methods that meet this requirement, and is not limited to only data from streamer acquisition.

[00014] Further, the 3D harmonic-source migration provided by the claimed invention is more appropriate for current wide-azimuth or multi-azimuth acquisitions, while 2D harmonic-source migration mainly fits to narrow azimuth migration. Also, a 3D harmonic-source migration allows for adjusting of sources and receivers to generate artificial sources (split spread), and migrating them altogether to obtain superior image without additional cost. In addition, for each 3D harmonic-source migration, the image produced can cover the whole area that has been surveyed and provides a full line migration aperture. On the other hand, for other known migration techniques such as common-shot migration, the migration aperture is limited in both directions and may fail to image the dipping events in far offsets.

[00015] In view of the drawbacks of methods known in the art, there is a great need for systems and methods that provide efficient and cost effective reverse time migration of seismic data. The present disclosure provides for improved methods and systems that produce high quality reverse time migration data without reduced computational costs and time.

BRIEF SUMMARY OF THE INVENTION

[00016] Embodiments~~One object~~ of the invention seek~~is~~ to provide enhanced systems and methods for performing RTM analysis of seismic data.

[00017] In accordance with one aspect of the invention, there is provided a method for processing seismic traces to produce an image of a subsurface area, said method comprising: receiving a series of seismic traces related to the subsurface area and recorded by one or more seismic receivers, wherein the series of seismic traces are originally generated by a source; applying a 3-dimensional (3D) phase encoding function to the series of seismic traces, at least a portion of said seismic traces comprise signals reflected by geological interfaces of the subsurface area; computing a forward wavefield by solving a first wave equation that is modified to include the phase encoding function; computing a backward wavefield by solving a second wave equation that is modified by a 3D harmonic-

source reverse time migration of the series of seismic traces encoded with the phase encoding function; and cross-correlating the forward wavefield with the backward wavefield to generate an image of the subsurface.~~To meet the above objective, there is provided, in accordance with one aspect of the invention, a method for processing seismic traces to produce an image of a subsurface area. The method includes the steps of applying a 3D phase encoding function to a series of seismic traces, at least a portion of the seismic traces include signals reflected by geological interfaces of a subsurface area, and the signals are recorded by one or more seismic receivers; computing a forward wavefield for one or more modeled shots of the seismic traces by solving a first two-wave equation, where the first two-wave equation is modified to include the phase-encoding algorithm; computing a backward wavefield for data recorded by the one or more receivers by solving a second two-way wave equation,~~

~~where the second two-wave equation is modified to include the phase-encoding algorithm. The phase-encoding algorithm implements the phase shifts in the time-domain. The steps of the method also includes rendering at least one image of the subsurface area by applying a cross-correlation imaging condition and summing the computed forward and backward wavefields to obtain a stacked image.~~

[00017a] In accordance with another aspect of the invention, there is provided a computing device for processing seismic traces to produce an image of a subsurface area, said computing device comprising: a processor configured to, receive a series of seismic traces related to the subsurface area and recorded by one or more seismic receivers, wherein the series of seismic traces are originally generated by a source; apply a 3-dimensional (3D) phase encoding function to the series of seismic traces, at least a portion of said seismic traces comprise signals reflected by geological interfaces of the subsurface area; compute a forward wavefield by solving a first wave equation that is modified to include the phase encoding function; compute a backward wavefield by solving a second wave equation that is modified by a 3D harmonic-source reverse time migration of the series of seismic traces encoded with the phase encoding function; and cross-correlate the forward wavefield with the backward wavefield to generate an image of the subsurface.

[00017b] In accordance with another aspect of the invention, there is provided a computer readable medium including computer executable instructions, wherein the instructions, when executed, implement a method for processing seismic traces to produce an image of a subsurface area, said method comprising: receiving a series of seismic traces related to the subsurface area and recorded by one or more seismic receivers, wherein the series of seismic traces are originally generated by a source; applying a 3-dimensional (3D) phase encoding function to the series of seismic traces, at least a portion of said seismic traces comprise signals reflected by geological interfaces of the subsurface area; computing a forward wavefield by solving a first wave equation that is modified to include the phase encoding function; computing a backward wavefield by solving a second wave equation that is modified by a 3D harmonic-source reverse time migration of the series of seismic traces encoded with the phase encoding function; and cross-correlating the forward wavefield with the backward wavefield to generate an image of the subsurface.

[00018] The foregoing has outlined rather broadly the features and technical advantages of the present invention in order that the detailed description of the invention that follows may be better understood. Additional features and advantages of the invention will be described hereinafter which form the subject of the claims of the invention. It should be appreciated by those skilled in the art that the conception and specific embodiment disclosed may be readily utilized as a basis for modifying or designing other structures for carrying out the same purposes of the present invention. It should also be realized by those skilled in the art that such equivalent constructions do not depart from the spirit and scope of the invention as set forth in the appended claims. The novel features which are believed to be characteristic of the invention, both as to its organization and method of operation, together with further objects and advantages, will be better understood from the following description when considered in connection with the accompanying figures. It is to be expressly understood, however, that each of the figures is provided for the purpose of illustration and description only and is not intended as a definition of the limits of the present invention.

BRIEF DESCRIPTION OF THE DRAWINGS

[00019] For a more complete understanding of the present invention, reference is now made to the following descriptions taken in conjunction with the accompanying drawing, in which:

[00020] FIG. 1 illustrates a source, receiver and a reflected wave recorded by the receiver according to an exemplary embodiment.

[00021] FIG. 2 illustrates a process for determining an image of a subsurface according to an exemplary embodiment.