Outline

- Introduction—converted wave statics
- Why *interferometry*?
- Why *raypaths*?
- *Common angle* gathers
- The Spring Coulee survey
- *Pilot trace* Interferometry
- *Differential* Interferometry
- Conclusions
Converted wave statics

- Receiver statics usually *much larger* than source statics
- S/N of CW events usually *less* than that of P-wave events
- *Brute force* methods often required (hand picking, trim statics methods)
- *Stationarity/surface-consistency* can be an issue
Why *interferometry*?

- *Interferometry* avoids hand picking
- Very *large* statics can be found and removed
- *Scattered* and *multi-path* events automatically accommodated
- *Interferometry* proven successful on difficult Arctic data
Why *raypaths*?

- Surface-consistency *not* required
- Event S/N often *better* on raypath gathers
- *Non-stationary* statics possible
- *Raypath* approach proven successful on difficult Arctic data
Conventional statics method approximations

- **Single time shift** approximately corrects for **event mismatch** on neighbouring traces
- **Stationarity** assumed (single shift corrects all events on a trace)
- **Surface-consistency** assumed (traces with common shot or receiver have a common static correction)
- **Single event arrival** assumed (no scattered or multi-path arrivals)
Conventional statics model assumptions and resulting **approximations**

- Near-surface raypath segments *vertical*: surface-consistent, stationary
- **Single** point Sources and receivers: surface-consistent, single event arrival
- No scattered or multi-path events: single event arrival
Generalizing the statics model and the consequences

- Near-surface raypath segments *not* vertical: *not* surface-consistent, stationary
- Source or receiver *arrays*: *not* surface-consistent, multiple event arrivals
- *Multi-path* events and *scattering* allowed: multiple event arrivals
Brute stack of MacKenzie Delta high resolution line
MacKenzie Delta line after raypath interferometry
The *raypath* domain—common angle gathers

- Transform *shot* or *receiver* gathers to the *radial trace* domain
- Sort the *radial traces* by apparent velocity (*raypath* angle) and surface location
- Apply *interferometry* to common *angle gathers*
- Sort common *angle gathers* back to *radial trace gathers*
- Invert *radial trace* gathers to *shot* or *receiver*
Near-surface raypath angle is an increasing function of reflection time for each trace in the X-T domain.
Near-surface raypath angle is *constant* for all reflection times for each trace in the R-T domain.
Pilot trace interferometry

- Choose an **ensemble** (shot, receiver, etc.)
- **Flatten events** on each ensemble, using picked horizon or trim statics approach
- Apply **trace mix** to flattened ensemble to produce **pilot traces**
- **Cross-correlate** raw **ensemble traces** with corresponding **pilot traces**
- Derive **inverse filters** from cross-correlations
- Apply **inverse filters** to raw **ensemble traces**
Differential interferometry

- Choose *ensemble* type (shot, receiver, angle)
- **Cross-correlate** sequential *pairs* of raw traces
- Derive *inverse filters* from cross-correlations
- Apply *inverse filter* for each *trace pair* to the second *trace* of the pair—this is the first-order differential correction
Typical common angle gather before interferometry
Common angle gather after interferometric correction
Typical common *angle gather* before *interferometry*
Common *angle gather* after *Interferometric* correction
Original processing—**CCP stack**

Good statics

Poor statics
Interferometry applied to angle gathers—approx. CCP stack
Receiver stack of original shot gathers
Receiver stack, interferometry on angle gathers
Differential interferometry on angle gathers—approx. CCP stack
Conclusions

- **Interferometric** methods improve event coherency
- **Raypath** methods solve for both shallow and deep events simultaneously
- Events on common **angle gathers** often have high S/N
- **Pilot trace** methods may lose geological structure, but work well on noisy traces
- **Differential** methods keep approximate structure, but are susceptible to noisy traces
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