switch (red light) which provides power/heat for the sample holder and the silver mercury trap may now be turned ON and operated as desired. A foot switch has been substituted for the HV power switch in the instrument in Jiddah for convenient operation.

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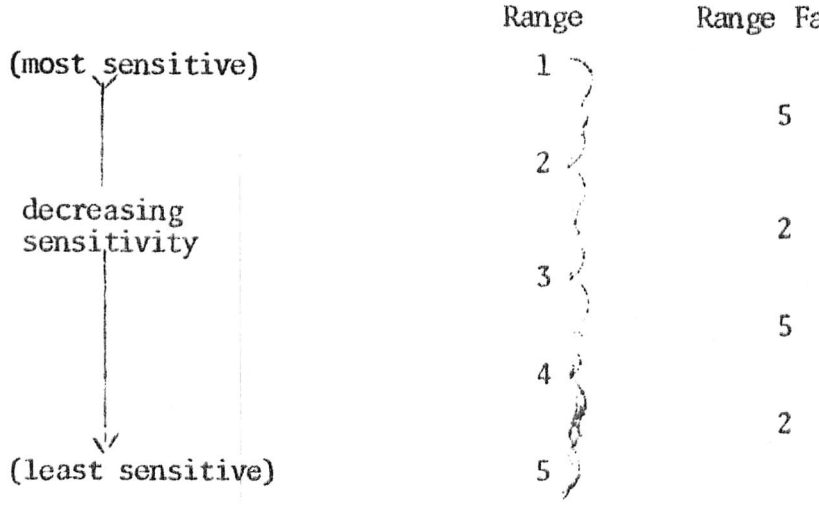
3. The large black bakelite switch on the front of the r-f induction unit alternately applies power to the steel sample holder and the silver mercury trap. This action sequentially releases Hg from the rock in the sample holder to the silver trap, and from the silver trap into the absorption chamber where the actual measurement takes place.

B. Amplifier unit

1. Set range switch selector to position #5.
2. Turn ON-OFF switch to ON.
3. Adjust variac blower control to 45.
4. Set COARSE zero control to the marker taped on the instrument panel.
5. Turn ON-OFF switch on the U-V lamp power supply to ON. The warm-up time for this U-V lamp is approximately 15 minutes.
6. As the U-V lamp warms up the emitted light becomes more intense and the meter needle will drift to the left. The range switch may be turned to progressively lower numbers (greater sensitivity) and the fine zero control adjusted to maintain an approximate zero setting during this warm-up period.



Note: Range 2 seems to be the one most used for mineral analysis. However, if the sensitivity of this range is too great, a second or third split of the sample may be run on a less sensitive range.

Procedure for analysis

1. Make sure all sample holders have been "baked out" - at least a few hours prior to analyzing a suite of samples.
2. Do not handle sample holders excessively by hand. Use needle nose pliers or a similar instrument. A finger print can cause interference.
3. Put sample material (.25 to 1 gr. of crushed rock 80-100 mesh) in each sample holder.
4. Be sure the r-f switch is in the lower position.
5. Place a sample holder in position on the glass rod and raise the holder, in the quartz tube, into the lower r-f induction coil.
6. Zero the meter with the fine zero control.
7. Press the foot switch and hold for 45 seconds. The mercury will be vaporized from the rock sample and collected on the silver mercury trap. There should be no noticeable increase in meter reading.
8. Throw the r-f switch to the upper position.
9. Again zero the meter with the fine zero control.
10. Press the foot switch and hold for 20 sec. If mercury has been released from the rock, the meter will deflect to the right. The maximum reading is proportional to the amount of mercury vaporized from the rock sample.
11. Return the sample holder to the heat sink after each run.

Note: This measurement is a "one shot" analysis. A second split of the same sample must be used for a re-run.

Calibration

Using a saturated mercury vapor:

1. The instrument should first be made to operate in a normal condition by following instructions for operation given above.
2. With no sample holder in place inject a known volume (1-2 cc) of gas from one of the calibration bottles, using the hyperdermic syringe and needle, into the lower end of the quartz tube.
3. With the r-f switch in the upper position, press the foot switch and heat the silver mercury trap for 20 seconds. Note the peak meter reading.
4. By using the saturation curve for mercury vapor figure 1, determine the amount of mercury in the gas sample.

5. The meter reading corresponding to the mercury in the gas standard can then be used to quantitize the unknown mercury value derived from a crushed rock sample.

Example:

Inject one cc of gas at 20°C into the system. From figure 1, this amount of gas contains 13 nanograms or $13X10^{-9}$ grams of mercury. If a meter reading of 26 is obtained, this reading is equivalent to 13 nanograms, or each small division of the meter equals 1 nanogram of mercury. Now if one gram of crushed rock is analyzed, each small division represents 1 ppb of mercury in the sample material. Therefore a 2 to 1 ratio exists between the meter reading and the ppb value in the sample. If only .5 gram of sample is analyzed then each small division represents 2 ppb of mercury in the sample.

This calibration may vary when the silver mercury trap is replaced. A new calibration must then be established even at the expense of deriving a new conversion factor between the meter reading and the ppb expression of mercury in the sample.