

Identification of multiple gas components at fault zone in SW Taiwan and its application for earthquake surveillance

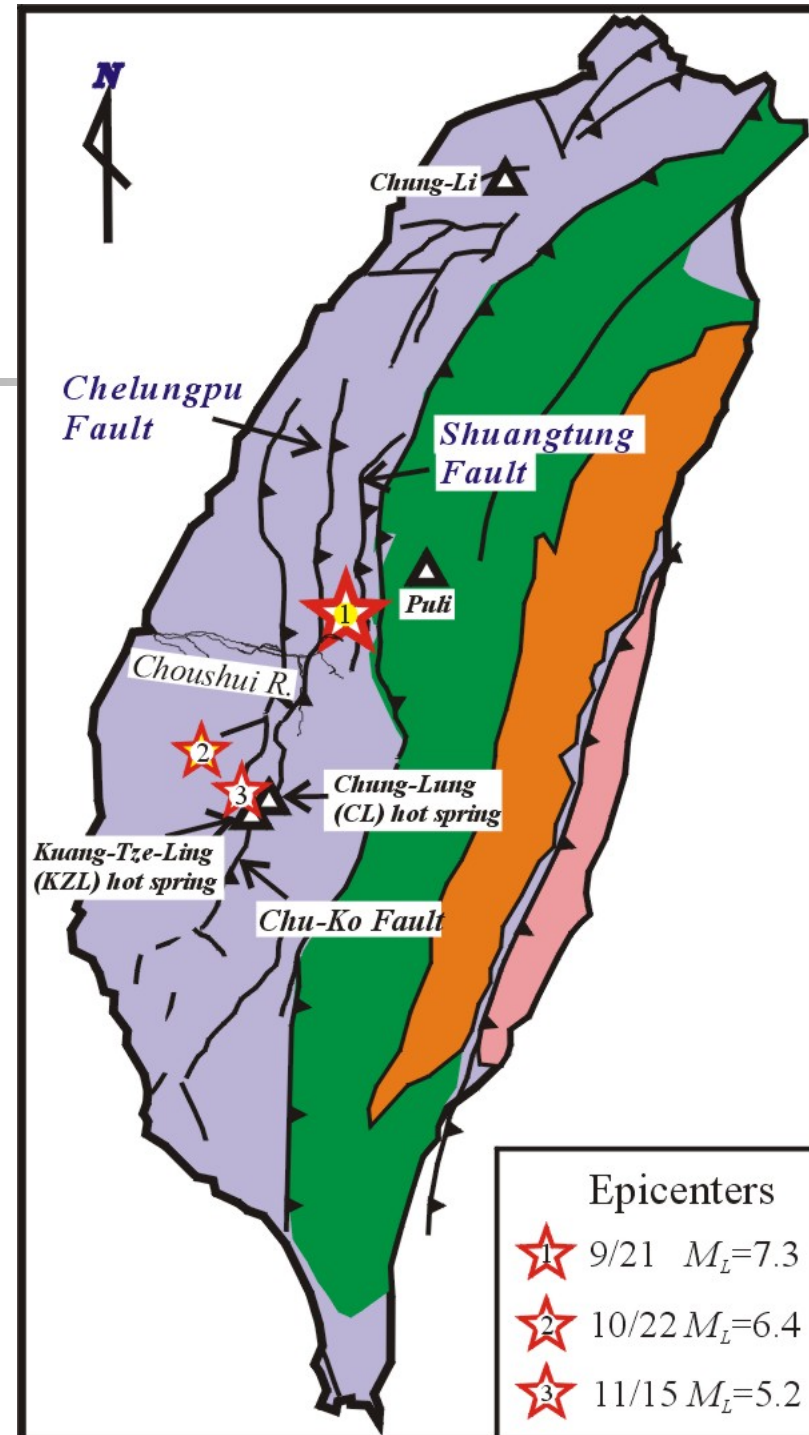
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Sponsored by CGS & NSC

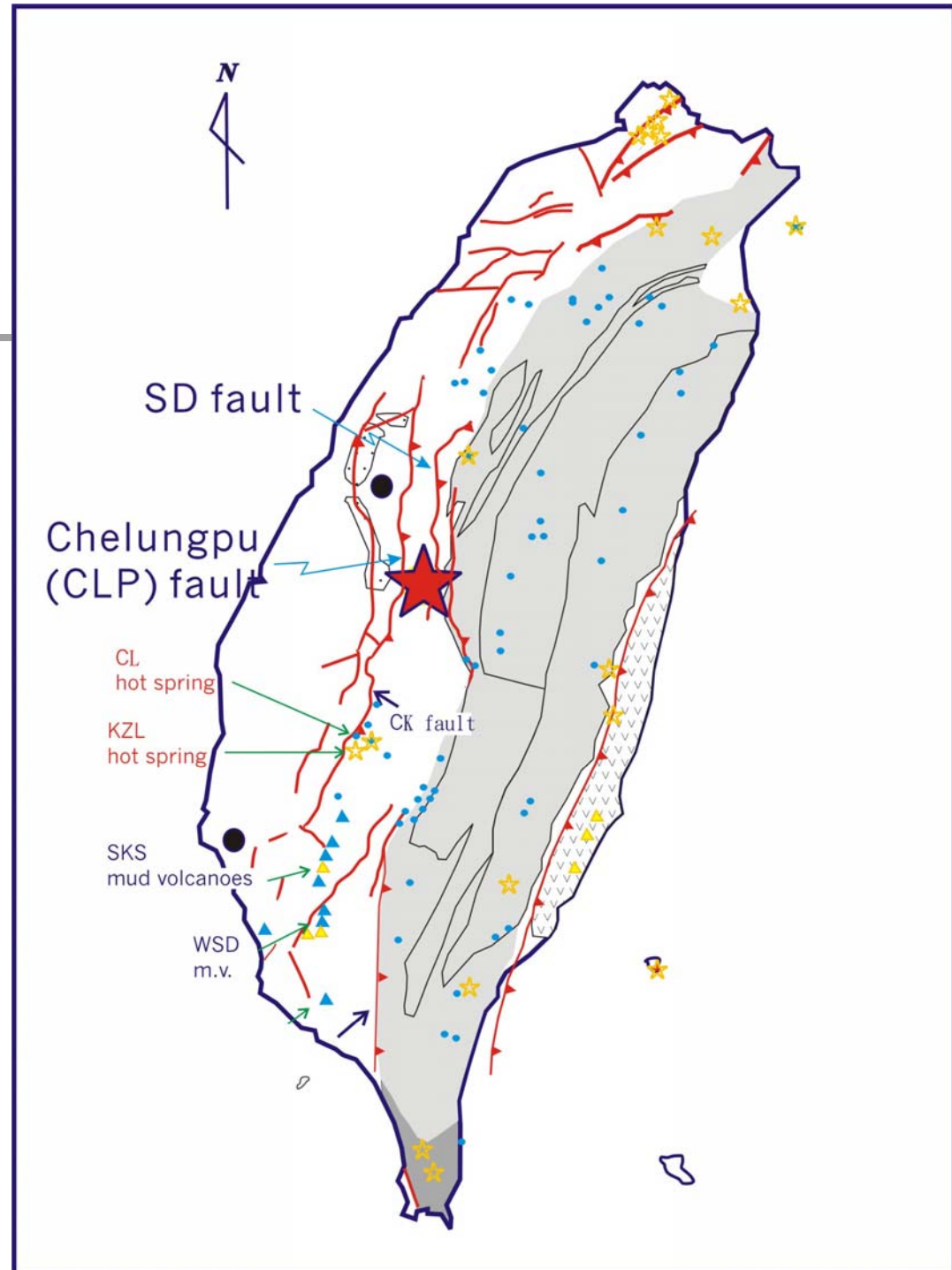
1999 Chi-Chi EQ

- ❑ Biggest earthquake of the century in Taiwan.
- ❑ $M_L=7.3$; $D=8\text{km}$
- ❑ >80 km surface rupture along CLP fault. Up to 8m vertical displacement.
- ❑ $>2,400$ people killed



Sample Localities

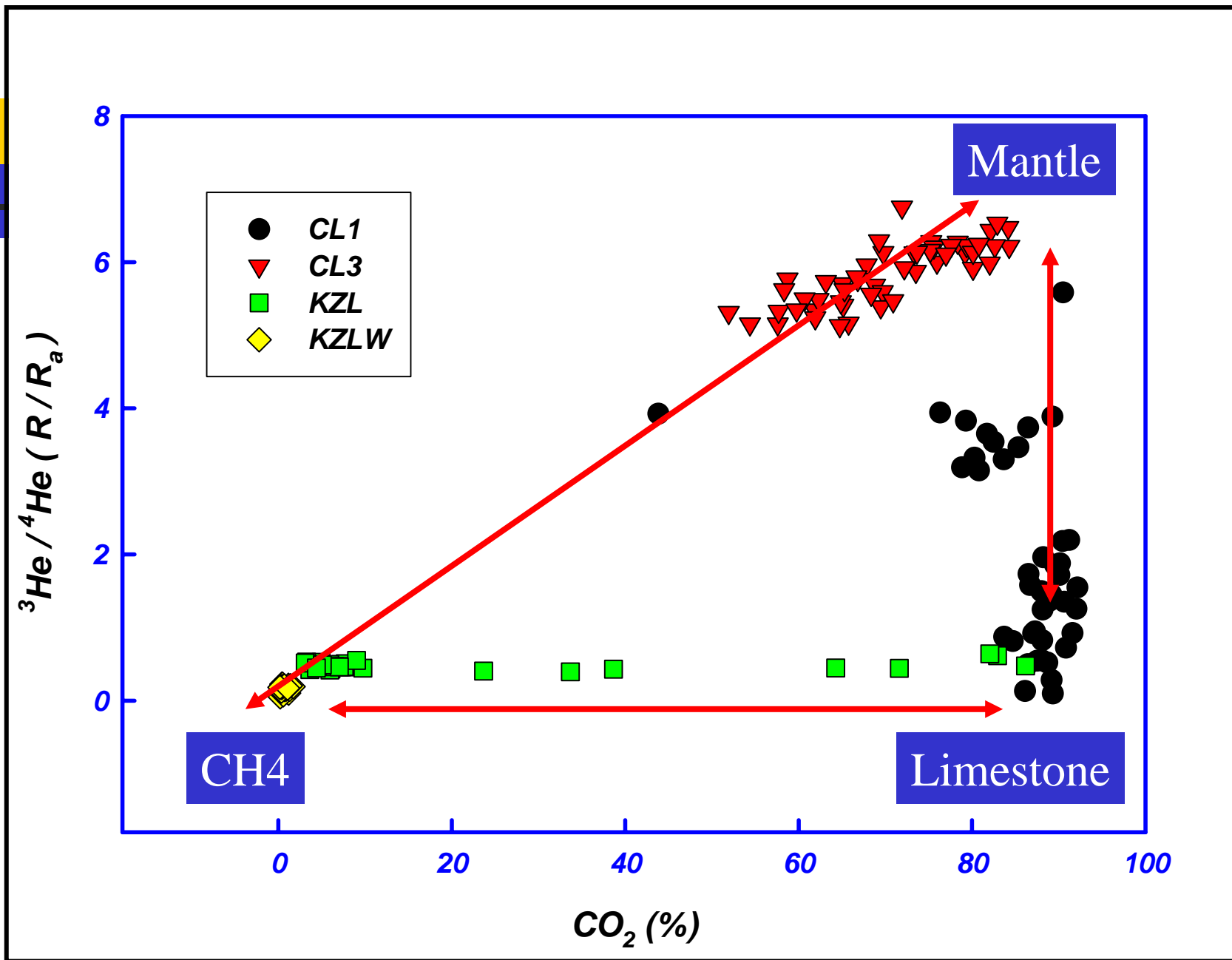
- CL hot springs & mud-pool.
- KZL hot springs
- Mud volcanoes



CL mud pool



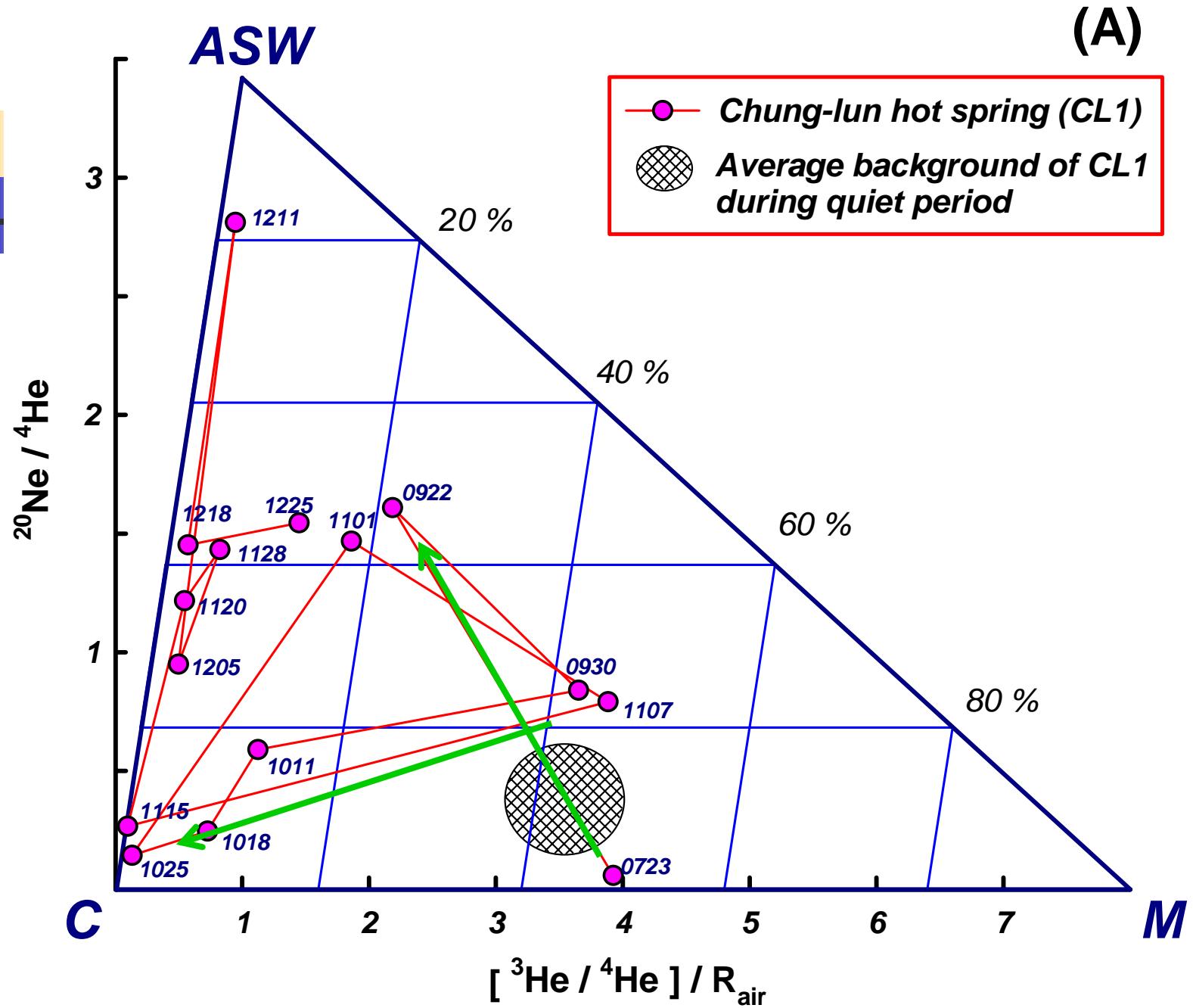
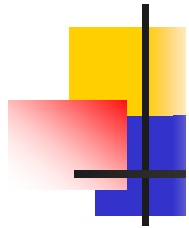
Mud volcano in SW Taiwan

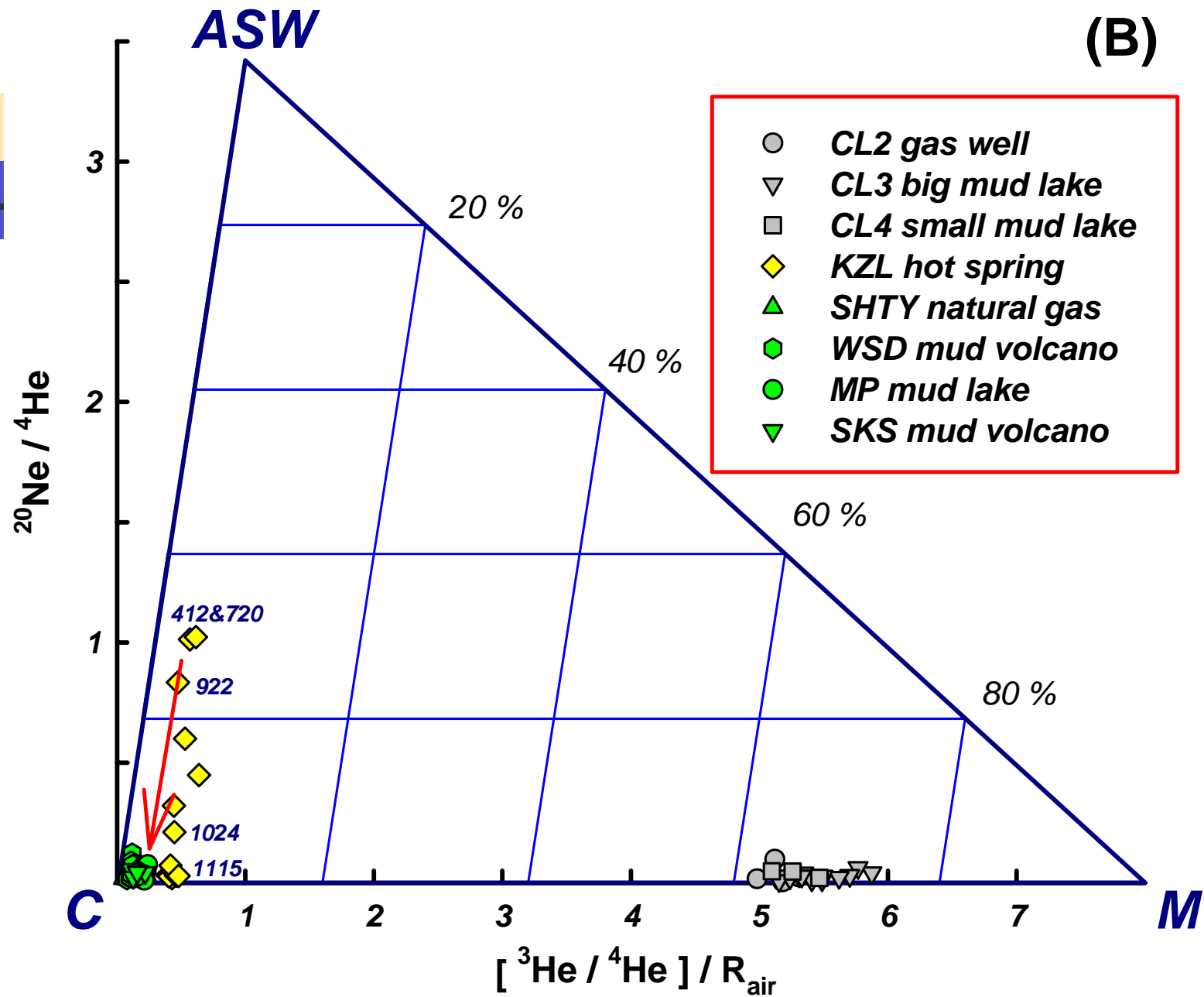
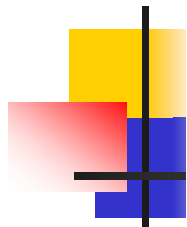


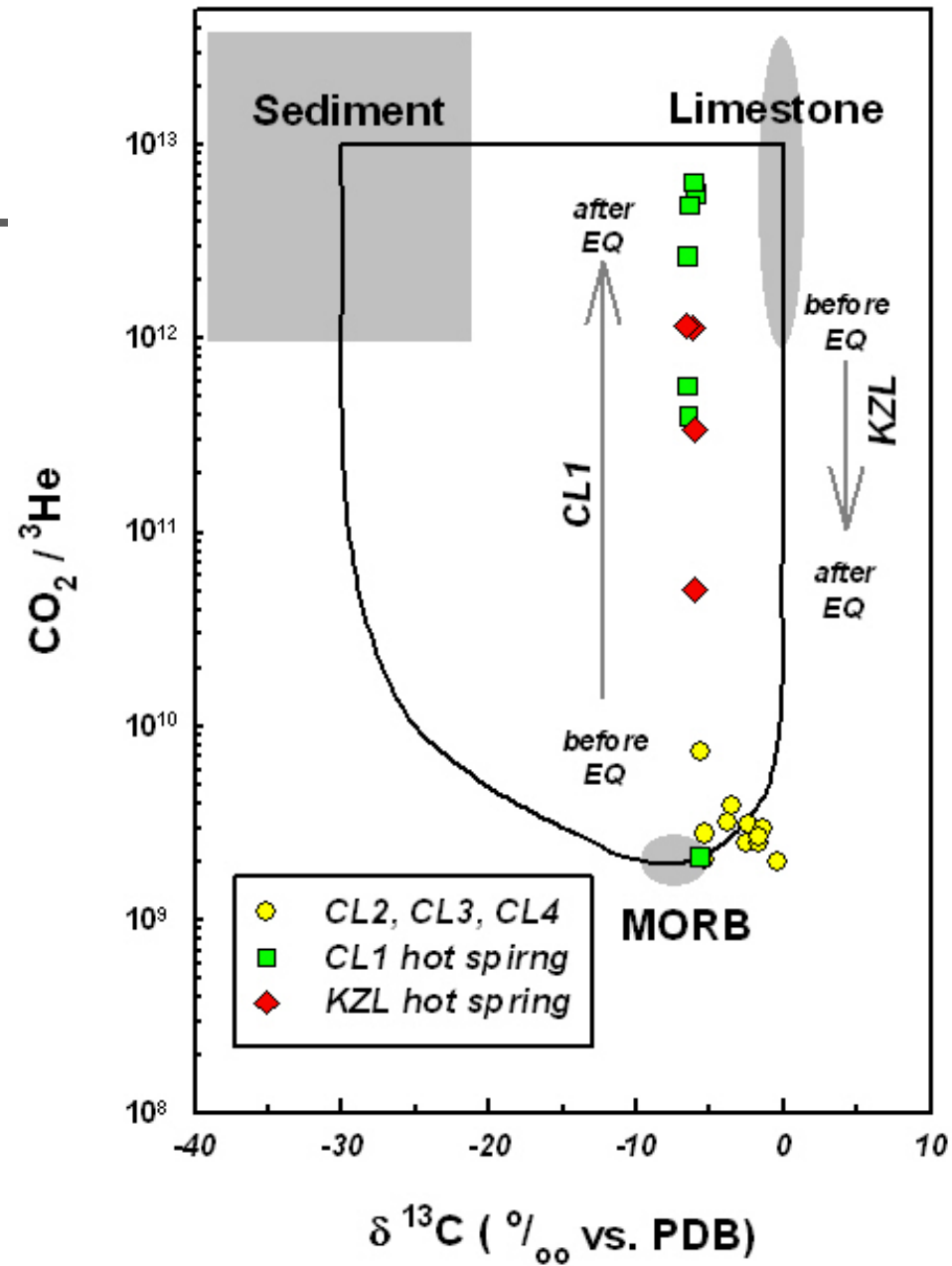
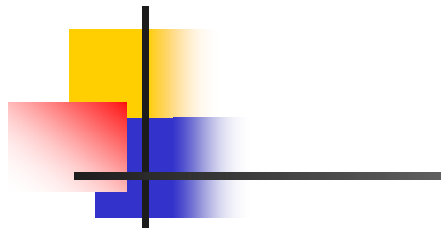


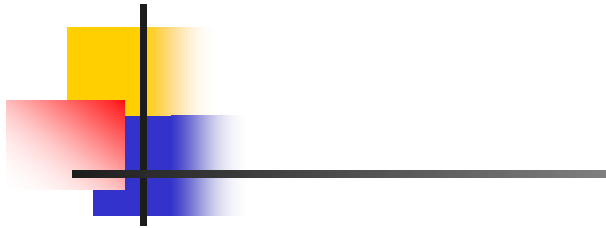
Identification of Gas Reservoirs

- ❑ ASW (air saturated water) – similar with air
very low conc of non-dissolved gases
(e.g., He...)
- ❑ Crustal CO₂ component:
 ${}^3\text{He}/{}^4\text{He} < 0.2Ra$; $\text{CO}_2/{}^3\text{He} = 10^{11} - 10^{13}$
- ❑ Crustal CH₄ component:
 ${}^3\text{He}/{}^4\text{He} < 0.2Ra$;
- ❑ Mantle – ${}^3\text{He}/{}^4\text{He} > 3Ra$; $\text{CO}_2/{}^3\text{He} = 2 * 10^9$

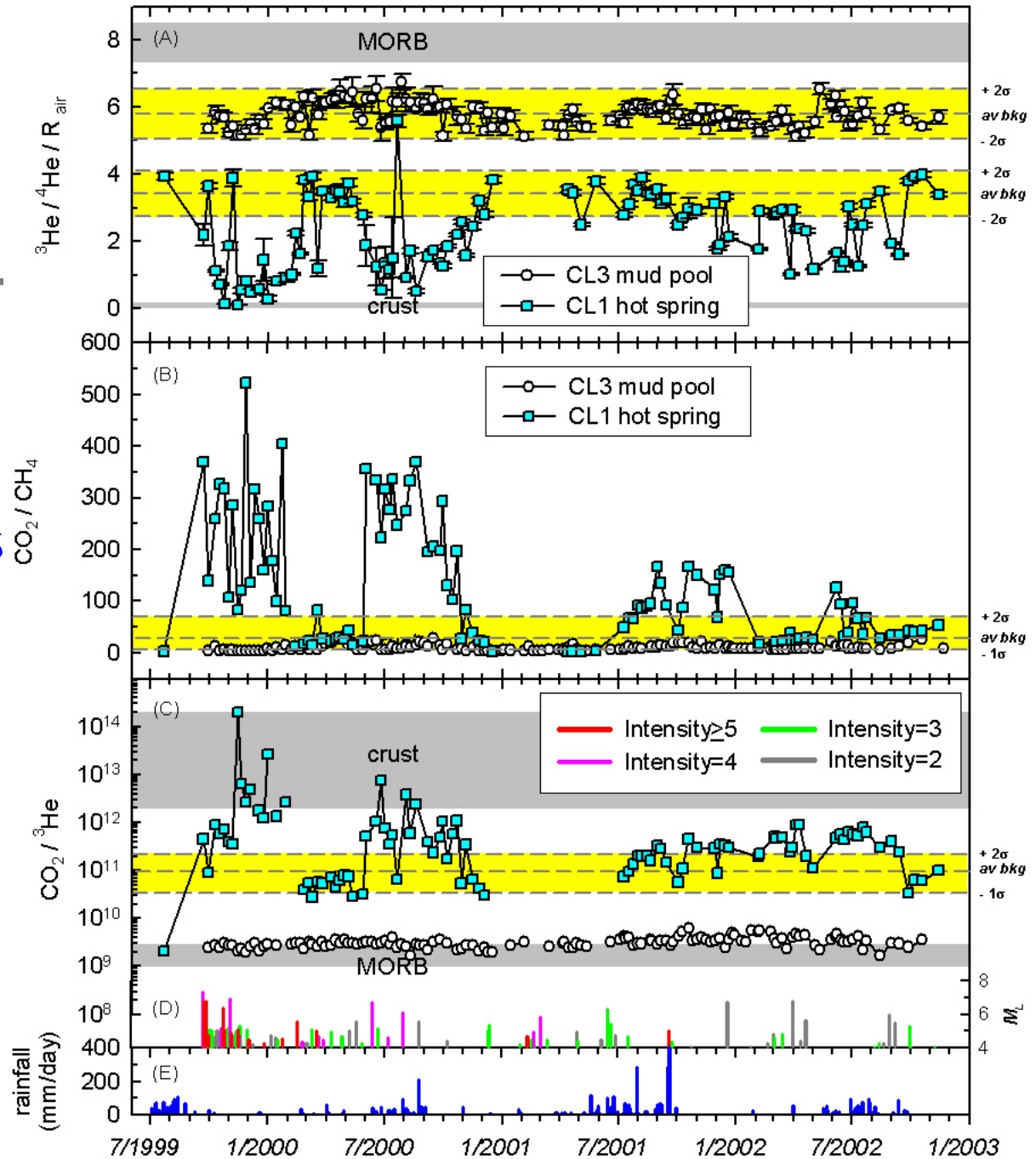




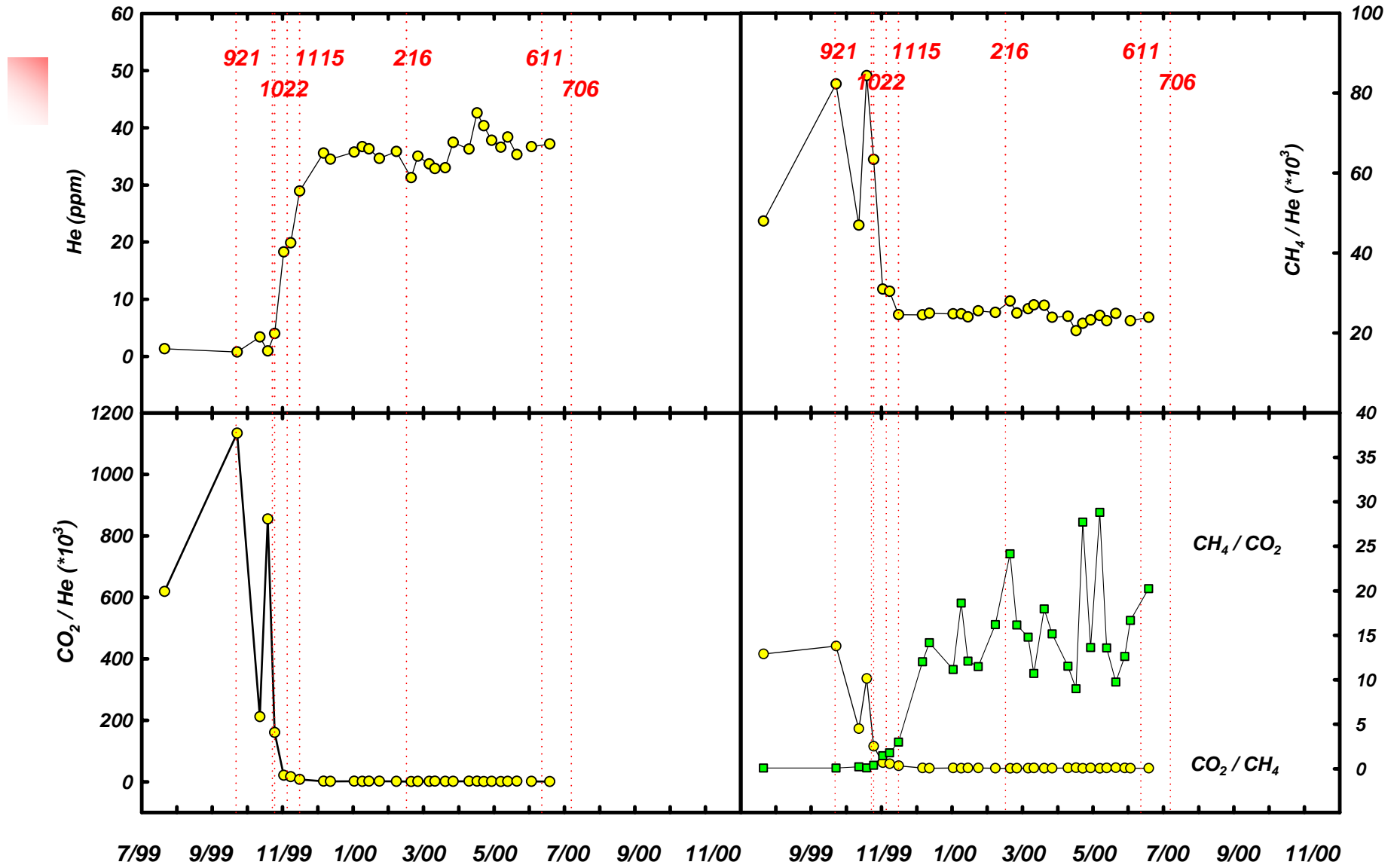




➤ CL hot springs gas compositions show significant variations associated with earthquakes.



Gas variations of KZL hot springs





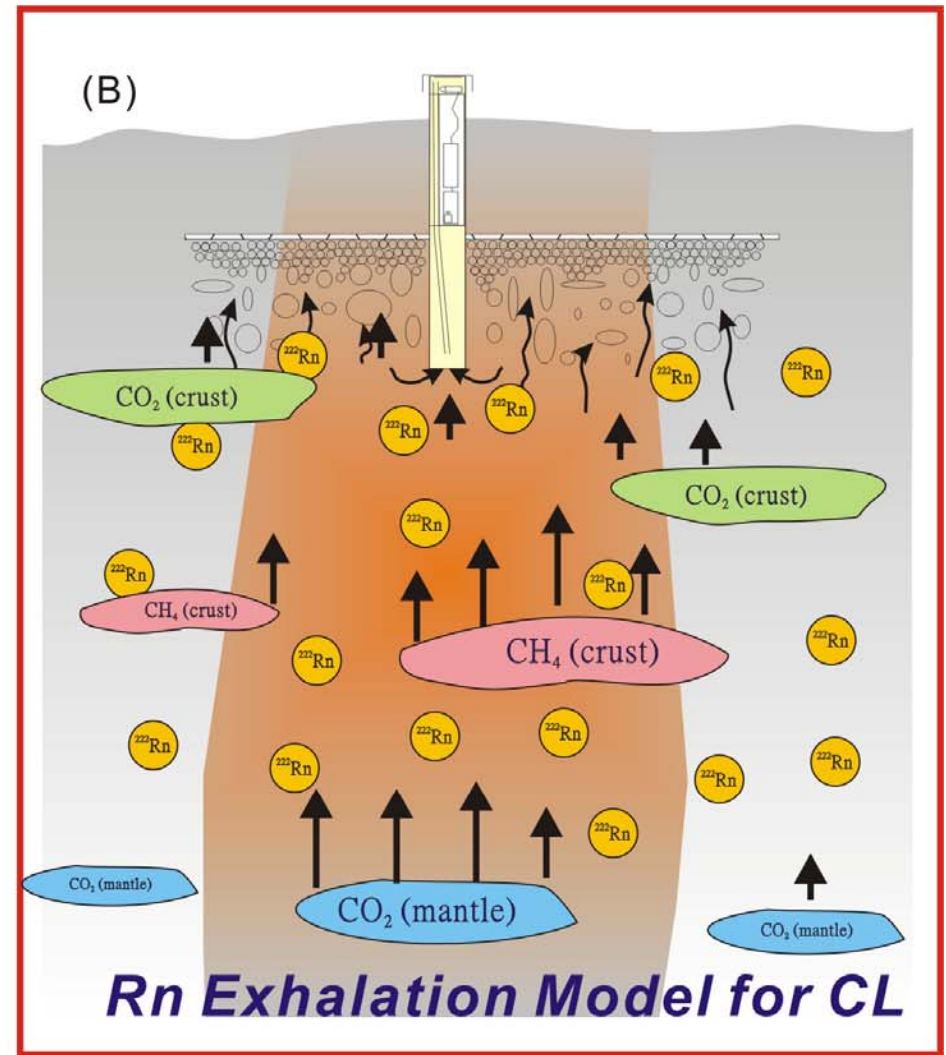
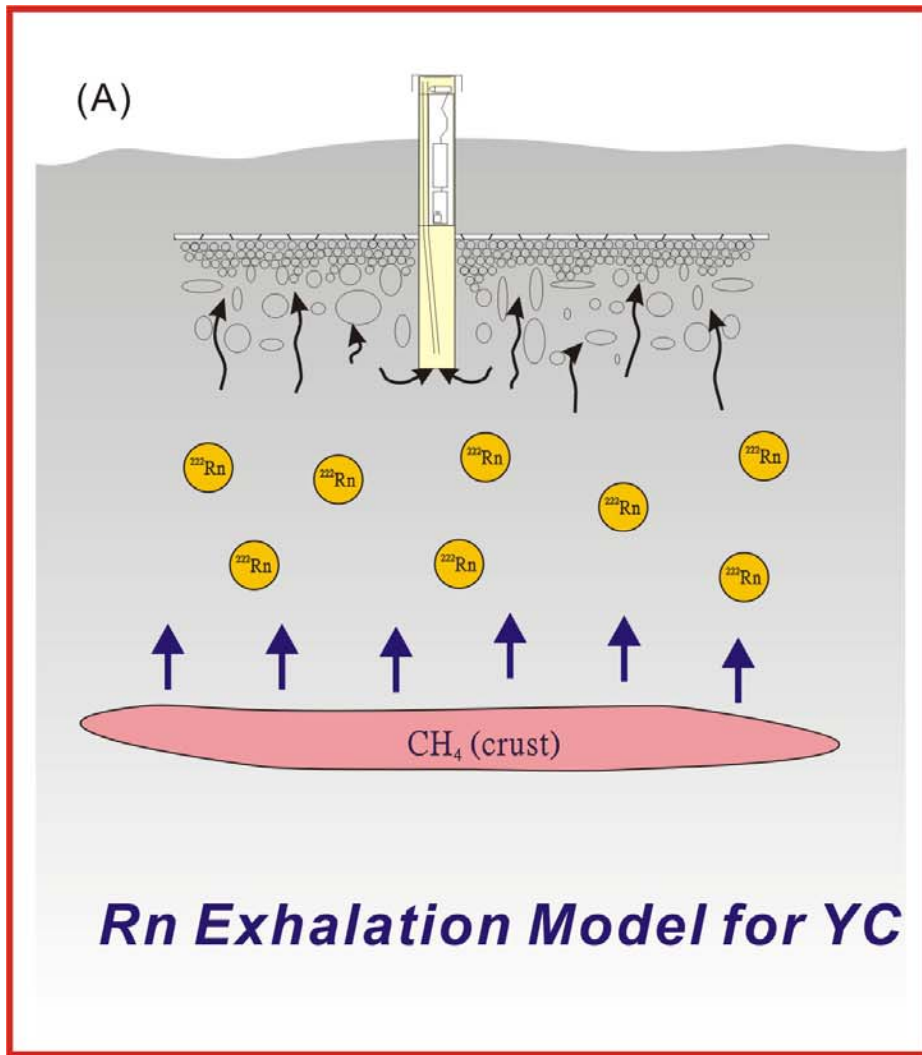
Summary

- ❑ KZL and CL hot springs exhibit more than one gas component, hence, showed significant gas variations associated with earthquakes, and may be suitable for earthquake monitoring.
- ❑ Gas from other areas may originate from single gas source component, hence did not show significant gas variations associated with EQ. Gas flux may be much sensitive to quakes instead of gas composition changes.



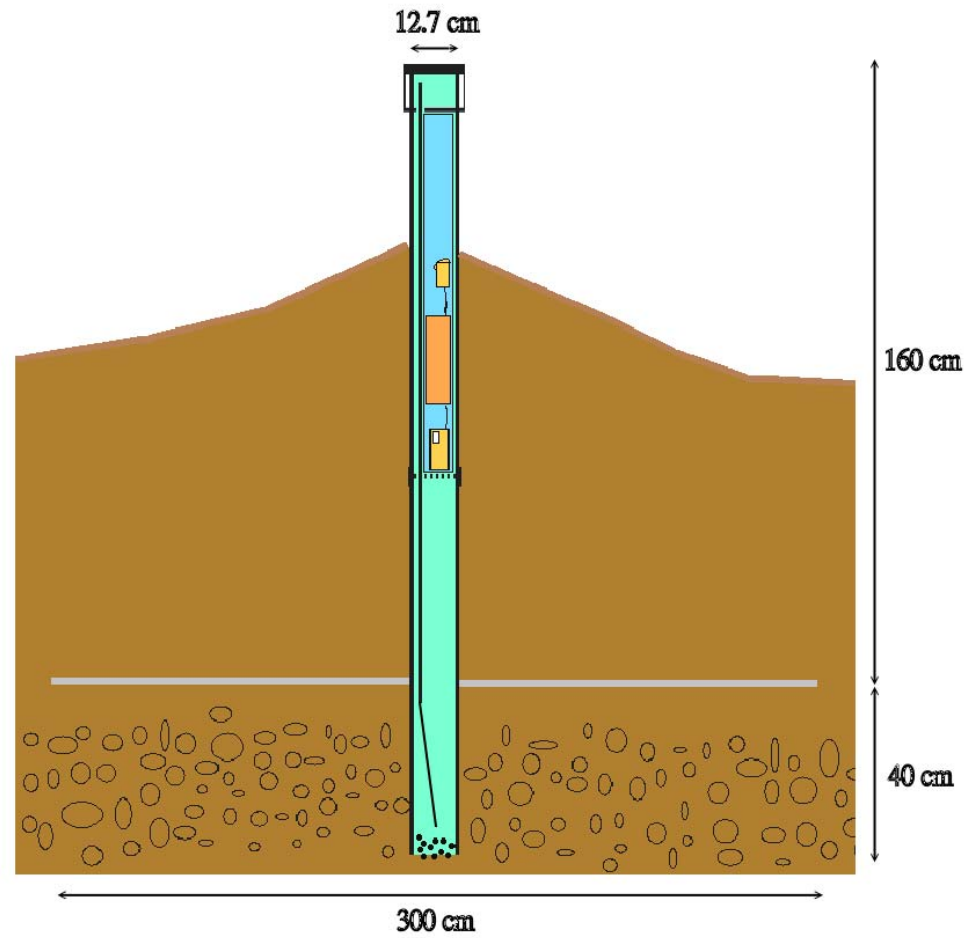
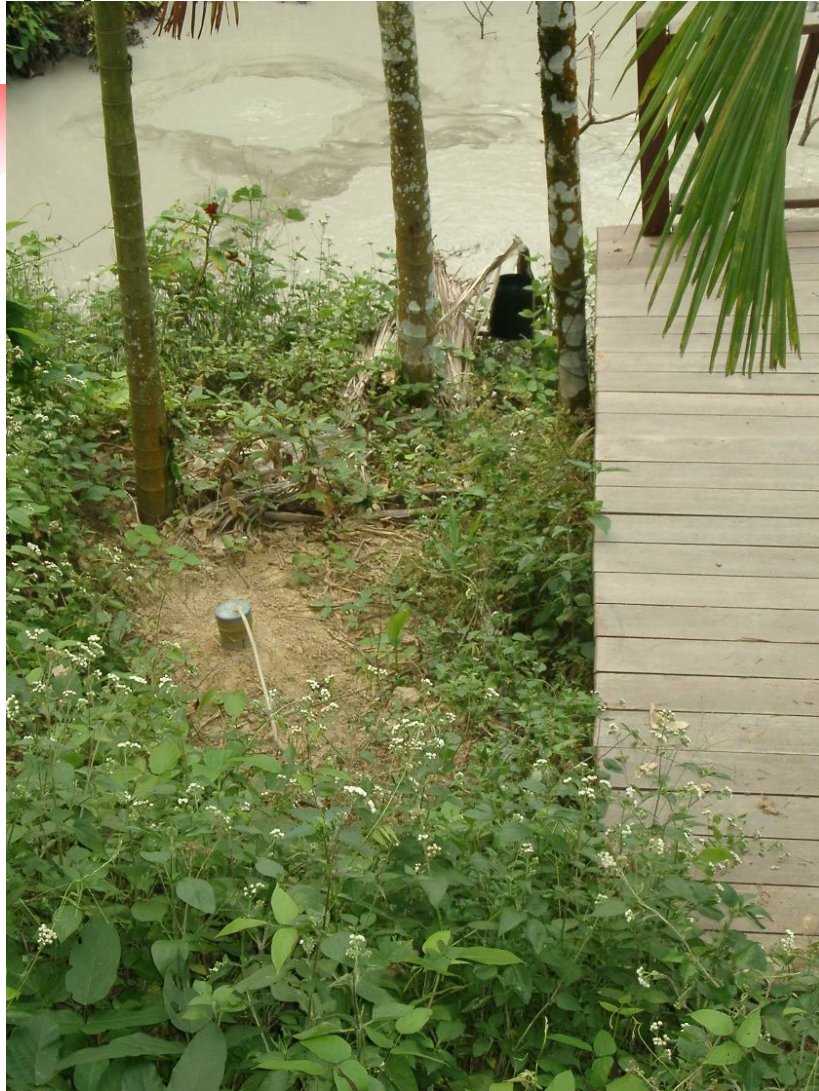
Summary

- Some variations, including CH_4/CO_2 , $\text{CO}_2/{}^3\text{He}$ and ${}^3\text{He}/{}^4\text{He}$ ratios, can also be found in this area before and after earthquake. It indicates that the variations of fluid compositions may be useful as a precursor of earthquake.

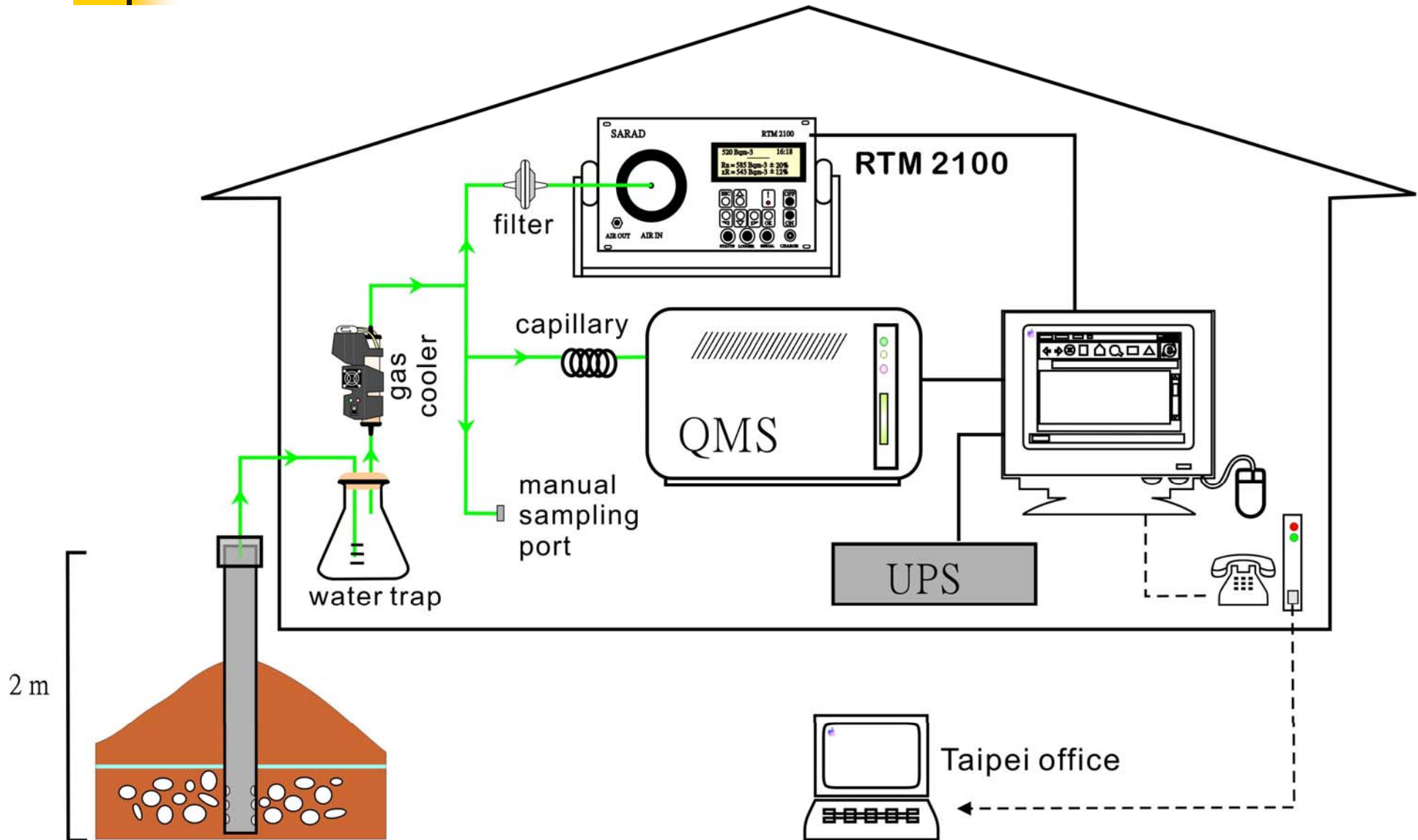


Yang et al. (2003)

Setting up for the soil gas monitoring



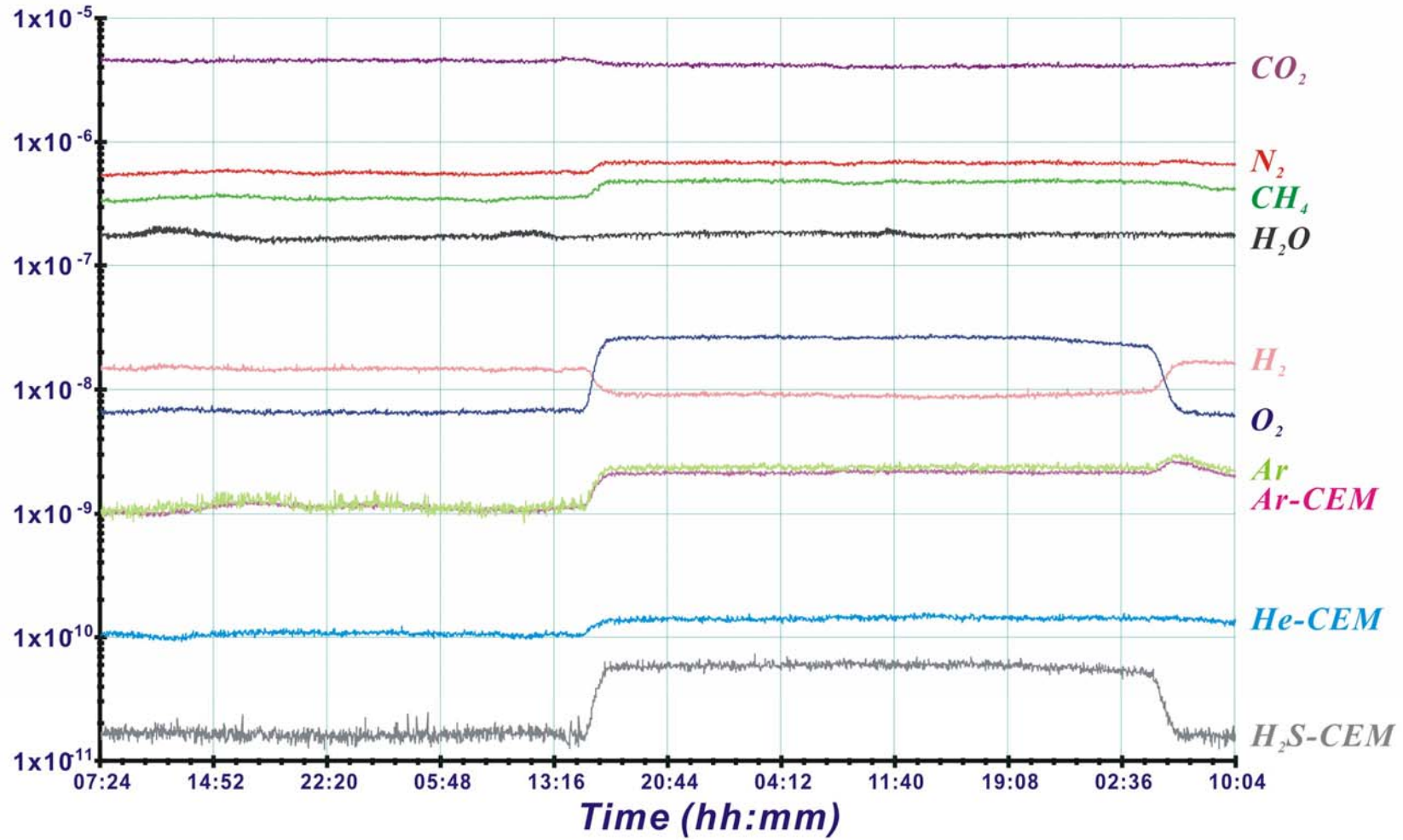
Configuration of CL monitoring station

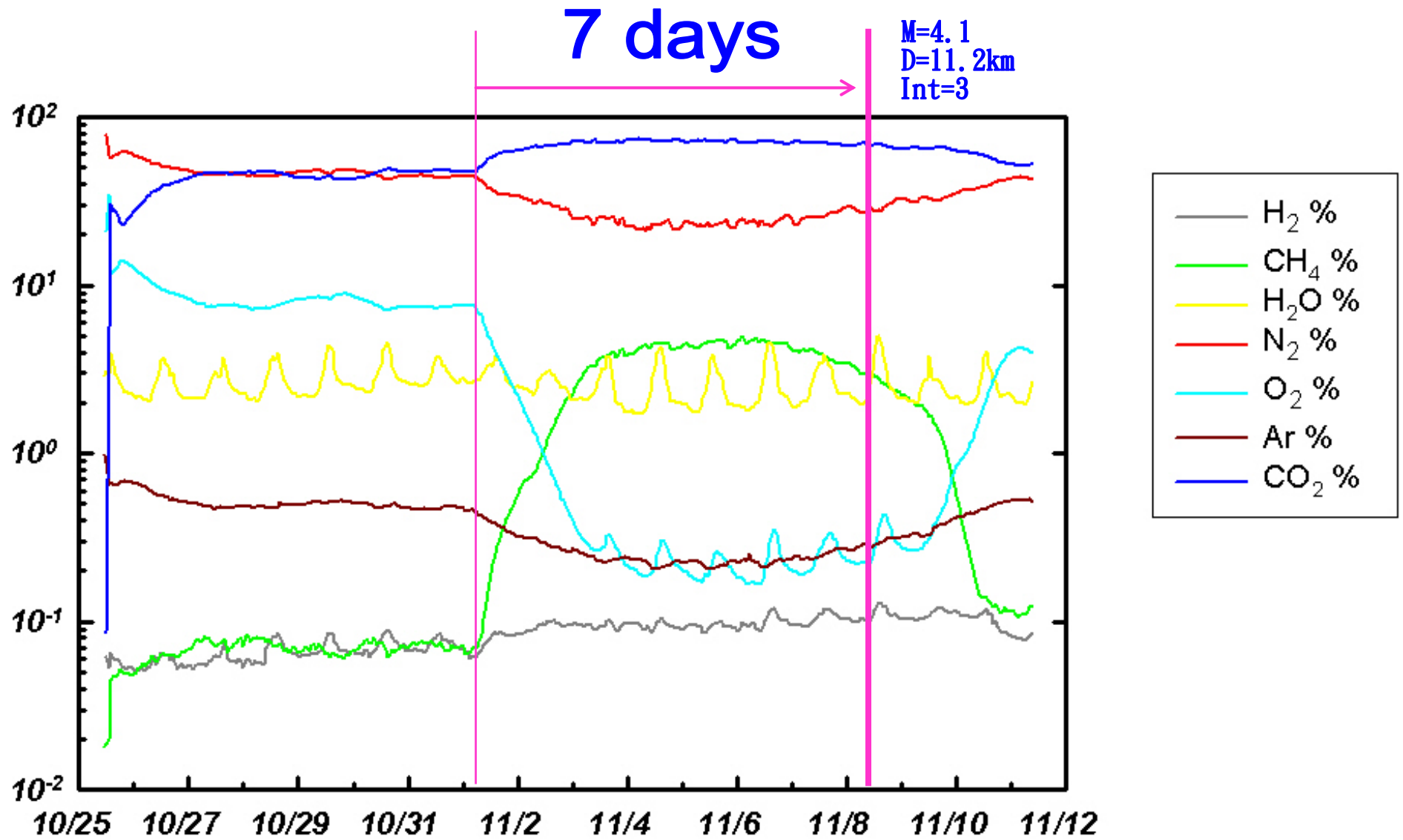


Torr

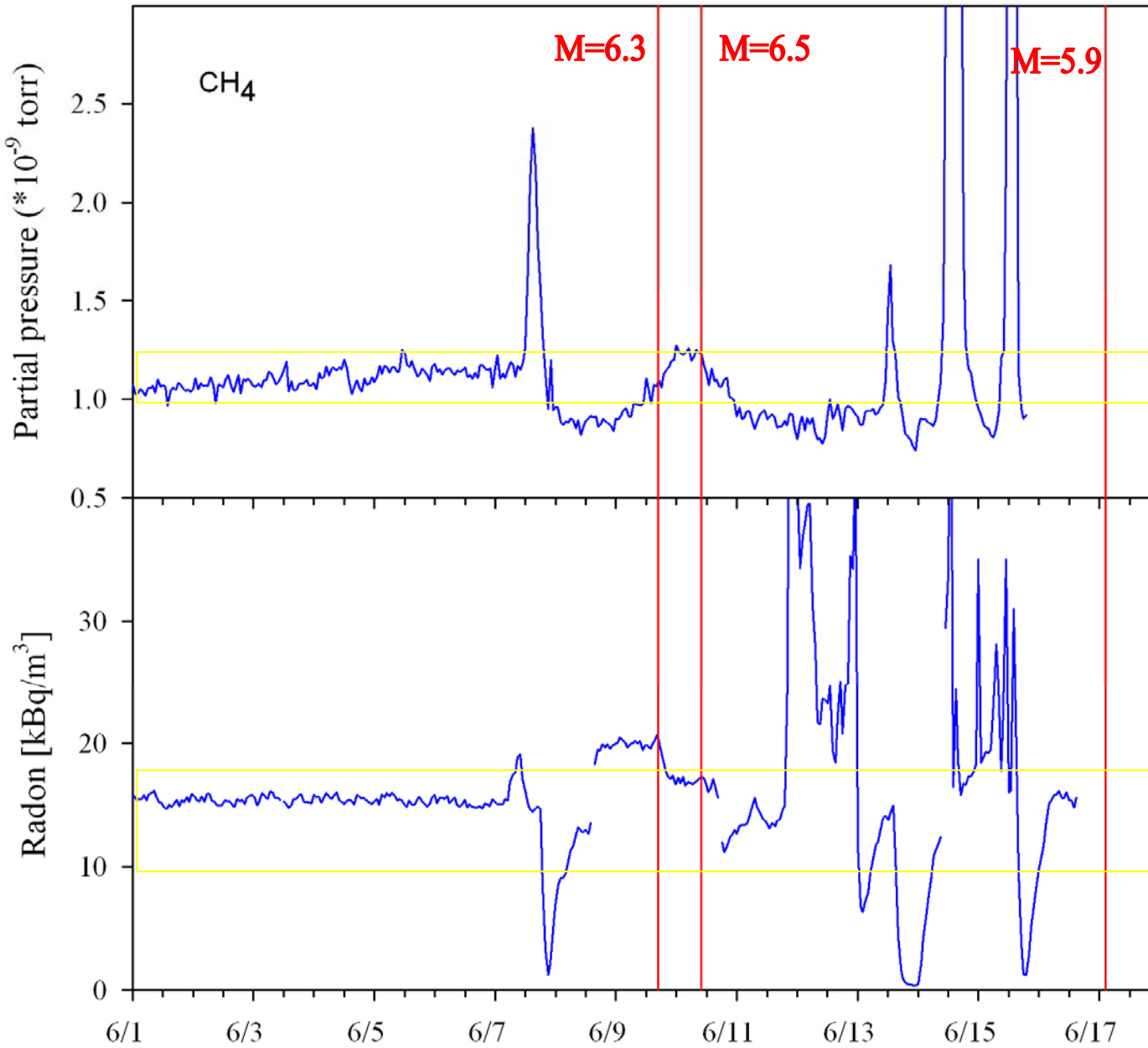
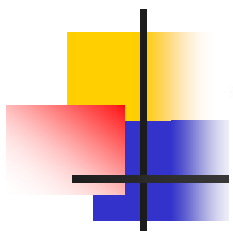
RGA P-T scan

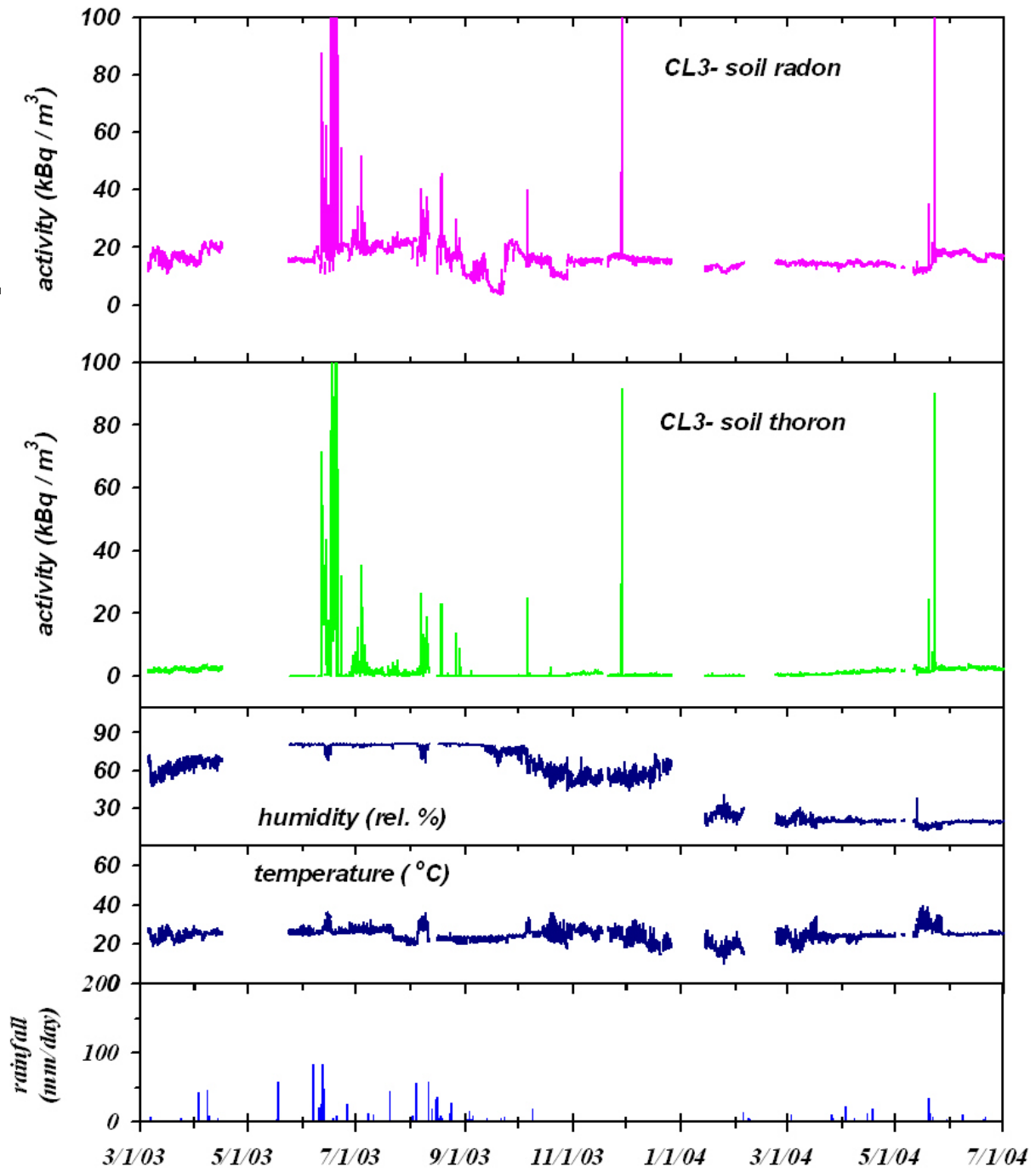
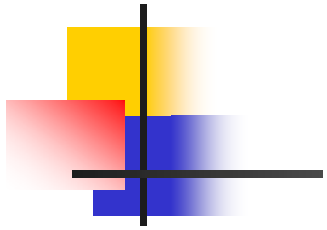
Aug 27 ~ Aug 30, 2001

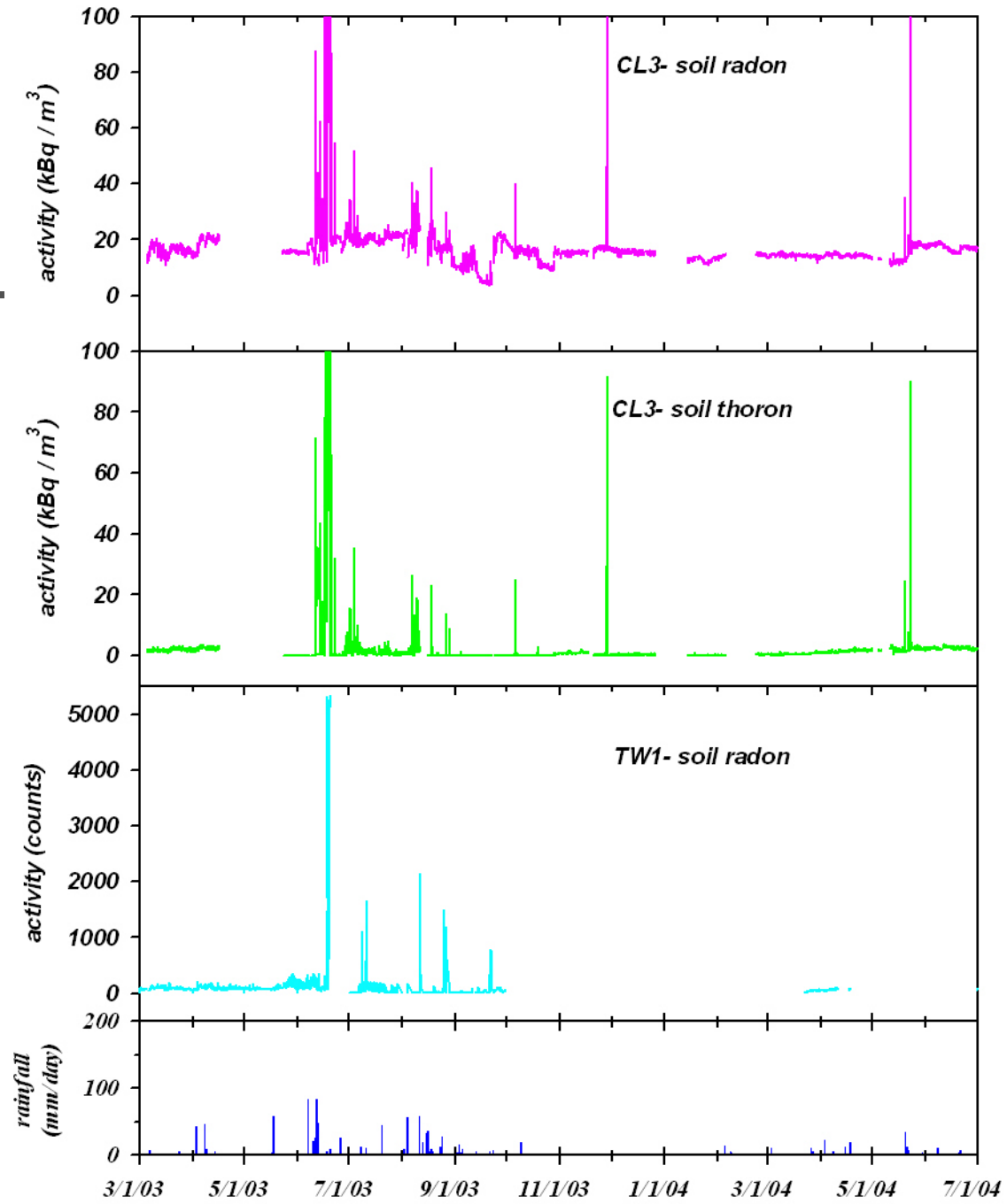
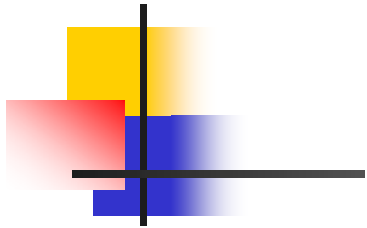


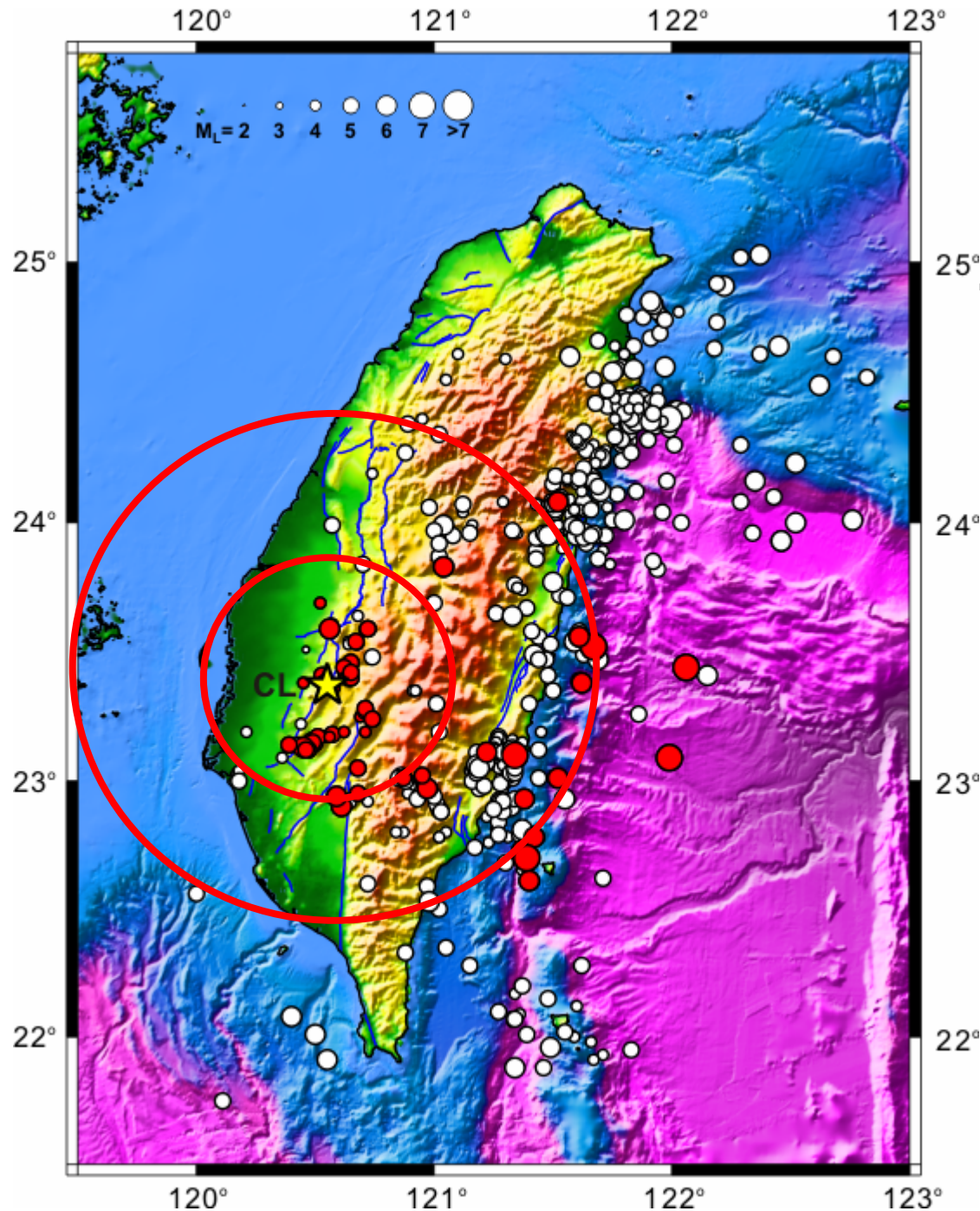


Paper submitted

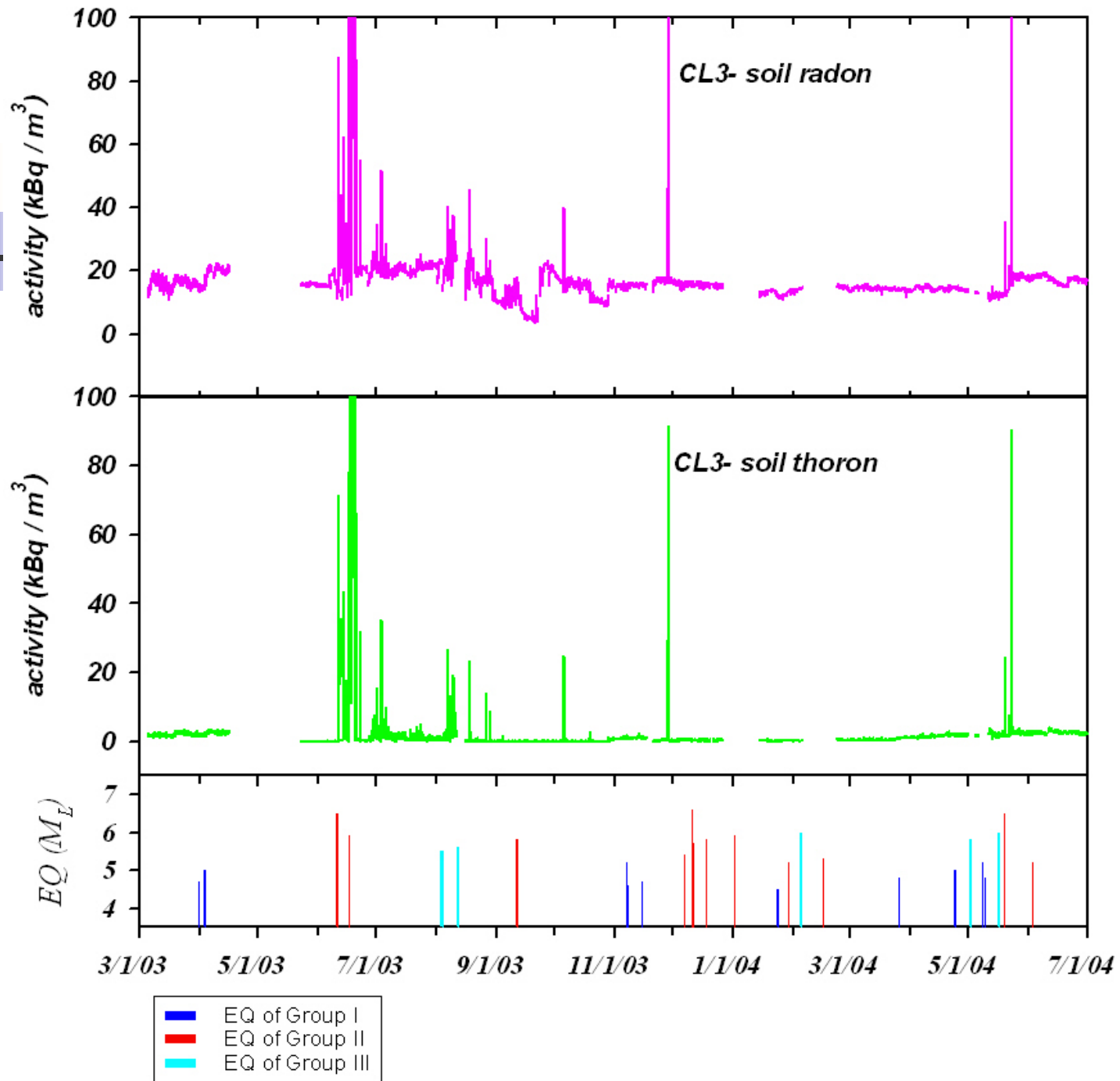
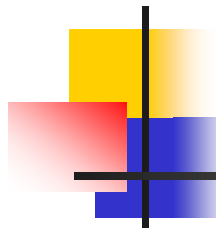


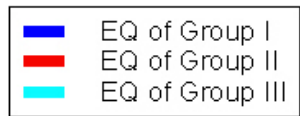
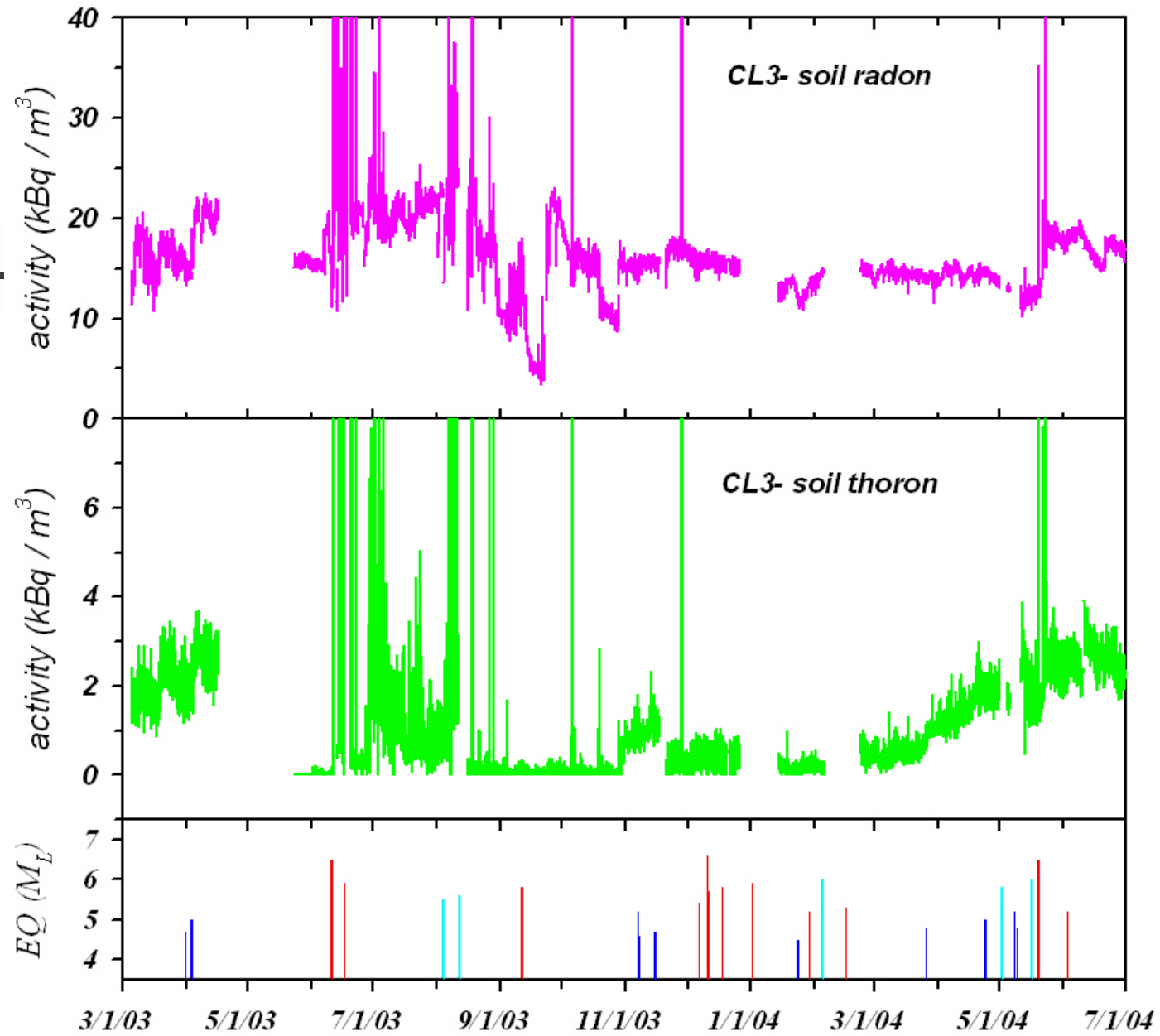
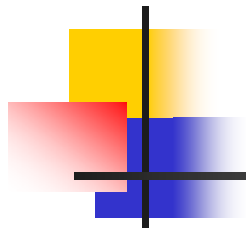


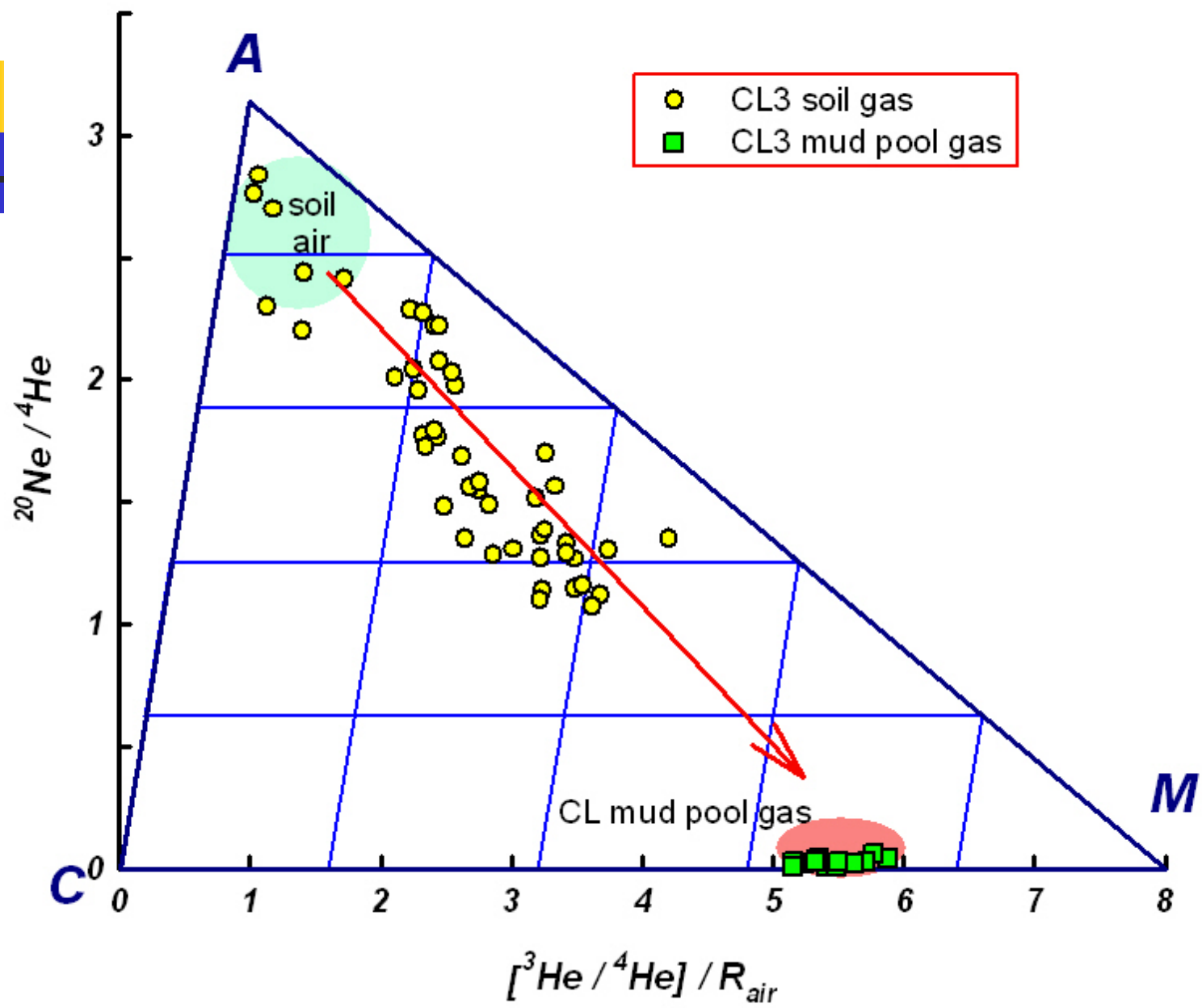
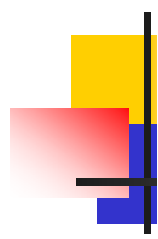




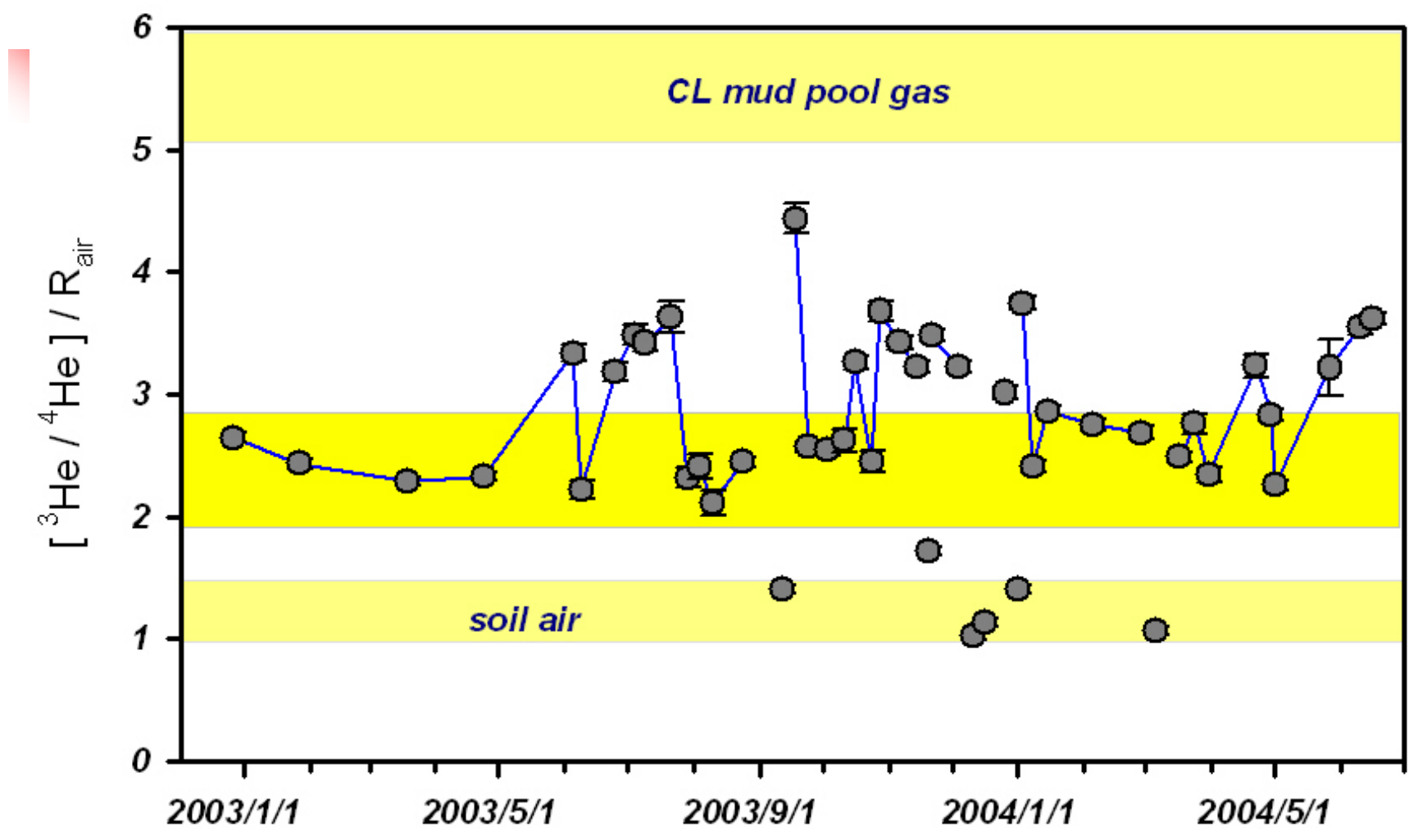
- Totally 488 EQ ($M_L \geq 4.0$) recorded in Taiwan from 2003/1/1 ~ 2004/7/31.
- Epicenter distance ≤ 60 km and local intensity ≥ 2 considered may be related to the monitoring site.
- Three groups:
 - I: ≤ 60 km; $M_L \geq 4.5$
 - II: 60-120 km; $M_L \geq 5.0$
 - III: > 120 km; $M_L \geq 5.0$

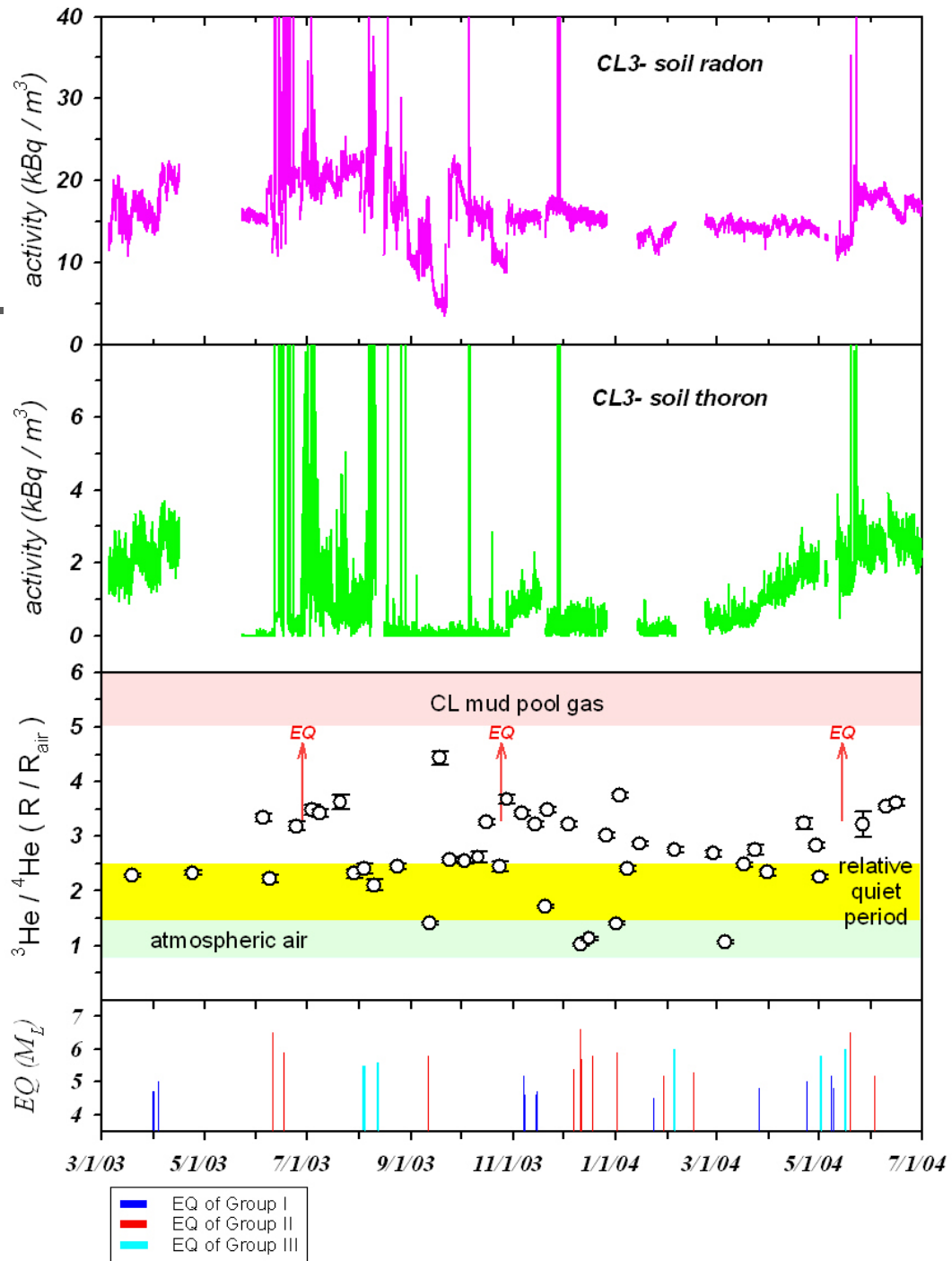
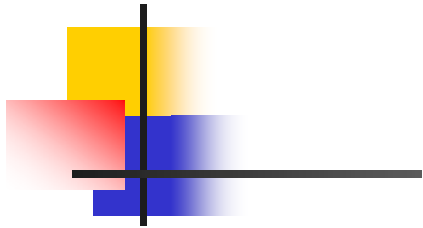


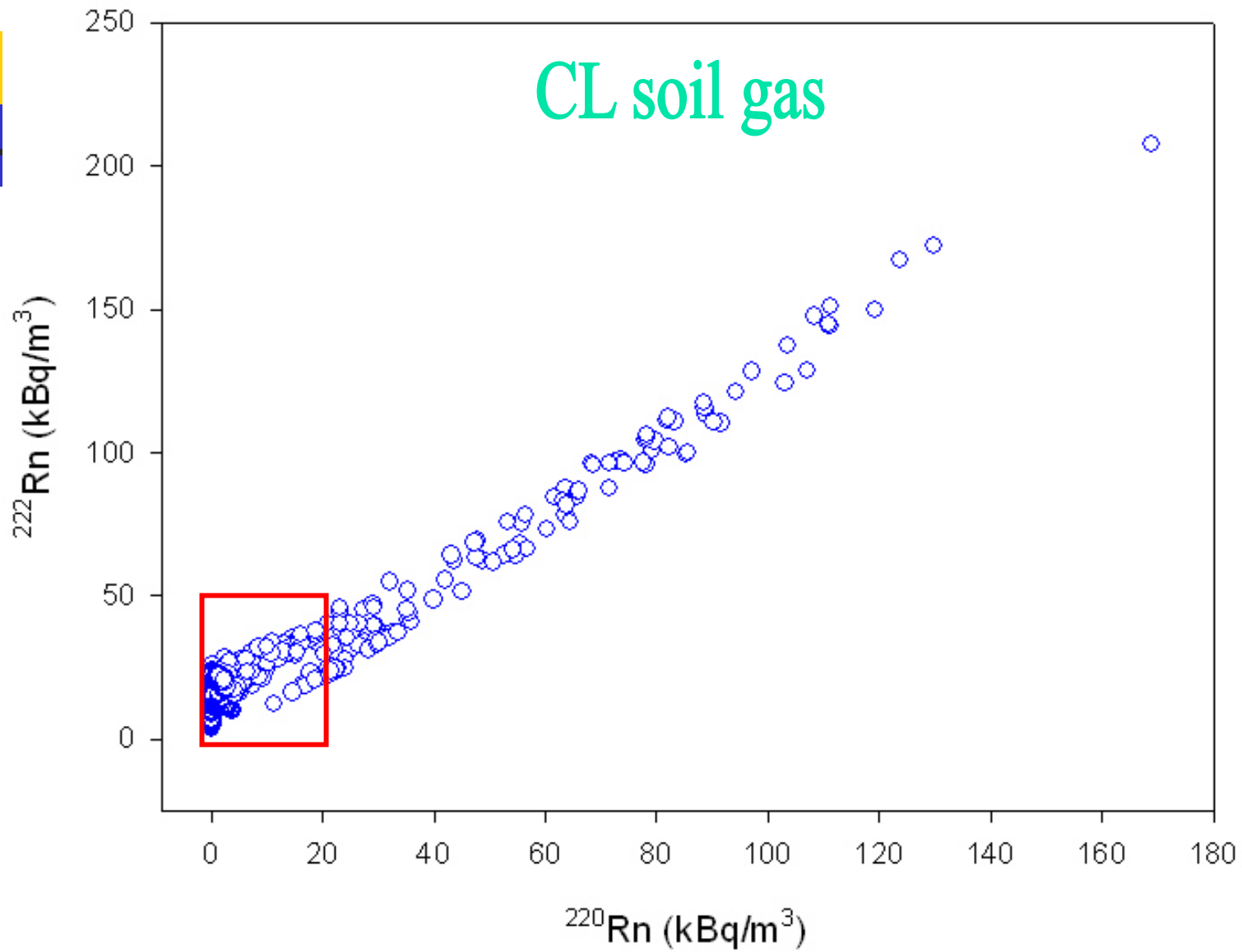




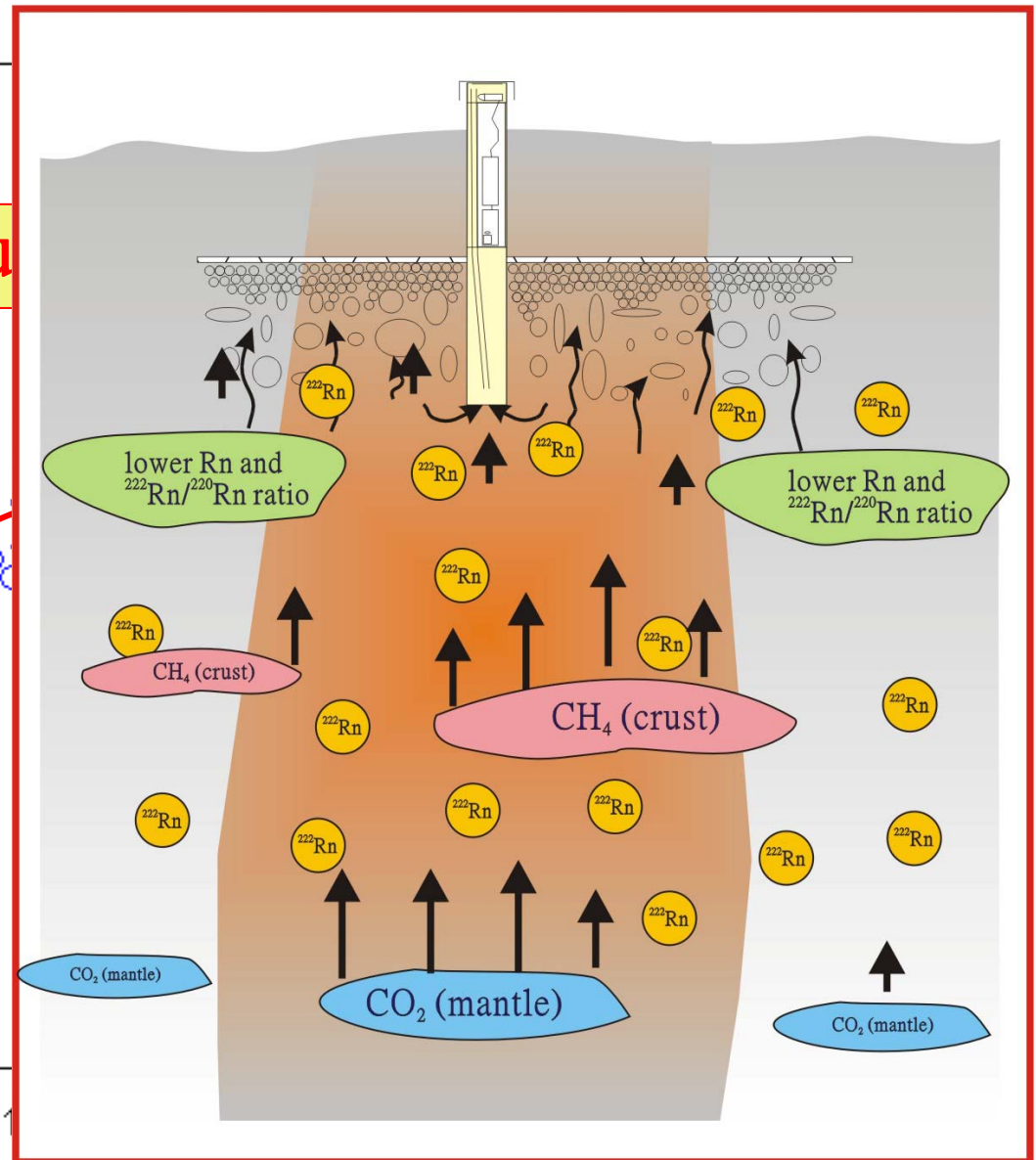
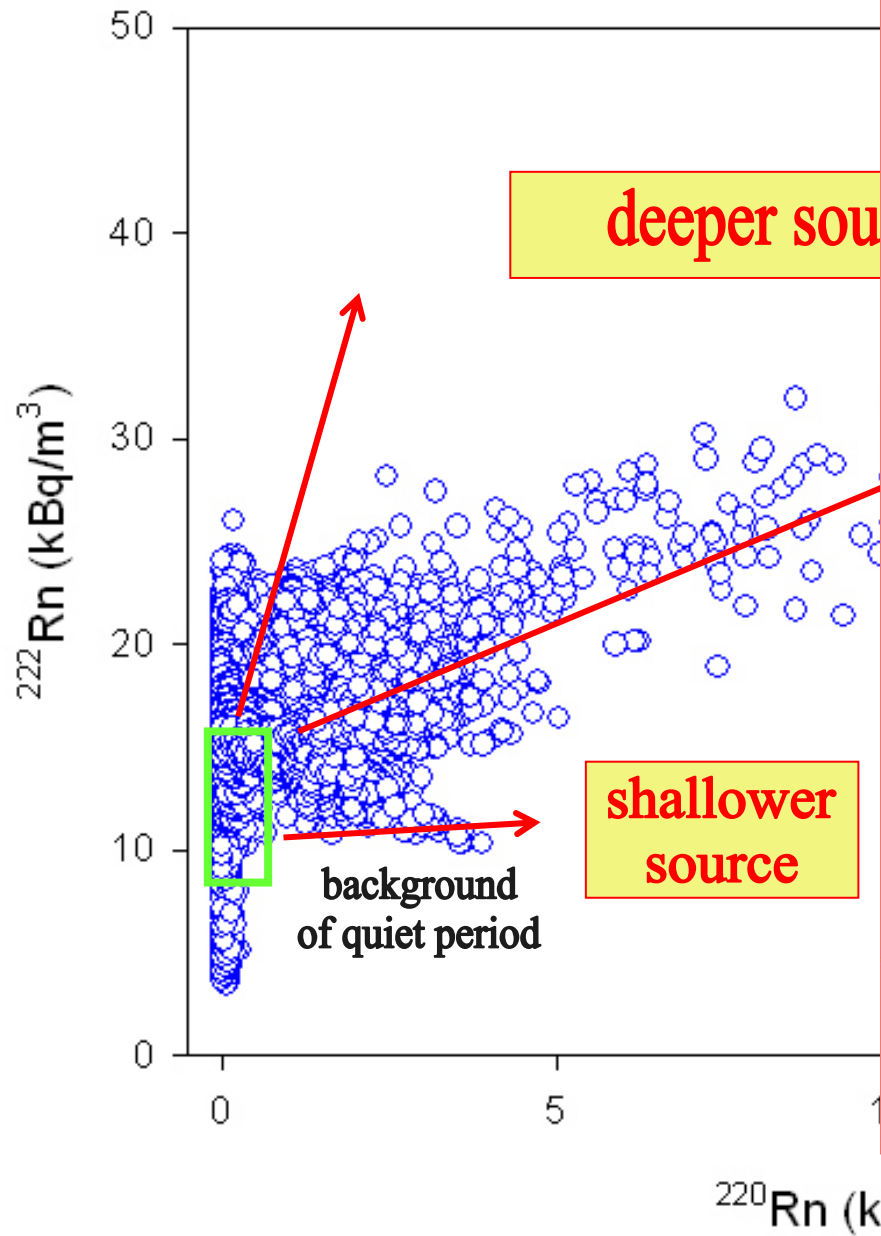
CL soil gas variations







Rn Exhalation Model for CL





Conclusions

- More than one year monitoring, soil gases from two automatic stations at a fault zone of SW Taiwan show consistent pattern of radon variations.
- Spike-like peaks occurred few days or weeks before the earthquakes ($M_L \geq 4.0$), it indicates that they are closely related.
- At least two gas sources required to explain the rare gas data: one from deeper source via fault zone; another from shallower source via micro-fractures.
- In addition to radon, thoron and helium are helpful to constrain the gas sources and can be served as a useful tool for EQ surveillance.
- More stations as a network are needed to delineate the relationship between EQ and gas variations in one area.



Acknowledgement

- *Central Geological Survey and National Science Council of Taiwan support this project.*