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G01V 1/30 (2006.01)

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(54) **Title:** AUTOMATED SEISMIC INTERPRETATION-GUIDED INVERSION

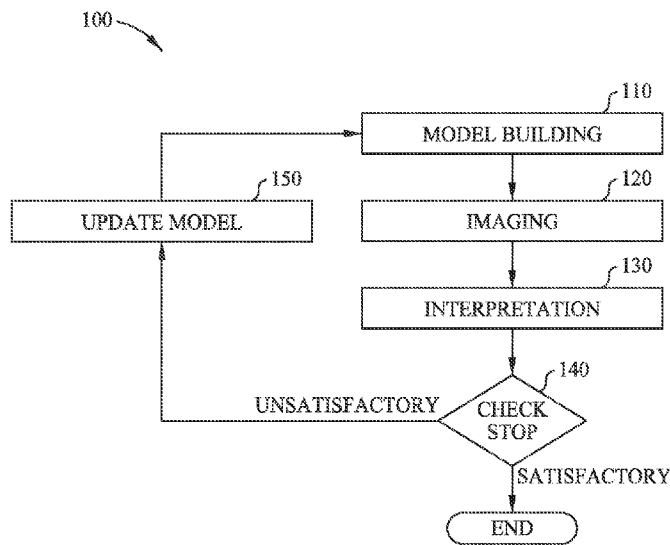


FIG. 1A

(57) **Abstract:** A method and apparatus for seismic analysis include obtaining an initial geophysical model and seismic data for a subsurface region; producing a subsurface image of the subsurface region with the seismic data and the geophysical model; generating a map of one or more geologic features of the subsurface region by automatically interpreting the subsurface image; and iteratively updating the geophysical model, subsurface image, and map of geologic features by: building an updated geophysical model based on the geophysical model of a prior iteration constrained by one or more geologic features from the prior iteration; imaging the seismic data with the updated geophysical model to produce an updated subsurface image; and automatically interpreting the updated subsurface image to generate an updated map of geologic features. The method and apparatus may also include post-stack migration, pre-stack time migration, pre-stack depth migration, reverse-time migration, gradient-based tomography, and/or gradient-based inversion methods.



OM, PA, PE, PG, PH, PL, PT, QA, RO, RS, RU, RW, SA, SC, SD, SE, SG, SK, SL, SM, ST, SV, SY, TH, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, ZA, ZM, ZW.

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Declarations under Rule 4.17:

- *as to applicant's entitlement to apply for and be granted a patent (Rule 4.17(ii))*
- *as to the applicant's entitlement to claim the priority of the earlier application (Rule 4.17(iii))*

Published:

- *with international search report (Art. 21(3))*
- *before the expiration of the time limit for amending the claims and to be republished in the event of receipt of amendments (Rule 48.2(h))*

(88) Date of publication of the international search report:

23 July 2020 (23.07.2020)

INTERNATIONAL SEARCH REPORT

International application No PCT/US2019/061795

A. CLASSIFICATION OF SUBJECT MATTER INV. G01V1/28 G01V1/30 G01V99/00 ADD.				
According to International Patent Classification (IPC) or to both national classification and IPC				
B. FIELDS SEARCHED				
Minimum documentation searched (classification system followed by classification symbols) G01V				
Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched				
Electronic data base consulted during the international search (name of data base and, where practicable, search terms used) EPO-Internal, WPI Data				
C. DOCUMENTS CONSIDERED TO BE RELEVANT				
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.		
X	US 2012/195165 A1 (VU CUNG KHAC [US] ET AL) 2 August 2012 (2012-08-02)	1,3,4, 6-8, 16-22		
Y	abstract; claims 1,2,4; figure 2 paragraphs [0034], [0035], [0044] - [0048]	2,5		
Y	----- US 2018/275300 A1 (AKCELIK VOLKAN [US] ET AL) 27 September 2018 (2018-09-27) abstract; claim 1 -----	2,5		
<input type="checkbox"/> Further documents are listed in the continuation of Box C. <input checked="" type="checkbox"/> See patent family annex.				
* Special categories of cited documents : <table style="width: 100%; border: none;"> <tr> <td style="width: 50%; border: none; vertical-align: top;"> "A" document defining the general state of the art which is not considered to be of particular relevance "E" earlier application or patent but published on or after the international filing date "L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified) "O" document referring to an oral disclosure, use, exhibition or other means "P" document published prior to the international filing date but later than the priority date claimed </td> <td style="width: 50%; border: none; vertical-align: top;"> "T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention "X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone "Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art "&" document member of the same patent family </td> </tr> </table>			"A" document defining the general state of the art which is not considered to be of particular relevance "E" earlier application or patent but published on or after the international filing date "L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified) "O" document referring to an oral disclosure, use, exhibition or other means "P" document published prior to the international filing date but later than the priority date claimed	"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention "X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone "Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art "&" document member of the same patent family
"A" document defining the general state of the art which is not considered to be of particular relevance "E" earlier application or patent but published on or after the international filing date "L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified) "O" document referring to an oral disclosure, use, exhibition or other means "P" document published prior to the international filing date but later than the priority date claimed	"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention "X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone "Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art "&" document member of the same patent family			
Date of the actual completion of the international search	Date of mailing of the international search report			
14 February 2020	25/06/2020			
Name and mailing address of the ISA/ European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Fax: (+31-70) 340-3016	Authorized officer Fernandes, Paulo			

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US2019/061795

Box No. II Observations where certain claims were found unsearchable (Continuation of item 2 of first sheet)

This international search report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1. Claims Nos.:
because they relate to subject matter not required to be searched by this Authority, namely:

2. Claims Nos.:
because they relate to parts of the international application that do not comply with the prescribed requirements to such an extent that no meaningful international search can be carried out, specifically:

3. Claims Nos.:
because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a).

Box No. III Observations where unity of invention is lacking (Continuation of item 3 of first sheet)

This International Searching Authority found multiple inventions in this international application, as follows:

see additional sheet

1. As all required additional search fees were timely paid by the applicant, this international search report covers all searchable claims.
2. As all searchable claims could be searched without effort justifying an additional fees, this Authority did not invite payment of additional fees.
3. As only some of the required additional search fees were timely paid by the applicant, this international search report covers only those claims for which fees were paid, specifically claims Nos.:
4. No required additional search fees were timely paid by the applicant. Consequently, this international search report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.:

1-8, 16-22

Remark on Protest

- The additional search fees were accompanied by the applicant's protest and, where applicable, the payment of a protest fee.
- The additional search fees were accompanied by the applicant's protest but the applicable protest fee was not paid within the time limit specified in the invitation.
- No protest accompanied the payment of additional search fees.

FURTHER INFORMATION CONTINUED FROM PCT/ISA/ 210

This International Searching Authority found multiple (groups of) inventions in this international application, as follows:

1. claims: 1-8, 16-22

A method of seismic analysis comprising producing a subsurface image with an initial geophysical model and seismic data, generating a map of geological features by automatic interpretation and iteratively updating the model, image and map wherein Full Wavefield Inversion (FWI) is used to build the updated geophysical model..

2. claims: 9-15

A method of seismic analysis comprising producing a subsurface image with an initial geophysical model and seismic data, generating a map of geological features by automatic interpretation and iteratively updating the model, image and map wherein the automated seismic interpretation comprises specific operations.

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No
PCT/US2019/061795

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 2012195165 A1	02-08-2012	NONE	

US 2018275300 A1	27-09-2018	US 2018275300 A1	27-09-2018
		WO 2018175013 A1	27-09-2018
