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# The Geologic Time Scale 2012 – Chapter 26: Jurassic J.G. Ogg and L.A. Hinnov, contributor C. Huang

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Eight years after the publication of the first edition of *The Geologic Time Scale* in 2004, a new revised version was published this year. *The Geologic Time Scale 2012*, by Felix M. Gradstein, James G. Ogg, Mark Schmitz and Gabi Ogg, is published by Elsevier and is a massive tome! Chapter 26, on the Jurassic, comprises 60 pages (731–791), updates the current (as of 2011) situation regarding definition at a GSSP for the Jurassic Stages and incorporates much new data on Physical Stratigraphy, particularly on Magnetostratigraphy and Cyclostratigraphy. It is a monumental piece of compilation and integration and a very welcome contribution to Jurassic stratigraphy.

## 26.1. HISTORY AND SUBDIVISION

**Overview of Jurassic.** A brief review is given of the history of the founding of the Jurassic and subsequent modifications and subdivisions into what are now called Series and Stages. The results of the 1962 Luxembourg Colloquium, with agreements to formalize most of the current Stages are mentioned, but not the earlier influential role of W.J. Arkell in reducing the huge number (>100) of proposed Jurassic "Stages" to near the current list. It would have been appropriate also to mention here the importance of subsequent Jurassic Symposia/Congresses in refining the database and (later) broadening the range of methods and concepts applied to the Jurassic. The website details for the Jurassic Subcommision are given, but it would have been appropriate to mention that ISJS Newsletters since 1999 can be downloaded from the website, since there are several references to them.

**Subdivisions of the Jurassic.** In Europe the basis for recognition of both Stages and Zones was the fossil assemblage content. This is particularly important for Oppel's Zones, which were established as what are now called assemblage zones. The name he gave to a zone was, instead of a place name, that of one common and characteristic species in the assemblage, but the "name species" did not have primary importance (see Arkell, 1933, p. 17). These are the "Standard Zones" of Jurassic stratigraphy in Europe (at least) and are different from biozones based on evolutionary lineages.

In Europe the Jurassic Stages (modified after d'Orbigny) were defined by the Zones (modified after Oppel) they contained. This evolved into defining the basal zone following discussions during the two Luxembourg Colloquia (1962, 1967). Identifying specific criteria for **recognizing** the basal boundary of a Zone (and, therefore, Stage) came later, followed by **defining** the boundary at a specific point in an outcrop of rock, where the key markers and their immediate predecessors could be identified. Much work on this remains to be achieved!

The section then reviews the Lower, Middle and then Upper Jurassic subdivisions – the Triassic-Jurassic boundary and each of the Jurassic Stages in turn. Emphasis is on basal boundary definition using key ammonite taxa and

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integration of other data where available. Figures summarising details of the six GSSP sections so far ratified are presented.

For each Stage subdivision into Substages is also discussed and available names are given. However, naming of Substages, other than as Lower/Middle/Upper, is not recognized by the International Commission on Stratigraphy and is discouraged by the Jurassic Subcommission. Note that work to propose GSSPs for Substages has begun (*e.g*. Upper Pliensbachian by Meister, Upper Bajocian by Pavia). The problems of the Upper Jurassic, with faunal provincialism and regional Stages are clearly explained.

## 26.2. JURASSIC STRATIGRAPHY

**Marine Biostratigraphy.** This section summarises the potential of the main fossil groups that have been used for marine biostratigraphy. Very little is written about *Ammonites* here – no need, recognized as of primary importance and already well-documented elsewhere! The problem (for non-Jurassic specialists) of nomenclature of Jurassic Standard Zones compared with biostratigraphic zones is clarified – but not used in the text and figures. No mention is made of further refinements of ammonite biochronology based on ammonite horizons. Other groups discussed include *Fish and Marine Reptiles*, *Other Marine Macrofauna* (brachiopods, bivalves, ostracods), *Foraminifers and Calpionellids*, *Calcareous Nannofossils*, *Dinoflagelate Cysts* and *Radiolarians*.

**Terrestrial Biostratigraphy.** Examples discussed are *Dinosaurs*, including a summary of the possibilities of "land-vertebrate faunachrons", and *Plants, Pollens and Spores* but mainly in relation to palaeoclimate.

**Physical Stratigraphy.** There is, not surprisingly, a much more complete description and discussion of *Magnetostratigraphy* that is very useful. Calibrations of polarity zones in the Lower Jurassic (plus Aalenian) with Stages and Zones are limited to only a few examples. Studies of longer sequences often appear to be poorly calibrated with the ammonite-based Zones and Stages and, unfortunately, some GSSP sections are unsuitable for magnetostratigraphy. For the Middle and Upper Jurassic there has been greater success in calibrating magnetostratigraphic events with Marine Magnetostratigraphic Anomalies and with the Late Jurassic Magnetic Polarity Scale, especially in the Kimmeridgian-Tithonian. For the Kimmeridgian in particular there is very close calibration with ammonite Zones and Subzones (and indicated preference for the GSSP at the *Pictonia flodigarriensis* level because this is very close to the base of a well known reversed polarity interval).

There are also detailed discussions of *Geochemical Stratigraphy* for which important examples include: Carbon Stable Isotopes (Triassic/Jurassic boundary interval and Lower Toarcian); Oxygen Stable Isotopes (mainly for palaeoclimate); Strontium and Osmium Isotope Ratios (potential for time resolution depending on the variable rates of change).

The section on *Cyclostratigraphy* (contributed by Chunju Huang) summarises for each of the Stages data obtained on estimating durations for the Stage or for some Zones based on interpretations of long-eccentricity (0.4 myr), short-eccentricity (0.1 myr) or obliquity (c. 37 kyr) cycles. Assumptions of stratigraphical completeness (*i.e*. no hiatuses) and the limited of number of studies for most intervals remain as concerns. However, there has been great progress with this technique in estimating durations of the subdivisions of the Jurassic and these have been integrated with biostratigraphy and magnetostratigraphy in arriving at the new Jurassic time scale.

Other aspects discussed are *Sequence Stratigraphy* and *Major Stratigraphic Events* (large igneous provinces and major bolide impacts).

## 26.3. JURASSIC TIME SCALE

There remain very few direct Radio-Isotopic Dates for the Jurassic Stages and Zones, reduced even further compared with the 2004 Time Scale by application of stricter criteria (single zircon grain and specific processing techniques for U-Pb; recalculation of $^{40}Ar/^{39}Ar$). The numerical age scale has been constructed for ammonite zones (mainly Tethyan for some reason!) using the following constraints:

- Selected radio-isotopic dates (Hettangian, Toarcian, Berriasian) and spline-fitting of the Jurassic-Cretaceous suite of ages (statistical guesswork !)
- Durations of Zones from cyclostratigraphy (Hettangian, Toarcian-Aalenian, Oxfordian-Tithonian);
- Calibration of Zones via magnetostratigraphy and Pacific spreading model (Oxfordian-Tithonian, preliminary results Bajocian-Callovian);
- Proportional scaling of Zones/Subzones from geochemical (*e.g*. Sr isotope) trends (Sinemurian-Pliensbachian);
- Proportional scaling of Zones by number of Subzones.

The derived ages for the bases and durations of the Jurassic Stages, with GSSP or working definition of base, methods of calibration of age of base and scaling of ammonite zones, are discussed in the text and summarized in Table 26.2 (pp. 767–769).

The interpolated numerical ages for the bases of the Tethyan ammonite zones, with notes on the calibration of base and duration, are summarized in Table 26.3 (pp, 770–772). Note that the base of the Tethyan *Epipeltoceras bimammatum* Zone (ex base Kimmeridgian) is correlated with the base of Magnetic Chron M28Ar at 158.54 Ma whereas the base of the Kimmeridgian at the Boreal *Pictonia baylei* Zone (*Pictonia flodigarriensis* Horizon) is correlated with the base of Magnetic Chron M26r at 157.3 Ma, a difference of 1.24 my.

The improvement in the time scale compared with the 2004 version can be measured by the reductions in the mean levels of uncertainty – from 4.0 to 1.0 in the Late Jurassic plus Callovian, from 3.0 to 1.2 for the Middle Jurassic (Aalenian to Bathonian) and from 1.5 to 0.5 for the Early Jurassic.

As indicated by the authors this 2012 time scale is very much a work in progress. For the future two suggestions:

- Improved calibration of Physical Stratigraphy data with the greatly refined ammonite biochronology now available for parts of the Jurassic;
- Verification of cyclostratigraphy calculations in other sections.

The differences between the GTS2004 and the new GTS2012 for the ages of the bases and durations of the Stages are summarized below [from Table 26.4 (p. 777)]:

| | GTS2012 Ages of base and Stage durations | | | |
|---|---|---|---|---|
| | age base | *cf*. GTS2004 | duration | *cf*. GTS2004 |
| Cretaceous (Berriasian) | 145.0 | – 0.5 | | |
| Tithonian | 152.1 | + 1.3 | 7.1 | + 1.8 |
| Kimmeridgian | 157.3 | + 1.6 | 5.2 | + 0.3 |
| Oxfordian | 163.5 | + 2.3 | 6.2 | + 0.7 |
| Callovian | 166.1 | + 1.4 | 2.6 | – 0.9 |
| Bathonian | 168.3 | + 0.6 | 2.2 | – 0.8 |
| Bajocian | 170.3 | – 1.3 | 2.0 | – 1.9 |
| Aalenian | 174.1 | – 1.5 | 3.8 | – 0.2 |
| Toarcian | 182.7 | – 0.3 | 8.6 | + 1.2 |
| Pliensbachian | 190.8 | + 1.2 | 8.1 | + 1.5 |
| Sinemurian | 199.3 | + 2.8 | 8.5 | + 1.6 |
| Hettangian | 201.3 | + 1.7 | 2.0 | – 1.1 |

## CONCLUSIONS

This is an extremely valuable publication containing a vast amount of new and revised work that has been well explained and integrated by the authors.