

## Questions and Responses in the Chat Box

**Meeting date: 14,16 Nov. 2020**

### **TALK 1 by Yajing Liu (14<sup>th</sup> Nov.)**

**Q1** (Tianjue Li): Hi, I have a question that in the summarised map showing the relationship between corner frequency and scalar seismic moment, there's error bar for corner frequency estimation while no for seismic moment, does this mean giving an error bar to seismic moment estimate is more difficult or the measurement is already accurate enough? Thanks

**Response:** Hongyu Yu would be the best person to answer this question. But I think  $M_0$  is calculated from the long-period (low-frequency) plateau part of the spectra, not from spectral ratio method.

**Q2** (Jianye Chen): What is the lithology of the 'seismogenic layer' or 'formation', where seismicity tends to concentrate when the wells penetrate? Thanks

**Response:** Montney formation is mainly fine grained sandstone, and bituminous siltstone. But I don't know if there are specific differences in the Upper vs Lower Montney. We are getting some drill hole samples from BCOGC Core facility (whenever we are able to travel again). That's part of the project to characterize and do friction experiments.

**Q3** (zqhe): Impressive talk. One question: can other relocation methods such as template matching perform better than hpoDD in the study of induced seismicity? Thanks. (answered orally)

**Q4** (Zonghu Liao)

what is the max anticipated stress drop (more importantly the friction drop? ) to the M4.5 in 5-km depth? 2. any comments about the velocity weakening in such small events spontaneously after hydro-fracturing ? to me it either takes time or high stress impacting. (answered orally)

**Q5** (Adnan Barkat) Do you think induced seismicity is significant for hydrocarbon

production i.e. it influences the basin properties such as porosity permeability of source and reservoir formations. (answered orally)

**Q6** (Guoyan Jiang): Can stress drop values reflect the status of background tectonic stress regime, high or low?

**Response:** Yes, we often use stress drop values as an index for background stress level... with some caveats.

**Q7** (Hongyu Yu): Hi Yajing, it is nice to hear about your new progress. I have a question about your rate and state modeling. When you add a stress perturbation during the earthquake cycle, how long does it last and why do you consider that, thanks!

**Response:** the perturbation time series was from the Comsol model results for the M4.5, stress perturbations on the basement thrust-fault. Alessandro just sent me a longer duration perturbation history. am trying that too!

**Q8** (Xinglin Lei): Hi Yajing, good works! Do you have any idea why the ML4.5 event is isolated?

**Response:** Thanks! I don't really have a good explanation why the M4.5 happened as a "lonely" event... If I have to come up with one, I would guess the fluid channelling is really "targeted", affecting a small area (thus nucleating slip) on the thrust fault. Any suggestions?

**Q9** (Zeng Hongyu)

Thanks for the presentation. In your interpretation of the seismicity after the M 4.5 earthquake, does the lag time between the aftershocks and mainshock match the time needed for fluid to migrate using the preferred permeability?

**Response:** we interpreted the aftershocks as triggered by the Coulomb stress change from the coseismic slip of the M4.5, not by fluid migration.

**Q10** (王帅): The ML 4.5 sequence seems having a large difference in focal mechanism. Why?

**Response:** yes, FMS of the main shock is primarily thrust-faulting (at ~ 4.5 km), the rest mainly strike-slip (in the shallow, upper ~ 2km). We think they are on different fault/fractures.

**Q11** (Tianjue Li): Another question, you haven't got a finite source solution to the M4.5 event yet because of the scarcity of seismic stations around the event, I wonder if we can get a slip distribution even we have a dense seismometers there, for modelling the small earthquake at high frequency is said to be difficult, what do you think about it? Thanks

**Response:** we did have a finite slip inversion. that's work by Zhang Yong (from PKU). he is not super happy about the results though. that's why we didn't base much interpretation on it. with good station coverage, it's possible, but i am not an expert.

**Q12** (Hongfeng YANG): yajing, the seismicity lineation seems to have an angle with the orientations of the fracking well and horizontal maximum stress. Any implications?

**Response:** Yes, there is a small angle between the two. I think it's consistent with most of the FMSs we got so far being primarily strike-slip (with the exception of the M4.5).

## **TALK 2 by Xiaowei Chen (14<sup>th</sup> Nov.)**

**Q1**(Liu Xiaoge): thanks four your presentation, earthquakes occured in early stage have relative samller stress drop, why? thanks a lot.

**Response:** Montney formation is mainly fine grained sandstone, and bituminous siltstone. But I don't know if there are specific differences in the Upper vs Lower Montney. We are getting some drill hole samples from BCOGC Core facility (whenever we are able to travel again). That's part of the project to characterize and do friction experiments.

**Q2** (Tianjue Li): A linear relationship between the stress shape ratio and background pore pressure is observed in part of the study region but not for the other region, when the hydraulic practices are present in whole the region. Could you give a more explanation about that? Thanks

**Response:** the correlation between stress shape ratio and background pore pressure is due to wastewater disposal in north central Oklahoma. The lack of correlation in the central eastern region is unclear, could be due to the overall high pore pressure and lack of spatial variations of pore pressure in central eastern Oklahoma

**Q3** (Hongfeng YANG): Xiaowei: any moderate size earthquakes in OK shallower than 4 km? e.g. M4 events?

**Response:** Yes! The M5 Cushing earthquake sequence is very shallow, around 2 to 3 km depth. This is mainly due to the shallow basement depth

### **TALK 3 by Xinglin Lei (14<sup>th</sup> Nov.)**

**Q1** (Xiaowei Chen): Do these events that have low aftershock productivity have foreshocks?

**Q2** (Hongfeng YANG): The M6 Changning earthquake shows thrust and strike-slip components, as claimed in different studies. Is such oblique faulting purely tectonic, or related to certain injections near different segments of the fault system?

**Q3** (Tianjue Li): How can we describe the maturity of a fault? If there's a blind fault buried in depth that we don't know before, while after an earthquake we figure it out. At this time, can we properly say it is newly generated and juvenile? Thanks

**Q4** (Chong Liu): Great presentation! I am interested in Feb 2019 Weiyuan shallow earthquake sequences. This earthquake is related to Molin fault reactivation (made by F1 in your presentation). You also suggested two blind faults (made by red dash line in your ppt) in Weiyuan earthquake area. How did you detect these two blind faults and how these two blind faults affected the reactivation?

**Q5** (Jianye Chen): Thanks for the very insightful talk. From lab experiments, carbonate rocks are extraordinarily acoustically silient due to strong attenuation. Is it possible that the post-seismic deformation is slient (lack of aftershocks) because the host rock is carbonate?

(All questions in the third talk were responded orally)

### **TALK 4 By Maomao Wang (16<sup>th</sup> Nov.)**

**Q1** (Liu Xiaoge) : 感谢王老师精彩报告，浅部地震反射剖面识别构造深度一般多深？分辨率随着深度降低，深部 deep thrust ramp 位置存在多大不确定性？不同人解释会不会有所不同？

**Q2** (地震局-鲁人齐) : 王教授，请问你们解释模拟的威远背斜缩短量有多大？是否向盆地腹部传递？传递大概多少？

**Q3** (Chong Liu) : 谢谢毛老师精彩的讲座，我有一个问题，Molin 断层和页岩滑脱面 detachment 都可以看成断层，那数值模拟断层重新激活的时候是否需要区别对待？谢谢

**Q4** (Jinping Zi) : 除了志留系龙马溪组之外，下部的寒武系筇竹寺组是否也有页岩气开发潜力

**Q5** (LC) : 请问威远背斜形成的时代？是一次事件还是多期事件形成？

## TALK 5 By Zonghu Liao (16<sup>th</sup> Nov.)

**Q1** (Ruijia Wang): 想问一下这些成像的横向/纵向分辨率大概是多少?

**Q2** (王毛毛): 请问 molin 断层的向下切割深度是多少, 从你的三维地震数据里面, 为什么会有分段?

**Q3** (Sizzer): 廖教授 我十分同意您的关于威远断裂带除了逆冲以外还带有右行走滑的观点 我的问题是: 这套隐伏压扭断层发育的深度 跟王毛毛老师讲到的那套基底滑脱层 是否在一个深度呢? 如果比较深的话, 如此深的隐伏断裂带跟那些发生在比较浅层位的浅源的威远地震序列之间, 是什么构造关系呢?

**Q4** (he dengfa): 你解释的威远走滑断层带, 你认为什么时间活动的?

**Q5** (wang shengli): 廖老师, 属性图是自动追踪的? 在属性急剧变化位置是否进行了人工检验? 是否能展示几条穿过属性急剧变化位置的剖面?

**Q6** (Chong Liu): 请问一下 Molin 断层的倾角 dip 大概是多少, 从王毛毛老师的图片中测量计算大概是 20 度左右, 您这边提供的图大概为 65 度左右, 为什么会存在这么大的区别? 还有就是切割深度区别也比较大?

(all questions were responded orally)

## TALK 6 by Risheng Chu (16<sup>th</sup> Nov.)

**Q1** (mingz): 刚才那个小地震震源机制很漂亮, 想请教下储老师是怎么做的啊?

**Q2** (李进武): 老师, 您好。W3 是在 W1 的正的库仑应力区域, 但是为什么因为 4 个月后才发生, 又推断 W3 不是因为 W1 触发的?

**Q3** (Jing Wu): 日升, 蛮系统的工作, 祝贺。我的问题: 威远东西两簇事件的地震学参数特征有不同, 原因是?

**Q4** (Chen Jie): 储老师 非常精彩的报告! 273 个震源机制解逆断层的倾角有何规律? 是高角度还是低角度逆断层?

**Response:** 非常感谢, 几个 3 级以上地震是高角度, 大部分地震比较小, 不太容易确定。

(Q1-Q3 were responded orally)

## TALK 7 by Haijiang Zhang (16<sup>th</sup> Nov.)

**Q1** (Ruijia Wang): 张老师, 请问双差定位的时候用到波形互相关了嘛? 还是只有时差呢?

**Q2** (Fanbao MENG): 老师你好, 我想问一下孔隙弹性应力是负值, 是指孔隙压力吗? 还是指泵入流体压力减小反馈得到负值? 这个地方不是很明白

**Q3** (朱家正): N5 造成了 N7 的库仑应力减小吗, 是为什么呢

**Q4** (LC): Coulomb stress 变化随深度分布如何? 所显示的图是哪个深度的?

**Q5** (LC): 不同深度 Vp 图像上画的地震似乎是一样的 (全部), 如果只给出相应深度的地震, 情况如何?

**Q6** (Liu Xiaoge): 感谢张老师精彩的报告, 张老师, 排除孔隙弹性机制时, N5 井下的接收断层几何如何设置的? 计算的库仑应力对应的深度是多少?

(all questions were responded orally)