Mistie Problem and Correction Method of Single Channel Seismic Data in Shallow Sea

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Abstract. In processing and interpreting the shallow sea single channel or 2D seismic data, it is found that there are Mistie problems when the sections intersect. The existence of Mistie caused great inconvenience to our interpretation work, fine stratigraphic interpretation and amplitude mapping is required to do Mistie correction, therefore, the closure of seismic data is an indispensable work in processing. Through the analysis of Mistie problem of a shallow seismic area, it is resulted from the inaccuracy of navigation position and the tide, and the coordinate correction technique and tidal correction technique are used to correct the position inaccuracy and tidal effects. The correction result shows that the Mistie problem has been greatly improved.

1. Introduction
When observing shallow sea seismic data sections, we can see the problems of mismatch between the intersect points. Some of these mismatches are visually distinguishable and often show wave differences and longitudinal time differences of the same reflector events. We call the phenomenon of the mismatch at the intersect point as Mistie. Different seismic acquisition and processing could cause this kind of differences, the Mistie causes great inconvenience to our interpretation work. Careful Mistie correction is required for detailed stratigraphic work and amplitude mapping, so the closure of seismic data is an indispensable part of seismic data processing [1-7].

For different types of intersect point mistiest, the former proposed corresponding solutions: Hongzhang Mao [1] used a unified linear decomposition analysis method to decompose errors into systematic errors and random errors, then solved the Mistie caused by amplitude calibration. Based on the principle of geometric seismology, Guanghui Lu [2] used the relationship between the lateral offset and the lateral dip and the apparent depth of the section to process the interpretation data of the 2D migration section, and eventually solved the migration Mistie. On the basis of accurately obtaining the intersect point, Kefei Shen [3] solved the Mistie of intersect point through methods such as single-point closure, anti-intersect point closure (faults on the upper and lower plates, slopes), multi-point closure, and ring closure. Rongtao Gao [4] used least squares algorithm to solve the Mistie between data acquired at different times by iterative matching of phase, amplitude and time difference. Based on the explicit iterative solution techniques, Thomas N. Bishop [5] corrected the Mistie to a large extent by applying the static time shift, gain factor and phase rotation to the seismic lines in the survey network.

Generally speaking, the near-surface conditions of ocean seismic data are relatively stable, so there is no Mistie between the lines. However, in the processing and interpreting the single-channel and 2D
seismic data in the shallow sea area, we found that the Mistie problem also exist, and the shallower the water is, the more serious the problem is.

This paper takes a shallow-sea area as an example to analyze the reasons of the Mistie and puts forward a reliable solution.

2. Overview of the work area
The working area is located in the offshore area of the South China Sea and the water-depth is about 30-45m. The survey line is shown in Figure 1, and the corresponding intersect points are shown in Table 1.

**Table.1.** The intersect point between lines, and the time differences of intersect points (ID=intersect point number, CL=cross line, ML= main line, SPI=Shot Point Number of Intersect point, WDDI=Water-depth Difference of Intersect point, TTDI=Tidal Time Difference of Intersect point)

| ID | CL | SPI on CL | ML | SPI on ML | WDDI(Ms) | TTDI(Ms) |
|----|----|-----------|----|-----------|----------|----------|
| 1  | L40| 1709      | M540| 4072      | 2.7      | 2.85     |
| 2  | L40| 4619      | M560| 25140     | 3        | 1.5      |
| 3  | L40| 7556      | M580| 3879      | -2.7     | -1.85    |
| 4  | L40| 10717     | M600| 9134      | -2.8     | -2.45    |
| 5  | L60| 17151     | M540| 7236      | 1.65     | 2.7      |
| 6  | L60| 14203     | M560| 21925     | -0.75    | 1.35     |
| 7  | L60| 11241     | M580| 7308      | -1.9     | -0.95    |
| 8  | L60| 7899      | M600| 5809      | -2.5     | -2.8     |
| 9  | L60| 4627      | M620| 2922      | -3.55    | -0.8     |
| 10 | L60| 712       | M640| 8174      | 0.9      | 0.35     |
| 11 | L100| 3712    | M540| 13250     | -3.8     | -1.5     |
| 12 | L100| 7016     | M560| 15686     | 2.5      | 0.35     |
| 13 | L100| 15979    | M620| 9094      | 1        | 1.15     |
| 14 | L100| 18772    | M640| 1659      | 2        | 1.8      |
| 15 | L140| 14938    | M540| 19965     | 0.2      | -1.4     |
| 16 | L140| 11363    | M560| 9832      | -5.1     | 0.3      |
| 17 | L140| 1930     | M620| 16148     | -5.6     | -1.2     |

**Figure. 1.** The locations of single-channel seismic sections and they intersect points
3. Mistie phenomenon and the reasons
Seismic acquisition of sea areas is influenced by tides. When the data of same location is acquired at different time, the water-depth is not the same, which causes the two-way travel time of the same Seismic reflection interface to be different, this is the Mistie phenomenon. After picking the seabed water-depth (in MS, the same below), Table 1 shows the water-depth difference (two-way travel time) and tidal time difference (converted to two-way travel time by 1500m/s) of intersect point. To analyze intuitively, the absolute value of the time difference is projected on the base-map, as shown in Figure 2, the larger the circle, the greater the time difference. It can be seen that most of the water-depth time difference is related to the tidal time difference, but the four intersect points of 6, 15, 16, 17 are significantly not.

![Figure 2](image2.png)

**Figure 2.** The time differences of intersect points (left: water-depth time difference, right: tidal time difference)

![Figure 3](image3.png)

**Figure 3.** The 17th intersect point between inline (left: M620) and crossline (right: L140)

Figure 3 shows the seismic sections at the 17th intersect point. It can be seen that not only there is a large Mistie at the seabed, but also the stratigraphic structure seems to be different. A further study found that, there is a certain distance between the GPS recorder and the seismic receiving center, in other words, the coordinates of the current record point are not its actual coordinates. Figure 4 shows the investigation equipment position at the survey ship, the deviation between the seismic record point and...
the navigation reference point is 67.54m in line direction, and 10.42m in the direction perpendicular to the line.

**Figure 4.** The relative position between survey equipment and navigation reference point

**Figure 5.** The flowchart of Mistie correction

In summary, there are two main reasons for the Mistie phenomenon in single channel seismic sections. The first is the horizontal position deviation between the navigation reference point and the actual acquisition point, and the second is the longitudinal time difference caused by the tide.

### 4. Mistie correction

A process as shown in Figure 5 was designed to correct Mistie after analyzing the seismic data and tidal data.

#### 4.1. Coordinate correction

The course of each line is shown in Figure 6, combined with Figure 4, the precise coordinate of the acquisition point can be calculated. As in Equation 1, where $\theta$ is the heading (radian) and $F$ is defined as the direction correction parameter, $x_0$, $y_0$ are the original coordinates, $x$, $y$ are the corrected coordinates, $\pm$ is chosen according to different headings.

$$F = \tan\left(\frac{\pi}{2} - \theta\right)$$

$$x = x_0 \pm \sqrt{\frac{67.54^2}{F^2 + 1} \pm \frac{10.42^2}{F^2 + 1}}$$

$$y = y_0 \pm \sqrt{\frac{67.54^2}{F^2 + 1} \pm \frac{10.42^2}{F^2 + 1}}$$

(1)
Figure 6. The heading of the seismic line

The intersect points after coordinate correction is shown in Table 2, and the absolute value of the time difference is projected onto the base-map, as shown in Figure 7, after coordinate correction, all the water-depth time differences show a significant correlation with the tidal time difference. As shown in Figure 8, the Mistie left only the time difference in the longitudinal direction.

Table 2. The intersect point after coordinate correction, and the time differences of intersect points after tidal correction. (CC=coordinate correction, TC=tidal correction)

| ID | CL | SPI on CL after CC | ML | SPI on ML after CC | WDDI after CC (ms) | WDDI after TC (ms) |
|----|----|--------------------|----|--------------------|--------------------|--------------------|
| 1  | L40 | 1718               | M540| 4085               | 2.5                | -0.35              |
| 2  | L40 | 4629               | M560| 25149              | 2.4                | 0.9                |
| 3  | L40 | 7565               | M580| 3893               | -2.2               | -0.35              |
| 4  | L40 | 10728              | M600| 9144               | -2.8               | -0.35              |
| 5  | L60 | 17162              | M540| 7244               | 1.8                | -0.9               |
| 6  | L60 | 14214              | M560| 21938              | 1.25               | -0.1               |
| 7  | L60 | 11253              | M580| 7318               | -1.2               | -0.25              |
| 8  | L60 | 7909               | M600| 5822               | -2.5               | 0.3                |
| 9  | L60 | 4639               | M620| 2930               | -0.8               | 0                  |
| 10 | L60 | 723                | M640| 8187               | 0.35               | 0                  |
| 11 | L100| 3721               | M540| 13261              | -0.7               | 0.8                |
| 12 | L100| 7027               | M560| 15697              | 0.2                | -0.15              |
| 13 | L100| 15988              | M620| 9107               | 1.3                | 0.15               |
| 14 | L100| 18784              | M640| 1668               | 2.1                | 0.3                |
| 15 | L140| 14950              | M540| 19977              | -0.4               | 1                  |
| 16 | L140| 11373              | M560| 9844               | 0.5                | 0.2                |
| 17 | L140| 1942               | M620| 16158              | -1                 | 0.2                |
Figure 7. The time differences of intersect point after coordinates correction (left: water-depth time difference, right: tidal time difference)

Figure 8. The 17th intersect point after coordinates correction (left: line M620; right: line L140)

Figure 9. Closure of the 17th intersect point after tidal correction (left: line M620; right: line L140)
4.2. **Tidal correction**

Base on the tidal data of the corresponding sea area published by National Marine Information Center [8], interpolated data to a second count, and accurately compared with seismic acquisition time, time differences in the longitudinal direction were eliminated almost by using residual static correction, as shown in Table 2 and Figure 9.

4.3. **Comparison before and after correction**

Compare Figure 9 with Figure 3, the Mistie problems wave solved, and there is a well correspondence of the events, it is conducive to the interpretation work. Figure 10 shows the projection on base-map of the absolute value of time difference in the last column of Table 2, it shows better closure of the intersect points.

![Figure 10. The time difference of intersect point after correction on base-map](image)

5. **Conclusion**

The Mistie between intersect points of seismic section has caused great inconvenience to our interpretation work. Therefore, we must analyze the reasons during processing and minimize or eliminate it.

This paper analyzes the Mistie of single channel seismic intersection in a shallow sea area. The main reason for the inconsistency of events is the horizontal coordinate is inaccurate and the time difference caused by tidal fluctuations. Then, the problem is solved by coordinate correction and residual static correction using tidal data. The intersection closure is greatly improved.

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