

## COMMENTS AND REPLIES

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# Comment

## Response to Autin and Holbrook on “Is the Anthropocene an issue of stratigraphy or pop culture?”

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### INTRODUCTION

We thank Whitney Autin and John Holbrook (2012) for their commentary on the Anthropocene concept. This term is under formal consideration by an International Commission on Stratigraphy working group (to which we belong), so critical analysis and comment is welcome and timely. We reply to clarify points raised and to encourage further discussion.

### THE SCALE AND SIGNIFICANCE OF THE ANTHROPOCENE

It seems clear to us that human impact is significant on a geological timescale. For instance (1) CO<sub>2</sub> (a key Earth-system driver) has reached levels not seen since Pliocene times; (2) perturbation of the nitrogen cycle may be the greatest since the Proterozoic (Canfield, 2011); (3) the currently elevated species extinction rate, if maintained, will lead to extinction on a “big-five” scale in a few centuries (Barnosky et al. 2011); (4) species invasion levels are unprecedented in Earth’s history; and (5) the lithostratigraphic signal of urbanization, agriculture, and resource extraction is substantial and qualitatively unique in Earth’s history, particularly in soils and deltaic/coastal regions sensitive to sea level rise.

### RELEVANCE TO STRATIGRAPHIC PRACTICE

The Anthropocene needs consideration as both a time unit of geochronology *sensu stricto* (e.g., an Anthropocene Epoch) and a

physical stratal record of chronostratigraphy (“time-rock”; i.e., an Anthropocene Series) with component lithostratigraphic, biostratigraphic, chemostratigraphic, and other units. An Anthropocene Series furthermore would comprise all deposits above its boundary, both anthropogenic and natural, including those (volcanic tuffs, desert sands) with no discernable human influence.

However, we do not believe that it is necessary to seek a “boundary stratigraphic marker” that reflects the time “since anthropogenic change began.” The issue here is not the presence or absence of human traces in strata. It is whether Earth’s stratigraphic record—and the processes that shape it—have changed sufficiently to make a new unit justifiable and useful and, if so, to seek the most effectively traceable boundary horizon for it.

We agree that selecting an effective boundary is not straightforward, with much anthropogenic change diachronous on a scale of centuries to millennia. However, there is potential for boundary selection, whether by Global Standard Stratigraphic Age (GSSA; numerical date) or Global Boundary Stratotype Section and Point (GSSP; “golden spike”). As an example, a putative ca. 1950 boundary would mark widespread expansion of “Artificial Ground” of geological maps (e.g. Price et al. 2011), the worldwide inclusion of measurable radionuclides from atmospheric tests into sediments, and marked shifts in nitrogen isotopes in lacustrine deposits (from global increase in fertilizer use: Holtgrieve et al. 2011).

Few of Earth’s other stratigraphic boundaries represent neatly definable, synchronous changes that can be everywhere precisely located. Efforts to recognize an “Anthropocene Series” would prove useful to constraining rates and scales of anthropogenic change to the Earth system.

### IS THE ANTHROPOCENE POP CULTURE OR SCIENCE?

The concept has certainly gone beyond the confines of stratigraphic research. But much of the interest has been among the wider scientific community, because *Anthropocene* explicitly compares human perturbation of the Earth system (as observed) with ancient natural perturbations (as preserved via proxy evidence in rock strata), and it considers together and integrates diverse forms of environmental change. This has the novel (in stratigraphy) corollary that the wider scientific community should be considered in the formalization debate (Nature, 2011).

We regard broader popular interest as positive. The Anthropocene has provided a longer-term perspective of humanity’s activities and brings stratigraphic principles and practice to a wider audience. Also, the phenomenon of contemporary global change—perhaps unlike the formal determination of past geological time units—potentially concerns everyone.

Autin and Holbrook question our “end game.” This is simple. It is to more clearly understand the role of human action in shaping Earth processes on a long-term time scale and, more narrowly, to establish whether there is justification and utility in formalizing the Anthropocene within the Geological Time Scale: these two “end-games” are complementary, in that formal analysis of stratigraphic boundaries, far from being “esoteric,” has led to increased understanding of the course and mechanism of fundamental Earth processes in deep time.

We hope this helps answer the queries of Austin and Holbrook. We emphasize that the Anthropocene, as articulated by Crutzen (2002), is a new concept and its study, both in formal stratigraphy and more widely, is work in progress. Its potential utility and significance make sustained, thorough study worthwhile, and we welcome further discussion.

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