Identification of shear mechanism in moderately overburied chemical explosive experiments and relation to the DPRK declared nuclear tests

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The Source Physics Experiments (SPE) provided new insights into explosion phenomenology. In particular, the data reveal a mechanism for generating shear energy in the near-source region which may explain why certain North Korean declared nuclear tests do not conform to explosion/earthquake discriminants based on relative body wave (m<sub>b</sub>) and shear wave (M<sub>S</sub>) magnitudes.

The SPE chemical explosive detonations in granite included three scaled depth of burial (SDOB) categories: 1) nominally buried defines the burial depths from which m<sub>b</sub>:M<sub>S</sub> discriminants were derived; 2) deeply overburied, or Green's function depth; and 3) moderately overburied, or between the two end cases above. This last category is a general descriptor for the North Korean declared nuclear tests which fail the m<sub>b</sub>:M<sub>S</sub> discriminant.

Near-source three-axis borehole accelerometers indicate that the nominal and deeply buried SPE experiments created the expected spherical shock environment dominated by radial ground motion with insignificant tangential response.

The moderately overburied SPE experiments indicate a significant contrast. The tangential records in these experiments are quiescent with initial shock arrival and then exhibit a sudden, significant surge immediately following the peak radial component. At distant ranges where the shock wave amplitude has attenuated the environment becomes more consistent with a spherical shock with no significant tangential components.

We interpret a “shear release” mechanism on an obliquely loaded rock joint:

- During incipient loading the normal shock component forces closure of the joint.
- In cases of low explosive loading and/or high in situ stress the tangential component is insufficient to cause joint sliding and this load is stored as shearing strain.
- As the ground shock peak passes the joint unloads and dilates, and the now open joint allows a sudden release of the stored shear strain resulting in sudden joint rupture and slippage.

Step 3 above is essential for identifying when this mechanism occurs. For large in situ stress accompanied by low explosive loading (i.e., deep burial, or high SDOB) the joint fails to open and
rupture does not occur. For low in situ stress accompanied by high explosive loading (i.e., shallow burial, or nominal SDOB) there is insufficient resistance to tangential slippage and no shear energy is stored for later release.

The above provides a fully geodynamic definition for why certain explosive events in jointed rock will fall within the correct explosion population of a $m_b$:$M_S$ discriminant while others may not. Moreover, we illustrate that these observations for the SPE results map directly to generally accepted yield and depth combinations for the six declared North Korean nuclear tests.