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Technical Memorandum

Prepared for: Center for Biological Diversity

Subject: Scoping Comments for proposed Ruby Oil and Gas Lease Analysis

This technical memorandum provides comments regarding the potential impacts to water resources in the Ruby Mountain resulting from potential oil or gas (O&G) development. It is anticipated that any development would be unconventional, meaning that it would be necessary to use hydraulic fracturing (fracking) to open the target formation to release oil or gas. The Forest Service (USFS) does not specify oil or gas. A target formation is the geologic formation expected to hold the oil or gas. For unconventional development, it is usually a shale which has very low permeability so that the oil or gas is not easily released unless the formation is broken apart by fracking.

The scoping notice states that a no surface occupancy (NSO) stipulation is being considered for the following factors:

- Great sage-grouse priority habitat management areas
- Occupied Lahontan Cutthroat Trout (LCT) stream corridors
- Lands with slopes greater than 40%
- Occupied Rare plant habitat
- Riparian habitats and wetlands

No surface occupancy near these sites is grossly insufficient to protect the two water-related habitats in the list. Those are the LCT waters and riparian habitats and wetlands. NSO does not protect the streams and springs from the many ways that gas or oil development, with directional drilling and hydraulic fracturing (fracking), can cause contaminants to reach the surface and streams and springs. Surface setbacks from these features will not protect them from:

- Gas migration to the surface or to shallow aquifers
- Fluid movement from the formation or from leaks in the well bore from reach the surface or shallow aquifers
- Depletion of flow if water for fracking is not obtained safely

Chemistry of Fracking Fluid and Natural Brine

Unconventional O&G development potentially releases three fluids to the environment. These are fracking fluid, natural brine from the targeted formation, and natural gas (methane and higher chain hydrocarbons). Every operator has a formula that varies for every targeted formation rendering it impossible to know advance the exact chemicals that will be injected into the formation, the USFS should consider the risks of releases of that fluid in a risk-based analysis. The USFS should consider policies that would reduce the toxicity of the fluid.

The USFS should also consider the contaminants in natural fluids, including high salinity and naturally occurring radioactive material. Brine contains extremely high concentrations of salt and naturally occurring radioactive materials. The injection of fracking fluid may displace brine into pathways that will start it flowing to the near surface. Increasing salt loads to pristine streams could ruin their water quality as a coldwater fishery.

Methane is also a fluid released by well drilling and development in many ways. It is the most common gas in natural gas, which includes ethane, propane, and other gaseous hydrocarbons. Although not toxic itself, natural gas can accumulate and either explode or burn. It can also replace dissolved oxygen in surface water, thereby causing problems for aquatic life.

The following sections discuss aspects of unconventional O&G development that the USFS should consider in any leasing decision, and specifically with regard to the Ruby O&G lease analysis.

Pathways for Contaminants to Reach the Surface

Natural gas released by unconventional O&G development has been found to contaminate shallow aquifers, wells, and springs near gas developments. Natural gas can discharge from three different sources -the deep shale, a natural gas well bore, or shallow microbial sources - to shallow groundwater or to streams and springs. Fracking can mobilize gas from either source which can cause short-term or long-term methane contamination on streams and springs. Simply drilling through formations with natural gas can provide a pathway for the gas in that formation to move vertically toward the surface; the pathway can be along the annulus between the casing and the hole wall; the formation can be sandstone or other conventional type gas formation that is not extensive enough to be developed conventionally. The well does not have to provide the entire pathway to the shallow groundwater but could simply connect the source with a shallow fault or fracture which could link the well to shallow groundwater.

Fracking releases both fracking fluid injected into the formation and brine which can follow natural or artificial pathways to shallow groundwater. The high pressure required for fracking can cause fracking fluid to leak from the well bores into surrounding formations, if the well bore leaks. From those sources, the fluid can follow natural pathways to shallow groundwater, streams and springs. The natural pathways include faults and fractures.

Nevada's Ruby Mountains are extensively faulted. The geology of the southern Ruby Mountains near Harrison Pass is conducive to contaminant transport from depth to shallow aquifers or springs. The southern lease section near Harrison Pass has a highly complex structural history (Colgan et al 2010) which leads to many pathways for fracking fluids or brine to reach the surface. A pluton intrudes and outcrops at Harrison Pass (Figures 1, 2, and 3). North and south of the pass, Middle and Upper Cambrian shale and limestone outcrop, along with Lone Mountain and Nevada Formation dolomite. These dip to the east to several normal faults (Figures 1, 2, and 3), which form the springs that support the Ruby Marshes and Lakes (Prudic et a. 1995). Recharge that occurs in the Ruby Mountains enters the dolomite and flows eastward to the springs (Id.). Contamination that enters those formations will eventually reach the springs. Many of the pathways may be unknown or the pressures caused by fracking could reactivate them.

On the west side of the mountain, the Ruby detachment fault underlies the whole complex (Colgan et al 2010). Numerous normal faults fracture and offset the strata and cut through the detachment fault (Colgan et al. 2010, p 15). The normal faults likely have fracture zones that are sufficiently permeable to allow groundwater to flow toward shallower zones (Caine 1996).

The Desert Research Institute (DRI) prepared a series of reports that considered fracking in the Huntington Valley near the southern Ruby Mountains (Pohll et al 2015, hereinafter DRI). DRI modeled transport of contaminants from the target formation to shallow groundwater considering various scenarios.

The DRI modeling does not accurately simulate fracking processes for several reasons. The first is that they assume that most fracking operations do not cause fractures to leave the target formation. Based on observed experience in the Marcellus shale, many operations cause fractures that leave the formation. Much fracking fluid leaves the shale during fracking through out-of-formation fractures which extend as much as 1500 feet above the Marcellus shale (Hammock et al. 2014; Fisher and Warpinski 2011). Hammock et al. (2014) documented 10,286 microseismic events as much as 1900 feet above the shale from 56 HF stages for six Marcellus wells, including many events that extended above the Tully limestone, which had been considered a barrier to fracturing. These fractures did not extend to shallow groundwater, but they provided a pathway from the shale to much more permeable formations closer to shallow groundwater. The new fractures also potentially connect with natural fractures and faults.

The second reason the DRI modeling underestimates the potential for migration is that they assume the permeability of the target formation does not change due to fracking. The modeling assumes that groundwater flow occurs through the shale with its extremely low permeability. The point of hydraulic fracturing is to increase the permeability of the formation. Therefore, modeling that assumes natural shale permeability values would grossly underestimate transport rates through shale that has been fractured. (p 116).

The USFS must analyze setbacks for wells from faults. This means that as part of the analysis, all faults must be mapped. The required setbacks are not simply from the surface but also from the well, wherever it is located below the ground surface. This is important especially if the wells are directionally drilled. If a target formation is close to a natural pathway, fracking fluids or natural brine could flow to the near surface. The analysis must consider the potential for faults in the area and any leasing decision must include such offsets.

Similarly, fracking pressure fractures the target formation, thereby potentially releasing fluids to surrounding formations. This is particularly problematic for out-of-formation fracking, which occurs when the fractures leave the target formation. It happens frequently. The pressure forces fracking fluid to flow outside of the shale, whether through out-of-formation fractures or through just making a contact with more permeable formations above the shale, and start the movement of fluid to shallow groundwater through natural pathways. Travel time for contaminants to reach the surface could vary from tens to thousands of years, depending on the conductivity of the connections (Myers 2012).

- The USFS should require complete mapping of faults and lineaments as part of the analysis of potential leasing, and require setbacks of the wellbore from potential contaminant pathways.

Water Use

Fracking requires millions of gallons of water, some of which remains underground, and the remainder is too contaminated for use. Pumping sufficient groundwater to frack a well could have short-term impacts on flow to springs and stream, some of which could support LCT. Cumulative impacts due to the development of many wells could have a long-term impact. The USFS should analyze these potential impacts as part of a leasing analysis. The results of such an analysis could be a decision to not lease at all, or to schedule leasing so that the effect on streams or springs is less than a threshold that could affect the stream.

The USFS should not consider water use as simply a Nevada state engineer (NSE) decision. The NSE would grant a temporary water right without considering the impact on the environment. The NSE's authority, unless the water would be used for an interbasin transfer, is to protect senior water rights. Unless it can be shown that obtaining groundwater for fracking would affect a senior water right, the NSE would grant it. The USFS has the authority to limit fracking based on whether the water use would affect environmental resources associated with the streams.

- As part of analysis of potential leasing, the USFS should consider the potential impacts to water quantity in the basins that could be used to provide the water.

Flowback and Spills

Flowback is the fluid that flows back up the well from the formation after the pressure induced to cause fracturing is released. Flowback is a natural result of most fracking operations. Flowback can be either fracking fluid or natural fluids occurring in the targeted formation. The operator must be prepared to capture the flow, or a spill will result. Any drill pad must be sufficiently far from surface water that flowback will not contaminate the surface water if the operator is unable to contain it. The drill pad must also have sufficient BMPs to contain spills on site. Most flowing streams in Nevada are very small, and contamination could devastate them due to their small size.

- As part of an analysis of potential leasing, the USFS should consider the potential contaminants in flowback. This requires a full consideration of the chemistry as discussed above.

Conclusion and Recommendations

The USFS should include the potential for O&G development to affect water resources as part of any environmental assessment of the potential for unconventional O&G development in areas in the Ruby Mountains. With respect to water resources, these areas are sensitive due to being habitat for LCT or simply valuable riparian and wetland areas. The USFS will possibly consider drilling with no surface occupancy, which generally means that directional drilling will approach the area from outside the area. This means the drilling will commence in the valley and extend under the mountains.

The geology under the Ruby Mountain is highly complex. There are many faults of different types. Faults provide pathways for fluids to flow from wellbore leaks or out-of-formation fracturing to shallow groundwater or surface water. The only way to minimize these risks is to accurately map all faults at all depths potentially drilled, and the require a setback that the wellbore must maintain from the faults. Setbacks must include uncertainty in the understanding of the fault locations. Due to the close spacing of faults, it is possible that there are no places within the southern Ruby Mountains in which unconventional wells could be safely drilled.

The conclusion, therefore, is that it is not possible to drill for oil or gas under the south Ruby Mountains without putting surface water and groundwater resources at risk. The USFS should not offer leases in this area because it is not possible to do so while also protecting water resources. A no surface occupancy stipulation is insufficient because it does not protect surface water from contamination that could result from the development of unconventional O&G wells beneath and along faults connected to streams.

References

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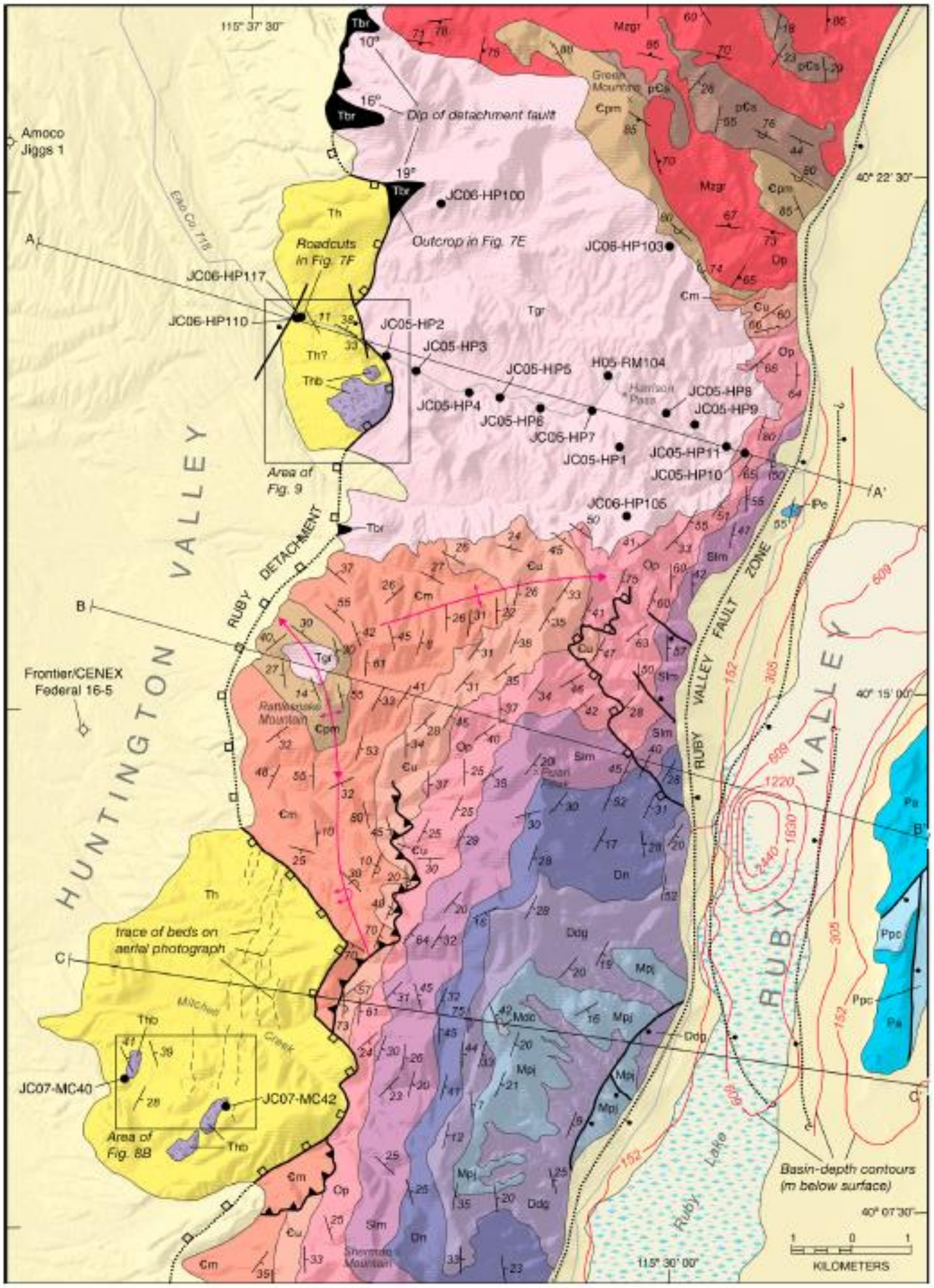

Figure 4

Figure 1: Figure 4 from Colgan et al (2010) showing geology of the Ruby Mountains from Harrison Pass southward. Figure 2 shows the legend explain formation types and structural symbols.

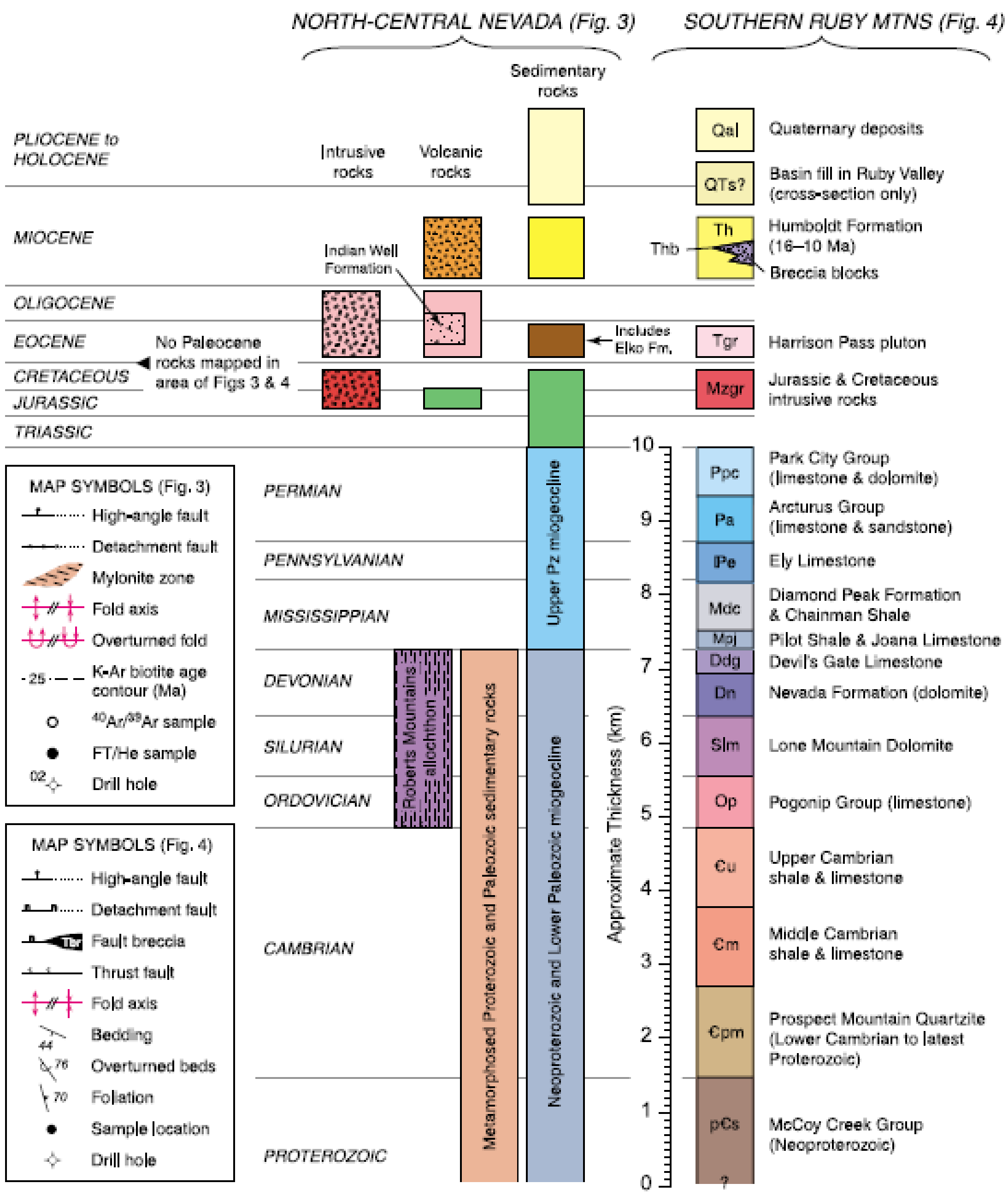

Figure 2. Guide to stratigraphic units and map symbols. (left three columns) Units in Figure 3. (right column) Units in Figure 4. Approximate stratigraphic thickness shown for Paleozoic units in the area of Figure 4. Compiled from map sources listed in Figures 3 and 4; additional sources of stratigraphic information noted in text.

Figure 2: Figure 2 from Colgan et al (2010) showing the legend for geology symbols in Figuyre 1. The formations are shown on the right side of this figure.

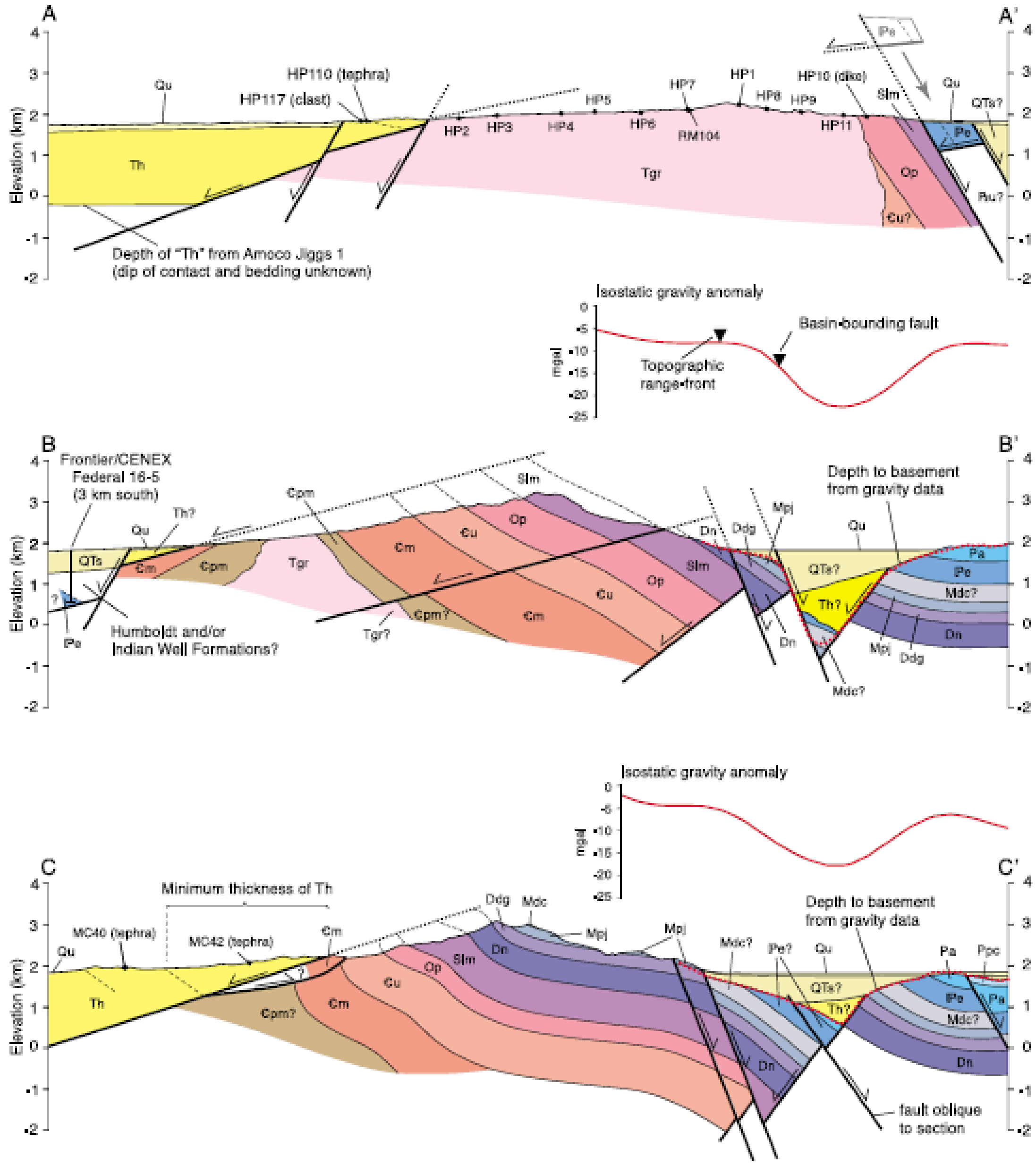

Figure 10. Geologic cross sections of the southern Ruby Mountains (section lines shown in Figure 4). Colors and symbols are shown in Figure 2.

Figure 3: Figure 10 from Colgan et al (2010) showing cross-sections shown in Figure 1.