QuakeML—An XML Representation of Seismological Data
Basic Event Description
Version 1.1

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Abstract

This document describes the standards for QuakeML, an XML-based data exchange format for seismology. It presents UML class diagrams for the two variants, QuakeML and QuakeML-RT, and explains the components used. XML Schema representations of the data models are given.

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1 Introduction

Seismological data cover a broad range of information and are stored in many different formats. In most cases, these format definitions are tailored to fit the specific requirements for a narrow field of applications. QuakeML, an XML representation of seismological data, is intended to standardize seismological data exchange, and to be applicable for a wide range of scientific and technical problems.

XML is a standardized general-purpose markup language that allows the formal definition of descriptive languages for a broad range of applications (Bray et al. 2000). One of its strengths is that it is plain-text based. Thus, it is platform-independent, readable by humans and machines, and probably reasonably future-proof regarding technological advancement.

A basic outline of the general concept of QuakeML can be found in Schorlemmer et al. (2004)[1].

The first part of QuakeML, as described in this document, provides a basic description of seismic event data and introduces a new concept for unambiguous resource identification. It includes information on origin, origin uncertainties, picks, amplitudes, magnitudes and focal mechanisms. The following parts of QuakeML will deal with the description of inventory information, and resource metadata. Future QuakeML development will cover waveform data, macroseismic information, slip distributions, and ground motion information.

QuakeML describes properties of seismic events in a hierarchical manner, using *a posteriori* knowledge of the relations between elements (e.g., association of origins to events). When dealing with real-time processing of seismic data, this information may not be present. Therefore, an alternative version using flatter hierarchies has been defined (QuakeML-RT).

While developing QuakeML we have kept an eye on similar concepts contained in existing applications like Earthworm[2] and CSS 3.0. For the part dealing with resource identifiers and metadata we have taken inspiration from recent development undertaken in the astrophysical *Virtual Observatory* community[3].

QuakeML version 1.1 contains a lot of improvements over the previous version that have been provided by the community. The previous version, 1.0.1, was subjected to a public *Request for Comments* (RFC) process from December 2007 until November 2008. A documentation of the RFC can be found on the project web page (`http://www.quakeml.org`).

The contact e-mail address for QuakeML is quakeml@sed.ethz.ch.

[1] Note, however, that the XML format definition given therein is outdated and is superseded by this document.
[2] `http://folkworm.ceri.memphis.edu/ew-doc/`
[3] `http://www.ivoa.net`

2 QuakeML Data Model

2.1 UML Class Diagrams

The QuakeML data model has been expressed in a UML[4] formulation which serves as a basis for further representations, like XML Schema[5] (XSD) or SQL database schema. Figs. 1 and 2 show the UML class diagrams for the two QuakeML flavours. Fig. 1 represents the standard (hierarchical) QuakeML version, while Fig. 2 shows the modified variant for real-time processing (QuakeML-RT). In the class diagrams, only two types of relations have been used in order to allow easy transformation to other schemas and for easy automated code generation. "Has-a" relationships are represented by UML compositions and are mapped to parent-child relations in XML. Associations are used to indicate less tight relations between objects.

UML elements that are present in both QuakeML flavours are *EventParameters*, *Event*, *Origin*, *OriginUncertainty*, *Arrival*, *Pick*, *Amplitude*, *Magnitude*, *StationMagnitude*, *StationMagnitudeContribution*, *FocalMechanism*, and *MomentTensor*.

QuakeML-RT additionally has the element *Reading*.

Complex data types can be found at the top of the diagrams, enumerations at the bottom.

In the hierarchical model, the class *EventParameters* is made up of *Event* objects and represents an earthquake catalog or a seismic bulletin. *Event* is connected via composition to *Origin*, *Magnitude*, *StationMagnitude*, *FocalMechanism*, *Amplitude*, and *Pick*, which all describe properties of a specific seismic event.

In QuakeML-RT *EventParameters* can additionally hold objects of type *Origin*, *Amplitude*, *Pick*, *Reading*, *Magnitude*, *StationMagnitude*, and *FocalMechanism*. These are hierarchically on the same level as *Event* and can be connected to specific events via references inside the *Event* element. QuakeML-RT has objects of type *Reading*. These are used to group *Amplitude* and *Pick* objects that are known to belong to the same event, but the event itself is unknown.

In both variants, *Arrival* is linked to *Origin* by composition. Thus, arrivals cannot exist independently from origins. An origin can have several arrivals, but is not required to have any. The connection between *Pick* and *Arrival* is quite weak which is expressed by an association. A pick can be related to several arrivals, i. e., concurrent different interpretations of the same amplitude anomaly in a seismogram may exist. *Amplitude* and *StationMagnitude* as well as *Amplitude* and *Pick* are relatively loosely coupled, as expressed by an association. *Magnitude* describes the "network" magnitude that has been derived from several station magnitudes. It is related to *StationMagnitude* via the class *StationMagnitudeContribution* and is connected to *Origin* by association. *StationMagnitude* is connected to *Origin* by association.

A detailed description of the complex types, enumerations, and elements used in the UML class diagrams can be found in Sect. 3.

[4] The *Unified Modeling Language* is a general-purpose modeling language that is developed under the auspices of the *Object Management Group* (http://www.omg.org).

[5] http://www.w3.org/TR/xmlschema-1/, http://www.w3.org/TR/xmlschema-2/

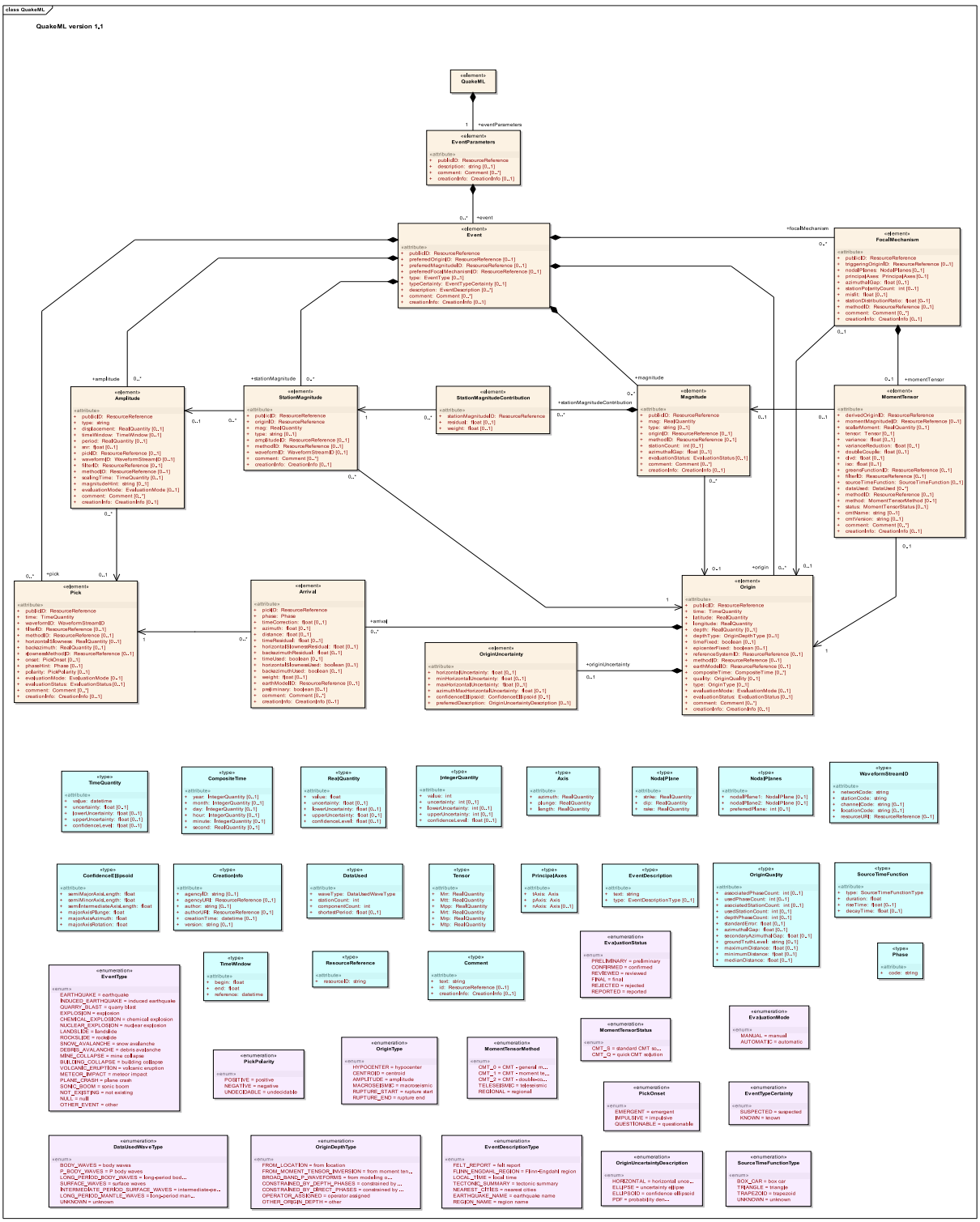

Figure 1: UML class diagram of the QuakeML data model. Two different types of relations between classes are used: (i) compositions, marked by lines with filled diamonds; and (ii) associations, marked by arrows. Compositions indicate a stronger coupling between two classes than associations.

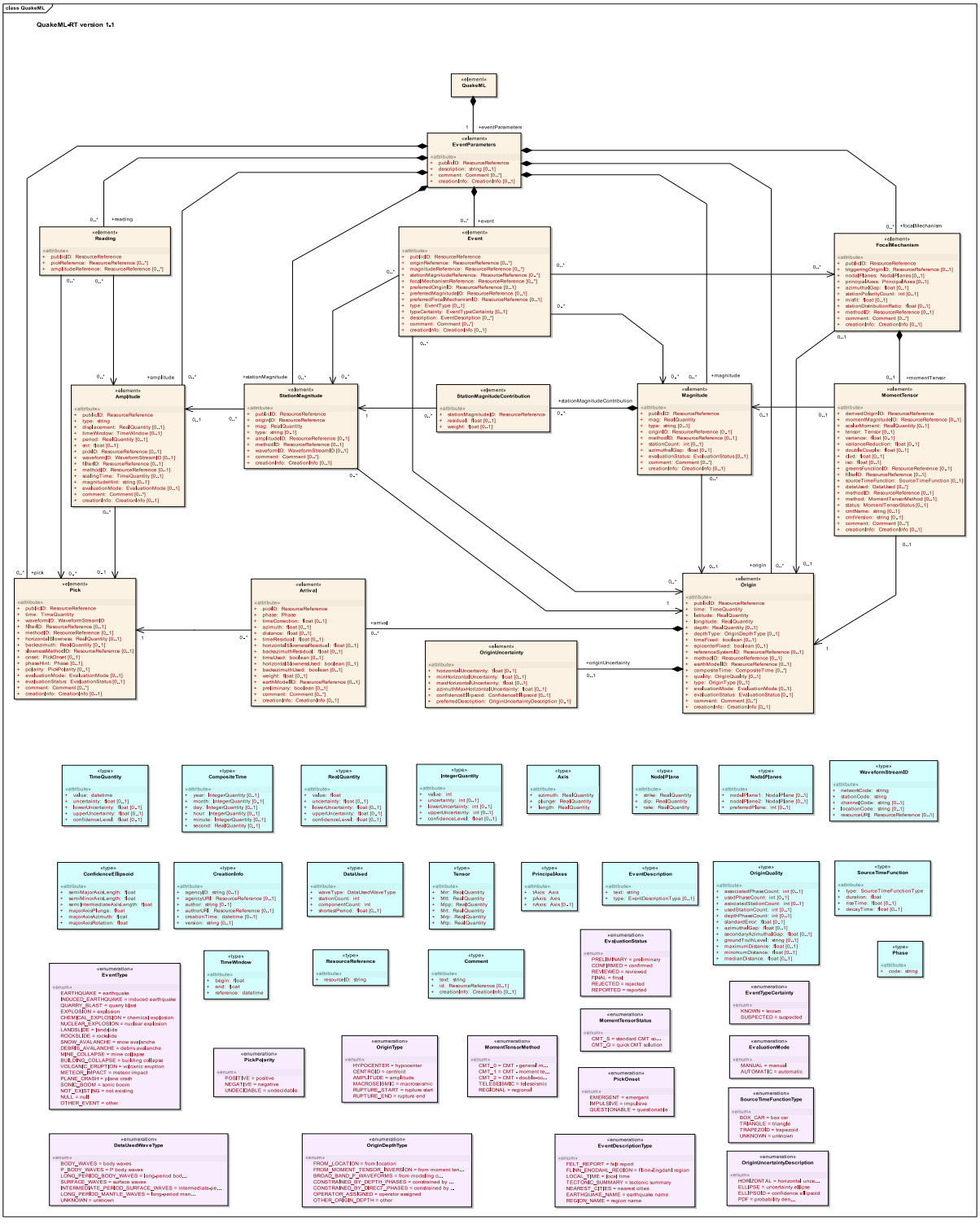

Figure 2: UML class diagram of the QuakeML-RT (real-time processing) data model.

3 XML Serialization

In this Section, we provide a detailed description of the classes used in the QuakeML data models (see the UML class diagrams in Figs. 1 and 2), and of the complex types that are used within these classes.

The last column of the tables describing the class attributes lists the XML representation of attributes which are of basic UML type (int, float, string, datetime, enum). Their XML representation can be either Element, Attribute, or CDATA. This information is contained as tagged values in the UML model and is used by an automated code generator when creating the XML Schema description for QuakeML from the XMI[6] representation of the UML model. In Sect. 3.5 XML format examples are given at the end of each class description.

3.1 Resource Identifiers

In a global network of seismological resources there is a need for a mechanism which allows to unambiguously identify resources. In this context, resources can be of vastly different character, e. g., institutions, working groups, seismic stations, technical equipment, but also algorithms, computer codes or published papers. We propose a naming scheme for resource identifiers which adopts the format of *Uniform Resource Identifiers* (URIs, Berners-Lee et al. 1988). Identifiers take the generic form of

smi:⟨authority-id⟩/⟨resource-id⟩[#⟨local-id⟩]

They consist of an authority identifier, a unique resource identifier, and an optional local identifier. The URI schema name `smi` stands for *seismological meta-information*, thus indicating a connection to a set of metadata associated with the resource.

The XML Schema definition of QuakeML resource identifiers is as follows:

```
<xs:simpleType name="ResourceIdentifier">
    <xs:restriction base="xs:anyURI">
      <xs:pattern value="(smi|quakeml):[\w\d][\w\d\-\.\*\(\)_~']{2,}/[\w\d
            \-\.\*\(\)_~'][\w\d\-\.\*\(\)\+\?_~'=,;#/&amp;]*"/>
    </xs:restriction>
  </xs:simpleType>
```

The authority-id part must consist of at least three characters, of which the first character has to be alphanumeric. The subsequent characters can be alphanumeric or from the following list: `-`, `_`, `.`, `~`, `*`, `'`, `(`, `)`. After the authority-id, a forward slash (`/`) must follow which separates the authority-id from the resource-id. The resource-id must contain at least one character, which can be either alphanumeric, or from the 8 special characters which are allowed for the authority-id. For the remaining characters of the resource-id, also the comma (“,”) and semicolon (“;”) characters and characters from the following list can be used: `+`, `?`, `=`, `#`, `/`, `&`. Note that the slash which separates authority-id and resource-id is always the first slash in the resource identifier. The resource-id may be followed by a stop character (#) and a local identifier which can be made up of alphanumeric characters, the comma (“,”) and semicolon (“;”) characters, and the characters from the following list: `-`, `_`, `.`, `~`, `*`, `'`, `(`, `)`, `/`, `+`, `=`, `?`. Local identifiers are thought to denote resources that have no own metadata description associated, but are part of a larger collection for which such metadata exists.

The URI schema name prefix is not strictly a part of the resource identifier. Other URI schema names can be used with the identifier in order to retrieve other kinds of information associated with the resource, e. g., `quakeml` for resources that have a QuakeML representation. For the description of resources which are not officially controlled by an authority, local identifiers can be assigned using the keyword “local” as authority-id.

Resource identifiers are intended to be resolved by registries, i. e., institutions acting as registries will provide web services that will return a metadata description of a resource if queried with a resource identifier as a parameter.

[6] XML Metadata Interchange (XMI) is an XML-based standard for the exchange of metadata information (http://www.omg.org/technology/documents/formal/xmi.htm).

The metadata description will be largely based on the Dublin Core vocabulary (Dublin Core Metadata Initiative 2003) and will provide information on the resource's identity, curation, general, collection and service content, and data quality. In particular, the metadata contain information on how to retrieve the resource, e. g., a URL pointer to an electronic document, or a Web Service description. This mechanism is particularly useful for resources that have a QuakeML representation. In that case, a resource identifier that is used in an extensive QuakeML file can be interpreted as a short cut for a QuakeML chunk that has been left out for conciseness.

The main purpose of the registry mechanism will be the resolution of identifiers which allows subsequent data retrieval in the way outlined above. Beyond this basic functionality, we envision future application of registries as the key infrastructure components for resource discovery. High-quality metadata collections are essential for advanced search services which can be used both by humans and intelligent information retrieval agents.

Resource identifiers in the UML formulation of QuakeML are of UML type *ResourceReference*. This type has an attribute **resourceID** which holds the identifier and is of the XSD type *ResourceIdentifer* given above. In the following sections the abbreviation *RI* is used to denote QuakeML resource identifiers.

3.2 Units and Conventions

3.2.1 SI Units

QuakeML exclusively uses the International System of Units[7] (SI). SI units used in QuakeML are meter (m), second (s), and newton (N). Furthermore, plane angles are measured in degrees (deg).

3.2.2 Coordinated Universal Time

Time information in QuakeML is generally given in Coordinated Universal Time (UTC). The representation is according to ISO 8601[8]. While ISO 8601 includes a time zone designator in order to account for non-UTC time, in QuakeML the allowed values are restricted to *Z*, *+00:00*, and *−00:00*. Omission of the time zone designator is allowed and is interpreted as UTC.

[7] http://www.bipm.org/en/si/
[8] http://www.iso.org/iso/iso_catalogue/catalogue_tc/catalogue_detail.htm?csnumber=40874

3.3 Complex Types

3.3.1 ResourceReference

This type is used to refer to QuakeML resources as described in Sect. 3.1. The attribute **resourceID** contains the reference string.

List of Attributes

Attribute	UML Type	Multiplicity	XML Type	XML Representation
resourceID	*string*	1	*ResourceIdentifer*	CDATA

Description of Attributes

resourceID String that is used as a reference to a QuakeML resource. It must adhere to the format specifications given in Sect. 3.1.

3.3.2 IntegerQuantity / RealQuantity

Physical quantities that can be expressed numerically—either as integers or as floating point numbers—are represented by their measured or computed values and optional values for symmetric or upper and lower uncertainties. The interpretation of these uncertainties is not defined in the standard. They can contain statistically well-defined error measures, but the mechnism can also be used to simply describe a possible value range. If the confidence level of the uncertainty is known, it can be listed in the optional attribute **confidenceLevel**. Note that **uncertainty**, **upperUncertainty**, and **lowerUncertainty** are not given as absolute values, but as deviations from the main **value**.

List of Attributes

Attribute	UML Type	Multiplicity	XML Type	XML Representation
value	*int / float*	1	*xs:integer / xs:double*	Element
uncertainty	*int / float*	0..1	*xs:integer / xs:double*	Element
lowerUncertainty	*int / float*	0..1	*xs:integer / xs:double*	Element
upperUncertainty	*int / float*	0..1	*xs:integer / xs:double*	Element
confidenceLevel	*float*	0..1	*xs:double*	Element

Description of Attributes

value Value of the quantity. The unit is implicitly defined and depends on the context.

uncertainty Symmetric uncertainty or boundary.

lowerUncertainty Relative lower uncertainty or boundary.

upperUncertainty Relative upper uncertainty or boundary.

confidenceLevel Confidence level of the uncertainty, given in percent.

3.3.3 TimeQuantity

This type describes a point in time, given in ISO 8601 format, with optional symmetric or asymmetric uncertainties given in seconds. The time has to be given in UTC.

List of Attributes

Attribute	UML Type	Multiplicity	XML Type	XML Representation
value	*datetime*	1	*xs:datetime*	Element
uncertainty	*float*	0..1	*xs:double*	Element
lowerUncertainty	*float*	0..1	*xs:double*	Element
upperUncertainty	*float*	0..1	*xs:double*	Element
confidenceLevel	*float*	0..1	*xs:double*	Element

Description of Attributes

value Point in time in ISO 8601 format, given in UTC (see Sect. 3.2.2).

uncertainty Symmetric uncertainty of point in time.
Unit: s

lowerUncertainty Lower uncertainty of point in time.
Unit: s

upperUncertainty Upper uncertainty of point in time.
Unit: s

confidenceLevel Confidence level of the uncertainty, given in percent.

3.3.4 TimeWindow

Describes a time window for amplitude measurements.

List of Attributes

Attribute	UML Type	Multiplicity	XML Type	XML Representation
begin	*float*	1	*xs:double*	Element
end	*float*	1	*xs:double*	Element
reference	*datetime*	1	*xs:datetime*	Element

Description of Attributes

begin Time interval before **reference** point in time window.
Unit: s

end Time interval after **reference** point in time window.
Unit: s

reference Reference point in time ("central" point), in ISO 8601 format. It has to be specified in UTC (see Sect. 3.2.2).

3.3.5 WaveformStreamID

Pointer to a stream description in an inventory. This is mostly equivalent to the combination of **networkCode**, **stationCode**, **locationCode**, and **channelCode**. However, additional information, e. g., sampling rate, can be referenced by the **resourceURI**.

List of Attributes

Attribute	UML Type	Multiplicity	XML Type	XML Representation
networkCode	*string*	1	*xs:string*	Attribute
stationCode	*string*	1	*xs:string*	Attribute
channelCode	*string*	0..1	*xs:string*	Attribute
locationCode	*string*	0..1	*xs:string*	Attribute
resourceURI	*ResourceReference*	0..1	*ResourceIdentifier*	CDATA

Description of Attributes

networkCode Network code.

stationCode Station code.

channelCode Channel code.

locationCode Location code.

resourceURI Resource identifier for the waveform stream. QuakeML adopts in many places resource descriptors with a well-defined syntax for unambiguous resource identification. A brief introduction to the concept of resource identifiers can be found in Sect. 3.1. Resource identifiers are designed to be backward compatible with existing descriptors.

3.3.6 Phase

Generic and extensible phase description that currently contains the phase code only.

List of Attributes

Attribute	UML Type	Multiplicity	XML Type	XML Representation
code	*string*	1	*xs:string*	CDATA

Description of Attributes

code Phase code as given in the IASPEI Standard Seismic Phase List (Storchak et al. 2003).

3.3.7 CompositeTime

Focal times differ significantly in their precision. While focal times of instrumentally located earthquakes are estimated precisely down to seconds, historic events have only incomplete time descriptions. Sometimes, even contradictory information about the rupture time exist. The *CompositeTime* type allows for such complex descriptions. The time specified in this element has to be given in UTC.

List of Attributes

Attribute	UML Type	Multiplicity	XML Type	XML Representation
year	*IntegerQuantity*	0..1	–	–
month	*IntegerQuantity*	0..1	–	–
day	*IntegerQuantity*	0..1	–	–
hour	*IntegerQuantity*	0..1	–	–
minute	*IntegerQuantity*	0..1	–	–
second	*RealQuantity*	0..1	–	–

Description of Attributes

year Year or range of years of the event's focal time.

month Month or range of months of the event's focal time.

day Day or range of days of the event's focal time.

hour Hour or range of hours of the event's focal time.

minute Minute or range of minutes of the event's focal time.

second Second and fraction of seconds or range of seconds with fraction of the event's focal time.

3.3.8 OriginQuality

This type contains various attributes commonly used to describe the quality of an origin, e. g., errors, azimuthal coverage, etc. *Origin* objects have an optional attribute of the type *OriginQuality*.

List of Attributes

Attribute	UML Type	Multiplicity	XML Type	XML Representation
associatedPhaseCount	*int*	0..1	*xs:integer*	Element
usedPhaseCount	*int*	0..1	*xs:integer*	Element
associatedStationCount	*int*	0..1	*xs:integer*	Element
usedStationCount	*int*	0..1	*xs:integer*	Element
depthPhaseCount	*int*	0..1	*xs:integer*	Element
standardError	*float*	0..1	*xs:double*	Element
azimuthalGap	*float*	0..1	*xs:double*	Element
secondaryAzimuthalGap	*float*	0..1	*xs:double*	Element
groundTruthLevel	*string*	0..1	*xs:string*	Element
minimumDistance	*float*	0..1	*xs:double*	Element
maximumDistance	*float*	0..1	*xs:double*	Element
medianDistance	*float*	0..1	*xs:double*	Element

Description of Attributes

associatedPhaseCount Number of associated phases, regardless of their use for origin computation.

usedPhaseCount Number of defining phases, i. e., phase observations that were actually used for computing the origin. Note that there may be more than one defining phase per station.

associatedStationCount Number of stations at which the event was observed.

usedStationCount Number of stations from which data was used for origin computation.

depthPhaseCount Number of depth phases (typically pP, sometimes sP) used in depth computation.

standardError RMS of the travel time residuals of the arrivals used for the origin computation.
Unit: s

azimuthalGap Largest azimuthal gap in station distribution as seen from epicenter.
Unit: deg

secondaryAzimuthalGap Secondary azimuthal gap in station distribution, i. e., the largest azimuthal gap a station closes.
Unit: deg

groundTruthLevel String describing ground-truth level, e. g. GT0, GT5, etc.

minimumDistance Epicentral distance of station closest to the epicenter.
Unit: deg

maximumDistance Epicentral distance of station farthest from the epicenter.
Unit: deg

medianDistance Median epicentral distance of used stations.
Unit: deg

3.3.9 ConfidenceEllipsoid

This class represents a description of the location uncertainty as a confidence ellipsoid with arbitrary orientation in space.

List of Attributes

Attribute	UML Type	Multiplicity	XML Type	XML Representation
semiMajorAxisLength	*float*	1	*xs:double*	Element
semiMinorAxisLength	*float*	1	*xs:double*	Element
semiIntermediateAxisLength	*float*	1	*xs:double*	Element
majorAxisPlunge	*float*	1	*xs:double*	Element
majorAxisAzimuth	*float*	1	*xs:double*	Element
majorAxisRotation	*float*	1	*xs:double*	Element

Description of Attributes

semiMajorAxisLength Largest uncertainty, corresponding to the semi-major axis of the confidence ellipsoid.
Unit: m

semiMinorAxisLength Smallest uncertainty, corresponding to the semi-minor axis of the confidence ellipsoid.
Unit: m

semiIntermediateAxisLength Uncertainty in direction orthogonal to major and minor axes of the confidence ellipsoid.
Unit: m

majorAxisPlunge Plunge angle of major axis of confidence ellipsoid.
Unit: deg

majorAxisAzimuth Azimuth angle of major axis of confidence ellipsoid.
Unit: deg

majorAxisRotation This angle describes a rotation about the confidence ellipsoid's major axis which is required to define the direction of the ellipsoid's minor axis. A zero **majorAxisRotation** angle means that the minor axis lies in the plane spanned by the major axis and the vertical.
Unit: deg

3.3.10 NodalPlanes

This class describes the nodal planes of a double-couple moment-tensor solution. The attribute **preferredPlane** can be used to define which plane is the preferred one.

List of Attributes

Attribute	UML Type	Multiplicity	XML Type	XML Representation
nodalPlane1	*NodalPlane*	0..1	–	–
nodalPlane2	*NodalPlane*	0..1	–	–
preferredPlane	*int*	0..1	*xs:integer*	Attribute

Description of Attributes

nodalPlane1 First nodal plane of double-couple moment tensor solution.

nodalPlane2 Second nodal plane of double-couple moment tensor solution.

preferredPlane Indicator for preferred nodal plane of moment tensor solution. It can take integer values 1 or 2.

XML code example See Sect. 3.5.6.

3.3.11 PrincipalAxes

This class describes the principal axes of a double-couple moment tensor solution. **tAxis** and **pAxis** are required, while **nAxis** is optional.

List of Attributes

Attribute	UML Type	Multiplicity	XML Type	XML Representation
tAxis	*Axis*	1	–	–
pAxis	*Axis*	1	–	–
nAxis	*Axis*	0..1	–	–

Description of Attributes

tAxis T axis of a double-couple moment tensor solution.

pAxis P axis of a double-couple moment tensor solution.

nAxis N axis of a double-couple moment tensor solution.

3.3.12 NodalPlane

This class describes a nodal plane using the attributes **strike**, **dip**, and **rake**. For a definition of the angles see Aki & Richards (1980).

List of Attributes

Attribute	UML Type	Multiplicity	XML Type	XML Representation
strike	*RealQuantity*	1	–	–
dip	*RealQuantity*	1	–	–
rake	*RealQuantity*	1	–	–

Description of Attributes

strike Strike angle of nodal plane.
Unit: deg

dip Dip angle of nodal plane.
Unit: deg

rake Rake angle of nodal plane.
Unit: deg

XML code example See Sect. 3.5.6.

3.3.13 Axis

This class describes an eigenvector of a moment tensor expressed in its principal-axes system. It uses the angles **azimuth**, **plunge**, and the eigenvalue **length**.

List of Attributes

Attribute	UML Type	Multiplicity	XML Type	XML Representation
azimuth	*RealQuantity*	1	–	–
plunge	*RealQuantity*	1	–	–
length	*RealQuantity*	1	–	–

Description of Attributes

azimuth Azimuth of eigenvector of moment tensor expressed in principal-axes system.
Unit: deg

plunge Plunge of eigenvector of moment tensor expressed in principal-axes system.
Unit: deg

length Eigenvalue of moment tensor expressed in principal-axes system.
Unit: N m

3.3.14 Tensor

The *Tensor* class represents the six moment-tensor elements M_{rr}, M_{tt}, M_{pp}, M_{rt}, M_{rp}, M_{tp}, where r is up, t is south, and p is east. See Aki & Richards (1980) for conversions to other coordinate systems.

Attribute	UML Type	Multiplicity	XML Type	XML Representation
Mrr	*RealQuantity*	1	–	–
Mtt	*RealQuantity*	1	–	–
Mpp	*RealQuantity*	1	–	–
Mrt	*RealQuantity*	1	–	–
Mrp	*RealQuantity*	1	–	–
Mtp	*RealQuantity*	1	–	–

Description of Attributes

Mrr Moment-tensor element M_{rr}.
Unit: N m

Mtt Moment-tensor element M_{tt}.
Unit: N m

Mpp Moment-tensor element M_{pp}.
Unit: N m

Mrt Moment-tensor element M_{rt}.
Unit: N m

Mrp Moment-tensor element M_{rp}.
Unit: N m

Mtp Moment-tensor element M_{tp}.
Unit: N m

XML code example See Sect. 3.5.7.

3.3.15 DataUsed

This class describes the type of data that has been used for a moment-tensor inversion.

Attribute	UML Type	Multiplicity	XML Type	XML Representation
waveType	*enum (DataUsedWaveType)*	1	–	Element
stationCount	*int*	1	*xs:integer*	Element
componentCount	*int*	1	*xs:integer*	Element
shortestPeriod	*float*	0..1	*xs:double*	Element

Description of Attributes

waveType Type of waveform data. This can be one of the following values:

DataUsedWaveType (enum)

- `body waves`
- `P body waves`
- `long-period body waves`
- `surface waves`
- `intermediate-period surface waves`
- `long-period mantle waves`
- `unknown`

stationCount Number of stations that have contributed data of the type given in **waveType**.

componentCount Number of data components of the type given in **waveType**.

shortestPeriod Shortest period present in data.
Unit: s

3.3.16 SourceTimeFunction

Source time function used in moment-tensor inversion.

Attribute	UML Type	Multiplicity	XML Type	XML Representation
type	*enum (SourceTimeFunctionType)*	1	–	Element
duration	*float*	1	*xs:double*	Element
riseTime	*float*	0..1	*xs:double*	Element
decayTime	*float*	0..1	*xs:double*	Element

Description of Attributes

type Type of source time function. Values can be taken from the following:

SourceTimeFunction (enum)

- `box car`
- `triangle`
- `trapezoid`
- `unknown`

duration Source time function duration.
Unit: s

riseTime Source time function rise time.
Unit: s

decayTime Source time function decay time.
Unit: s

3.3.17 EventDescription

Free-form string with additional event description. This can be a well-known name, like `1906 San Francisco Earthquake`. A number of categories can be given in **type**.

List of Attributes

Attribute	UML Type	Multiplicity	XML Type	XML Representation
text	*string*	1	*xs:string*	Element
type	*enum (EventDescriptionType)*	0..1	–	Element

Description of Attributes

text Free-form text with earthquake description.

type Category of earthquake description. Values can be taken from the following:

EventDescriptionType (enum)

- `felt report`
- `Flinn-Engdahl region`
- `local time`
- `tectonic summary`
- `nearest cities`
- `earthquake name`
- `region name`

3.3.18 CreationInfo

CreationInfo is used to describe author, version, and creation time of a resource.

Attribute	UML Type	Multiplicity	XML Type	XML Representation
agencyID	*string*	0..1	*xs:string*	Element
agencyURI	*ResourceReference*	0..1	*ResourceIdentifier*	Element
author	*string*	0..1	*xs:string*	Element
authorURI	*ResourceReference*	0..1	*ResourceIdentifier*	Element
creationTime	*datetime*	0..1	*xs:datetime*	Element
version	*string*	0..1	*xs:string*	Element

Description of Attributes

agencyID Designation of agency that published a resource.

agencyURI RI of the agency that published a resource.

authorID Name describing the author of a resource.

authorURI RI of the author of a resource.

creationTime Time of creation of a resource, in ISO 8601 format. It has to be given in UTC (see Sect. 3.2.2).

version Version string of a resource.

3.3.19 Comment

Comment holds information on comments to a resource as well as author and creation time information.

List of Attributes

Attribute	UML Type	Multiplicity	XML Type	XML Representation
text	*string*	1	*xs:string*	Element
id	*ResourceReference*	0..1	*ResourceIdentifier*	Attribute
creationInfo	*CreationInfo*	0..1	–	–

Description of Attributes

text Text of comment.

id Identifier of comment, in QuakeML resource identifier format.

creationInfo Creation info of comment (author, version, creation time).

3.4 Common Enumerations

In this section enumerations that are used in more than one class are listed. Enumerations which are specific to only one class are presented within the context of the class.

3.4.1 EvaluationMode

Mode of an evaluation (used in *Pick*, *Amplitude*, *Origin*). Allowed values are

- `automatic`
- `manual`.

3.4.2 EvaluationStatus

Status of of an evaluation (used in *Pick*, *Origin*, *Magnitude*). Allowed values are

- `preliminary`
- `confirmed`
- `reviewed`
- `final`
- `rejected`
- `reported`.

3.5 Elements

3.5.1 EventParameters

In the standard model, this class serves as a container for *Event* objects. In the real-time version, it can hold objects of type *Event*, *Origin*, *Magnitude*, *StationMagnitude*, *FocalMechanism*, *Reading*, *Amplitude*, and *Pick*.

List of Attributes

Attribute	UML Type	Multiplicity	XML Type	XML Representation
publicID	*ResourceReference*	1	*ResourceIdentifier*	Attribute
description	*string*	0..1	*xs:string*	Element
comment	*Comment*	0..∗	–	–
creationInfo	*CreationInfo*	0..1	–	–

Description of Attributes

publicID Resource identifier of *EventParameters*.

description Description string that can be assigned to the earthquake catalog, or collection of events.

comment Additional comments.

creationInfo Creation info.

XML example

```
<eventParameters publicID="smi:ch.ethz.sed/catalog/switzerland/1">
    <event>...</event>
    <event>...</event>
<eventParameters>
```

3.5.2 Event

The class *Event* describes a seismic event which does not necessarily need to be a tectonic earthquake. An event is usually associated with one or more origins, which contain information about focal time and geographical location of the event. Multiple origins can cover automatic and manual locations, a set of location from different agencies, locations generated with different location programs and earth models, etc. Furthermore, an event is usually associated with one or more magnitudes, and with one or more focal mechanism determinations. In standard QuakeML, *Origin*, *Magnitude*, *StationMagnitude*, and *FocalMechanism* are child elements of *Event*. In QuakeML-RT all these elements are on the same hierarchy level as child elements of *EventParameters*. The association of origins, magnitudes, and focal mechanisms to a particular event is expressed using references inside *Event*.

List of Attributes

Attribute	UML Type	Multiplicity	XML Type	XML Representation
publicID	*ResourceReference*	1	*RI*	Attribute
preferredOriginID	*ResourceReference*	0..1	*RI*	Element
preferredMagnitudeID	*ResourceReference*	0..1	*RI*	Element
preferredFocalMechanismID	*ResourceReference*	0..1	*RI*	Element
type	*enum (EventType)*	0..1	–	Element
typeCertainty	*enum (EventTypeCertainty)*	0..1	–	Element
description	*EventDescription*	0..1	–	–
comment	*Comment*	0..∗	–	–
creationInfo	*CreationInfo*	0..1	–	–
only in real-time variant:				
originReference	*ResourceReference*	0..∗	*RI*	Element
magnitudeReference	*ResourceReference*	0..∗	*RI*	Element
stationMagnitudeReference	*ResourceReference*	0..∗	*RI*	Element
focalMechanismReference	*ResourceReference*	0..∗	*RI*	Element

Description of Attributes

publicID Resource identifier of *Event*.

preferredOriginID Refers to the **publicID** of the preferred *Origin* object.

preferredMagnitudeID Refers to the **publicID** of the preferred *Magnitude* object.

preferredFocalMechanismID Refers to the **publicID** of the preferred *FocalMechanism* object.

type Describes the type of an event. Allowed values are the following:

EventType (enum)

- `earthquake`
- `induced earthquake`
- `quarry blast`
- `explosion`
- `chemical explosion`
- `nuclear explosion`
- `landslide`
- `rockslide`
- `snow avalanche`
- `debris avalanche`
- `mine collapse`

- building collapse
- volcanic eruption
- meteor impact
- plane crash
- sonic boom
- not existing
- null
- other

typeCertainty Denotes how certain the information on event type is. Allowed values are the following:

EventTypeCertainty (enum)

- suspected
- known

description Additional event description, like earthquake name, Flinn-Engdahl region, etc.

comment Comments.

creationInfo Creation information.

originReference Reference to an associated *Origin*. Only applicable for real-time variant (QuakeML-RT).

magnitudeReference Reference to an associated *Magnitude*. Only applicable for real-time variant (QuakeML-RT).

stationMagnitudeReference Reference to an associated *StationMagnitude*. Only applicable for real-time variant (QuakeML-RT).

focalMechanismReference Reference to an associated *FocalMechanism*. Only applicable for real-time variant (QuakeML-RT).

XML example

```
<event publicID="smi:ch.ethz.sed/event/historical/1165">
    <preferredOriginID>smi:ch.ethz.sed/origin/2054</preferredOriginID>
    <preferredMagnitudeID>smi:ch.ethz.sed/magnitude/1015</preferredMagnitudeID>
    <preferredFocalMechanismID>smi:ch.ethz.sed/fm/23151</preferredFocalMechanismID>
    <type>earthquake</type>
    <description>
        <text>1906 San Francisco Earthquake</text>
        <type>earthquake name</type>
    </description>
    <comment>
        <text>Relocated after re-evaluation of historical intensity reports</text>
    </comment>
</event>
```

3.5.3 Origin

This class represents the focal time and geographical location of an earthquake hypocenter, as well as additional meta-information. *Origin* can have objects of type *OriginUncertainty* and *Arrival* as child elements.

List of Attributes

Attribute	UML Type	Multiplicity	XML Type	XML Representation
publicID	*ResourceReference*	1	*ResourceIdentifier*	Attribute
time	*TimeQuantity*	1	–	–
latitude	*RealQuantity*	1	–	–
longitude	*RealQuantity*	1	–	–
depth	*RealQuantity*	0..1	–	–
depthType	*enum (OriginDepthType)*	0..1	–	Element
timeFixed	*boolean*	0..1	*xs:boolean*	Element
epicenterFixed	*boolean*	0..1	*xs:boolean*	Element
referenceSystemID	*ResourceReference*	0..1	*ResourceIdentifier*	Element
methodID	*ResourceReference*	0..1	*ResourceIdentifier*	Element
earthModelID	*ResourceReference*	0..1	*ResourceIdentifier*	Element
compositeTime	*CompositeTime*	0..∗	–	–
quality	*OriginQuality*	0..1	–	–
type	*enum (OriginType)*	0..1		Element
evaluationMode	*enum (EvaluationMode)*	0..1	–	Element
evaluationStatus	*enum (EvaluationStatus)*	0..1	–	Element
comment	*Comment*	0..∗	–	–
creationInfo	*CreationInfo*	0..1	–	–

Description of Attributes

publicID Resource identifier of *Origin*.

time Focal time.

latitude Hypocenter latitude.
Unit: deg

longitude Hypocenter longitude.
Unit: deg

depth Depth of hypocenter.
Unit: m

depthType Type of depth determination. Allowed values are the following:

OriginDepthType (enum)

- `from location`
- `constrained by depth phases`
- `constrained by direct phases`
- `operator assigned`
- `other`.

timeFixed Boolean flag. True if focal time was kept fixed for computation of the *Origin*.

epicenterFixed Boolean flag. True if epicenter was kept fixed for computation of *Origin*.

referenceSystemID Identifies the reference system used for hypocenter determination.

methodID Identifies the method used for locating the event.

earthModelID Identifies the earth model used in **methodID**.

compositeTime Supplementary information on time of rupture start. Complex descriptions of focal times of historic event are possible, see description of the *CompositeTime* type.

quality Additional parameters describing the quality of an origin determination.

type Describes the origin type. Allowed values are the following:

OriginType (enum)

- `rupture start`
- `centroid`
- `rupture end`
- `hypocenter`
- `amplitude`
- `macroseismic`

evaluationMode Evaluation mode of *Origin* (see Sect. 3.4.1).

evaluationStatus Evaluation status of *Origin* (see Sect. 3.4.2).

comment Additional comments.

creationInfo Creation info.

XML example

```
<origin publicID="smi:org.globalcmt/origin/C200501010120A">
    <time>
        <value>2005-01-01T01:20:05.1Z</value>
        <uncertainty>0.9</uncertainty>
    </time>
    <latitude>
        <value>13.76</value>
        <uncertainty>0.06</uncertainty>
    </latitude>
    <longitude>
        <value>-89.08</value>
        <uncertainty>0.09</uncertainty>
    </longitude>
    <depth>
        <value>162800</value>
        <uncertainty>12500</uncertainty>
    </depth>
    <depthType>from moment tensor inversion</depthType>
</origin>
```

3.5.4 OriginUncertainty

This class describes the location uncertainties of an origin. The uncertainty can be described either as a simple circular horizontal uncertainty, an uncertainty ellipse according to IMS1.0, or a confidence ellipsoid. The preferred variant can be given in the attribute **preferredDescription**.

List of Attributes

Attribute	UML Type	Multiplicity	XML Type	XML Representation
preferredDescription	*enum (OriginUncertaintyDescription)*	0..1	–	Element
horizontalUncertainty	*float*	0..1	*xs:double*	Element
minHorizontalUncertainty	*float*	0..1	*xs:double*	Element
maxHorizontalUncertainty	*float*	0..1	*xs:double*	Element
azimuthMaxHorizontalUncertainty	*float*	0..1	*xs:double*	Element
confidenceEllipsoid	*ConfidenceEllipsoid*	0..1	–	–

Description of Attributes

preferredDescription Preferred uncertainty description. Allowed values are the following:

OriginUncertaintyDescription (enum)

- `horizontal uncertainty`
- `uncertainty ellipse`
- `confidence ellipsoid`
- `probability density function`

horizontalUncertainty Circular confidence region, given by single value of horizontal uncertainty.
Unit: m

minHorizontalUncertainty Semi-major axis of confidence ellipse.
Unit: m

maxHorizontalUncertainty Semi-minor axis of confidence ellipse.
Unit: m

azimuthMaxHorizontalUncertainty Azimuth of major axis of confidence ellipse.
Unit: deg

confidenceEllipsoid Confidence ellipsoid (see Sect. 3.3.9).

XML example

```
<originUncertainty>
    <preferredDescription>uncertainty ellipse</preferredDescription>
    <horizontalUncertainty>9000</horizontalUncertainty>
    <minHorizontalUncertainty>6000</minHorizontalUncertainty>
    <maxHorizontalUncertainty>10000</maxHorizontalUncertainty>
    <azimuthMaxHorizontalUncertainty>80.0</azimuthMaxHorizontalUncertainty>
</originUncertainty>
```

3.5.5 Magnitude

Describes a magnitude which can, but need not be associated with an *Origin*. Association with an origin is expressed with the optional attribute **originID**. It is either a combination of different magnitude estimations, or it represents the reported magnitude for the given *Event*.

List of Attributes

Attribute	UML Type	Multiplicity	XML Type	XML Representation
publicID	*ResourceReference*	1	*ResourceIdentifier*	Attribute
mag	*RealQuantity*	1	–	–
type	*string*	0..1	*xs:string*	Element
originID	*ResourceReference*	0..1	*ResourceIdentifier*	Element
methodID	*ResourceReference*	0..1	*ResourceIdentifier*	Element
stationCount	*int*	0..1	*xs:integer*	Element
azimuthalGap	*float*	0..1	*xs:double*	Element
evaluationStatus	*enum (EvaluationStatus)*	–	0..1	Element
comment	*Comment*	0..∗	–	–
creationInfo	*CreationInfo*	0..1	–	–

Description of Attributes

publicID Resource identifier of *Magnitude*.

mag Resulting magnitude value from combining values of type *StationMagnitude*. If no estimations are available, this value can represent the reported magnitude.

type Describes the type of magnitude. This is a free-text field because it is impossible to cover all existing magnitude type designations with an enumeration. Possible values are unspecified magitude (`M`), local magnitude (`ML`), body wave magnitude (`Mb`), surface wave magnitude (`MS`), moment magnitude (`Mw`), duration magnitude (`Md`), coda magnitude (`Mc`), `MH`, `Mwp`, `M50`, `M100`, etc.

originID Reference to an origin's **publicID** if the magnitude has an associated *Origin*.

methodID Identifies the method of magnitude estimation. Users should avoid to give contradictory information in **methodID** and **type**.

stationCount Number of used stations for this magnitude computation.

azimuthalGap Azimuthal gap for this magnitude computation.
Unit: deg

evaluationStatus Evaluation status of *Magnitude* (see Sect. 3.4.2).

comment Additional comments.

creationInfo Creation info.

XML example

```
<magnitude publicID="smi:ch.ethz.sed/magnitude/37465">
    <mag>
        <value>5.5</value>
        <uncertainty>0.1</uncertainty>
    </mag>
    <type>MS</type>
    <methodID>smi:ch.ethz.sed/magnitude/generic/surface_wave_magnitude</methodID>
    <stationCount>8</stationCount>
</magnitude>
```

3.5.6 FocalMechanism

This class describes the focal mechanism of an *Event*. It includes different descriptions like nodal planes, principal axes, and a moment tensor. The moment tensor description is provided by objects of the class *MomentTensor* which can be specified as child elements of *FocalMechanism*.

List of Attributes

Attribute	UML Type	Multiplicity	XML Type	XML Representation
publicID	*ResourceReference*	1	*ResourceIdentifier*	Attribute
triggeringOriginID	*ResourceReference*	0..1	*ResourceIdentifier*	Element
nodalPlanes	*NodalPlanes*	0..1	–	–
principalAxes	*PrincipalAxes*	0..1	–	–
azimuthalGap	*float*	0..1	*xs:double*	Element
stationPolarityCount	*int*	0..1	*xs:integer*	Element
misfit	*float*	0..1	*xs:double*	Element
stationDistributionRatio	*float*	0..1	*xs:double*	Element
methodID	*ResourceReference*	0..1	*ResourceIdentifier*	Element
comment	*Comment*	0..∗	–	–
creationInfo	*CreationInfo*	0..1	–	–

Description of Attributes

publicID Resource identifier of *FocalMechanism*.

triggeringOriginID Refers to the **publicID** of the triggering origin.

nodalPlanes Nodal planes of the focal mechanism.

principalAxes Principal axes of the focal mechanism.

azimuthalGap Largest azimuthal gap in distribution of stations used for determination of focal mechanism. *Unit:* deg

stationPolarityCount Number of station polarities used for determination of focal mechanism.

misfit Fraction of misfit polarities in a first-motion focal mechanism determination. Fractional value between 0 and 1.

stationDistributionRatio Station distribution ratio (STDR) parameter. Indicates how the stations are distributed about the focal sphere. Fractional value between 0 and 1.

methodID Resource identifier of the method used for determination of the focal mechanism.

comment Aditional comments.

creationInfo Creation information.

XML example

```
<focalMechanism publicID="smi:org.globalcmt/fm/C200501010120A">
    <nodalPlanes>
        <nodalPlane1>
            <strike>
                <value>9.0</value>
            </strike>
            <dip>
                <value>29.0</value>
            </dip>
            <rake>
                <value>142.0</value>
            </rake>
        </nodalPlane1>
        <nodalPlane2>
            <strike>
                <value>133.0</value>
            </strike>
            <dip>
                <value>72.0</value>
            </dip>
            <rake>
                <value>66.0</value>
            </rake>
        </nodalPlane2>
    </nodalPlanes>
</focalMechanism>
```

3.5.7 MomentTensor

This class represents a moment tensor solution for an *Event*. It is part of a *FocalMechanism* description.

List of Attributes

Attribute	UML Type	Multiplicity	XML Type	XML Representation
derivedOriginID	*ResourceReference*	1	*ResourceIdentifier*	Element
momentMagnitudeID	*ResourceReference*	0..1	*ResourceIdentifier*	Element
scalarMoment	*RealQuantity*	0..1	–	–
tensor	*Tensor*	0..1	–	–
variance	*float*	0..1	*xs:double*	Element
varianceReduction	*float*	0..1	*xs:double*	Element
doubleCouple	*float*	0..1	*xs:double*	Element
clvd	*float*	0..1	*xs:double*	Element
iso	*float*	0..1	*xs:double*	Element
greensFunctionID	*ResourceReference*	0..1	*ResourceIdentifier*	Element
filterID	*ResourceReference*	0..1	*ResourceIdentifier*	Element
sourceTimeFunction	*SourceTimeFunction*	0..1	–	–
dataUsed	*DataUsed*	0..1	–	–
methodID	*ResourceReference*	0..1	*ResourceIdentifier*	Element
method	*enum (MomentTensorMethod)*	0..1	–	Element
status	*enum (MomentTensorStatus)*	0..1	–	Element
cmtName	*string*	0..1	*xs:string*	Element
cmtVersion	*string*	0..1	*xs:string*	Element
comment	*Comment*	0..∗	–	–
creationInfo	*CreationInfo*	0..1	–	–

Description of Attributes

derivedOriginID Refers to the **publicID** of the *Origin* derived in the moment tensor inversion.

momentMagnitudeID Refers to the **publicID** of the *Magnitude* object which represents the derived moment magnitude.

scalarMoment Scalar moment as derived in moment tensor inversion.
Unit: N m

tensor *Tensor* object holding the moment tensor elements.

variance Variance of moment tensor inversion.

varianceReduction Variance reduction of moment tensor inversion.

doubleCouple Double couple parameter obtained from moment tensor inversion (fractional value between 0 and 1).

clvd CLVD (compensated linear vector dipole) parameter obtained from moment tensor inversion (fractional value between 0 and 1).

iso Isotropic part obtained from moment tensor inversion (fractional value between 0 and 1).

greensFunctionID Resource identifier of the Green's function used in moment tensor inversion.

filterID Resource identifier of the filter setup used in moment tensor inversion.

sourceTimeFunction Source time function used in moment-tensor inversion.

dataUsed Describes waveform data used for moment-tensor inversion.

methodID Resource identifier of the method used for moment-tensor inversion.

method Method used for moment tensor inversion. Users should avoid to give contradictory information in **method** and **methodID**. Valid entries are given in the following list:

MomentTensorMethod (enum)

- `CMT - general moment tensor`
- `CMT - moment tensor with zero trace`
- `CMT - double-couple source`
- `teleseismic`
- `regional`

status Status of moment tensor inversion. Valid entries are given in the following list:

MomentTensorStatus (enum)

- `standard CMT solution`
- `quick CMT solution`

cmtName Name describing CMT solution, as given in ndk[9] format.

cmtVersion Version of code used for CMT solution, as given in ndk format.

comment Aditional comments.

creationInfo Creation information.

[9] http://www.ldeo.columbia.edu/~gcmt/projects/CMT/catalog/allorder.ndk_explained

XML example

```
<momentTensor>
    <derivedOriginID>smi:org.globalcmt/origin/C200501010120A</derivedOriginID>
    <scalarMoment>
        <value>1.312e15</value>
    </scalarMoment>
    <tensor>
        <Mrr>
            <value>0.838e15</value>
            <uncertainty>0.201e15</uncertainty>
        </Mrr>
        <Mtt>
            <value>-0.005e15</value>
            <uncertainty>0.231e15</uncertainty>
        </Mtt>
        <Mpp>
            <value>-0.833e15</value>
            <uncertainty>0.270e15</uncertainty>
        </Mpp>
        <Mrt>
            <value>1.050e15</value>
            <uncertainty>0.121e15</uncertainty>
        </Mrt>
        <Mrp>
            <value>-0.369e15</value>
            <uncertainty>0.161e15</uncertainty>
        </Mrp>
        <Mtp>
            <value>0.044e15</value>
            <uncertainty>0.240e15</uncertainty>
        </Mtp>
    </tensor>
    <dataUsed>
        <waveType>long-period body waves</waveType>
        <stationCount>4</stationCount>
        <componentCount>4</componentCount>
        <shortestPeriod>40.0</shortestPeriod>
    </dataUsed>
    <sourceTimeFunction>
        <type>triangle</type>
        <duration>0.6</duration>
    </sourceTimeFunction>
    <method>CMT - moment-tensor with constraint of zero trace</method>
    <status>standard CMT solution</status>
    <cmtName>C200501010120A</cmtName>
    <cmtVersion>V10</cmtVersion>
    <creationInfo>
        <creationTime>2005-03-22T12:52:01Z</creationTime>
    </creationInfo>
</momentTensor>
```

3.5.8 StationMagnitude

This class describes the magnitude derived from a single waveform stream.

List of Attributes

Attribute	UML Type	Multiplicity	XML Type	XML Representation
publicID	*ResourceReference*	1	*ResourceIdentifier*	Attribute
originID	*ResourceReference*	1	*ResourceIdentifier*	Element
mag	*RealQuantity*	1	–	–
type	*string*	0..1	*xs:string*	Element
amplitudeID	*ResourceReference*	0..1	*ResourceIdentifier*	Element
methodID	*ResourceReference*	0..1	*ResourceIdentifier*	Element
waveformID	*WaveformStreamID*	0..1	–	–
comment	*Comment*	0..∗	–	–
creationInfo	*CreationInfo*	0..1	–	–

Description of Attributes

publicID Resource identifier of *StationMagnitude*.

originID Reference to an origin's **publicID** if the *StationMagnitude* has an associated *Origin*.

mag Estimated magnitude.

type See class *Magnitude* (Sect. 3.5.5).

amplitudeID Identifies the data source of the *StationMagnitude*. For magnitudes derived from amplitudes in waveforms (e. g., local magnitude M_{L}), **amplitudeID** points to **publicID** in class *Amplitude*.

waveformID Identifes the waveform stream.

methodID See class *Magnitude* (Sect. 3.5.5).

comment Additional comments.

creationInfo Creation info.

XML example

```
<stationMagnitude publicID="smi:ch.ethz.sed/magnitude/station/881342">
    <mag>
        <value>6.5</value>
        <uncertainty>0.2</uncertainty>
    </mag>
    <methodID>smi:ch.ethz.sed/magnitude/generic/surface_wave_magnitude</methodID>
    <stationAmplitudeID>smi:ch.ethz.sed/amplitude/824315</stationAmplitudeID>
    <type>MS</type>
    <waveformID>smi:ch.ethz.sed/waveform/201754</waveformID>
</stationMagnitude>
```

3.5.9 StationMagnitudeContribution

This class describes the weighting of magnitude values from several *StationMagnitude* objects for computing *Magnitude* estimations.

List of Attributes

Attribute	UML Type	Multiplicity	XML Type	XML Representation
stationMagnitudeID	*ResourceReference*	1	*ResourceIdentifier*	Element
residual	*float*	0..1	*xs:double*	Element
weight	*float*	0..1	*xs:double*	Element

Description of Attributes

stationMagnitudeID Refers to the **publicID** of a *StationMagnitude* object.

residual Residual of magnitude computation.

weight Weight of the magnitude value from class *StationMagnitude* for computing the magnitude value in class *Magnitude*.

XML example

```
<stationMagnitudeContribution>
    <stationMagnitudeID>smi:ch.ethz.sed/magnitude/station/55897</stationMagnitudeID>
    <weight>0.15</weight>
</stationMagnitudeContribution>
```

3.5.10 Arrival

Successful association of a pick with an origin qualifies this pick as an arrival. An arrival thus connects a pick with an origin and provides additional attributes that describe this relationship. Usually qualification of a pick as an arrival for a given origin is a hypothesis, which is based on assumptions about the type of arrival (phase) as well as observed and (on the basis of an earth model) computed arrival times, or the residual, respectively. Additional pick attributes like the horizontal slowness and backazimuth of the observed wave—especially if derived from array data—may further constrain the nature of the arrival.

List of Attributes

Attribute	UML Type	Multiplicity	XML Type	XML Representation
pickID	*ResourceReference*	1	*ResourceIdentifier*	Element
phase	*Phase*	1	–	–
timeCorrection	*float*	0..1	*xs:double*	Element
azimuth	*float*	0..1	*xs:double*	Element
distance	*float*	0..1	*xs:double*	Element
timeResidual	*float*	0..1	*xs:double*	Element
horizontalSlownessResidual	*float*	0..1	*xs:double*	Element
backazimuthResidual	*float*	0..1	*xs:double*	Element
timeUsed	*boolean*	0..1	*xs:boolean*	Element
horizontalSlownessUsed	*boolean*	0..1	*xs:boolean*	Element
backazimuthUsed	*boolean*	0..1	*xs:boolean*	Element
weight	*float*	0..1	*xs:double*	Element
earthModelID	*ResourceReference*	0..1	*ResourceIdentifier*	Element
preliminary	*boolean*	0..1	*xs:boolean*	Attribute
comment	*Comment*	0..∗	–	–
creationInfo	*CreationInfo*	0..1	–	–

Description of Attributes

pickID Refers to a **publicID** of a *Pick*.

phase Phase identification.

timeCorrection Time correction value.
Unit: s

azimuth Azimuth of station as seen from the epicenter.
Unit: deg

distance Epicentral distance.
Unit: deg

timeResidual Residual between observed and expected arrival time assuming proper phase identification and given the **earthModelID** of the *Origin*.
Unit: s

horizontalSlownessResidual Residual of horizontal slowness.
Unit: $\mathrm{s} \cdot \mathrm{deg}^{-1}$

backazimuthResidual Residual of backazimuth.
Unit: deg

timeUsed Boolean flag. True if arrival time was used for computation of the associated *Origin*.

horizontalSlownessUsed Boolean flag. True if horizontal slowness was used for computation of the associated *Origin*.

backazimuthUsed Boolean flag. True if backazimuth was used for computation of the associated *Origin*.

weight Weight of this *Arrival* in the computation of the associated *Origin*.

earthModelID Earth model which is used for the association of *Arrival* to *Pick* and computation of the residuals.

preliminary Boolean flag. True if arrival designation is preliminary.

comment Additional comments.

creationInfo Creation info.

XML example

```
<arrival>
    <pickID>smi:ch.ethz.sed/pick/117634</pickID>
    <phase>Pn</phase>
    <azimuth>12.0</azimuth>
    <distance>0.5</distance>
    <earthModelID>smi:ch.ethz.sed/earthmodel/U21</earthModelID>
</arrival>
```

3.5.11 Pick

A pick is the observation of an amplitude anomaly in a seismogram. It is not necessarily related to a seismic event.

List of Attributes

Attribute	UML Type	Multiplicity	XML Type	XML Representation
publicID	*ResourceReference*	1	*ResourceIdentifier*	Attribute
time	*TimeQuantity*	1	–	–
waveformID	*WaveformStreamID*	1	–	–
filterID	*ResourceReference*	0..1	*ResourceIdentifier*	Element
methodID	*ResourceReference*	0..1	*ResourceIdentifier*	Element
horizontalSlowness	*RealQuantity*	0..1	–	–
backazimuth	*RealQuantity*	0..1	–	–
slownessMethodID	*ResourceReference*	0..1	*ResourceIdentifier*	Element
onset	*enum (PickOnset)*		0..1	Element
phaseHint	*Phase*	0..1	–	–
polarity	*enum (PickPolarity)*	–	0..1	Element
evaluationMode	*enum (EvaluationMode)*	–	0..1	Element
evaluationStatus	*enum (EvaluationStatus)*	–	0..1	Element
comment	*Comment*	0..*	–	–
creationInfo	*CreationInfo*	0..1	–	–

Description of Attributes

publicID Resource identifier of *Pick*.

time Observed onset time ("pick time").

waveformID Identifes the waveform stream.

filterID Identifies the filter or filter setup used for filtering the waveform stream referenced by **waveformID**.

methodID Identifies the picker that produced the pick. This can be either an autopicker program or a person.

horizontalSlowness Observed horizontal slowness of the signal. Most relevant in array measurements.
Unit: $\mathrm{s} \cdot \mathrm{deg}^{-1}$

backazimuth Observed backazimuth of the signal. Most relevant in array measurements.
Unit: deg

slownessMethodID Identifies the method that was used to determine the slowness.

onset Flag that roughly categorizes the sharpness of the onset. Allowed values are:

PickOnset (enum)

- `impulsive`
- `emergent`
- `questionable`.

phaseHint Tentative phase identification as specified by the picker.

polarity Indicates the polarity of first motion, usually from impulsive onsets. Allowed values are:

PickPolarity (enum)

- `positive`
- `negative`
- `undecidable`

evaluationMode Evaluation mode of *Pick* (see Sect. 3.4.1).

evaluationStatus Evaluation status of *Pick* (see Sect. 3.4.2).

comment Additional comments.

creationInfo Creation info.

XML example

```
<pick publicID="smi:ch.ethz.sed/pick/117634">
    <time>
        <value>2005-09-18T22:04:35Z</value>
        <uncertainty>0.012</uncertainty>
    </time>
    <waveformID>smi:ch.ethz.sed/waveform/201754</waveformID>
    <filterID>smi:ch.ethz.sed/filter/lowpass/standard</filterID>
    <methodID>smi:ch.ethz.sed/picker/autopicker/6.0.2</methodID>
    <backazimuth>
        <value>44.0</value>
    </backazimuth>
    <onset>impulsive</onset>
    <phaseHint>Pn</phaseHint>
    <polarity>positive</polarity>
    <evaluationMode>manual</evaluationMode>
    <evaluationStatus>confirmed</evaluationStatus>
</pick>
```

3.5.12 Amplitude

This class represents a single amplitude measurement or a measurement of the visible end of a record for duration magnitudes.

List of Attributes

Attribute	UML Type	Multiplicity	XML Type	XML Representation
publicID	*ResourceReference*	1	*ResourceIdentifier*	Attribute
type	*string*	1	*xs:string*	Element
displacement	*RealQuantity*	0..1	–	–
timeWindow	*TimeWindow*	0..1	–	–
period	*RealQuantity*	0..1	–	–
snr	*float*	0..1	*xs:double*	Element
pickID	*ResourceReference*	0..1	*ResourceIdentifier*	Element
waveformID	*WaveformStreamID*	0..1	–	–
filterID	*ResourceReference*	0..1	*ResourceIdentifier*	Element
methodID	*ResourceReference*	0..1	*ResourceIdentifier*	Element
scalingTime	*TimeQuantity*	0..1	–	–
magnitudeHint	*string*	0..1	*xs:string*	Element
evaluationMode	*enum (EvaluationMode)*	0..1	–	Element
comment	*Comment*	0..*	–	–
creationInfo	*CreationInfo*	0..1	–	–

Description of Attributes

publicID Resource identifier of *Amplitude*.

type Describes the type of amplitude using the nomenclature from Storchak et al. (2003). Possible values are unspecified amplitude reading (`A`), amplitude reading for local magnitude (`AL`), amplitude reading for body wave magnitude (`AB`), amplitude reading for surface wave magnitude (`AS`), and time of visible end of record for duration magnitude (`END`).

displacement Measured displacement value for the given **waveformID**.
Unit: m

timeWindow Description of the time window used for amplitude measurement. Mandatory for duration magnitudes.

period Measured period in the **timeWindow** in case of amplitude measurements. Not used for duration magnitude.
Unit: s

snr Signal-to-noise ratio of the spectrogram at the location the amplitude was measured.

pickID Refers to the **publicID** of an associated *Pick* object.

waveformID Identifies the waveform stream on which the amplitude was measured.

filterID Identifies the filter or filter setup used for filtering the waveform stream referenced by **waveformID**.

methodID Describes the method of amplitude determination.

scalingTime Scaling time for amplitude measurement.

magnitudeHint Type of magnitude the amplitude measurement is used for. For valid values see class *Magnitude* (Sect. 3.5.5).

evaluationMode Evaluation mode of *Amplitude* (see Sect. 3.4.1).

comment Additional comments.

creationInfo Creation info.

XML example

```
<amplitude publicID="smi:ch.ethz.sed/amplitude/962435">
    <displacement>
        <value>1.5e-6</value>
        <uncertainty>0.2e-6</uncertainty>
    </displacement>
    <type>AL</type>
    <pickID>smi:ch.ethz.sed/pick/20238</pickID>
    <waveformID>smi:ch.ethz.sed/waveform/33826</waveformID>
    <filterID>smi:ch.ethz.sed/filter/wood_anderson/1.2</filterID>
    <methodID>smi:ch.ethz.sed/amplitude/generic/AL</methodID>
</amplitude>
```

3.5.13 Reading

Used only in QuakeML-RT as child element of *EventParameters*. This class groups *Pick* and *Amplitude* elements which are thought to belong to the same *Event*, but for which the event identification is not known.

List of Attributes

Attribute	UML Type	Multiplicity	XML Type	XML Representation
publicID	*ResourceReference*	1	*ResourceIdentifier*	Attribute
pickReference	*ResourceReference*	0..∗	*ResourceIdentifier*	Element
amplitudeReference	*ResourceReference*	0..∗	*ResourceIdentifier*	Element

Description of Attributes

publicID Resource identifier of *Reading*.

pickReference Reference to the **publicID** of a *Pick* object.

amplitudeReference Reference to the **publicID** of an *Amplitude* object.

XML example

```
<reading publicID="smi:ch.ethz.sed/reading/962435">
    <pickReference>smi:ch.ethz.sed/pick/924235</pickReference>
    <amplitudeReference>smi:ch.ethz.sed/amlitude/367523</amplitudeReference>
</reading>
```

4 References

Aki, K. & Richards, P.G. (1980) Quantitative Seismology, W. H. Freeman, San Francisco.

Berners-Lee, T. et al. (1998) Uniform Resource Identifier (URI): Generic Syntax (IETF RFC 2396).

Bray, T., Paoli, J., Sperberg-McQueen, C.M., Maler, E. (eds.) (2000) Extensible Markup Language (XML) 1.0, Second Edition, W3C Recommendation, 6 October 2000, http://www.w3.org/TR/2000/REC-xml-20001006.

Dublin Core Metadata Element Set, Version 1.1: Reference Description, 02 June 2003, http://dublincore.org/documents/2003/06/02/dces/.

Schorlemmer, D. et al. (2004) QuakeML—An XML schema for seismology, ORFEUS Newsletter, 6(2), 9.

Storchak D.A., Schweitzer J., Bormann P. (2003) The IASPEI Standard Seismic Phase List, Seismol. Res. Lett. 74, 6, 761–772, ftp://ftp.isc.ac.uk/pub/docs/srl_sspl.pdf.

A QuakeML—XML Schema Description

In this Section the XML Schema descriptions for QuakeML and QuakeML-RT, version 1.1, are listed. The schemas can be found online at
http://quakeml.org/docs/xml?action=AttachFile&do=get&target=QuakeML-BED-1.1.xsd
(QuakeML) and
http://quakeml.org/docs/xml?action=AttachFile&do=get&target=QuakeML-RT-BED-1.1.xsd
(QuakeML-RT).

A.1 QuakeML, Version 1.1

```
<?xml version="1.0"?>
<xs:schema xmlns:xs="http://www.w3.org/2001/XMLSchema" xmlns:qml="http://quakeml.
       org/xmlns/quakeml/1.1" targetNamespace="http://quakeml.org/xmlns/quakeml/1.1
       " elementFormDefault="qualified" attributeFormDefault="unqualified">
  <xs:simpleType name="ResourceIdentifier">
    <xs:restriction base="xs:anyURI">
      <xs:pattern value="(smi|quakeml):[\w\d][\w\d\-\.\*\(\)_~']{2,}/[\w\d
            \-\.\*\(\)_~'][\w\d\-\.\*\(\)\+\?_~'=,;#/&amp;]*"/>
    </xs:restriction>
  </xs:simpleType>
  <xs:simpleType name="ResourceReference">
    <xs:restriction base="qml:ResourceIdentifier"/>
  </xs:simpleType>
  <xs:simpleType name="OriginUncertaintyDescription">
    <xs:restriction base="xs:string">
      <xs:enumeration value="horizontal uncertainty"/>
      <xs:enumeration value="uncertainty ellipse"/>
      <xs:enumeration value="confidence ellipsoid"/>
      <xs:enumeration value="probability density function"/>
    </xs:restriction>
  </xs:simpleType>
  <xs:simpleType name="MomentTensorStatus">
    <xs:restriction base="xs:string">
      <xs:enumeration value="standard CMT solution"/>
      <xs:enumeration value="quick CMT solution"/>
    </xs:restriction>
  </xs:simpleType>
  <xs:simpleType name="OriginDepthType">
    <xs:restriction base="xs:string">
      <xs:enumeration value="from location"/>
      <xs:enumeration value="from moment tensor inversion"/>
      <xs:enumeration value="from modeling of broad-band P waveforms"/>
      <xs:enumeration value="constrained by depth phases"/>
      <xs:enumeration value="constrained by direct phases"/>
      <xs:enumeration value="operator assigned"/>
      <xs:enumeration value="other"/>
    </xs:restriction>
  </xs:simpleType>
  <xs:simpleType name="OriginType">
    <xs:restriction base="xs:string">
      <xs:enumeration value="hypocenter"/>
      <xs:enumeration value="centroid"/>
      <xs:enumeration value="amplitude"/>
      <xs:enumeration value="macroseismic"/>
      <xs:enumeration value="rupture start"/>
      <xs:enumeration value="rupture end"/>
```

```
  </xs:restriction>
</xs:simpleType>
<xs:simpleType name="EvaluationMode">
  <xs:restriction base="xs:string">
    <xs:enumeration value="manual"/>
    <xs:enumeration value="automatic"/>
  </xs:restriction>
</xs:simpleType>
<xs:simpleType name="EvaluationStatus">
  <xs:restriction base="xs:string">
    <xs:enumeration value="preliminary"/>
    <xs:enumeration value="confirmed"/>
    <xs:enumeration value="reviewed"/>
    <xs:enumeration value="final"/>
    <xs:enumeration value="rejected"/>
    <xs:enumeration value="reported"/>
  </xs:restriction>
</xs:simpleType>
<xs:simpleType name="PickOnset">
  <xs:restriction base="xs:string">
    <xs:enumeration value="emergent"/>
    <xs:enumeration value="impulsive"/>
    <xs:enumeration value="questionable"/>
  </xs:restriction>
</xs:simpleType>
<xs:simpleType name="MomentTensorMethod">
  <xs:restriction base="xs:string">
    <xs:enumeration value="CMT␣–␣general␣moment␣tensor"/>
    <xs:enumeration value="CMT␣–␣moment␣tensor␣with␣zero␣trace"/>
    <xs:enumeration value="CMT␣–␣double–couple␣source"/>
    <xs:enumeration value="teleseismic"/>
    <xs:enumeration value="regional"/>
  </xs:restriction>
</xs:simpleType>
<xs:simpleType name="DataUsedWaveType">
  <xs:restriction base="xs:string">
    <xs:enumeration value="body␣waves"/>
    <xs:enumeration value="P␣body␣waves"/>
    <xs:enumeration value="long–period␣body␣waves"/>
    <xs:enumeration value="surface␣waves"/>
    <xs:enumeration value="intermediate–period␣surface␣waves"/>
    <xs:enumeration value="long–period␣mantle␣waves"/>
    <xs:enumeration value="unknown"/>
  </xs:restriction>
</xs:simpleType>
<xs:simpleType name="EventDescriptionType">
  <xs:restriction base="xs:string">
    <xs:enumeration value="felt␣report"/>
    <xs:enumeration value="Flinn–Engdahl␣region"/>
    <xs:enumeration value="local␣time"/>
    <xs:enumeration value="tectonic␣summary"/>
    <xs:enumeration value="nearest␣cities"/>
    <xs:enumeration value="earthquake␣name"/>
    <xs:enumeration value="region␣name"/>
  </xs:restriction>
</xs:simpleType>
<xs:simpleType name="EventType">
  <xs:restriction base="xs:string">
    <xs:enumeration value="earthquake"/>
```

```
      <xs:enumeration value="induced earthquake"/>
      <xs:enumeration value="quarry blast"/>
      <xs:enumeration value="explosion"/>
      <xs:enumeration value="chemical explosion"/>
      <xs:enumeration value="nuclear explosion"/>
      <xs:enumeration value="landslide"/>
      <xs:enumeration value="rockslide"/>
      <xs:enumeration value="snow avalanche"/>
      <xs:enumeration value="debris avalanche"/>
      <xs:enumeration value="mine collapse"/>
      <xs:enumeration value="building collapse"/>
      <xs:enumeration value="volcanic eruption"/>
      <xs:enumeration value="meteor impact"/>
      <xs:enumeration value="plane crash"/>
      <xs:enumeration value="sonic boom"/>
      <xs:enumeration value="not existing"/>
      <xs:enumeration value="null"/>
      <xs:enumeration value="other"/>
    </xs:restriction>
  </xs:simpleType>
  <xs:simpleType name="EventTypeCertainty">
    <xs:restriction base="xs:string">
      <xs:enumeration value="known"/>
      <xs:enumeration value="suspected"/>
    </xs:restriction>
  </xs:simpleType>
  <xs:simpleType name="SourceTimeFunctionType">
    <xs:restriction base="xs:string">
      <xs:enumeration value="box car"/>
      <xs:enumeration value="triangle"/>
      <xs:enumeration value="trapezoid"/>
      <xs:enumeration value="unknown"/>
    </xs:restriction>
  </xs:simpleType>
  <xs:simpleType name="PickPolarity">
    <xs:restriction base="xs:string">
      <xs:enumeration value="positive"/>
      <xs:enumeration value="negative"/>
      <xs:enumeration value="undecidable"/>
    </xs:restriction>
  </xs:simpleType>
  <xs:complexType name="TimeQuantity">
    <xs:choice minOccurs="0" maxOccurs="unbounded">
      <xs:element name="value" type="xs:dateTime" minOccurs="1" maxOccurs="1"/>
      <xs:element name="uncertainty" type="xs:double" minOccurs="0" maxOccurs="1"/>
      <xs:element name="lowerUncertainty" type="xs:double" minOccurs="0" maxOccurs=
          "1"/>
      <xs:element name="upperUncertainty" type="xs:double" minOccurs="0" maxOccurs=
          "1"/>
      <xs:element name="confidenceLevel" type="xs:double" minOccurs="0" maxOccurs="
          1"/>
    </xs:choice>
  </xs:complexType>
  <xs:complexType name="CreationInfo">
    <xs:choice minOccurs="0" maxOccurs="unbounded">
      <xs:element name="agencyID" type="xs:string" minOccurs="0" maxOccurs="1"/>
      <xs:element name="agencyURI" type="qml:ResourceReference" minOccurs="0"
          maxOccurs="1"/>
      <xs:element name="author" type="xs:string" minOccurs="0" maxOccurs="1"/>
```

```
    <xs:element name="authorURI" type="qml:ResourceReference" minOccurs="0"
          maxOccurs="1"/>
    <xs:element name="creationTime" type="xs:dateTime" minOccurs="0" maxOccurs="1
          "/>
    <xs:element name="version" type="xs:string" minOccurs="0" maxOccurs="1"/>
  </xs:choice>
</xs:complexType>
<xs:complexType name="EventDescription">
  <xs:choice minOccurs="0" maxOccurs="unbounded">
    <xs:element name="text" type="xs:string" minOccurs="1" maxOccurs="1"/>
    <xs:element name="type" type="qml:EventDescriptionType" minOccurs="0"
          maxOccurs="1"/>
  </xs:choice>
</xs:complexType>
<xs:complexType name="Phase">
  <xs:simpleContent>
    <xs:extension base="xs:string"/>
  </xs:simpleContent>
</xs:complexType>
<xs:complexType name="Comment">
  <xs:choice minOccurs="0" maxOccurs="unbounded">
    <xs:element name="text" type="xs:string" minOccurs="1" maxOccurs="1"/>
    <xs:element name="creationInfo" type="qml:CreationInfo" minOccurs="0"
          maxOccurs="1"/>
  </xs:choice>
  <xs:attribute name="id" type="qml:ResourceReference"/>
</xs:complexType>
<xs:complexType name="Axis">
  <xs:choice minOccurs="0" maxOccurs="unbounded">
    <xs:element name="azimuth" type="qml:RealQuantity" minOccurs="1" maxOccurs="1
          "/>
    <xs:element name="plunge" type="qml:RealQuantity" minOccurs="1" maxOccurs="1"
          />
    <xs:element name="length" type="qml:RealQuantity" minOccurs="1" maxOccurs="1"
          />
  </xs:choice>
</xs:complexType>
<xs:complexType name="PrincipalAxes">
  <xs:choice minOccurs="0" maxOccurs="unbounded">
    <xs:element name="tAxis" type="qml:Axis" minOccurs="1" maxOccurs="1"/>
    <xs:element name="pAxis" type="qml:Axis" minOccurs="1" maxOccurs="1"/>
    <xs:element name="nAxis" type="qml:Axis" minOccurs="0" maxOccurs="1"/>
  </xs:choice>
</xs:complexType>
<xs:complexType name="DataUsed">
  <xs:choice minOccurs="0" maxOccurs="unbounded">
    <xs:element name="waveType" type="qml:DataUsedWaveType" minOccurs="1"
          maxOccurs="1"/>
    <xs:element name="stationCount" type="xs:integer" minOccurs="1" maxOccurs="1"
          />
    <xs:element name="componentCount" type="xs:integer" minOccurs="1" maxOccurs="
          1"/>
    <xs:element name="shortestPeriod" type="xs:double" minOccurs="0" maxOccurs="1
          "/>
  </xs:choice>
</xs:complexType>
<xs:complexType name="CompositeTime">
  <xs:choice minOccurs="0" maxOccurs="unbounded">
```

```
    <xs:element name="year" type="qml:IntegerQuantity" minOccurs="0" maxOccurs="1
        "/>
    <xs:element name="month" type="qml:IntegerQuantity" minOccurs="0" maxOccurs="
        1"/>
    <xs:element name="day" type="qml:IntegerQuantity" minOccurs="0" maxOccurs="1"
        />
    <xs:element name="hour" type="qml:IntegerQuantity" minOccurs="0" maxOccurs="1
        "/>
    <xs:element name="minute" type="qml:IntegerQuantity" minOccurs="0" maxOccurs=
        "1"/>
    <xs:element name="second" type="qml:RealQuantity" minOccurs="0" maxOccurs="1"
        />
  </xs:choice>
</xs:complexType>
<xs:complexType name="Tensor">
  <xs:choice minOccurs="0" maxOccurs="unbounded">
    <xs:element name="Mrr" type="qml:RealQuantity" minOccurs="1" maxOccurs="1"/>
    <xs:element name="Mtt" type="qml:RealQuantity" minOccurs="1" maxOccurs="1"/>
    <xs:element name="Mpp" type="qml:RealQuantity" minOccurs="1" maxOccurs="1"/>
    <xs:element name="Mrt" type="qml:RealQuantity" minOccurs="1" maxOccurs="1"/>
    <xs:element name="Mrp" type="qml:RealQuantity" minOccurs="1" maxOccurs="1"/>
    <xs:element name="Mtp" type="qml:RealQuantity" minOccurs="1" maxOccurs="1"/>
  </xs:choice>
</xs:complexType>
<xs:complexType name="OriginQuality">
  <xs:choice minOccurs="0" maxOccurs="unbounded">
    <xs:element name="associatedPhaseCount" type="xs:integer" minOccurs="0"
        maxOccurs="1"/>
    <xs:element name="usedPhaseCount" type="xs:integer" minOccurs="0" maxOccurs="
        1"/>
    <xs:element name="asociatedStationCount" type="xs:integer" minOccurs="0"
        maxOccurs="1"/>
    <xs:element name="usedStationCount" type="xs:integer" minOccurs="0" maxOccurs
        ="1"/>
    <xs:element name="depthPhaseCount" type="xs:integer" minOccurs="0" maxOccurs=
        "1"/>
    <xs:element name="standardError" type="xs:double" minOccurs="0" maxOccurs="1"
        />
    <xs:element name="azimuthalGap" type="xs:double" minOccurs="0" maxOccurs="1"/
        >
    <xs:element name="secondaryAzimuthalGap" type="xs:double" minOccurs="0"
        maxOccurs="1"/>
    <xs:element name="groundTruthLevel" type="xs:string" minOccurs="0" maxOccurs=
        "1"/>
    <xs:element name="maximumDistance" type="xs:double" minOccurs="0" maxOccurs="
        1"/>
    <xs:element name="minimumDistance" type="xs:double" minOccurs="0" maxOccurs="
        1"/>
    <xs:element name="medianDistance" type="xs:double" minOccurs="0" maxOccurs="1
        "/>
  </xs:choice>
</xs:complexType>
<xs:complexType name="RealQuantity">
  <xs:choice minOccurs="0" maxOccurs="unbounded">
    <xs:element name="value" type="xs:double" minOccurs="1" maxOccurs="1"/>
    <xs:element name="uncertainty" type="xs:double" minOccurs="0" maxOccurs="1"/>
    <xs:element name="lowerUncertainty" type="xs:double" minOccurs="0" maxOccurs=
        "1"/>
```

```
    <xs:element name="upperUncertainty" type="xs:double" minOccurs="0" maxOccurs=
        "1"/>
    <xs:element name="confidenceLevel" type="xs:double" minOccurs="0" maxOccurs="
        1"/>
  </xs:choice>
</xs:complexType>
<xs:complexType name="NodalPlane">
  <xs:choice minOccurs="0" maxOccurs="unbounded">
    <xs:element name="strike" type="qml:RealQuantity" minOccurs="1" maxOccurs="1"
        />
    <xs:element name="dip" type="qml:RealQuantity" minOccurs="1" maxOccurs="1"/>
    <xs:element name="rake" type="qml:RealQuantity" minOccurs="1" maxOccurs="1"/>
  </xs:choice>
</xs:complexType>
<xs:complexType name="TimeWindow">
  <xs:choice minOccurs="0" maxOccurs="unbounded">
    <xs:element name="begin" type="xs:double" minOccurs="1" maxOccurs="1"/>
    <xs:element name="end" type="xs:double" minOccurs="1" maxOccurs="1"/>
    <xs:element name="reference" type="xs:dateTime" minOccurs="1" maxOccurs="1"/>
  </xs:choice>
</xs:complexType>
<xs:complexType name="WaveformStreamID">
  <xs:choice minOccurs="0" maxOccurs="unbounded">
    <xs:element name="resourceURI" type="qml:ResourceReference" minOccurs="0"
        maxOccurs="1"/>
  </xs:choice>
  <xs:attribute name="networkCode" type="xs:string" use="required"/>
  <xs:attribute name="stationCode" type="xs:string" use="required"/>
  <xs:attribute name="channelCode" type="xs:string"/>
  <xs:attribute name="locationCode" type="xs:string"/>
</xs:complexType>
<xs:complexType name="IntegerQuantity">
  <xs:choice minOccurs="0" maxOccurs="unbounded">
    <xs:element name="value" type="xs:integer" minOccurs="1" maxOccurs="1"/>
    <xs:element name="uncertainty" type="xs:integer" minOccurs="0" maxOccurs="1"/
        >
    <xs:element name="lowerUncertainty" type="xs:integer" minOccurs="0" maxOccurs
        ="1"/>
    <xs:element name="upperUncertainty" type="xs:integer" minOccurs="0" maxOccurs
        ="1"/>
    <xs:element name="confidenceLevel" type="xs:double" minOccurs="0" maxOccurs="
        1"/>
  </xs:choice>
</xs:complexType>
<xs:complexType name="SourceTimeFunction">
  <xs:choice minOccurs="0" maxOccurs="unbounded">
    <xs:element name="type" type="qml:SourceTimeFunctionType" minOccurs="1"
        maxOccurs="1"/>
    <xs:element name="duration" type="xs:double" minOccurs="1" maxOccurs="1"/>
    <xs:element name="riseTime" type="xs:double" minOccurs="0" maxOccurs="1"/>
    <xs:element name="decayTime" type="xs:double" minOccurs="0" maxOccurs="1"/>
  </xs:choice>
</xs:complexType>
<xs:complexType name="NodalPlanes">
  <xs:choice minOccurs="0" maxOccurs="unbounded">
    <xs:element name="nodalPlane1" type="qml:NodalPlane" minOccurs="0" maxOccurs=
        "1"/>
    <xs:element name="nodalPlane2" type="qml:NodalPlane" minOccurs="0" maxOccurs=
        "1"/>
```

```
    </xs:choice>
    <xs:attribute name="preferredPlane" type="xs:integer"/>
  </xs:complexType>
  <xs:complexType name="ConfidenceEllipsoid">
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      <xs:element name="semiMajorAxisLength" type="xs:double" minOccurs="1"
          maxOccurs="1"/>
      <xs:element name="semiMinorAxisLength" type="xs:double" minOccurs="1"
          maxOccurs="1"/>
      <xs:element name="semiIntermediateAxisLength" type="xs:double" minOccurs="1"
          maxOccurs="1"/>
      <xs:element name="majorAxisPlunge" type="xs:double" minOccurs="1" maxOccurs="
          1"/>
      <xs:element name="majorAxisAzimuth" type="xs:double" minOccurs="1" maxOccurs=
          "1"/>
      <xs:element name="majorAxisRotation" type="xs:double" minOccurs="1" maxOccurs
          ="1"/>
    </xs:choice>
  </xs:complexType>
  <xs:complexType name="MomentTensor">
    <xs:sequence>
      <xs:choice minOccurs="0" maxOccurs="unbounded">
        <xs:element name="derivedOriginID" type="qml:ResourceReference" minOccurs="
            1" maxOccurs="1"/>
        <xs:element name="momentMagnitudeID" type="qml:ResourceReference" minOccurs
            ="0" maxOccurs="1"/>
        <xs:element name="scalarMoment" type="qml:RealQuantity" minOccurs="0"
            maxOccurs="1"/>
        <xs:element name="tensor" type="qml:Tensor" minOccurs="0" maxOccurs="1"/>
        <xs:element name="variance" type="xs:double" minOccurs="0" maxOccurs="1"/>
        <xs:element name="varianceReduction" type="xs:double" minOccurs="0"
            maxOccurs="1"/>
        <xs:element name="doubleCouple" type="xs:double" minOccurs="0" maxOccurs="1
            "/>
        <xs:element name="clvd" type="xs:double" minOccurs="0" maxOccurs="1"/>
        <xs:element name="iso" type="xs:double" minOccurs="0" maxOccurs="1"/>
        <xs:element name="greensFunctionID" type="qml:ResourceReference" minOccurs=
            "0" maxOccurs="1"/>
        <xs:element name="filterID" type="qml:ResourceReference" minOccurs="0"
            maxOccurs="1"/>
        <xs:element name="sourceTimeFunction" type="qml:SourceTimeFunction"
            minOccurs="0" maxOccurs="1"/>
        <xs:element name="methodID" type="qml:ResourceReference" minOccurs="0"
            maxOccurs="1"/>
        <xs:element name="method" type="qml:MomentTensorMethod" minOccurs="0"
            maxOccurs="1"/>
        <xs:element name="status" type="qml:MomentTensorStatus" minOccurs="0"
            maxOccurs="1"/>
        <xs:element name="cmtName" type="xs:string" minOccurs="0" maxOccurs="1"/>
        <xs:element name="cmtVersion" type="xs:string" minOccurs="0" maxOccurs="1"/
            >
        <xs:element name="creationInfo" type="qml:CreationInfo" minOccurs="0"
            maxOccurs="1"/>
      </xs:choice>
      <xs:choice minOccurs="0" maxOccurs="unbounded">
        <xs:element name="dataUsed" type="qml:DataUsed"/>
        <xs:element name="comment" type="qml:Comment"/>
      </xs:choice>
    </xs:sequence>
```

```
</xs:complexType>
<xs:complexType name="FocalMechanism">
  <xs:sequence>
    <xs:choice minOccurs="0" maxOccurs="unbounded">
      <xs:element name="triggeringOriginID" type="qml:ResourceReference"
          minOccurs="0" maxOccurs="1"/>
      <xs:element name="nodalPlanes" type="qml:NodalPlanes" minOccurs="0"
          maxOccurs="1"/>
      <xs:element name="principalAxes" type="qml:PrincipalAxes" minOccurs="0"
          maxOccurs="1"/>
      <xs:element name="azimuthalGap" type="xs:double" minOccurs="0" maxOccurs="1
          "/>
      <xs:element name="stationPolarityCount" type="xs:int" minOccurs="0"
          maxOccurs="1"/>
      <xs:element name="misfit" type="xs:double" minOccurs="0" maxOccurs="1"/>
      <xs:element name="stationDistributionRatio" type="xs:double" minOccurs="0"
          maxOccurs="1"/>
      <xs:element name="methodID" type="qml:ResourceReference" minOccurs="0"
          maxOccurs="1"/>
      <xs:element name="creationInfo" type="qml:CreationInfo" minOccurs="0"
          maxOccurs="1"/>
    </xs:choice>
    <xs:choice minOccurs="0" maxOccurs="unbounded">
      <xs:element name="comment" type="qml:Comment"/>
      <xs:element name="momentTensor" type="qml:MomentTensor"/>
    </xs:choice>
  </xs:sequence>
  <xs:attribute name="publicID" type="qml:ResourceReference" use="required"/>
</xs:complexType>
<xs:complexType name="Amplitude">
  <xs:sequence>
    <xs:choice minOccurs="0" maxOccurs="unbounded">
      <xs:element name="type" type="xs:string" minOccurs="1" maxOccurs="1"/>
      <xs:element name="displacement" type="qml:RealQuantity" minOccurs="0"
          maxOccurs="1"/>
      <xs:element name="timeWindow" type="qml:TimeWindow" minOccurs="0" maxOccurs
          ="1"/>
      <xs:element name="period" type="qml:RealQuantity" minOccurs="0" maxOccurs="
          1"/>
      <xs:element name="snr" type="xs:double" minOccurs="0" maxOccurs="1"/>
      <xs:element name="pickID" type="qml:ResourceReference" minOccurs="0"
          maxOccurs="1"/>
      <xs:element name="waveformID" type="qml:WaveformStreamID" minOccurs="0"
          maxOccurs="1"/>
      <xs:element name="filterID" type="qml:ResourceReference" minOccurs="0"
          maxOccurs="1"/>
      <xs:element name="methodID" type="qml:ResourceReference" minOccurs="0"
          maxOccurs="1"/>
      <xs:element name="scalingTime" type="qml:TimeQuantity" minOccurs="0"
          maxOccurs="1"/>
      <xs:element name="magnitudeHint" type="xs:string" minOccurs="0" maxOccurs="
          1"/>
      <xs:element name="evaluationMode" type="qml:EvaluationMode" minOccurs="0"
          maxOccurs="1"/>
      <xs:element name="creationInfo" type="qml:CreationInfo" minOccurs="0"
          maxOccurs="1"/>
    </xs:choice>
    <xs:choice minOccurs="0" maxOccurs="unbounded">
      <xs:element name="comment" type="qml:Comment"/>
```

```
    </xs:choice>
  </xs:sequence>
  <xs:attribute name="publicID" type="qml:ResourceReference" use="required"/>
</xs:complexType>
<xs:complexType name="StationMagnitudeContribution">
  <xs:choice minOccurs="0" maxOccurs="unbounded">
    <xs:element name="stationMagnitudeID" type="qml:ResourceReference" minOccurs=
        "1" maxOccurs="1"/>
    <xs:element name="residual" type="xs:double" minOccurs="0" maxOccurs="1"/>
    <xs:element name="weight" type="xs:double" minOccurs="0" maxOccurs="1"/>
  </xs:choice>
</xs:complexType>
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  <xs:sequence>
    <xs:choice minOccurs="0" maxOccurs="unbounded">
      <xs:element name="mag" type="qml:RealQuantity" minOccurs="1" maxOccurs="1"/
          >
      <xs:element name="type" type="xs:string" minOccurs="0" maxOccurs="1"/>
      <xs:element name="originID" type="qml:ResourceReference" minOccurs="0"
          maxOccurs="1"/>
      <xs:element name="methodID" type="qml:ResourceReference" minOccurs="0"
          maxOccurs="1"/>
      <xs:element name="stationCount" type="xs:integer" minOccurs="0" maxOccurs="
          1"/>
      <xs:element name="azimuthalGap" type="xs:double" minOccurs="0" maxOccurs="1
          "/>
      <xs:element name="evaluationStatus" type="qml:EvaluationStatus" minOccurs="
          0" maxOccurs="1"/>
      <xs:element name="creationInfo" type="qml:CreationInfo" minOccurs="0"
          maxOccurs="1"/>
    </xs:choice>
    <xs:choice minOccurs="0" maxOccurs="unbounded">
      <xs:element name="comment" type="qml:Comment"/>
      <xs:element name="stationMagnitudeContribution" type="
          qml:StationMagnitudeContribution"/>
    </xs:choice>
  </xs:sequence>
  <xs:attribute name="publicID" type="qml:ResourceReference" use="required"/>
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  <xs:sequence>
    <xs:choice minOccurs="0" maxOccurs="unbounded">
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          maxOccurs="1"/>
      <xs:element name="mag" type="qml:RealQuantity" minOccurs="1" maxOccurs="1"/
          >
      <xs:element name="type" type="xs:string" minOccurs="0" maxOccurs="1"/>
      <xs:element name="amplitudeID" type="qml:ResourceReference" minOccurs="0"
          maxOccurs="1"/>
      <xs:element name="methodID" type="qml:ResourceReference" minOccurs="0"
          maxOccurs="1"/>
      <xs:element name="waveformID" type="qml:WaveformStreamID" minOccurs="0"
          maxOccurs="1"/>
      <xs:element name="creationInfo" type="qml:CreationInfo" minOccurs="0"
          maxOccurs="1"/>
    </xs:choice>
    <xs:choice minOccurs="0" maxOccurs="unbounded">
      <xs:element name="comment" type="qml:Comment"/>
    </xs:choice>
```

```
  </xs:sequence>
  <xs:attribute name="publicID" type="qml:ResourceReference" use="required"/>
</xs:complexType>
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  <xs:sequence>
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          />
      <xs:element name="waveformID" type="qml:WaveformStreamID" minOccurs="1"
          maxOccurs="1"/>
      <xs:element name="filterID" type="qml:ResourceReference" minOccurs="0"
          maxOccurs="1"/>
      <xs:element name="methodID" type="qml:ResourceReference" minOccurs="0"
          maxOccurs="1"/>
      <xs:element name="horizontalSlowness" type="qml:RealQuantity" minOccurs="0"
           maxOccurs="1"/>
      <xs:element name="backazimuth" type="qml:RealQuantity" minOccurs="0"
          maxOccurs="1"/>
      <xs:element name="slownessMethodID" type="qml:ResourceReference" minOccurs=
          "0" maxOccurs="1"/>
      <xs:element name="onset" type="qml:PickOnset" minOccurs="0" maxOccurs="1"/>
      <xs:element name="phaseHint" type="qml:Phase" minOccurs="0" maxOccurs="1"/>
      <xs:element name="polarity" type="qml:PickPolarity" minOccurs="0" maxOccurs
          ="1"/>
      <xs:element name="evaluationMode" type="qml:EvaluationMode" minOccurs="0"
          maxOccurs="1"/>
      <xs:element name="evaluationStatus" type="qml:EvaluationStatus" minOccurs="
          0" maxOccurs="1"/>
      <xs:element name="creationInfo" type="qml:CreationInfo" minOccurs="0"
          maxOccurs="1"/>
    </xs:choice>
    <xs:choice minOccurs="0" maxOccurs="unbounded">
      <xs:element name="comment" type="qml:Comment"/>
    </xs:choice>
  </xs:sequence>
  <xs:attribute name="publicID" type="qml:ResourceReference" use="required"/>
</xs:complexType>
<xs:complexType name="Event">
  <xs:sequence>
    <xs:choice minOccurs="0" maxOccurs="unbounded">
      <xs:element name="preferredOriginID" type="qml:ResourceReference" minOccurs
          ="0" maxOccurs="1"/>
      <xs:element name="preferredMagnitudeID" type="qml:ResourceReference"
          minOccurs="0" maxOccurs="1"/>
      <xs:element name="preferredFocalMechanismID" type="qml:ResourceReference"
          minOccurs="0" maxOccurs="1"/>
      <xs:element name="type" type="qml:EventType" minOccurs="0" maxOccurs="1"/>
      <xs:element name="typeCertainty" type="qml:EventTypeCertainty" minOccurs="0
          " maxOccurs="1"/>
      <xs:element name="creationInfo" type="qml:CreationInfo" minOccurs="0"
          maxOccurs="1"/>
    </xs:choice>
    <xs:choice minOccurs="0" maxOccurs="unbounded">
      <xs:element name="description" type="qml:EventDescription"/>
      <xs:element name="comment" type="qml:Comment"/>
      <xs:element name="focalMechanism" type="qml:FocalMechanism"/>
      <xs:element name="amplitude" type="qml:Amplitude"/>
      <xs:element name="magnitude" type="qml:Magnitude"/>
      <xs:element name="stationMagnitude" type="qml:StationMagnitude"/>
```

```
      <xs:element name="origin" type="qml:Origin"/>
      <xs:element name="pick" type="qml:Pick"/>
    </xs:choice>
  </xs:sequence>
  <xs:attribute name="publicID" type="qml:ResourceReference" use="required"/>
</xs:complexType>
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  <xs:choice minOccurs="0" maxOccurs="unbounded">
    <xs:element name="horizontalUncertainty" type="xs:double" minOccurs="0"
        maxOccurs="1"/>
    <xs:element name="minHorizontalUncertainty" type="xs:double" minOccurs="0"
        maxOccurs="1"/>
    <xs:element name="maxHorizontalUncertainty" type="xs:double" minOccurs="0"
        maxOccurs="1"/>
    <xs:element name="azimuthMaxHorizontalUncertainty" type="xs:double" minOccurs
        ="0" maxOccurs="1"/>
    <xs:element name="confidenceEllipsoid" type="qml:ConfidenceEllipsoid"
        minOccurs="0" maxOccurs="1"/>
    <xs:element name="preferredDescription" type="
        qml:OriginUncertaintyDescription" minOccurs="0" maxOccurs="1"/>
  </xs:choice>
</xs:complexType>
<xs:complexType name="Arrival">
  <xs:sequence>
    <xs:choice minOccurs="0" maxOccurs="unbounded">
      <xs:element name="pickID" type="qml:ResourceReference" minOccurs="1"
          maxOccurs="1"/>
      <xs:element name="phase" type="qml:Phase" minOccurs="1" maxOccurs="1"/>
      <xs:element name="timeCorrection" type="xs:double" minOccurs="0" maxOccurs=
          "1"/>
      <xs:element name="azimuth" type="xs:double" minOccurs="0" maxOccurs="1"/>
      <xs:element name="distance" type="xs:double" minOccurs="0" maxOccurs="1"/>
      <xs:element name="timeResidual" type="xs:double" minOccurs="0" maxOccurs="1
          "/>
      <xs:element name="horizontalSlownessResidual" type="xs:double" minOccurs="0
          " maxOccurs="1"/>
      <xs:element name="backazimuthResidual" type="xs:double" minOccurs="0"
          maxOccurs="1"/>
      <xs:element name="timeUsed" type="xs:boolean" minOccurs="0" maxOccurs="1"/>
      <xs:element name="horizontalSlownessUsed" type="xs:boolean" minOccurs="0"
          maxOccurs="1"/>
      <xs:element name="backazimuthUsed" type="xs:boolean" minOccurs="0"
          maxOccurs="1"/>
      <xs:element name="weight" type="xs:double" minOccurs="0" maxOccurs="1"/>
      <xs:element name="earthModelID" type="qml:ResourceReference" minOccurs="0"
          maxOccurs="1"/>
      <xs:element name="creationInfo" type="qml:CreationInfo" minOccurs="0"
          maxOccurs="1"/>
    </xs:choice>
    <xs:choice minOccurs="0" maxOccurs="unbounded">
      <xs:element name="comment" type="qml:Comment"/>
    </xs:choice>
  </xs:sequence>
  <xs:attribute name="preliminary" type="xs:boolean"/>
</xs:complexType>
<xs:complexType name="Origin">
  <xs:sequence>
    <xs:choice minOccurs="0" maxOccurs="unbounded">
```

```
      <xs:element name="time" type="qml:TimeQuantity" minOccurs="1" maxOccurs="1"
            />
      <xs:element name="latitude" type="qml:RealQuantity" minOccurs="1" maxOccurs
            ="1"/>
      <xs:element name="longitude" type="qml:RealQuantity" minOccurs="1"
            maxOccurs="1"/>
      <xs:element name="depth" type="qml:RealQuantity" minOccurs="0" maxOccurs="1
            "/>
      <xs:element name="depthType" type="qml:OriginDepthType" minOccurs="0"
            maxOccurs="1"/>
      <xs:element name="timeFixed" type="xs:boolean" minOccurs="0" maxOccurs="1"/
            >
      <xs:element name="epicenterFixed" type="xs:boolean" minOccurs="0" maxOccurs
            ="1"/>
      <xs:element name="referenceSystemID" type="qml:ResourceReference" minOccurs
            ="0" maxOccurs="1"/>
      <xs:element name="methodID" type="qml:ResourceReference" minOccurs="0"
            maxOccurs="1"/>
      <xs:element name="earthModelID" type="qml:ResourceReference" minOccurs="0"
            maxOccurs="1"/>
      <xs:element name="quality" type="qml:OriginQuality" minOccurs="0" maxOccurs
            ="1"/>
      <xs:element name="type" type="qml:OriginType" minOccurs="0" maxOccurs="1"/>
      <xs:element name="evaluationMode" type="qml:EvaluationMode" minOccurs="0"
            maxOccurs="1"/>
      <xs:element name="evaluationStatus" type="qml:EvaluationStatus" minOccurs="
            0" maxOccurs="1"/>
      <xs:element name="creationInfo" type="qml:CreationInfo" minOccurs="0"
            maxOccurs="1"/>
    </xs:choice>
    <xs:choice minOccurs="0" maxOccurs="unbounded">
      <xs:element name="compositeTime" type="qml:CompositeTime"/>
      <xs:element name="comment" type="qml:Comment"/>
      <xs:element name="originUncertainty" type="qml:OriginUncertainty"/>
      <xs:element name="arrival" type="qml:Arrival"/>
    </xs:choice>
  </xs:sequence>
  <xs:attribute name="publicID" type="qml:ResourceReference" use="required"/>
</xs:complexType>
<xs:complexType name="EventParameters">
  <xs:sequence>
    <xs:choice minOccurs="0" maxOccurs="unbounded">
      <xs:element name="creationInfo" type="qml:CreationInfo" minOccurs="0"
            maxOccurs="1"/>
      <xs:element name="description" type="xs:string" minOccurs="0" maxOccurs="1"
            />
    </xs:choice>
    <xs:choice minOccurs="0" maxOccurs="unbounded">
      <xs:element name="comment" type="qml:Comment"/>
      <xs:element name="event" type="qml:Event"/>
    </xs:choice>
  </xs:sequence>
  <xs:attribute name="publicID" type="qml:ResourceReference" use="required"/>
</xs:complexType>
<xs:element name="quakeml">
  <xs:complexType>
    <xs:all>
      <xs:element name="eventParameters" type="qml:EventParameters" minOccurs="0"
            maxOccurs="1"/>
```

```
      </xs:all>
    </xs:complexType>
  </xs:element>
</xs:schema>
```

A.2 QuakeML-RT, Version 1.1

```
<?xml version="1.0"?>
<xs:schema xmlns:xs="http://www.w3.org/2001/XMLSchema" xmlns:qml="http://quakeml.
       org/xmlns/quakeml-rt/1.1" targetNamespace="http://quakeml.org/xmlns/quakeml-
       rt/1.1" elementFormDefault="qualified" attributeFormDefault="unqualified">
  <xs:simpleType name="ResourceIdentifier">
    <xs:restriction base="xs:anyURI">
      <xs:pattern value="(smi|quakeml):[\w\d][\w\d\-\.\*\(\)_~']{2,}/[\w\d
            \-\.\*\(\)_~'][\w\d\-\.\*\(\)\+\?_~'=,;#/&amp;]*"/>
    </xs:restriction>
  </xs:simpleType>
  <xs:simpleType name="ResourceReference">
    <xs:restriction base="qml:ResourceIdentifier"/>
  </xs:simpleType>
  <xs:simpleType name="OriginUncertaintyDescription">
    <xs:restriction base="xs:string">
      <xs:enumeration value="horizontal␣uncertainty"/>
      <xs:enumeration value="uncertainty␣ellipse"/>
      <xs:enumeration value="confidence␣ellipsoid"/>
      <xs:enumeration value="probability␣density␣function"/>
    </xs:restriction>
  </xs:simpleType>
  <xs:simpleType name="MomentTensorStatus">
    <xs:restriction base="xs:string">
      <xs:enumeration value="standard␣CMT␣solution"/>
      <xs:enumeration value="quick␣CMT␣solution"/>
    </xs:restriction>
  </xs:simpleType>
  <xs:simpleType name="OriginDepthType">
    <xs:restriction base="xs:string">
      <xs:enumeration value="from␣location"/>
      <xs:enumeration value="from␣moment␣tensor␣inversion"/>
      <xs:enumeration value="from␣modeling␣of␣broad-band␣P␣waveforms"/>
      <xs:enumeration value="constrained␣by␣depth␣phases"/>
      <xs:enumeration value="constrained␣by␣direct␣phases"/>
      <xs:enumeration value="operator␣assigned"/>
      <xs:enumeration value="other"/>
    </xs:restriction>
  </xs:simpleType>
  <xs:simpleType name="OriginType">
    <xs:restriction base="xs:string">
      <xs:enumeration value="hypocenter"/>
      <xs:enumeration value="centroid"/>
      <xs:enumeration value="amplitude"/>
      <xs:enumeration value="macroseismic"/>
      <xs:enumeration value="rupture␣start"/>
      <xs:enumeration value="rupture␣end"/>
    </xs:restriction>
  </xs:simpleType>
  <xs:simpleType name="EvaluationMode">
    <xs:restriction base="xs:string">
      <xs:enumeration value="manual"/>
      <xs:enumeration value="automatic"/>
    </xs:restriction>
  </xs:simpleType>
  <xs:simpleType name="EvaluationStatus">
    <xs:restriction base="xs:string">
      <xs:enumeration value="preliminary"/>
```

```
      <xs:enumeration value="confirmed"/>
      <xs:enumeration value="reviewed"/>
      <xs:enumeration value="final"/>
      <xs:enumeration value="rejected"/>
      <xs:enumeration value="reported"/>
    </xs:restriction>
  </xs:simpleType>
  <xs:simpleType name="PickOnset">
    <xs:restriction base="xs:string">
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      <xs:enumeration value="impulsive"/>
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    </xs:restriction>
  </xs:simpleType>
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      <xs:enumeration value="CMT - moment tensor with zero trace"/>
      <xs:enumeration value="CMT - double-couple source"/>
      <xs:enumeration value="teleseismic"/>
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  </xs:simpleType>
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      <xs:enumeration value="P body waves"/>
      <xs:enumeration value="long-period body waves"/>
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      <xs:enumeration value="long-period mantle waves"/>
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  </xs:simpleType>
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      <xs:enumeration value="Flinn-Engdahl region"/>
      <xs:enumeration value="local time"/>
      <xs:enumeration value="tectonic summary"/>
      <xs:enumeration value="nearest cities"/>
      <xs:enumeration value="earthquake name"/>
      <xs:enumeration value="region name"/>
    </xs:restriction>
  </xs:simpleType>
  <xs:simpleType name="EventType">
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      <xs:enumeration value="induced earthquake"/>
      <xs:enumeration value="quarry blast"/>
      <xs:enumeration value="explosion"/>
      <xs:enumeration value="chemical explosion"/>
      <xs:enumeration value="nuclear explosion"/>
      <xs:enumeration value="landslide"/>
      <xs:enumeration value="rockslide"/>
      <xs:enumeration value="snow avalanche"/>
      <xs:enumeration value="debris avalanche"/>
      <xs:enumeration value="mine collapse"/>
      <xs:enumeration value="building collapse"/>
```

```
      <xs:enumeration value="volcanic eruption"/>
      <xs:enumeration value="meteor impact"/>
      <xs:enumeration value="plane crash"/>
      <xs:enumeration value="sonic boom"/>
      <xs:enumeration value="not existing"/>
      <xs:enumeration value="null"/>
      <xs:enumeration value="other"/>
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    </xs:restriction>
  </xs:simpleType>
  <xs:simpleType name="SourceTimeFunctionType">
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      <xs:enumeration value="trapezoid"/>
      <xs:enumeration value="unknown"/>
    </xs:restriction>
  </xs:simpleType>
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      <xs:enumeration value="negative"/>
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    </xs:restriction>
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      <xs:element name="upperUncertainty" type="xs:double" minOccurs="0" maxOccurs=
          "1"/>
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          1"/>
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  </xs:complexType>
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      <xs:element name="agencyURI" type="qml:ResourceReference" minOccurs="0"
          maxOccurs="1"/>
      <xs:element name="author" type="xs:string" minOccurs="0" maxOccurs="1"/>
      <xs:element name="authorURI" type="qml:ResourceReference" minOccurs="0"
          maxOccurs="1"/>
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  <xs:complexType name="EventDescription">
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```
    <xs:element name="type" type="qml:EventDescriptionType" minOccurs="0"
          maxOccurs="1"/>
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  <xs:simpleContent>
    <xs:extension base="xs:string"/>
  </xs:simpleContent>
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          maxOccurs="1"/>
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    <xs:element name="plunge" type="qml:RealQuantity" minOccurs="1" maxOccurs="1"
          />
    <xs:element name="length" type="qml:RealQuantity" minOccurs="1" maxOccurs="1"
          />
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    <xs:element name="pAxis" type="qml:Axis" minOccurs="1" maxOccurs="1"/>
    <xs:element name="nAxis" type="qml:Axis" minOccurs="0" maxOccurs="1"/>
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    <xs:element name="stationCount" type="xs:integer" minOccurs="1" maxOccurs="1"
          />
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          1"/>
    <xs:element name="shortestPeriod" type="xs:double" minOccurs="0" maxOccurs="1
          "/>
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    <xs:element name="month" type="qml:IntegerQuantity" minOccurs="0" maxOccurs="
          1"/>
    <xs:element name="day" type="qml:IntegerQuantity" minOccurs="0" maxOccurs="1"
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    <xs:element name="hour" type="qml:IntegerQuantity" minOccurs="0" maxOccurs="1
          "/>
    <xs:element name="minute" type="qml:IntegerQuantity" minOccurs="0" maxOccurs=
          "1"/>
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    <xs:element name="second" type="qml:RealQuantity" minOccurs="0" maxOccurs="1"
        />
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    <xs:element name="Mtt" type="qml:RealQuantity" minOccurs="1" maxOccurs="1"/>
    <xs:element name="Mpp" type="qml:RealQuantity" minOccurs="1" maxOccurs="1"/>
    <xs:element name="Mrt" type="qml:RealQuantity" minOccurs="1" maxOccurs="1"/>
    <xs:element name="Mrp" type="qml:RealQuantity" minOccurs="1" maxOccurs="1"/>
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  <xs:choice minOccurs="0" maxOccurs="unbounded">
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        maxOccurs="1"/>
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        1"/>
    <xs:element name="asociatedStationCount" type="xs:integer" minOccurs="0"
        maxOccurs="1"/>
    <xs:element name="usedStationCount" type="xs:integer" minOccurs="0" maxOccurs
        ="1"/>
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        "1"/>
    <xs:element name="standardError" type="xs:double" minOccurs="0" maxOccurs="1"
        />
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        maxOccurs="1"/>
    <xs:element name="groundTruthLevel" type="xs:string" minOccurs="0" maxOccurs=
        "1"/>
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        1"/>
    <xs:element name="minimumDistance" type="xs:double" minOccurs="0" maxOccurs="
        1"/>
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    <xs:element name="lowerUncertainty" type="xs:double" minOccurs="0" maxOccurs=
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    <xs:element name="upperUncertainty" type="xs:double" minOccurs="0" maxOccurs=
        "1"/>
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        1"/>
  </xs:choice>
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  <xs:choice minOccurs="0" maxOccurs="unbounded">
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        />
    <xs:element name="dip" type="qml:RealQuantity" minOccurs="1" maxOccurs="1"/>
```

```
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    </xs:choice>
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          maxOccurs="1"/>
    </xs:choice>
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    <xs:attribute name="channelCode" type="xs:string"/>
    <xs:attribute name="locationCode" type="xs:string"/>
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          >
      <xs:element name="lowerUncertainty" type="xs:integer" minOccurs="0" maxOccurs
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          ="1"/>
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          1"/>
    </xs:choice>
  </xs:complexType>
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      <xs:element name="riseTime" type="xs:double" minOccurs="0" maxOccurs="1"/>
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  </xs:complexType>
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          "1"/>
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          "1"/>
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          maxOccurs="1"/>
```

```
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    <xs:element name="majorAxisAzimuth" type="xs:double" minOccurs="1" maxOccurs=
        "1"/>
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        ="1"/>
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      <xs:element name="amplitudeReference" type="qml:ResourceReference"/>
    </xs:choice>
  </xs:sequence>
  <xs:attribute name="publicID" type="qml:ResourceReference" use="required"/>
</xs:complexType>
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      <xs:element name="momentMagnitudeID" type="qml:ResourceReference" minOccurs
          ="0" maxOccurs="1"/>
      <xs:element name="scalarMoment" type="qml:RealQuantity" minOccurs="0"
          maxOccurs="1"/>
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          maxOccurs="1"/>
      <xs:element name="doubleCouple" type="xs:double" minOccurs="0" maxOccurs="1
          "/>
      <xs:element name="clvd" type="xs:double" minOccurs="0" maxOccurs="1"/>
      <xs:element name="iso" type="xs:double" minOccurs="0" maxOccurs="1"/>
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      <xs:element name="filterID" type="qml:ResourceReference" minOccurs="0"
          maxOccurs="1"/>
      <xs:element name="sourceTimeFunction" type="qml:SourceTimeFunction"
          minOccurs="0" maxOccurs="1"/>
      <xs:element name="methodID" type="qml:ResourceReference" minOccurs="0"
          maxOccurs="1"/>
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          maxOccurs="1"/>
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          maxOccurs="1"/>
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      <xs:element name="cmtVersion" type="xs:string" minOccurs="0" maxOccurs="1"/
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      <xs:element name="creationInfo" type="qml:CreationInfo" minOccurs="0"
          maxOccurs="1"/>
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    <xs:choice minOccurs="0" maxOccurs="unbounded">
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      <xs:element name="comment" type="qml:Comment"/>
    </xs:choice>
  </xs:sequence>
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```

```
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        <xs:element name="principalAxes" type="qml:PrincipalAxes" minOccurs="0"
            maxOccurs="1"/>
        <xs:element name="azimuthalGap" type="xs:double" minOccurs="0" maxOccurs="1
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            maxOccurs="1"/>
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        <xs:element name="stationDistributionRatio" type="xs:double" minOccurs="0"
            maxOccurs="1"/>
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            maxOccurs="1"/>
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      <xs:choice minOccurs="0" maxOccurs="unbounded">
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        <xs:element name="momentTensor" type="qml:MomentTensor"/>
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    <xs:attribute name="publicID" type="qml:ResourceReference" use="required"/>
  </xs:complexType>
  <xs:complexType name="Amplitude">
    <xs:sequence>
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            1"/>
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        <xs:element name="waveformID" type="qml:WaveformStreamID" minOccurs="0"
            maxOccurs="1"/>
        <xs:element name="filterID" type="qml:ResourceReference" minOccurs="0"
            maxOccurs="1"/>
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            maxOccurs="1"/>
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            maxOccurs="1"/>
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        <xs:element name="evaluationMode" type="qml:EvaluationMode" minOccurs="0"
            maxOccurs="1"/>
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            maxOccurs="1"/>
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      </xs:choice>
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        "1" maxOccurs="1"/>
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    <xs:element name="weight" type="xs:double" minOccurs="0" maxOccurs="1"/>
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          >
      <xs:element name="type" type="xs:string" minOccurs="0" maxOccurs="1"/>
      <xs:element name="originID" type="qml:ResourceReference" minOccurs="0"
          maxOccurs="1"/>
      <xs:element name="methodID" type="qml:ResourceReference" minOccurs="0"
          maxOccurs="1"/>
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      <xs:element name="azimuthalGap" type="xs:double" minOccurs="0" maxOccurs="1
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          maxOccurs="1"/>
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    <xs:choice minOccurs="0" maxOccurs="unbounded">
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          qml:StationMagnitudeContribution"/>
    </xs:choice>
  </xs:sequence>
  <xs:attribute name="publicID" type="qml:ResourceReference" use="required"/>
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          >
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          maxOccurs="1"/>
      <xs:element name="methodID" type="qml:ResourceReference" minOccurs="0"
          maxOccurs="1"/>
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          maxOccurs="1"/>
      <xs:element name="creationInfo" type="qml:CreationInfo" minOccurs="0"
          maxOccurs="1"/>
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    <xs:choice minOccurs="0" maxOccurs="unbounded">
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  </xs:sequence>
  <xs:attribute name="publicID" type="qml:ResourceReference" use="required"/>
```

```
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          />
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          maxOccurs="1"/>
      <xs:element name="methodID" type="qml:ResourceReference" minOccurs="0"
          maxOccurs="1"/>
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          "0" maxOccurs="1"/>
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      <xs:element name="phaseHint" type="qml:Phase" minOccurs="0" maxOccurs="1"/>
      <xs:element name="polarity" type="qml:PickPolarity" minOccurs="0" maxOccurs
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      <xs:element name="evaluationStatus" type="qml:EvaluationStatus" minOccurs="
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          maxOccurs="1"/>
    </xs:choice>
    <xs:choice minOccurs="0" maxOccurs="unbounded">
      <xs:element name="comment" type="qml:Comment"/>
    </xs:choice>
  </xs:sequence>
  <xs:attribute name="publicID" type="qml:ResourceReference" use="required"/>
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  <xs:sequence>
    <xs:choice minOccurs="0" maxOccurs="unbounded">
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      <xs:element name="preferredMagnitudeID" type="qml:ResourceReference"
          minOccurs="0" maxOccurs="1"/>
      <xs:element name="preferredFocalMechanismID" type="qml:ResourceReference"
          minOccurs="0" maxOccurs="1"/>
      <xs:element name="type" type="qml:EventType" minOccurs="0" maxOccurs="1"/>
      <xs:element name="typeCertainty" type="qml:EventTypeCertainty" minOccurs="0
          " maxOccurs="1"/>
      <xs:element name="creationInfo" type="qml:CreationInfo" minOccurs="0"
          maxOccurs="1"/>
    </xs:choice>
    <xs:choice minOccurs="0" maxOccurs="unbounded">
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      <xs:element name="magnitudeReference" type="qml:ResourceReference"/>
      <xs:element name="stationMagnitudeReference" type="qml:ResourceReference"/>
      <xs:element name="focalMechanismReference" type="qml:ResourceReference"/>
      <xs:element name="description" type="qml:EventDescription"/>
      <xs:element name="comment" type="qml:Comment"/>
    </xs:choice>
  </xs:sequence>
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  <xs:choice minOccurs="0" maxOccurs="unbounded">
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        maxOccurs="1"/>
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        maxOccurs="1"/>
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        ="0" maxOccurs="1"/>
    <xs:element name="confidenceEllipsoid" type="qml:ConfidenceEllipsoid"
        minOccurs="0" maxOccurs="1"/>
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        qml:OriginUncertaintyDescription" minOccurs="0" maxOccurs="1"/>
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  <xs:sequence>
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          "1"/>
      <xs:element name="azimuth" type="xs:double" minOccurs="0" maxOccurs="1"/>
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      <xs:element name="timeResidual" type="xs:double" minOccurs="0" maxOccurs="1
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      <xs:element name="horizontalSlownessResidual" type="xs:double" minOccurs="0
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      <xs:element name="backazimuthResidual" type="xs:double" minOccurs="0"
          maxOccurs="1"/>
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      <xs:element name="horizontalSlownessUsed" type="xs:boolean" minOccurs="0"
          maxOccurs="1"/>
      <xs:element name="backazimuthUsed" type="xs:boolean" minOccurs="0"
          maxOccurs="1"/>
      <xs:element name="weight" type="xs:double" minOccurs="0" maxOccurs="1"/>
      <xs:element name="earthModelID" type="qml:ResourceReference" minOccurs="0"
          maxOccurs="1"/>
      <xs:element name="creationInfo" type="qml:CreationInfo" minOccurs="0"
          maxOccurs="1"/>
    </xs:choice>
    <xs:choice minOccurs="0" maxOccurs="unbounded">
      <xs:element name="comment" type="qml:Comment"/>
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  </xs:sequence>
  <xs:attribute name="preliminary" type="xs:boolean"/>
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  <xs:sequence>
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          ="1"/>
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      <xs:element name="depthType" type="qml:OriginDepthType" minOccurs="0"
            maxOccurs="1"/>
      <xs:element name="timeFixed" type="xs:boolean" minOccurs="0" maxOccurs="1"/
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      <xs:element name="epicenterFixed" type="xs:boolean" minOccurs="0" maxOccurs
            ="1"/>
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            maxOccurs="1"/>
      <xs:element name="earthModelID" type="qml:ResourceReference" minOccurs="0"
            maxOccurs="1"/>
      <xs:element name="quality" type="qml:OriginQuality" minOccurs="0" maxOccurs
            ="1"/>
      <xs:element name="type" type="qml:OriginType" minOccurs="0" maxOccurs="1"/>
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            0" maxOccurs="1"/>
      <xs:element name="creationInfo" type="qml:CreationInfo" minOccurs="0"
            maxOccurs="1"/>
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    <xs:choice minOccurs="0" maxOccurs="unbounded">
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      <xs:element name="comment" type="qml:Comment"/>
      <xs:element name="originUncertainty" type="qml:OriginUncertainty"/>
      <xs:element name="arrival" type="qml:Arrival"/>
    </xs:choice>
  </xs:sequence>
  <xs:attribute name="publicID" type="qml:ResourceReference" use="required"/>
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  <xs:sequence>
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            maxOccurs="1"/>
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            />
    </xs:choice>
    <xs:choice minOccurs="0" maxOccurs="unbounded">
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      <xs:element name="focalMechanism" type="qml:FocalMechanism"/>
      <xs:element name="amplitude" type="qml:Amplitude"/>
      <xs:element name="magnitude" type="qml:Magnitude"/>
      <xs:element name="stationMagnitude" type="qml:StationMagnitude"/>
      <xs:element name="pick" type="qml:Pick"/>
      <xs:element name="event" type="qml:Event"/>
      <xs:element name="origin" type="qml:Origin"/>
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  </xs:sequence>
  <xs:attribute name="publicID" type="qml:ResourceReference" use="required"/>
</xs:complexType>
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    </xs:complexType>
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</xs:schema>
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