Supplementary Material (1) for Xiaodong Qin et al.:

GROT: A new rotation file format for GPlates

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Contents

Introduction

GPlates and the GPlate Geological Information Model (GPGIM) and the GPlates markup language (GPML) have opened new ways of working with plate tectonic data. Whereas the feature-centric data model has been vastly improved, the way the rotation model data is handled has not changed since the early days of the PLATES software. There is, however, a need to enhance the "richness" of the rotation file in terms of metadata, bibliographic annotation, revision histories and integration of rotation uncertainty estimates. I propose to model this new standard on the currently implemented GMT

OGR format and a Multimarkdown-type set of attributes which should allow for an easy, streamlined processing in tools such as `awk`, `Python` or simple shell scripts as well as integration of these enhanced features into the GPlates software.

Commented lines in current rotation files

Previously rotation files only allowed comments if they were denoted as `999` rotations. This is error prone as already pointed out during the early phases of the GPlates development and cumbersome when directly working with rotation files in a text editor.

999 rotations to comment out lines

An example of a commented line using the current practice of replacing the Plate ID of the moving plate with a `999` to disable it. The inactive rotation sequence data looks like this:

```
999   200.00 -55.810  -41.520  101.880 802 ! FLI-ANT Norton & Sclater 1979 fit
```

This methods has the severe disadvantage, that the original plate ID (PlateID1, moving plate) is lost when inserting a comment. Secondly the comment area is not structured well enough for automatic processing, e.g. extracting bibliographic references related to individual rotations or groups of rotations. It is quite easy to conceive that simple file exchange in collaborations or the omission of metadata can lead to a significant loss of important information contained in the rotation file. In addition, the introduction of novel methods, such as deformation, or Hellinger-style rotation uncertainty parameters requires a much larger set of rotations to be dealt with.

*The GPlates rotation file format – *.grot*

The new GPlates rotation file format encapsulates important rotation metadata in a simple and logical way. It emulates various language syntaxes such as GMT OGR, MultiMarkDown, LaTeX Python and XML to provide a clean, logical and easy-to-use metadata framework. The file suffix for the new rotation file format is `*.grot` for **G**Plates **rot**ation file, pronounced g-rot (and not grot...) .

The new file format uses `*.grot` as extension

The `*.grot` syntax: Basic features

The following section outlines the proposed new standard for encoding metadata (essentially everything beyond the mandatory rotation parameters) which is backward-compatible, and machine-digestible .

Please comment or send feedback to Christian Heine (`mailto:christian.heine@sydney.edu.au`

Flags: Comments and moving plate rotation sequences

Two new flags are introduced in the new `*.grot` rotation file format:

Flags: # for comments and > for denoting moving plate rotation sequences

```
# for commenting lines out
> denoting moving plate rotation sequences
```

Lines starting with # and followed by text are ignored by GPlates unless they contain marked `@ATTRIBUTE` data. If the # is followed by a valid rotation pole specification, the line will be read by GPlates but the rotation pole itself will be disabled (inactive). In the new file format commented lines and comments would appear as :

Lines starting with # and followed by text are *ignored* by GPlates

Lines starting with # and followed by a valid rotation pole specification are regarded *disabled/inactive* by GPlates

```
# Comment which is ignored by GPlates
@C"Comment which is read by GPlates and associated with the next rotation pole below"
288  200.00 -55.81 -41.52  101.88 802
#288  200.00 -55.81 -41.52  101.88 802 @C"Comment read by GPlates but DISABLED rotation"
```

For legacy applications using rotation files a simple `awk` one-liner using RegExp can be used strip off all commented lines or simply preceed them by a `999 0.0 0.0 0.0 0.0 999 #` rotation line.

A new **Moving Plate Rotation Sequence (MPRS)** is introduced in this version of the rotation file. The MPRS serves as header or "segment" and follows the idea of "bookmarking" individual blocks of rotation sequences in various text editors as well as in GPlates as well as the concept of multi line segments in GMT. Detailed info on the syntax of the MPRS in Sec. *Moving Plate Rotation Sequence (MPRS) header*.

Moving Plate Rotation Sequences (**MPRS**) are all rotations applying to an individual moving plate, including cross overs

```
> @MPRS:pid"002" @MPRS:code"PHS" @MPRS:name"Pacific Hotspots"
002     0.780  49.3000  -49.500   -1.020  901
002     2.580  53.7200  -56.880   -2.660  901
002     5.890  59.6500  -66.050   -5.390  901
002     8.860  62.8700  -70.870   -8.230  901
```

Standardised metadata `attribute/value` format

Metadata attributes recognised by GPlates in the new format have a specific format. They are prefixed by an "@" symbol followed by a text string which is the name of the attribute. The attribute value is enclosed in a pair of double quotes "". The allowed set of keywords is listed completely in Sec. "Attribute List".

@ATTRIBUTE"VALUE" is the basic metadata format

```
@ATTRIBUTE"VALUE"

@AU"CHHEI"
```

The syntax allows to have multiple fields for the Value. These fields must be separated by vertical bars/pipes without whitespace before or after the attribute (akin to GMT OGR) :

Attribute Values can have *multiple fields*

```
@ATTRIBUTE"Value 1|Value 2|Value 3"

@MPRS"101|NAM|North America"
```

The following variations for the different attribute:value pairs are allowed, depending on the complexity of the original attribute :

Attributes can have (nested) child attributes

```
@ATTRIBUTE:subattribute"Value"

@MPRS:name"North America"
@MPRS:pid"101"
@MPRS:code"NAM"
```

Attribute and subattributes allow nesting at deeper levels. Consider the following example:

Nested attributes can be written in compact or verbose forms

```
# Template
@ATTRIBUTE:subattribute:subsubattribute"Value"

# Compact version
@DC:contributor"JOCA|John Cannon|john.cannon@sydney.edu.au"

# Extended version
@DC:contributor:name"John Cannon"
@DC:contributor:id"JOCA"
@DC:contributor:email"john.cannon@sydney.edu.au"
```

Here, one complex set of subattribute and subsubattributes can be combined in one line or listed separately in sequence on individual lines.

Attribute aliases and external structures

This method also allows the creation of *aliases* which can be created by referencing certain fields to reduce complexity of nested parent:children attributes. In the current version the use of user-defined aliases is not supported. Example:

Nested attributes can be *aliased*

User-defined aliases are not supported at present

```
#Template
@ATTRIBUTE:subattribute"ID|Name|Email"

# Header info
@DC:contributor"JOCA|John Cannon|john.cannon@sydney.edu.au"
@DC:contributor"MCHIN|Michael Chin|michael.chin@sydney.edu.au"
@DC:contributor"CHHEI|Christian Heine|christian.heine@sydney.edu.au"

# This creates an alias
# However, user-defined aliases are not supported currently!
alias @AU = @DC:contributor:id

# Use alias in rotation sequence
@AU"JOCA"
@AU"CHHEI"
@AU"MCHIN"
```

In this example, an attribute and subattribute (`DC:contributor`) contains a list of values, all separated by a vertical bar/pipe. These attribute values conform to a standardised list where the first element is a unique Author ID, the second specifies the real world name of this author and the third his email. The attribute alias can now be created by assigning the @AU attribute a list of possible values which are all derived from all available `DC:contributor"ID"` fields.

Attributes can reference external sources

This setup allows even to fetch complex structures from external files. Say we keep a BibTeX bibliographic database along with our rotation file. In this file, bibliographic data is collected, with each entry having a unique identifier (the so-called `citekey`). Using nested attributes and aliases we are able to create the following setup:

```
# Header
@BIBINFO:bibliographyfile"file://rotationfile.bib"

# Alias
alias @REF = @BIBINFO:bibliographyfile:citekey

# Actual rotation metadata
@REF"Heine.AGU-GM.04"
```

This creates the possiblity to relatively link unique elements from one source into the rotation file by direct mapping of this unique identifier. A possibly query would yield the BibTeX record for the citation key “Heine.PEPI.08” in the associated bibliographic data file which was specified in the header record using the `@BIBINFO:bibliographyfile` attribute.

Another application is the **possiblity of spatial queries** by referencing certain feature types in an associated GPML file or a remote data source. Consider the following example:

Attributes can be used to generate spatial queries

```
# Header
@GPML:namespace"http://www.earthbyte.org/Resources/GPGIM/public/"

# Alias
alias @CHRONID = @GPML:MagneticAnomalyIdentification:polarityChronID

# Rotation
101    33.100  75.9900    5.9800    9.770  714 @CHRONID"C13"
```

With the available information, GPlates can go and run a spatial query to extract all the relevant features from a source file (e.g. a GPML file with all magnetic anomaly picks). The query would look like:

```
Find all C13 picks on plate ID 101 which have a conjugate plate id 714
```

Naturally, a magnetic anomaly picking scheme has to be agreed upon or explicity stated in the `CHRONID` (e.g. the young end of C13–C13y). As the GPGIM specification states, this information should be included in the value part of this attribute. Refer to `http://www.earthbyte.org/Resources/GPGIM/public/#PolarityChronId` for details. Such a geospatial query can be run for all applicable features.

Currently supported aliases are:

- `CHRONID --> GPML:MagneticAnomalyIdentification:polarityChronID`
- `AU  --> DC:contributor:id`
- `REF --> BIBINFO:bibliographyfile:citekey`
- `DOI --> BIBINFO:doibase:doi`
- `GTS --> GEOTIMESCALE:id`

File structure

The new rotation file format is subdivided into two parts :

`*.grot` Files have a *Header* and *Body*

1. a file header containing metadata and global definitions used in the rotation sequences (Sec. *File header*)
2. the rotation sequence body (Sec. *File body*), composed of individual moving plate rotation sequences (MPRS) which are in turn composed of lines containing rotation data (adhereing to the basic PLATES rotation file syntax)

File header [mandatory]

New GPlates rotation files have a mandatory file header which must be present in all rotation files. The file header contains important information on how to processes different parts of the file and also carries important metadata, such as information on the Geological Time Scale used for rotations . Apart from the mandatory metadata in the header, there are also optional blocks which allow the user to put revision information or any other data the user finds necessary. Future version of GPlates (> 1.3) will include the opportunity to edit this information through a GUI.

The file header contains global metadata which are referenced in the file body. It adheres to specific format and contains mandatory attributes

The file header follows the core elements of the Dublin Core metadata initiative which specifies 15 standard tags to identify electronic documents (see `http://dublincore.org/documents/dcmi-terms`).

Let's start out with the mandatory Dublin Core information in the file header, here's an example:

Rotation file version

`@GPLATESROTATIONFILE:version` — File format versioning

The first line uses the `@GPLATESROTATIONFILE:version"xx"` attribute to specify that this file adheres to the new rotation file standard and gives the current rotation file version number.

```
@GPLATESROTATIONFILE:version"1.0"
```

Dublin Core Document information

`@DC` — document metadata

The subsequent attributes use the `@DC` parent attribute to denote a set of Dublin Core metadata describing the file content. This also includes links to licenses, modification dates and proper citations for the file. See the complete list and explanation of the header attribute data in Sec. *Header attribute list*.

```
@DC:namespace"http://purl.org/dc/elements/1.1/"
@DC:title"GPlates rotation file -  NEW ROTATION FORMAT SAMPLE FILE"
@DC:creator:name"Christian Heine"
@DC:creator:email"mailto:christian.heine@sydney.edu.au"
@DC:creator:url"http://www.gplates.org"
@DC:creator:affiliation"EarthByte Research Group, School of Geosciences"
@DC:creator:affiliation"The University of Sydney, NSW 2006, Australia"
@DC:rights:license"Attribution-NonCommercial-ShareAlike 3.0 Unported (CC BY-NC-SA 3.0)"
@DC:rights:url"http://creativecommons.org/licenses/by-nc-sa/3.0/"
@DC:date:created"2/06/11 4:08:05 PM"
@DC:date:modified"$Date: 2012-05-11 08:10:42 +1000 (Fri, 11 May 2012) $"
@DC:coverage:temporal"0-600 Ma"
@DC:bibliographicCitation"""Chin, Mueller, Cannon, Landgrebe, Heine,
                           Watson, Turner (2012) The GPGIM vol:pp-pp,
                           J. Digitial Earth. doi:xxxxxxxxx """
@DC:description"""
```

```
A sample rotation file in the new GPlates rotation file format v1.1

Based on moving Indian/Atlantic hotspots (O'Neill et. al. 2005)
to 100 Ma and true polar wander corrected palaeomagnetic
reference frame (derived from Steinberger and Torsvik 2008)
from 100 - 200 Ma.  250 Ma is the extent of this rotation model.
Pacific absolute reference frame based on Wessell and Kroenke 2008
with a switch to Wessel et. al. 2006 at 118.4 Ma
Reference for rotation model: Seton et. al. (submitted to ESR)"""
```

Contributing authors

The next mandatory block is the contributor information related to individuals who have worked on various parts of the rotation sequences. In order to correctly attribute contributions which have not made it into publications, this section lists authors with their contact details and full name. The lines use the `@DC:contributor` form of the Dublin Core specifications and the value field contains multiple values. In most cases, especially in intra-institutional use, not all rotations are published in the form of a citable reference, enlisting contributing authors still provides a reference to the creator.

`@DC:contributor` — Contributing authors

```
# Template
@DC:contributor"id | Real Name | Email | URL | [Postal address, other contact details]

# Example (single line)
@DC:contributor"RDM | R. Dietmar Muller | dietmar.muller@sydney.edu.au | http://www.earthbyte.org | EarthByte Group, The University o

# Example (multi line)
@DC:contributor"""CHHEI |
                 Christian Heine |
                 christian.heine@sydney.edu.au |
                 http://www.earthbyte.org |
                 EarthByte Group, School of Geosciences, The University of Sydney
```

Bibliographic and reference section

The next mandatory block encompasses the bibliographic or reference data valid for the file globally. The field contain a reference to a bibliographic data base in BibTeX format (see Sec. *Bibliographic data*) as well as to the GPlates Information Model (GPGIM) website and a base URL for the Digital Object Identifier (DOI). All these attribute will be referenced from the individual MPRS or rotations.

`@BIBINFO` — Optional inclusion of bibliographic databases

The inclusion of mandatory bibliographic reference data allows a future use of GPlates in conjunction with hyperlinks (through the DOI) to a publication as well as direct links to a bibliographic companion database file:

```
@BIBINFO:bibfile"file://rotationfile_v2.bib"
```

```
@BIBINFO:doibase"http://dx.doi.org/"
@GPML:namespace"http://www.earthbyte.org/Resources/GPGIM/public/"
```

Geological Time Scales

One of the most important piece of metadata is information about the geological time scales (GTS) used to convert relative geological ages to absolute times . These GTS constantly evolve and a Base Aptian on some timescale from the 1990's has a few Million Years difference to a Base Aptian from the 2010's. The GTS are listed in the header section and are referenced through a tag at individual rotation level.

`@GTS` — Mandatory inclusion of Geological Time Scales

```
# Template
@GEOTIMESCALE" ID | DOI/URL/ISSN (specify) | CiteKey | Bibliographic record/Comment"

# Multiline specification of GTS
@GEOTIMESCALE""" GEEK07 |
              doi:10.1016/B978-044452748-6.00097-3 |
              Gee.ToC.07 |
              Gee, J.S. and Kent, D.V. (2012) 5.12 - Source of Oceanic \
 Magnetic Anomalies and the Geomagnetic Polarity Timescale, in: Treatise on\
 Geophysics, Volume 5, Pages 455--507, Elsevier, Amsterdam"""
#
@GEOTIMESCALE""" CK95G94 |
             doi:10.1029/94JB03098; doi:10.1029/94JB01889|
             Cande.JGR.95; Gradstein.JGR.94 |
             S. C. Cande and D. V. Kent. Revised Calbration of the\
 geomagnetic polarity timescale for the Late Cretaceous and Cenozoic. \
 J. Geophys. Res., 100(B4):6093--6095, 1995.;
 F. M. Gradstein, F. P. Agterberg, J. G. Ogg, J. Hardenbol, P. van Veen,\
 J. Thierry, and Z. Huang. A Mesozoic time scale. J. Geophys. Res.,\
 99:24051--24074, 1994. doi:10.1029/94JB01889."""
#
@GEOTIMESCALE""" Absolute
             |
             |
             Absolute numerical time in Ma"""
```

Optional: Revision history

The optional revision history block is used for versioning. The actual list of applicable subattributes depends on the versioning system used . Each Keyword should be shortened and prefixed by `@REVISIONHIST[keyword]"value"`. Example for a Subversion repository setup:

`@REVISIONHIST` — Optional inclusion of versioning information

```
@REVISIONHIST"$Id: CHHEI_RotFileStd.tex 1789 2012-05-10 22:10:42Z christian $"
```

File body: The rotation sequences

The file body contains all Moving Plate Rotation Sequences (MPRS) which are in turn composed of individual lines listing rotation parameters.

Moving Plate Rotation Sequence (MPRS) header

`@MPRS` — The Moving plate rotation sequence

The moving plate rotation sequence (MPRS) specifies a block of rotations which all have the same moving plate id. It is denotes by a > flag at the start of each line and allows multi-line headers. The introduction of a header for any moving plate rotation sequence follows the idea that most metadata is applied to a whole sequence of rotations and allows for better "bookmarking" in GPlates' rotation file editor or other external text editors. The rotation header sequence denominator is modelled as follows:

```
# Template
> @MPRS:pid"PID1" @MPRS:code"XXX" @MPRS:name"Moving Plate name"

# Compact version
> @MPRS"288 | FLI" | Falkland Islands"

# Extended version
> @MPRS:pid"288" @MPRS:code"FLI" @MPRS:name"Falkland Islands" @C"optional comment"

# Multiline version
> @MPRS:pid"288"
> @MPRS:code"FLI"
> @MPRS:name"Falkland Islands"
> @C"Optional comment" @AU"CHHEI"
```

`>@MPRS` — Default metadata for individual rotations

Oftentimes the full moving plate rotation sequence is taken from a single author/publication. In that case, adding metadata to each rotation line would increase the possibility for mistakes . The new rotation file format allows the user to specify metadata for a whole MPRS in the header which then applies to all rotations in that sequence:

```
> @MPRS:pid"002" @MPRS:code"PHS" @MPRS:name"Pacific Hotspots"
002     2.580  53.7200  -56.880   -2.660  901 @PP"PHS-PAC" @REF"Wessel.JGR.08" @C"Model WK08-A" @GTS"GeeK07"
002     5.890  59.6500  -66.050   -5.390  901 @PP"PHS-PAC" @REF"Wessel.JGR.08" @C"Model WK08-A" @GTS"GeeK07"
002     8.860  62.8700  -70.870   -8.230  901 @PP"PHS-PAC" @REF"Wessel.JGR.08" @C"Model WK08-A" @GTS"GeeK07"
002    12.290  65.3700  -68.680  -10.300  901 @PP"PHS-PAC" @REF"Wessel.JGR.08" @C"Model WK08-A" @GTS"GeeK07"
002    17.470  68.2500  -61.530  -15.500  901 @PP"PHS-PAC" @REF"Wessel.JGR.08" @C"Model WK08-A" @GTS"GeeK07"
002    24.060  68.7800  -69.830  -20.400  901 @PP"PHS-PAC" @REF"Wessel.JGR.08" @C"Model WK08-A" @GTS"GeeK07"
002    28.280  67.7200  -70.800  -23.600  901 @PP"PHS-PAC" @REF"Wessel.JGR.08" @C"Model WK08-A" @GTS"GeeK07"
002    33.540  66.5700  -68.730  -27.700  901 @PP"PHS-PAC" @REF"Wessel.JGR.08" @C"Model WK08-A" @GTS"GeeK07"
002    40.100  65.4300  -64.250  -31.600  901 @PP"PHS-PAC" @REF"Wessel.JGR.08" @C"Model WK08-A" @GTS"GeeK07"
```

can now be replaced with

```
> @MPRS:pid"002" @MPRS:code"PHS" @MPRS:name"Pacific Hotspots"
> @PP"PHS-PAC" @REF"Wessel.JGR.08" @C"Model WK08-A" @GTS"GeeK07"
002     2.580  53.7200  -56.880   -2.660  901
002     5.890  59.6500  -66.050   -5.390  901
002     8.860  62.8700  -70.870   -8.230  901
002    12.290  65.3700  -68.680  -10.300  901
002    17.470  68.2500  -61.530  -15.500  901
002    24.060  68.7800  -69.830  -20.400  901
002    28.280  67.7200  -70.800  -23.600  901
002    33.540  66.5700  -68.730  -27.700  901
002    40.100  65.4300  -64.250  -31.600  901
```

In case there are changes to individual rotations in the MPRS these can be done on line/rotation pole level and will overide the MPRS header data :

Multiline comment metadata in `@MPRS` header

```
> @MPRS:pid"002" @MPRS:code"PHS" @MPRS:name"Pacific Hotspots"
> @PP"PHS-PAC" @REF"Wessel.JGR.08" @C"Model WK08-A" @GTS"GeeK07"
002     2.580  53.7200  -56.880   -2.660  901
002     5.890  59.6500  -66.050   -5.390  901
002     9.0    62.8700  -70.870   -8.230  901 @AU"CHHEI" @T"2012-05-03" @C"Changed time from 8.860"
002    12.290  65.3700  -68.680  -10.300  901
002    17.470  68.2500  -61.530  -15.500  901
002    24.060  68.7800  -69.830  -20.400  901
002    28.280  67.7200  -70.800  -23.600  901
002    33.540  66.5700  -68.730  -27.700  901
002    40.100  65.4300  -64.250  -31.600  901
```

Given the above, the new 9.0 Ma rotation will carry the metadata specified on for the individual pole and *only the specified pole metadata overrides the MPRS metadata* (non-overridden metadata is still inherited from the MPRS).

Rotation line data

We adopt the legacy PLATES rotation format which consists of 6 mandatory parameters specifying the stage pole of any given rotation . The format has not changed and is fully compatible with legacy applications.

Backwards compatibility with PLATES rotation data

```
       PID1 STARTAGE POLELAT POLELON ANGLE PID2
```

`PID1` Plate ID 1 (moving plate)

`FROMAGE` Excuse the french. Start age.

`PLAT` Rotation pole latitude

`PLON` Rotation pole longitude

`ROTANGLE` Rotation pole angle

`PID2` Fixed Plate, plate ID 2

Rotation metadata attributes

New optional meta data attributes from the dictionary can be added to the individual lines . The optional attributes follow the structure layed out in Sec. *Attribute format* and can consist of the following elements:

`@PP|` Abbreviated description of the relative plate motions, e.g. Africa-South America to `@PP"SAM-AFR"`, the abbreviated names have to adhere to the `@MPRS:code` from the MPRS.

`@C` Free form comment

`@GTS:id` Unique ID of the geological time scale used in idenfiying the magnetic anomaly picks. References the `GEOTIMESCALE:id` in the file header

`@AU` Abbreviation/ID of modification author. *Alias* which references `DC:contributor:id` in the file header.

`@DOI` Digitial object identifier for reference related to that individual rotation. *Alias* to `@BIBINFO:doibase:doi`.

`@REF` Citation key for reference related to that individual rotation. *Alias* for `@BIBINFO:bibliographyfile:citekey`.

`@HELL` set of attribute:value pairs for uncertainty parameters for this rotation. For details see Sec. *Uncertainty parameters*.

`@T` Modification date/time. Adhere to ISO standard (ie [YYYY]-[MM]-[DD]T[hh]:[mm]:[ss]).

`@CHRONID` Magnetic anomaly chron ID. Alias to `GPML:MagneticAnomalyIdentification:polarityChronID` and adheres to strict naming convention. The identifier used for magnetic picks evolved to be a combination of letters and numbers, of the form

```
(C/M)<number><combination of letters>
```

See `http://www.earthbyte.org/Resources/GPGIM/public/#PolarityChronId` for details.

Example:

```
833    53.300 -14.1900  130.4100   -0.7200  801 @PP"LHR-AUS"  @DOI"10.1029/98JB00386" @CHRONID"C24o"
```

Uncertainty data for rotations

The Hellinger method allows to compute statistical uncertainties for rotations, representing them as a series of parameters and a 3D-covariance matrix . These parameters are

Hellinger Statistics attributes for individual rotations

r total misfit (sum of squares of the weighted distances of data points to great circle segment) in [km]

N number of data points

s number of great circle segments

dF number of degrees of freedom

$\hat{\kappa}$ kappahat,quality factor which relates the uncertainties assigned to the data to their true estimates

- a 3×3 covariance matrix which needs to be divided by the factor kappahat to convert in square radians

An example matrix is given here obtained from the file satl.34 and running the `hellinger1` program:

$$\begin{pmatrix} 8.71113084 & -4.33230877 & -4.97091355 \\ -4.33230877 & 4.01436998 & 3.23033819 \\ -4.97091355 & 3.23033819 & 3.6493551 \end{pmatrix} \times 10^{-7} \qquad (1)$$

So far, Hellinger-fit criteria have not been explicity expressed in the rotation file. For the new standard, the Hellinger statistics need to be included explicity in the format expressed below. The complete Hellinger values can either be represented as coherent string with the some matrix values omitted due to the rotational symmetry of the matrix:

`@HELL"r|(N,s)|dF|kappahat|(($x_1$,$x_2$,$x_3$)($y_2$,$y_3$)($z_3$))"`

or as a separate set of arguments using the `@HELL` Parent:Children attributes:

`@HELL:r` total misfit

`@HELL:Ns` number of data points and segment length

`@HELL:dF` number of degrees of freedom

`@HELL:kappahat` Quality factor $\hat{\kappa}$

`@HELL:cov` Covariance matrix, here we ONLY USE `((`x_1`,`x_2`,`x_3`)(`y_2`,`y_3`)(`z_3`))` due to the rotational symmetry of the matrix used.

Example:

```
# Multi line version
@HELL:r"41.1911338"
@HELL:Ns"75,16"
@HELL:dF"40."
@HELL:kappahat"0.971082763"
@HELL:matrix"(8.71113084E-07,-4.33230877E-07,-4.97091355E-07) \
            (4.01436998E-07,3.23033819E-07)(3.6493551E-07)"

# Compact single line
@HELL"41.1911338 |75,16 | 40.| 0.971082763|\
 (8.71113084E-07,-4.33230877E-07,-4.97091355E-07) \
 (4.01436998E-07,3.23033819E-07)(3.6493551E-07)"
```

Bibliography information

Each rotation file should come with a companion bibliographic reference database in the ascii-based BibTeX format (`http://www.bibtex.org/Format/`) . The choice for BibTeX is driven by the fact that the format is text-based, accepted as one of the bibliographic data standards and many software tools allow to either directly use this format (BibDesk, JabREF) or import/export it (e.g. Endnote). At a future data the bibliographic information can possibly be incorporated consistently into the rotation file format without the need for two separate files.

Companion BibTeX databases

Online resources

- GPlates web site: `http://www.gplates.org`
- BibTeX resources: `http://www.bibtex.org/`
- Info about Dublin Core: `http://en.wikipedia.org/wiki/Dublin_Core`

Attribute list

Header attribute list

All Dublin Core elements are prefixed with a “DC”.

`@GPLATESROTATIONFILE` Mandatory: Declaration of file type

`@ = :version` Mandatory: Declaration of file version number.

@DC:namespace

`@DC:namespace` Mandatory: Dublin Core Elements RDF schema link. Value: “`http://purl.org/dc/elements/1.1/`”.

@DC:title

`@DC:title` Title of the document, e.g. “GPlates rotation file - NEW ROTATION FORMAT SAMPLE FILE” .

@DC:creator:name

`@DC:creator:name` Mandatory: Name of the creator of the document. Multiple occurrences of attribute allowed. Example: “Christian Heine”.

@DC:creator:email

`@DC:creator:email` Mandatory: Email of the document creator. Multiple occurrences of attribute allowed. Example: “christian.heine@sydney.edu.au”.

@DC:creator:url

`@DC:creator:url` Mandatory: URL related to creator such as homepage. Multiple occurrences of attribute allowed. Example “http://www.earthbyte.org/people/christian” .

@DC:creator:affiliation

`@DC:creator:affiliation` Mandatory: Affiliation of creator, such as Institute, postal address, phone. Multiple occurrences of attribute allowed. Example: “EarthByte Research Group, School of Geosciences” .

@DC:rights:license

`@DC:rights:license` Mandatory: Appropriate licensing terms for the data included in the file. Example: “Attribution-NonCommercial-ShareAlike 3.0 Unported (CC BY-NC-SA 3.0)” .

@DC:rights:url

`@DC:rights:url` Mandatory: URI of licensing terms for the data. Example: “`http://creativecommons.org/licenses/by-nc-sa/3.0/`” .

@DC:date:created

`@DC:date:created` Mandatory: Creation date of document, follow ISO standard (ie [YYYY]-[MM]-[DD]T[hh]:[mm]:[ss]). Example “2011-06-01T09:08:05” .

@DC:date:modified

`@DC:date:modified` Optional: Latest modification date of document. Multiple occurrences of attribute allowed. Can hold revision date if under revision control. Example “Date: 2012-05-08 16:55:58 +1000 (Tue, 08 May 2012)” .

@DC:coverage:temporal

`@DC:coverage:temporal` Optional: Temporal coverage of data included in this file. Example “0-600 Ma” .

@DC:bibliographicCitation

`@DC:bibliographicCitation` Optional: Full, plain text bibliographic citation for the current file. Example: “Mueller, R.D. and Seton, M. and Roest, W. (2008): Global. Geochem., Geophys., Geosys. xx:” .

@DC:description

`@DC:description` Mandatory: Description of data set contained in this file. Multiline comment wrapped in triple quotation marks """ (like in Python) are allowed, as are multiple ocurrences of the attribute to mimick the same effect as for multiline value. Example: “ A sample rotation file in the new GPlates rotation file format v1.1” .

@REVISIONHIST

`@REVISIONHIST` Optional. Parent attribute for data which is under a revisioning system. User can generate child attributes by separating them with a colon (:) from the parent tag. Example:

@REVISIONHIST:id"rotationfile_v2.rot 1774 2012-05-08 06:55:58Z christian". See example rotation file.

@BIBINFO

`@BIBINFO` Optional. Parent attribute for bibliographic reference data related to this rotation file.

@BIBINFO:blbiographyfile

`@ = :bibliographyfile` Optional. URI for location of bibliographic reference data in BibTeX format. Example: “"file://rotationfile_v2.bib"”

@BIBINFO:doibase

`@ = :doibase` Mandatory. URL for resolving DOIs used in the bibliographic data. Example: “http://dx.doi.org/”.

@GPML

`@GPML` Parent attribute for GPGIM-derived attributes.

@GPML:namespace

`@GPML:namespace` Mandatory. URI for the location of the GPGIM Schema document. Currently: `http://www.earthbyte.org/Resources/GPGIM/stable/`.

@GPML:MagneticAnomalyPickingScheme

`@GPML:MagneticAnomalyPickingScheme` Optional. URI for a picking scheme for the magnetic anomaly identifications. Example: “http://www.earthbyte.org/Resources/MagPickScheme”.

@DC:contributor

`@DC:contributor` Mandatory: Author data attribute for every contributor to this file. Data needs to be split into at least 5 different fields separated by vertical bars (|): **ID** — Unique ID for contributor (CHHEI), maps to @AU in rotation sequence comments; **Real Name** – of contributor (Christian Heine); **Email** — Email of contributor; **URL** — Website of contributor; Institute, Postal address, other contact details for contributor. Fields can be left blank.

@GTS

`@GTS` Mandatory. Parent tag for Geological Time Scale used for correlating geological ages with absolute time.

@GTS:info

`@GTS:info` Mandatory. Bibliographic data for individual time scales used. Data is split into at least 3 fields, separated by vertical bars (|) and can extend over multiple lines using the triple quotation marks. These are 1) **ID** — unique ID of timescale to be used in the @GTS tag for the individual rotation sequences. 2) **DOI/URL/ISSN** — Unique identifier for publication the timescale is based upon, prefixing the actual values (like `doi:12.12312/991823`); 3) Plain text full **bibliographic reference** for timescale or comments.

Rotation sequence metadata

@MPRS

`@MPRS` Parent element for Moving Plate rotation sequence

@MPRS:id

`@MPRS:pid` Mandatory. Moving Plate ID. Denotes the start of a block of rotations which all belong to a single moving plate. Example `@MPRS:pid“801”`.

@MPRS:code

`@MPRS:code` Mandatory. Unique letter acronym (variable length) for a moving plate. Example `@MPRS:code“SAM”` for South America.

@MRPS:name

`@MPRS:name` Mandatory. Unique full name for moving plate. Example: `@MPRS:name“South America”`.

@PP

`@PP` Mandatory. Plate pair of moving plate–fixed plate as specified by plate IDs, allowed values can only be composed of valid `@MPRS:code` values. Example `@PP“SAM-AFR”` for rotations expressing the rotation between South America relative to Africa.

@REF

`@REF` Optional. Unique citation key of bibliographic data used for this rotation. Maps to entries specified in `@BIBINFO:bibfile` value.

@DOI – Alias

`@DOI` Optional. Digitial object identifier for bibliographic data used for this rotation. Maps to entries specified in `@BIBINFO:doibase` value for complete a valid URL.

@AU – Alias

`@AU` Optional. Author of rotation sequence data, maps to first field of `@DC:contributor`, which is the unique contributor ID. Example: `@AU‘‘CHHEI’’`.

@T

`@T` Optional. Modification time stamp for rotation sequence data. Adhere to ISO standards in the for of YYYY-MM-DD [HH:MM:SS TZ]. Example: “2012-05-04 10:30:22+10 ”.

@C

`@C` Optional. Freeform comment.

@GTS

`@GTS:id` Mandatory. Geological time scale ID. Maps to first field of `@GTS:info` which is the unique identifier for the timescale used.

@CHRONID – Alias

`@CHRONID` Alias for Magnetic anomaly chrons as specified in GPGIM. References: `@GPML:MagneticAnomalyIdentification:AnomalyPickID`.

@HELL

`@HELL` Parent element for Hellinger statistical fit parameters.

@HELL:r

`@HELL:r` Total misfit.

@HELL:Ns

`@HELL:Ns` number of data points and segment length.

@HELL:dF

`@HELL:dF` number of degrees of freedom.

@HELL:kappahat

`@HELL:kappahat` Quality factor $\hat{\kappa}$

@HELL:cov

`@HELL:cov` Covariance matrix, here we ONLY USE `((`x_1`,`x_2`,`x_3`)(`y_2`,`y_3`)(`z_3`))` due to the rotational symmetry of the matrix used.

Rotation file example

```
@GPLATESROTATIONFILE:version"1.0"
@GPLATESROTATIONFILE:documentation"http://www.gplates.org/grot/"
# ---- SUPPORTED ATTRIBUTE ALIASES
#
# CHRONID --> GPML:MagneticAnomalyIdentification:polarityChronID
# AU  --> DC:contributor:id (Author)
# REF --> BIBINFO:bibliographyfile:citekey (Reference)
# DOI --> BIBINFO:doibase:doi
# GTS --> GEOTIMESCALE:id
#
# ----------+-------------------------------------------------------------------
# KEYWORDS  | starting with ATTRIBUTE"Value" -- ALLOWS MULTIPLE VALUE FIELDS BY
#           | separating them with a | (vertical bar). Values can be enclosed in
#           | single quotes.
#           | PLEASE CONSULT http://www.gplates.org/grot/ for valid attributes
# ----------+-------------------------------------------------------------------
# C         | Comment
# DC:subattr| DublinCore document description metadata (see documentation)
# GPML      | GPlates Markup Language Schema (can use GPML:FeatureType as subset)
# MPRS:pid  | Denotes Moving Plate ID
# MPRS:name | Moving plate full name
# MPRS:code | Moving plate letter code, usually 3-4 capital letters
# PP        | Plate pair with Plates denoted as letter acronyms separated by minus sign (-)
# T         | Modification date/time in YYYY-MM-DD [TZ HH:MM:SS]
#
# ---- FILE METADATA ------------------------------------------------
#
@DC:namespace"http://purl.org/dc/elements/1.1/"
@DC:title"GPlates rotation file -  NEW ROTATION FORMAT SAMPLE FILE"
@DC:creator:name"Christian Heine"
@DC:creator:email"mailto:christian.heine@sydney.edu.au"
@DC:creator:url"http://www.gplates.org"
@DC:creator:affiliation"EarthByte Research Group, School of Geosciences"
@DC:creator:affiliation"The University of Sydney, NSW 2006, Australia"
@DC:rights:license"Attribution-NonCommercial-ShareAlike 3.0 Unported (CC BY-NC-SA 3.0)"
@DC:rights:url"http://creativecommons.org/licenses/by-nc-sa/3.0/"
@DC:date:created"2/06/11 4:08:05 PM"
@DC:date:modified"$Date: 2012-05-11 08:10:42 +1000 (Fri, 11 May 2012) $"
@DC:coverage:temporal"0-600 Ma"
@DC:bibliographicCitation"""Chin, Mueller, Cannon, Landgrebe, Heine,
                           Watson, Turner (2012) The GPGIM vol:pp-pp,
                           J. Digitial Earth. doi:xxxxxxxxx """
@DC:description"""
 A sample rotation file in the new GPlates rotation file format v1.1

 Taken from the current GPlates release rot file
 Based on moving Indian/Atlantic hotspots (O'Neill et. al. 2005)
 to 100 Ma and true polar wander corrected palaeomagnetic
 reference frame (derived from Steinberger and Torsvik 2008)
 from 100 - 200 Ma.  250 Ma is the extent of this rotation model.
 Pacific absolute reference frame based on Wessell and Kroenke 2008
 with a switch to Wessel et. al. 2006 at 118.4 Ma"""
#
# ---- REVISION HISTORY INFORMATION ----------------------------------------
#
@REVISIONHIST"$Id: rotationfile_1-0.grot 1789 2012-05-10 22:10:42Z christian $"
#
# ---- BIBLIOGRAPHIC AND DATA REFERENCE INFORMATION -------------------------
#
@BIBINFO:bibfile"file://rotationfile_v2.bib"
@BIBINFO:doibase"http://dx.doi.org/"
@GPML:namespace"http://www.earthbyte.org/Resources/GPGIM/public/"
#
# ----- AUTHOR INFORMATION -------------------------------------------------
#
@DC:contributor"RDM   | R. Dietmar Muller      | dietmar.muller@sydney.edu.au     | http://www.earthbyte.org  | Geosciences, The University of Sydney, Australia"
@DC:contributor"MS    | Maria Seton (Sdrolias) | maria.seton@sydney.edu.au        | http://www.earthbyte.org  | Geosciences, The University of Sydney, Australia"
@DC:contributor"CG    | Carmen Gaina           | carmen.gaina@fys.uio.no          | http://www.geodynamics.no | University of Oslo, Norway"
@DC:contributor"""CHHEI |
                 Christian Heine |
                 christian.heine@sydney.edu.au |
                 http://www.earthbyte.org |
                 EarthByte Group, School of Geosciences, The University of Sydney, Australia"""
@DC:contributor"CRS   | Christopher R. Scotese |                                  |                           | UT/Paleomap Project"
@DC:contributor"LAL   | Larry A. Lawver        |                                  |                           | UTIG PLATES Project"
@DC:contributor"IWD   | Ian W. Dalziel         |                                  |                           | UTIG PLATES Project"
@DC:contributor"LMG   | Lisa M. Gahagan        |                                  |                           | UTIG PLATES Project"
@DC:contributor"DN    | Dirk Nuernberg         |                                  |                           | CAU-Kiel University, Germany"
@DC:contributor"EBYTE | EarthByte Group        |                                  | http://www.earthbyte.org  | School of Geosciences, Sydney Uni"
@DC:contributor"THT   | Trond Helge Torsvik    | Trond.Torsvik@fys.uio.no         | http://www.geodynamics.no | PGP, University of Oslo, Norway"
#
#---- GEOLOGICAL TIME SCALE INFORMATION -------------------------
#
@GEOTIMESCALE""" GeeK07 |
             doi:10.1016/B978-044452748-6.00097-3 |
             Gee.ToC.07 |
             Gee, J.S. and Kent, D.V. (2012) 5.12 - Source of Oceanic Magnetic
             Anomalies and the Geomagnetic Polarity Timescale, in: Treatise on
             Geophysics, Volume 5, Pages 455âĂŞ507, Elsevier, Amsterdam"""
@GEOTIMESCALE""" CK95G94 |
             doi:10.1029/94JB03098; doi:10.1029/94JB01889 |
             |
             S. C. Cande and D. V. Kent. Revised Calbration of the geomagnetic
             polarity timescale for the Late Cretaceous and Cenozoic. J. Geophys.
             Res., 100(B4):6093âĂŞ6095, 1995;
             F. M. Gradstein, F. P. Agterberg, J. G. Ogg, J. Hardenbol, P. van Veen,
             J. Thierry, and Z. Huang. A Mesozoic time scale. J. Geophys. Res.,
             99:24051âĂŞ24074, 1994. doi:10.1029/94JB01889.
```

```
"""
@GEOTIMESCALE""" Absolute
                 |
                 |
                 Absolute numerical time in Ma"""
# ----------------------------------------------------------------
# --- END ROTATION FILE HEADER -----------------------------------
# ----------------------------------------------------------------
# This comment will be ignored by GPlates
> @MPRS:pid"001" @MPRS:code"AHS" @MPRS:name"Present day Atlantic-Indian hotspots" @PP"AHS-HOT"
> @C"This comment will be read by GPlates and will appear at Moving plate rotation sequence level"
001     0.000   0.0000    0.0000    0.0000  000 @C"This comment will only appear at this rotation"
001   200.000   0.0000    0.0000    0.0000  000
001   600.000   0.0000    0.0000    0.0000  000
> @C"Below an example of the new MOVING_PLATE_ROTATION_SEQUENCE (MPRS)"
> @C"The comment applies to the MPRS below"
# @C"This comment flags a warning and is ignored"
> @MPRS:pid"002"
> @MPRS:code"PHS"
> @MPRS:name"Pacific Hotspots"
> @PP"PHS-PAC"  @REF"Wessel.JGR.08" @DOI"10.1029/2007JB005499" @C"Model WK08-A" @GTS"GeeK07"
002     0.000   0.0000    0.000    0.000  901
002     0.780  49.3000  -49.500   -1.020  901
002     2.580  53.7200  -56.880   -2.660  901
002     5.890  59.6500  -66.050   -5.390  901
002     8.860  62.8700  -70.870   -8.230  901
002    12.290  65.3700  -68.680  -10.300  901
002    17.470  68.2500  -61.530  -15.500  901
# The foo pole by John
002    24.060  68.7800  -69.830  -20.400  901
002    28.280  67.7200  -70.800  -23.600  901
002    33.540  66.5700  -68.730  -27.700  901
002    40.100  65.4300  -64.250  -31.600  901
002    47.910  63.0200  -66.680  -34.600  901
002    53.350  60.6000  -69.670  -36.100  901
002    61.100  56.9300  -72.930  -38.400  901
002    74.500  50.0300  -78.350  -44.000  901
002    83.500  47.3000  -82.100  -48.800  901
002    95.000  46.9000  -82.680  -54.100  901
002   106.200  51.3200  -85.120  -60.100  901
002   112.300  52.1700  -85.800  -62.400  901
002   118.400  52.5300  -80.330  -66.500  901
002   125.000  54.1300  -88.180  -69.600  901
002   131.900  56.2200 -112.250  -78.600  901
002   144.000  54.4300 -123.570  -84.400  901
> @MPRS:pid"003"  @MPRS:code"PPH" @MPRS:name"Present day Pacific hotspots"
> @PP"PPH-HOT"
003     0.000   0.0000    0.0000    0.0000  000
003   600.000   0.0000    0.0000    0.0000  000
> @MPRS:pid"101" @MPRS:code"NAM" @MPRS:name"North America"
> @PP"NAM-NWA" @REF"Mueller.99" @DOI"10.1016/S1874-5997(99)80036-7" @CHRONID"An5" @GTS"GEEK07"
101     0.000   0.0000    0.0000    0.000  714
101    10.900  81.0000   22.9000    2.840  714 @CHRONID"C5" @GTS"GEEK07"
101    20.100  80.6000   24.5000    5.530  714 @CHRONID"C6"
101    33.100  75.9900    5.9800    9.770  714 @CHRONID"C13"
101    40.100  74.5000   -1.2000   12.600  714 @CHRONID"C18"
101    47.900  74.9000   -4.6000   15.610  714 @CHRONID"C21"
101    55.900  80.6400    6.5700   17.900  714 @CHRONID"C25"
101    67.700  82.3000   -1.7000   21.510  714 @CHRONID"C30"
@CHRONID"C34"
101    83.500  76.8100  -20.5900   29.510  714
101   120.400  66.2800  -19.8200   54.440  714 @REF"Mueller.97" @DOI"10.1029/96JB01781"
101   126.700  66.1100  -18.9500   56.480  714 @REF"Mueller.97" @DOI"10.1029/96JB01781"
101   131.900  65.9500  -18.5000   57.450  714 @REF"Mueller.97" @DOI"10.1029/96JB01781"
101   139.600  66.1200  -18.3800   59.900  714 @REF"Mueller.97" @DOI"10.1029/96JB01781"
101   147.700  66.5400  -17.9800   62.080  714 @REF"Mueller.97" @DOI"10.1029/96JB01781"
101   154.300  67.1500  -15.9800   64.750  714 @REF"Mueller.97" @DOI"10.1029/96JB01781"
101   170.000  67.0900  -13.8600   70.550  714 @REF"Labails.EPSL.10" @DOI"10.1016/j.epsl.2010.06.024" @C"BSMA"
101   190.000  64.3100  -15.1900   77.090  714 @REF"Labails.EPSL.10" @DOI"10.1016/j.epsl.2010.06.024" @C"min closure"
101   203.000  64.2800  -14.7400   78.050  714 @REF"Labails.EPSL.10" @DOI"10.1016/j.epsl.2010.06.024" @C"min closure"
101   215.000  67.0000  -12.0000   79.000  714 @REF"Torsvik.Tectp.02" @DOI"10.1016/S1874-5997(99)80036-7" @C"Torsvik et.al 2002"
101   320.000  67.0000  -12.0000   79.000  714 @REF"Torsvik.Tectp.02" @DOI"10.1016/S1874-5997(99)80036-7" @C"Torsvik et.al 2002"
101   600.000  67.0000  -12.0000   79.000  714 @REF"Torsvik.Tectp.02" @DOI"10.1016/S1874-5997(99)80036-7" @C"Torsvik et.al 2002"
> @MPRS:pid"102" @MPRS:code"GRN" @MPRS:name"Greenland"
> @PP"GRN-NAM" @C"""this
is
a
very
long
comment
"""
102     0.000   0.0000    0.0000    0.0000  101
102    33.100   0.0000    0.0000    0.0000  101 @REF"Gaina.EPSL.02" @DOI"10.1016/S0012-821X(02)00499-5" @CHRONID"C13 Derived"
102    40.100  62.4600  -28.0200   -1.2500  101 @REF"Gaina.EPSL.02" @DOI"10.1016/S0012-821X(02)00499-5" @CHRONID"C13 Derived"
102    43.800  63.2500  -79.5800   -1.8100  101 @REF"Gaina.EPSL.02" @DOI"10.1016/S0012-821X(02)00499-5" @CHRONID"C20 Derived"
102    47.900  60.6600  -97.2600   -2.8100  101 @REF"Gaina.EPSL.02" @DOI"10.1016/S0012-821X(02)00499-5" @CHRONID"C21 Derived"
102    49.700  61.5800  -97.0900   -3.3300  101 @REF"Gaina.EPSL.02" @DOI"10.1016/S0012-821X(02)00499-5" @CHRONID"C21 Derived"
102    53.300  39.6800 -116.1600   -3.7400  101 @REF"Gaina.EPSL.02" @DOI"10.1016/S0012-821X(02)00499-5" @CHRONID"C24 Derived"
102    55.900  19.2800 -136.1900   -3.1600  101 @REF"Gaina.EPSL.02" @DOI"10.1016/S0012-821X(02)00499-5" @CHRONID"C25 Derived"
102    68.700  41.1900 -169.5800   -5.7100  101 @REF"Gaina.EPSL.02" @DOI"10.1016/S0012-821X(02)00499-5" @CHRONID"C31 Derived"
102    79.100  61.3800 -157.7000   -8.4300  101 @REF"Gaina.EPSL.02" @DOI"10.1016/S0012-821X(02)00499-5" @CHRONID"C33o Derived"
102    83.500  65.3000 -122.4500  -11.0000  101 @REF"Roest.G.89" @DOI"10.1130/0091-7613(1989)017<1000:SFSITL>2.3.CO;2" @GTS"CK95G94" @CHRONID"C34"
102    92.000  66.6000 -119.4800  -12.2000  101 @REF"Roest.G.89" @DOI"10.1130/0091-7613(1989)017<1000:SFSITL>2.3.CO;2" @C"Start of seafloor spreading"
102   125.000  67.5000 -118.4800  -14.0000  101 @PP"GRN-NWA" @REF"Torsvik.RG.10" @DOI"10.1029/2007RG000227" @C"FITRECON"
102   600.000  67.5000 -118.4800  -14.0000  101 @PP"GRN-NWA" @REF"Torsvik.RG.10" @DOI"10.1029/2007RG000227"
> @MPRS:pid"103" @MPRS:code"NSL" @MPRS:name"North Slope Alaska"
103     0.000   0.0000    0.0000    0.0000  101 ! @PP"NSL-NAM"
103   126.000   0.0000    0.0000    0.0000  101 ! @PP"NSL-NAM"
103   132.000  60.0000 -126.0000   -3.0000  101 ! @PP"NSL-NAM" @REF"Alvey.EPSL.08" @DOI"10.1016/j.epsl.2008.07.036" @C"Derived"
103   136.500  60.0000 -126.0000   -6.5000  101 ! @PP"NSL-NAM" @REF"Alvey.EPSL.08" @DOI"10.1016/j.epsl.2008.07.036" @C"Derived"
103   139.600  60.0000 -126.0000  -10.0000  101 ! @PP"NSL-NAM" @REF"Alvey.EPSL.08" @DOI"10.1016/j.epsl.2008.07.036" @C"Derived"
103   142.500  65.0000 -130.2000  -30.0000  101 ! @PP"NSL-NAM" @AU"CG" @T"2008-06-xx" @C"FITRECON | Derived"
```

```
103   145.000  65.0000 -130.2000  -34.0000  101 ! @PP"NSL-NAM" @REF"Lawver.90"
103   600.000  65.0000 -130.2000  -34.0000  101 ! @PP"NSL-NAM" @REF"Lawver.90" @C"FITRECON"
> @MPRS:pid"201" @MPRS:code"SAM" @MPRS:name"South America"
> @PP"SAM-AFR" @REF"Mueller.99"  @DOI"10.1016/S1874-5997(99)80036-7"
201     0.0      0.0      0.0      0.0      701
201    10.9     61.2    -39.7      3.68     701  @CHRONID"C5"
201    20.1     58.5    -37.1      7.52     701  @CHRONID"C6"
201    33.1     56.17   -33.64     13.41    701  @CHRONID"C13"
#201    40.1     57.1    -32.5      16.6     701 @CHRONID"C18"
201    47.9     57.5    -31.2      19.7     701  @CHRONID"C21"
201    55.9     61.35   -32.21     22.27    701  @CHRONID"C25"
201    67.7     63.7    -33.5      25.39    701  @CHRONID"C30"
# Another example for comment data BEFORE the actual rotation line
# @PP"SAM-AFR" @REF"Mueller.99"  @DOI"10.1016/S1874-5997(99)80036-7"
# @CHRONID"An34"
# @HELL:r"41.1911338" @HELL:Ns"75,16" @HELL:dF"40." @HELL:kappahat"0.971082763"
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201    83.500  61.8800  -34.2600   33.5100  701
#
# If you want you can put each comment for a following
# rotation on a single line.
# @PP"SAM-AFR"
# @REF"Torsvik.GJI.09"
# @DOI"10.1111/j.1365-246X.2009.04137.x"
# @C"Forced break North of PEFZ/FFZ"
201   112.000  52.4000  -35.0000   51.3000  701
201   120.400  51.6000  -35.0000   52.9200  701 @PP"SAM-AFR" @REF"Nuernberg.Tectp.91" @DOI"10.1016/0040-1951(91)90231-G"
201   126.700  50.4000  -33.5000   54.4200  701 @PP"SAM-AFR" @REF"Nuernberg.Tectp.91" @DOI"10.1016/0040-1951(91)90231-G"
201   131.700  50.0000  -32.5000   55.0800  701 @PP"SAM-AFR" @REF"Nuernberg.Tectp.91" @DOI"10.1016/0040-1951(91)90231-G" @FITRECON
201   600.000  50.0000  -32.5000   55.5200  701 @PP"SAM-AFR" @REF"Nuernberg.Tectp.91" @DOI"10.1016/0040-1951(91)90231-G"
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833    52.0     0.0000    0.0000   0.0000  801  @PP"LHR-AUS"
833    53.300 -14.1900  130.4100   -0.7200  801 @PP"LHR-AUS"
833    55.800 -15.9300  133.4700   -2.1100  801 @PP"LHR-AUS"
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@article{Torsvik.GJI.09,
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@article{Torsvik.RG.08,
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