Supplementary Information: Methods

To explore the issue of errors in seismic data processing, called over- or under-migration, we use the expression for the lateral movement applied to a time sample in a stacked section by a constant-velocity 2D migration, denoted Δx_m (Yilmaz, 1987: *Seismic Data Processing*, SEG)

$$\Delta x_m = \frac{p t_{in} v_m^2}{4}. \tag{1}$$

In equation (1), t_{in} is the two-way reflection time of a time sample in a stacked section, v_m is the migration velocity, and p is the slope of the fault-plane reflection in a stacked section, called the time dip. The time dip is given by

$$p = \frac{2\sin\theta}{v}, \tag{2}$$

where θ is the dip of the fault-plane and v is the true subsurface velocity, not necessarily equal to the migration velocity v_m. Given the true subsurface velocity, the amount of lateral movement applied by migration should be

$$\Delta x = \frac{p t_{in} v^2}{4}. \tag{3}$$

The difference in the amount of lateral movement applied by migration, Δx_m, and the amount of lateral movement that should be applied, Δx, is the error in the lateral placement of the input point Δx_e due to an incorrect migration velocity

$$\Delta x_e = \Delta x_m - \Delta x = \frac{p t_{in}(v_m^2 - v^2)}{4}. \tag{4}$$

Denoting the depth of the time sample in the stacked section as z, t_{in} is given by

$$t_{in} = \frac{2z}{v\cos\theta}. \tag{5}$$

Therefore using equations (2) and (5), equation (4) may be written as

$$\Delta x_e = z\tan\theta\left[\left(\frac{v_m}{v}\right)^2 - 1\right]. \tag{6}$$

To estimate the amount of error in lateral positioning due to over- or under-migration at the B-fault, we use the approximate depth z and dip θ of the fault given by 2 km and 45º, respectively (see supplementary Fig. 1B). From equation (6), a ±5% error in migration velocity results in a lateral positioning error of approximately 200 m, less than the 700 m of lateral movement we observe at the B-fault in the 1985 and 1992 seismic surveys. Given that the geology above the B-fault is essentially a vertically-varying, compacting stack of soft sediments and that a considerable number of wells with wireline data passed through this section, we feel that a ±5% error in migration velocity is a high estimate of the error. In fact, a 700 m error in lateral positioning requires a ±17.5% error in migration velocity, much too large for a target beneath a layered geology and above salt. Furthermore, the movement of the pulse we observe in the 1985 and 1992 data, if an artifact of incorrect migration velocities, would require that the errors in the two data sets be negatively correlated. For example, if the 1985 data had a -5% error in migration velocity (under-migration) and the 1992 data had a +5% error in migration velocity (over-migration), the residual mis-positioning between the two surveys would still only be 400 m. If both surveys had a +5% error in migration velocity, there would be no apparent mis-positioning in the two surveys. As a result, systematic errors, or biases, in the standard seismic data processing sequence (e.g., the use of summation along a hyperbolic trajectory) do not contribute to the observed lateral movement. Only random errors in the imaging process can cause the patch of reflectivity in the two surveys to apparently move; however, based on the above analysis, these errors would have to be unreasonably large to explain the observed movement. We therefore conclude that 1 km of movement up the B-fault is significant enough to stand out in the presence of typical positioning errors due to incorrect migration velocities.