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高分辨率地震资料处理技术

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摘要: 油田勘探储层解释对地震资料处理提出了更高的要求, 以往的常规地震资料处理手段已难以适应高分辨率地震资料处理和解释的需要。为此, 针对原始资料的特点, 探讨了高分辨率处理中需要解决的几个关键问题, 并研究出一套实用的高分辨率处理技术, 重点阐述了合理利用叠前去噪、振幅保真、反褶积和剩余静校正处理等提高地震资料分辨率的技术问题。在大庆油田三维地震区块的资料处理结果表明, 成果剖面中各反射层位波组特征清楚, 层间信息丰富, 波形自然稳定, 断层走向清晰, 断点干脆, 能够较好地满足地震资料解释的要求。该实验区的解释成果也表明, 所采用的关键技术及处理流程设计正确、合理, 具有推广价值。

关键词: 地震资料处理; 叠前去噪; 剩余静校正; 反褶积; 速度分析

中图分类号: P631.4⁺43

文献标识码: A

目前, 油田勘探中地震资料解释已经从构造解释逐步转向了更细致的储层砂体预测, 这种技术的发展要求地震资料处理具有高保真度、高信噪比、高分辨率的特征^[1,2]。由于通过现有的高分辨率采集工作方式所得到的地震资料具有频带宽、信息丰富的特点, 使以往的常规地震资料处理手段难以适应高分辨率地震资料处理的要求。因此, 必须解决 4 个方面的问题:

- (1) 在振幅保真的基础上, 恰当地压制噪音。
- (2) 保护好原始资料的频率, 拓宽有效信号频带。
- (3) 做好静校正工作, 包括长、短波长静校正问题。
- (4) 要有配套的精细速度分析手段, 对层间弱反射的速度要认真分析。

1 高分辨率处理技术要点

1.1 振幅处理

振幅处理是高分辨率处理的一项重要内容, 它既能使振幅得到有效恢复, 又能改善资料的横向一致性, 为后续的反褶积处理奠定良好的基础。对工区地震测线跨度大、横向振幅不一致的野外原始资料, 采用地表一致性振幅补偿技术^[3], 可以有效地补偿炮点、检波点、共中心点、偏移距等各分量上的振幅差异。

1.2 叠前噪音压制

对一般的地震资料而言, 高频端的噪音相对突

出, 而高频信号对高分辨率处理又是至关重要的, 因此压制叠前噪音是高分辨率处理的重要环节^[4]。

面波压制是在利用面波的频率特性和线性特征识别出面波后, 采用减去法达到压制面波的目的。同单纯的滤波方法相比, 该方法充分保留不具有线性特征的低频有效信号, 而且压制效果也比单纯的滤波方法好。

对于高能干扰及随机干扰, 采用多道识别、单道压制的方法, 使其得到有效的衰减。由于噪音在不同的频段、不同的时间段有不同的特征, 所以采用分频、分时的压制方法效果更好。如果参数选择合理, 也可以使相干噪音得到压制。该方法使处理后的叠加剖面波形自然, 无畸变, 保留了原始资料的原有特征。

1.3 静校正与交互速度分析

地震资料的高频信号对静校正反应敏感, 在地表高程起伏较大或低、降速带横向变化大的地区, 常规的高程静校正方法不能满足高分辨率处理的需要, 应采用初至折射波静校正方法, 对全区进行初至波拾取、统一计算, 在反演出地下低、降速带的厚度和速度场后, 求出各炮点、检波点的静校正量, 从而提高静校正的精度。

解决好剩余静校正问题对于高分辨率处理是非常重要的, 由于剩余静校正量在炮检距、炮点、检波点、共中心点等都存在横向差异, 因此对于测线跨度大的工区, 需采用地表一致性剩余静校正。此外, 考虑到地震

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信号的剩余静校正量在不同频段、不同深度也有差异,采用分频、分时剩余静校正处理效果更好。

要得到好的剩余静校正结果,需要提供精确的速度场。通常,速度分析要与剩余静校正多次迭代,要求有准确、快捷的速度分析手段。采用每个分析点速度临域内实时扫描叠加的分析方式,可以对层间弱反射进行充分地解释,从而保证每个速度分析点速度的正确性。

1.4 反褶积

采用叠前地表一致性反褶积与单道反褶积组合,能使资料的频带明显拓宽,视主频得到明显提高。然后,再进行叠后反褶积处理,使剖面的分辨率得到进一步提高。

地表一致性反褶积不仅使分辨率得到一定提高,而且改善了资料的横向能量一致性,在此基础上进一步拓宽频带,能较好地保持振幅的横向一致性。单道反褶积能使分辨率得到进一步提高,频带进一步拓宽。

叠加效应将导致剖面的分辨率下降,采用叠后反褶积处理技术可以提高资料的视主频,进而满足地震资料解释的需要^[5]。

2 应用与效果

应用高分辨率处理技术,在大庆地区的三维地震资料处理中取得了理想效果,成果剖面的频带宽、视主频高,各反射层波组特征清楚,层间信息丰富,波形自然稳定,断层走向清晰,断点干脆,处理效果明显提高,使油层对比、断层识别和砂体预测等解释效果更加明显。

2.1 油层对比

在高分辨率处理的水平叠加剖面(图 1 - b)上,

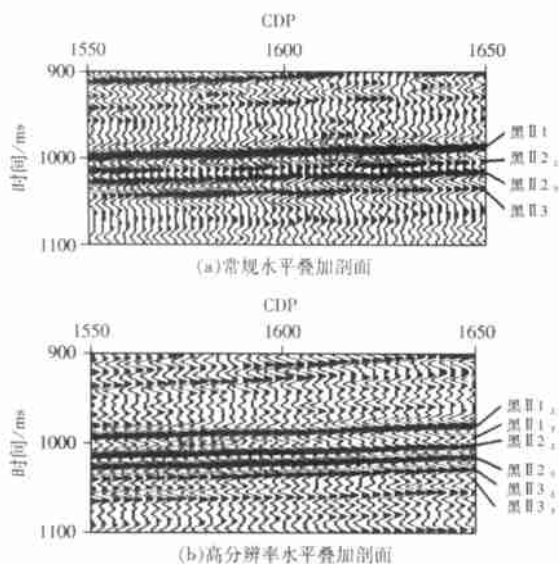


图 1 黑帝庙油层黑二组剖面对比

可以清楚地分辨黑帝庙油层黑二组的 6 个反射层位,这些层位的反射在横向上变化明显。而在采用常规处理流程做出的水平叠加剖面(图 1 - a)上,仅能识别出黑 2 油层组的 2 个砂体(黑 2_上、黑 2_下被分开),其余的层位(黑 1、黑 3)没有被分开。相比之下,黑帝庙油层黑二组在相等时间段内的高分辨率水平叠加剖面比常规水平叠加剖面的视频率提高了 30 Hz。

2.2 断层识别

采用常规处理流程做出的地震剖面可以识别 5 条断层(见图 2 中的 5 条“暗”色断层线),而经过高分辨率技术处理后,又识别出 5 条小断层(见图 2 中“亮”色断层线),不仅有效地保留了常规处理结果(断层的性质、位置基本一致),而且新识别的断层特征也十分明显。由此可见高分辨率处理技术的实用性和有效性。

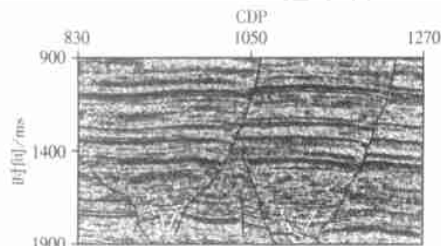


图 2 高分辨率水平叠加剖面

2.3 砂体预测

在高保真的地震剖面(图 3)上,砂体横向变化的层位所对应的地震反射同相轴也产生了明显的强、弱变化(图 3 中箭头所示位置)。因此,通过地震振幅的横向变化,能够反映砂体的空间分布规律,进而准确地判断砂体在横向上的变化情况。

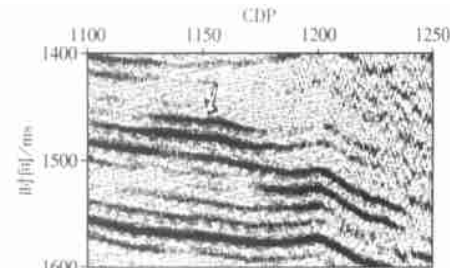


图 3 预测砂体横向变化

3 结 论

(1) 采用折射波静校正及地表一致性剩余静校正,能够较好地解决静校正存在的问题。

(2) 有针对性地采用叠前去噪技术,可以提高剖面的信噪比,为后续的高分辨率处理奠定了基础。

(3) 地表一致性技术的应用,可以提高剖面的保真度。

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也发生了明显变化。杏 4-42-P43 井, 于 1 137.4 ~ 1 140 m 储层处, 出现正自然电位幅度, 加测的流体电阻率曲线在该深度也出现了明显的变化 (图 1)。

以上 2 口井实例说明储层压力大于泥浆柱压力, 地层水流入井内, 泥浆滤液电阻率发生变化。自然电位曲线基线偏移就是由于地层水流入井内造成的, 而自然电位反向是由于地层压力大于泥浆柱压力而产生正的过滤电位的原因。

在南 6-21-更 2136 井进行在不同的泥浆密度情况下的测井验证, 泥浆密度由 1.55 g/cm^3 提高到 1.70 g/cm^3 , 用同一支自然电位测井仪再次进行自然电位测井, 由图 3 看出, 在泥浆加重前所测的自然电位曲线在渗透层处几乎完全平直, 泥浆密度加大后, 渗透层处自然电位幅度较明显。这说明了: (1) 过滤电位在渗透层处的自然电位构成中所占的比重是很大的; (2) 测井仪器工作是正常的。

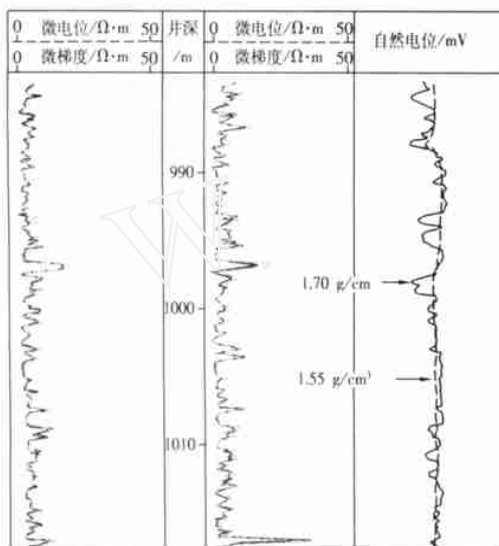


图 3 南 6-21-更 2136 井测井曲线

从图 3 还可以看出, 自然电位曲线异常处微电极曲线无幅度差或幅度差很小, 这是由于: 微电极测井是采用微梯度和微电位两种电极系, 同时测得微梯度和微电位两条测井曲线, 由于探测的深度不同, 泥饼、冲洗带电阻率对其影响也不同, 当井筒内钻井液的压力与储层内流体压力基本一致或小于储层内流体压力时, 井壁形不成泥饼, 这样微梯度和微电位测井值基本一致, 不能产生幅度差或产生较小的幅度差。泥浆密度加重后, 微电极曲线也有一定的改善。进一步证实了自然电位异常的原因。

3 结 论

(1) 过滤电位在渗透层处的自然电位构成中所占的比重很大, 而薄膜电位和扩散电位与开发初期比较已经明显减小。

(2) 自然电位曲线基线偏移这一异常现象是由于井筒内有地层水流入造成的。

(3) 在一些井中, C_w 与 C_{mf} 比较接近, 而 p_w 与 p_m 相当或 p_w 大于 p_m 时, 造成自然电位在渗透层处无幅度或出现正自然电位幅度, 而且微电极曲线一般行不成幅度差。

(4) 建议利用激发极化电位与自然电位两种方法共同使用来解决生产问题。

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(4) 叠前组合反褶积能够提高地震信号的视主频, 拓宽频带。

(5) 高分辨率处理技术的流程设计合理, 具有实用价值。

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tentiality of polymer flooding. The result shows that it is feasible and reliable to use the geological model, which can reflect vertical heterogeneity of the block, fitting overall water cut and recovery percent of reserves to predict the potentiality of enhanced oil recovery by polymer flooding. It is able to quantitatively predict potentiality of polymer flooding, which is consistency with used standard. It is possible that enhanced oil recovery is more than 10.9% and recoverable reserves is more than 120×10^4 t after polymer flooding.

Key words: ideal model; polymer flooding; enhanced oil recovery; potentiality prediction

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The Application of Wave-equation Datum in Velocity-analysis

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Abstract: The main task of future exploration in Daqing Oilfield is deep layer exploration. It is the kernel problem to study from now that how to remove the bad inflections (such as weakly seismic signals) to deep layer's exploration from upper layers, how to overcome the harming infection from the upper layers' spatial speed variety, and to have good seismic image of complicated geological body, especially in deep layer. It is the main topic of this paper that how to make analysis-velocity in deep complicated geological body using datum technology both in shot gather and in receiver gather field. A operator is given in this paper that can deal with irregular surface, complicated structure and variable velocity. It is based on the up-to-date research results of datum and prestack depth migration. It is proved by application and theory that the method has a better effect after datuming than before datuming in velocity-analysis, especially in complicated geological body or the reversal velocity case.

Key words: wave-equation; datum; continuation; irregular surface; velocity-analysis

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High Resolution Seismic Data Processing

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Abstract: Higher requirement is appeared for the oilfield exploration reservoir interpretation. The conventional seismic data processing is hardly satisfied for high resolution seismic data processing and interpretation. According to the real seismic data characteristics, we analyzed a few key problems on the high resolution seismic processing and gave a practical process flow for high resolution processing. The Daqing oilfield 3D processed seismic data result proves that there are some more clear reflection events, faults and stable waveforms within each reflection layer on the seismic section. They are satisfied for seismic data interpretation. The application also proves the technique and the process flow we used are correct.

Key words: seismic data processing; prestack noise attenuation; residual statics; deconvolution; velocity analysis

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Changing Rules of Well Log Interpretation Permeability in Dif-

ferent Period in Daqing Placanticline

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Abstract: In order to know the change of the reservoir permeability with waterflood of the Daqing Placanticline, to research the waterflood course of the reservoir, to find the distribution of remaining oil, to meet the need of geologic model and numerical modeling, to analysis the reason of the difference of the log interpretation permeability in different development period, the permeability of waterflood experiment, the permeability of core analysis and the well log interpretation permeability are researched and compared. The results show that the reservoir permeability increased with the course of waterflood, there are two reasons that cause the difference of the log interpretation permeability in different development period, one reason is the change of permeability with the course of waterflood; the other more important reason is the difference of well log interpretation model. According to these results, the verification of the log interpretation permeability is suggested to meet the needs of fine reservoir research.

Key words: Daqing Placanticline; well log interpretation; air permeability; effective permeability

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Reason Analysis for SP Curve Abnormality

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Abstract: Enormous changes have been taken place in formation water salinity and formation pressure within reservoir of Daqing Placanticline due to long period of waterflooding, for this reason, the SP curves gathered recently are much different from those gathered from the same zone in early period of development and during 1980's and 1990's, abnormality appeared; the SP magnitude near some permeable formation became smaller or even to zero, opposite direction even had been appeared in some permeable formation (that is positive SP magnitude); the ground line of SP curve offsets distinctly. Therefore, from the analysis of the mechanism for forming SP and factors influencing SP, reasons for SP curve abnormality had been found out; the difference between formation water salinity and mud fluid salinity reduced from original 6 000 - 7 000 mg/L to 0 - 2 000 mg/L currently, lead to the diffusion potential and membrane potential reduce or even vanish; in order to prevent the oil bed from contamination, new drilling technology such as near balance or under balance were adopted in some blocks, made reservoir pressure equal to or smaller than mud column pressure, so as to lead these reservoir not produce filter potential or produce positive filter potential; a great amount of waterflooding leads to formation pressure factor changes, some high pressure zone appears, so that formation water will penetrate into well, the salinity of well mud changed and such change is not uniform, the ground line of SP curve offsets. Through a great number of field tests, further corroborated the correctness of analysis mentioned above. Determine the reasons for abnormality occurred in SP curve at last.

Key words: SP; reason analysis; microelectrode; abnormality

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