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Biogeosciences Discussions

Interactive comment on "*Lingulodinium machaerophorum* expansion over the last centuries in the Caspian Sea reflects global warming" *by* S. A. G. Leroy et al.

Anonymous Referee #2

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This paper is generally well-written in clear language and it contains a lot of useful new information that is of value for paleoecologists and palynologists studying the history of the Caspian Sea region, particularly as recorded by changes in dinoflagellate cysts, organic carbon and foraminifera over the past 3,000 years. It potentially contains data of good scientific quality but presently has some errors in methodology.

The paper is also mostly supplied with ample references to previous work. However, there is a salient exception to the completeness of references and methodology in absence of reference to work of Mertens et al. (J. Quaternary Science Reviews 39, 2012, p. 45-59) on quantitative estimation of Holocene surface salinity variation in the Black

Sea corridor using dinoflagellate cyst process length. In the Mertens et al, 2012 study, six Caspian Sea surface samples of Lingulodinium machaerophorum (=Lm) cysts were included in a larger data set used to generate a robust mathematical equation for quantitative estimate of annual surface water salinity based on the spine length of the Lm cysts. In contrast, the current work does not measure spine length and only reports a qualitatitive apparent correlation between increased Lm percentages and a rise in temperature of the Caspian Sea. Unfortunately use of the closed value relative abundance (%) method has large weaknesses, particularly when based on low total cyst numbers, <100 specimens, as for many sample in the Leroy et al. study. The further deduction by Leroy et al. that the accompanying increase in dinocyst concentrations reflects global climate change, especially increased sea surface temperature (SST), is neither quantitative nor is it clearly justified on the basis of the qualitative data presented.

Other methods in this paper are also unusual in the separation of Brigantedinium cysts from the total count. This practice further lowers the numbers on which percentage abundances of Lm are based and it raises questions as to how closely the dinocyst data set can be compared with that reported for the Black Sea and the global oceans. The Methods also fail to provide a quantitative measure of spine length (mean and range) for the Lm groups given as ss, A and B (not defined in the text or references). After searching online, some of that information appeared to be explained in Leroy et al. (2006) who describe their arbitrary categories in the hypersaline Kara-Bogaz Gol as: ss = sensu stricta = long spines, average 11.5 microns; A = shorted spines around 9 microns long; C= globose spines 2-3 microns. However, it is not clear if these same spine lengths pertain to Lm in the Caspian Sea and this must be clarified in the current paper. The methods also fail to specify the meaning of dinoflagellate cyst concentration. Presumably, but not stated, this means number per gram or standard volume of sediment. Finally, in order to date the base of cores, the age models for two of 4 cores mostly assume constant sedimentation rate below the base of the radionuclide signals. The validity of this assumption is not always clear, and the absence good age constraints for the lower parts of the cores means that cyst influx rates cannot be calcu-

lated with confidence below the base of the artificial radionuclide Cs-137 (presumably that marks 1952-1965 A; this needs to be stated clearly). By using concentrations instead of influxes as an index of biomass production, the potential impact of reduced inorganic sediment input, including biosilica from possibly reduced diatom production, is excluded from the measurement of algal production. The effect of bioturbation on the age model and possible blurring of fluctuations in Lm concentrations also needs to be considered.

Overall, the conclusion that SST change is the causal factor because water level changes (here equated with salinity changes) are not seen in the cyst records could be an over-simplification of the complex parameters that affect the abundance cysts produced, including stratification, salinity, nutrients, predation and competition from toxin producers, in addition to temperature. Again, application of the quantitative approach used by Mertens et al. (2009) could be helpful because the mean spine length of Lm populations has been related quantitatively to the ratio of temperature to salinity (SST:SSS)at a water depth of 30 m. Use of the Mertens et al. 2009 equation could test the hypothesis that the Lm cysts record increased SST if the changes in SSS for the Caspian Sea were calculated for the times of measured increased or reduced water level.

On a global scale, there is no clear evidence that higher abundances/g of Lm cysts are correlated with warm-water conditions in surface sediments (see Zonneveld et al. 2012, Atlas of Modern Dinoflagellate Cyst Distribution). Furthermore, the most recent reports on global ocean warming indicate that diatoms abundances now exceed dinoflagellate abundances, indicating that that warmer surface water favours the short-lived siliceous-walled diatoms over the larger, organic-walled dinoflagellates (Hinder et al., Nature Climate Change 2: 271-275). This trend is clearly counter to that interpreted for the Caspian Sea in this paper. The case for a recent local increase in cyst abundances and % Lm in the Caspian Sea is interesting, however, in the context of its apparent rarity or absence during the Holocene hypsithermal maximum period (ca. 7-6 ka BP) at which

time it is prevalent in the adjoining Black Sea. The virtually first appearance of Lm in the Caspian around 3 ka BP and its gradual ascendance in relative abundance after 3270 yr BP (core TM) appear more like a progressive increase in species population abundance than a sensitive index of fluctuating environment. The question needs to be raised as to possible introduction of the species from the Black Sea around 3 ka. A relatively recent introduction would also explain the similarity of the rDNA in the Caspian and Black Sea Lm populations (Mertens et al., 2012)- basins that have been isolated during post of the Holocene.

Another issue not addressed in this paper is the question of preferential cyst preservation – especially in conditions of low total organic matter in the sediment cores. For example, the record of foraminiferal linings in US01 could be very helpful in showing that the sediments were not totally oxidizing despite the large drop in %OM above 25cm. The apparent contradiction between decline in benthic foraminifera production and the interpreted increase in Lm cyst production despite reduced OM deserves more discussion: under usual circumstances, benthic foram abundances increase with increased phytoplankton production (their primary food source). Given the usefulness of the foram data in this study, it is also recommended that a photoplate be included to show how the microforaminiferal linings in core US01 are related to the foraminiferal test records shown in Fig. A1.

Overall, this paper is interesting and provides thought-provoking new information. However, it requires some major revision to address the issues raised above. The revised MS may require a re-interpretation of the conclusion regarding Lm cyst abundance and SST during the anthropocene (note that this is not yet a formally accepted time unit), including clarification of what "Anthropocene" means in the context of the Caspian Sea - an area inhabited by mankind since pre-Holocene times.

Technical comments: 1) please explain (p, 16674, line 3) what pure and cold hydrofluoric acid (60%) means – how can 60% HF be pure? 2) Check all dinoflagellate species names and make sure that the genus name is fully spelled out at first mention of the

taxon. 3) Please define the time-frame of Kvalynian, NeoCaspian and Anthropogene 4) Add a brief note on contruction of dams on the inflowing large rivers and the timing/impact of the Volga–Don canal construction for shipping traffic from Baltic-Black-Caspian seas. 5) Add names of rivers mentioned (p. 16670. Sect. 2.4) 6) 4.3.4 and 5.3.1 – please do not equate massive algal biomass with high dinocyst production: the cysts are just one portion of the production in response to conditions that trigger encystment in the plankton populations; other algae may be much more abundant and contribute to greater biomass that is recorded in high %OM. 7. On Fig. 4 caption, please explain the nature of the horizontal stripes and vertical wiggles.

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