

A paleogeographic map of the Earth during the Phanerozoic eon, showing the arrangement of continents and the global ocean circulation. The map uses a color gradient from blue (low salinity) to red (high salinity) to indicate salinity levels. Blue arrows represent the direction and relative strength of ocean currents. The map shows a supercontinent in the center with surrounding ocean basins. The text "Atlas of Phanerozoic Oceanic Circulation and Salinity" is overlaid in the center.

Atlas of Phanerozoic Oceanic Circulation and Salinity

CR Scotese, PALEOMAP Project

Atlas of Phanerozoic Ocean Currents and Salinity

This Atlas of Phanerozoic Ocean Currents and Salinity shows the patterns of surface ocean currents and salinity for 22 time periods from the base of the Cambrian (542 Ma) to the Middle/Late Miocene (Serravallian & Tortonian, 10.5 Ma), plus one additional map for the Neoproterozoic (Middle Ediacaran, 600 Ma). Regions of high salinity are shown in red. Regions of low salinity and brackish conditions are shown in blue. Blue arrows indicate the direction of surface ocean currents during the winter months (December – January – February).

These plate tectonic and paleogeographic maps are the work of C. R. Scotese. The paleoclimate simulations were done by T.L. Moore using the FOAM (Fast Ocean and Atmosphere) Climate Simulation Program. The differences in color and symbology are due to the fact that the maps were originally published in four separate reports (Scotese et al., 2007; 2008; 2009; & 2011).

There are some patterns of salinity and ocean currents are illustrated by the maps. Areas of hypersalinity occur in both the north and south subtropical belts (15 – 35 degrees latitude). Hyposaline ocean waters, by contrast, tend to be located along the Equator and at temperate and polar latitudes. Salinity is also reduced along the many continental coastlines where freshwater from rivers enters the oceans. The broad shallow, epicontinental seas of the Paleozoic appear to have been susceptible to salinity extremes depending on the latitude of the continent and the proximity to runoff from adjacent land areas.

The pattern of surface ocean currents in the open ocean is largely zonal, following the prevailing winds. The currents move from east to west near the Equator, whereas at temperate latitudes the currents generally move eastwards. As in the modern world, these zonal surface currents are deflected N or S, depending on latitude, where they run into the continents. In the open ocean between these two zonal patterns of flow, large gyres are often present. These gyres rotate clockwise in the northern hemisphere and counter-clockwise in the southern hemisphere. It is interesting to note that in a few cases (Maps 35 & 63), the surface currents in large inland seas move in a unidirectional pattern. This is due to the fact that upwelling occurs along one shore of the inland sea and the currents move across the shallow and dive back down into the ocean in an "down-welling" zone adjacent to the opposite shore.

A complimentary set of surface ocean currents for the summer months (July-August-September) are plotted in the Atlas of Phanerozoic Oceanic Anoxia. Though similar to the results shown here, there are maps that show opposite flow directions due to monsoonal changes in wind directions.

The maps are from volumes 1-6 of the PALEOMAP PaleoAtlas for ArcGIS (Scotese, 2014a,b,c,d). Absolute age assignments are from Gradstein, Ogg & Smith (2008).

The following maps are included in the Atlas of Phanerozoic Ocean Currents and Salinity:

- Map 5 Middle/Late Miocene (Serravallian & Tortonian, 10.5 Ma)
- Map 7 Early Miocene (Aquitainian & Burdigalian, 19.5 Ma)
- Map 9 Early Oligocene (Rupelian, 31.1 Ma)
- Map 12 early Middle Eocene (middle Lutetian, 44.6 Ma)

Map 17 Late Cretaceous (Maastrichtian, 68 Ma)
 Map 21 Mid-Cretaceous (Turonian, 91.1 Ma)
 Map 23 Early Cretaceous (late Albian, 101.8 Ma)
 Map 27 Early Cretaceous (early Aptian, 121.8 Ma)
 Map 31 Early Cretaceous (Berriasian, 143 Ma)
 Map 35 Late Jurassic (Oxfordian, 158.4 Ma)
 Map 39 Early Jurassic (Toarcian, 179.3 Ma)
 Map 45 Late Triassic (Carnian, 222.6 Ma)
 Map 49 Permo-Triassic Boundary (251 Ma)
 Map 54 Early Permian (Artinskian, 280 Ma)
 Map 57 Late Pennsylvanian (Gzhelian, 301.2 Ma)
 Map 63 Middle Mississippian (early Visean, 341.1 Ma)
 Map 65 Late Devonian (latest Famennian, 359.2 Ma)
 Map 70 Early Devonian (Emsian, 394.3 Ma)
 Map 75 Early Silurian (late Llandovery, 432.1 Ma)
 Map 82 Early Ordovician (Tremadoc, 480 Ma)
 Map 88 Cambrian – Precambrian Boundary (542 Ma)
 Map 90 Late Neoproterozoic (Middle Ediacaran, 600 Ma)

This work should be cited as

Scotese, C.R., and Moore, T.L., 2014. Atlas of Phanerozoic Ocean Currents and Salinity (Mollweide Projection), Volumes 1-6, *PALEOMAP Project* PaleoAtlas for ArcGIS, PALEOMAP Project, Evanston, IL.

References Cited:

Scotese, C.R., Illich, H., Zumberge, J, and Brown, S., and Moore, T., 2007. The GANDOLPH Project: Year One Report: Paleogeographic and Paleoclimatic Controls on Hydrocarbon Source Rock Deposition, A Report on the Methods Employed, the Results of the Paleoclimate Simulations (FOAM), and Oils/Source Rock Compilation, Conclusions at the End of Year One: Cenomanian/Turonian (93.5 Ma), Kimmeridgian/Tithonian (151 Ma), Sakmarian/Artinskian (284 Ma), Frasnian/Famennian (375 Ma), February, 2007. GeoMark Research Ltd, Houston, Texas, 142 pp.

Scotese, C.R., Illich, H., Zumberge, J, and Brown, S., and Moore, T., 2008. The GANDOLPH Project: Year Two Report: Paleogeographic and Paleoclimatic Controls on Hydrocarbon Source Rock Deposition, A Report on the Methods Employed, the Results of the Paleoclimate Simulations (FOAM), and Oils/Source Rock Compilation, Conclusions at the End of Year Two: Miocene (10Ma), Aptian/Albian (120 Ma), Berriasian/Barremian (140 Ma), Late Triassic (220 Ma), and Early Silurian (430 Ma), July, 2008. GeoMark Research Ltd, Houston, Texas, 177 pp.

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on Hydrocarbon Source Rock Deposition, A report on the Results of the Paleogeographic, Paleoclimatic Simulations (FOAM), and Oils/Source Rock Compilation, Conclusions at the End of Year Four: Oligocene (30 Ma), Cretaceous/Tertiary (70 Ma), Permian/Triassic (250 Ma), Silurian/Devonian (400 Ma), Cambrian/Ordovician (480 Ma), April, 2011. GeoMark Research Ltd, Houston, Texas, 219 pp.

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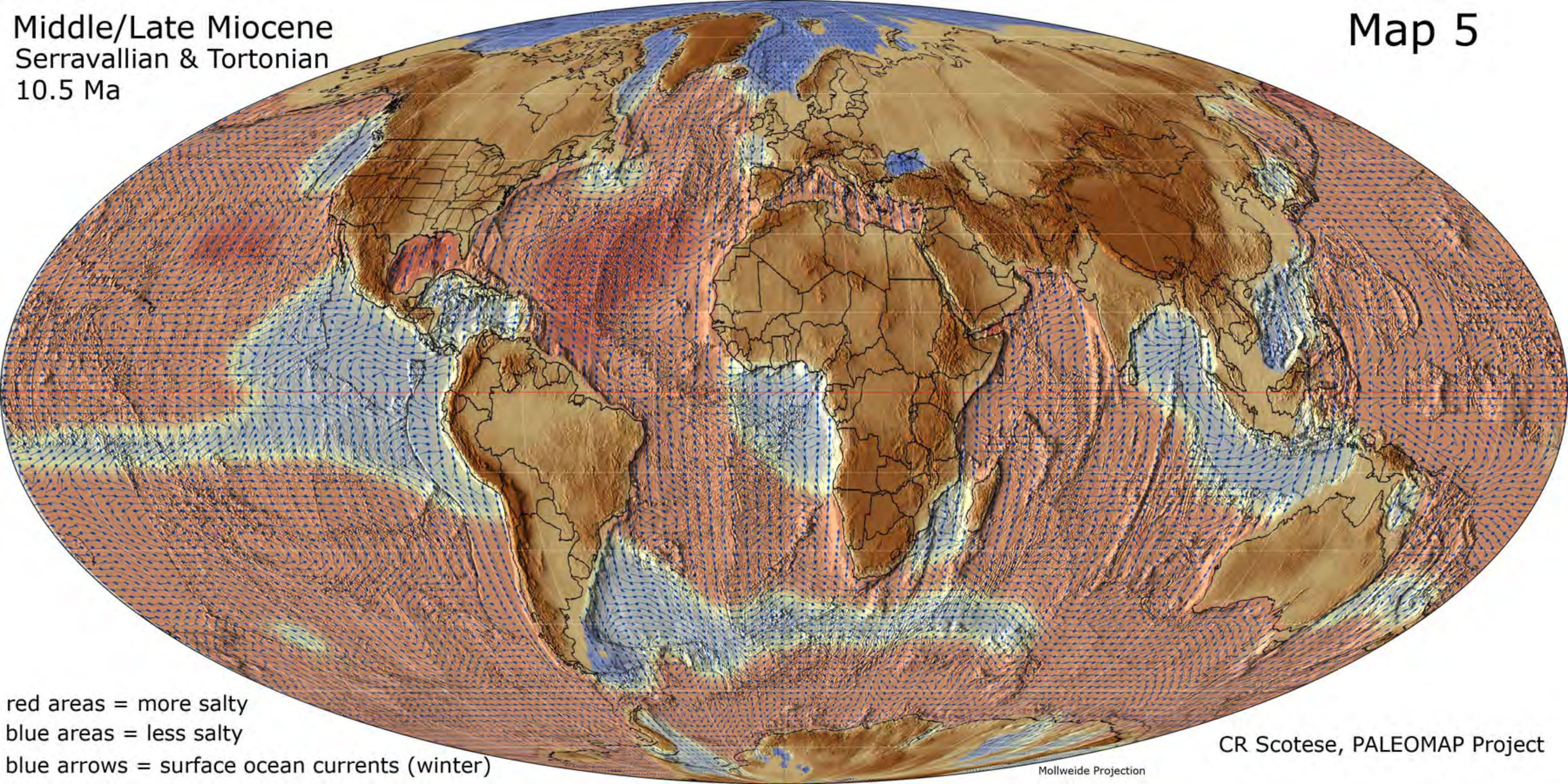
Scotese, C.R., 2014d, *The PALEOMAP Project PaleoAtlas for ArcGIS*, version 2, Volume 4, Late Paleozoic Plate Tectonic, Paleogeographic, and Paleoclimatic Reconstructions, Map 49-74, PALEOMAP Project, Evanston, IL.

Scotese, C.R., 2014e, *The PALEOMAP Project PaleoAtlas for ArcGIS*, version 2, Volume 5, Early Paleozoic Plate Tectonic, Paleogeographic, and Paleoclimatic Reconstructions, Maps 75-88, PALEOMAP Project, Evanston, IL.

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Middle/Late Miocene
Serravallian & Tortonian
10.5 Ma

Map 5



red areas = more salty
blue areas = less salty
blue arrows = surface ocean currents (winter)

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Mollweide Projection

Early Miocene
Aquitania & Burdigalia
19.5 Ma

Map 7

In Preparation

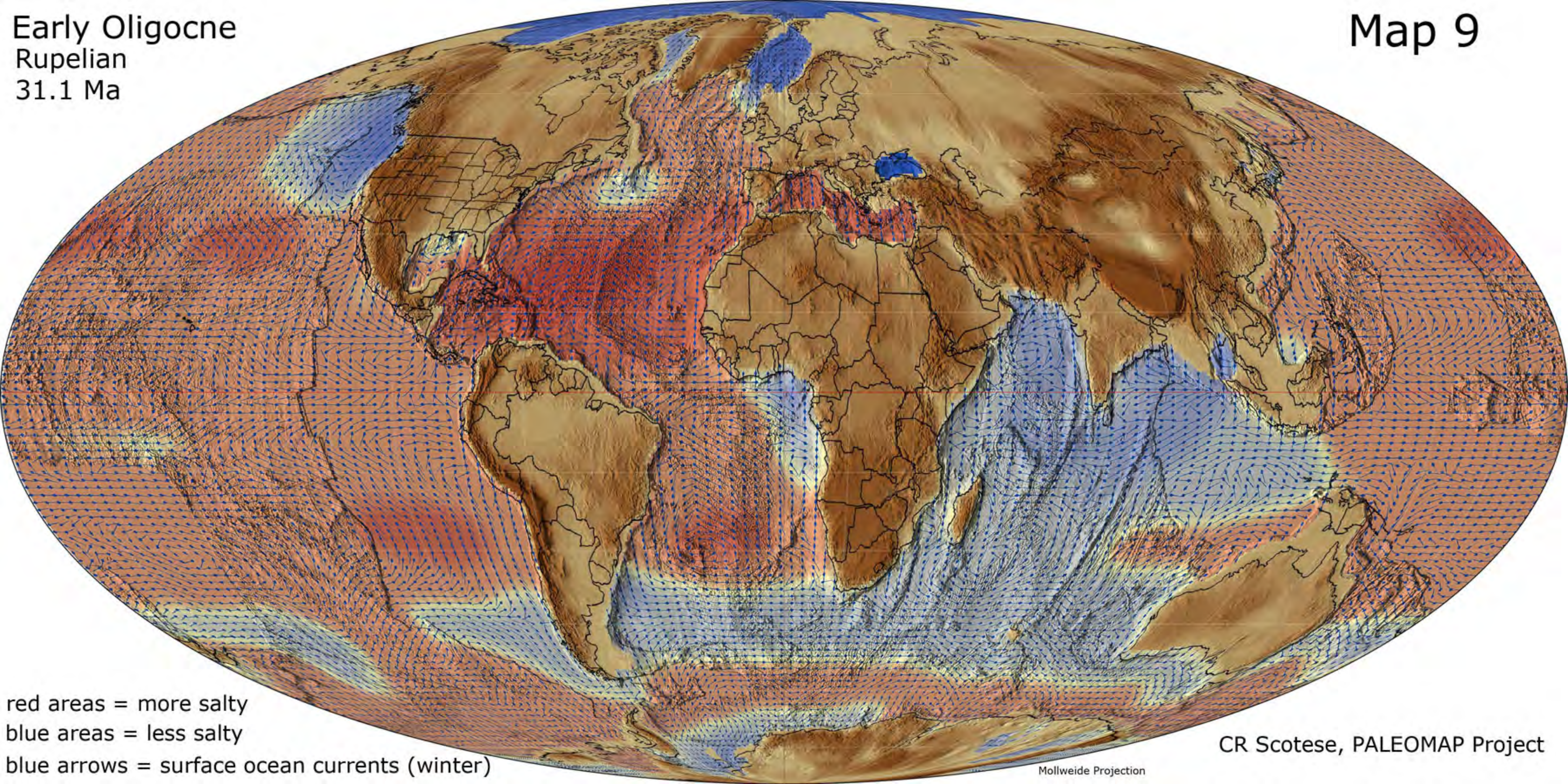
red areas = more salty
blue areas = less salty
blue arrows = surface ocean currents (winter)

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Mollweide Projection

Early Oligocene
Rupelian
31.1 Ma

Map 9



red areas = more salty
blue areas = less salty
blue arrows = surface ocean currents (winter)

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Mollweide Projection

early Middle Eocene
middle Lutetian
44.6 Ma

Map 12

In Preparation

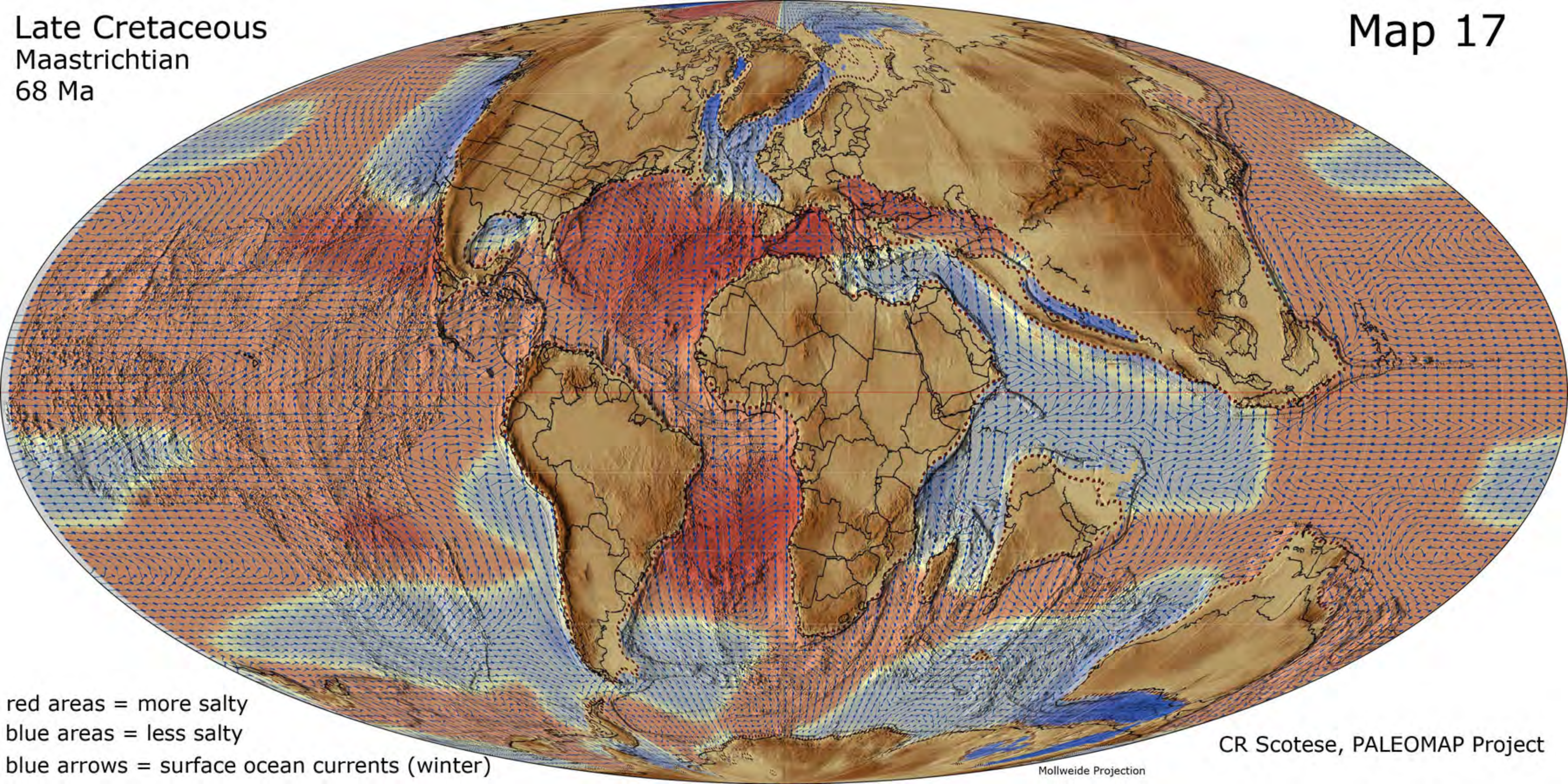
red areas = more salty
blue areas = less salty
blue arrows = surface ocean currents (winter)

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Mollweide Projection

Late Cretaceous
Maastrichtian
68 Ma

Map 17



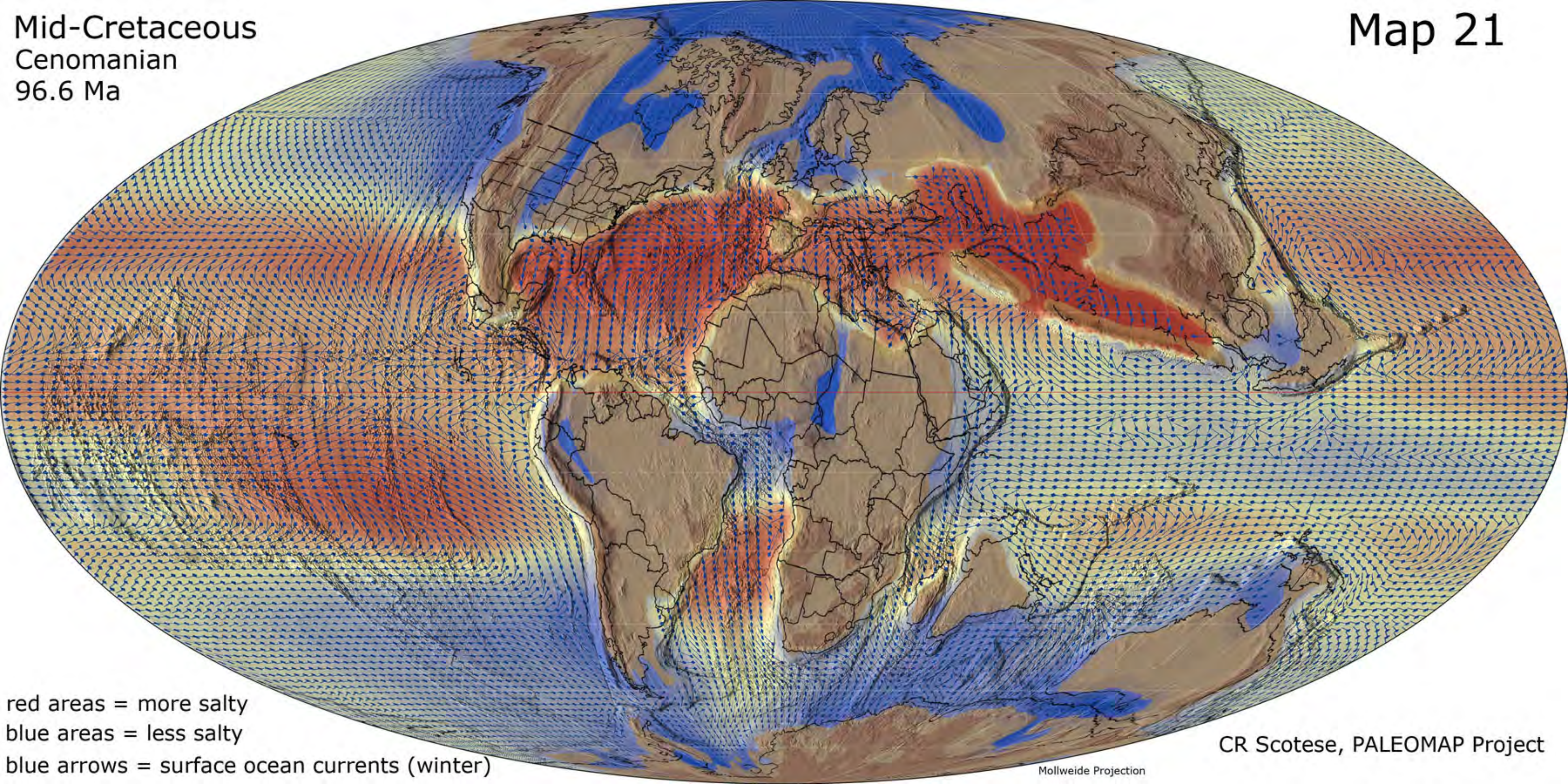
red areas = more salty
blue areas = less salty
blue arrows = surface ocean currents (winter)

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Mollweide Projection

Mid-Cretaceous
Cenomanian
96.6 Ma

Map 21



red areas = more salty
blue areas = less salty
blue arrows = surface ocean currents (winter)

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Mollweide Projection

Early Cretaceous
late Albian
110 Ma

Map 23

In Preparation

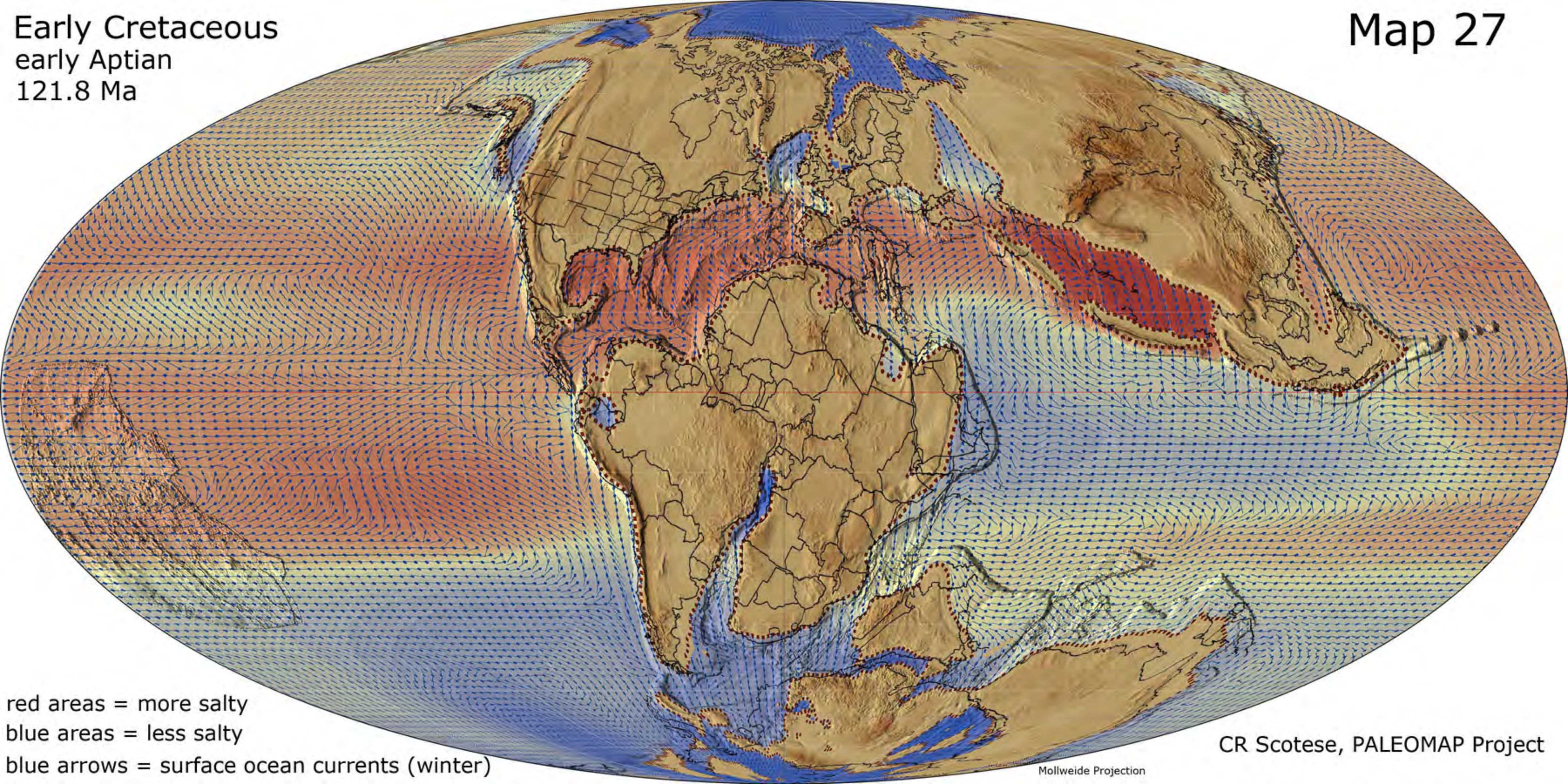
red areas = more salty
blue areas = less salty
blue arrows = surface ocean currents (winter)

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Mollweide Projection

Early Cretaceous
early Aptian
121.8 Ma

Map 27



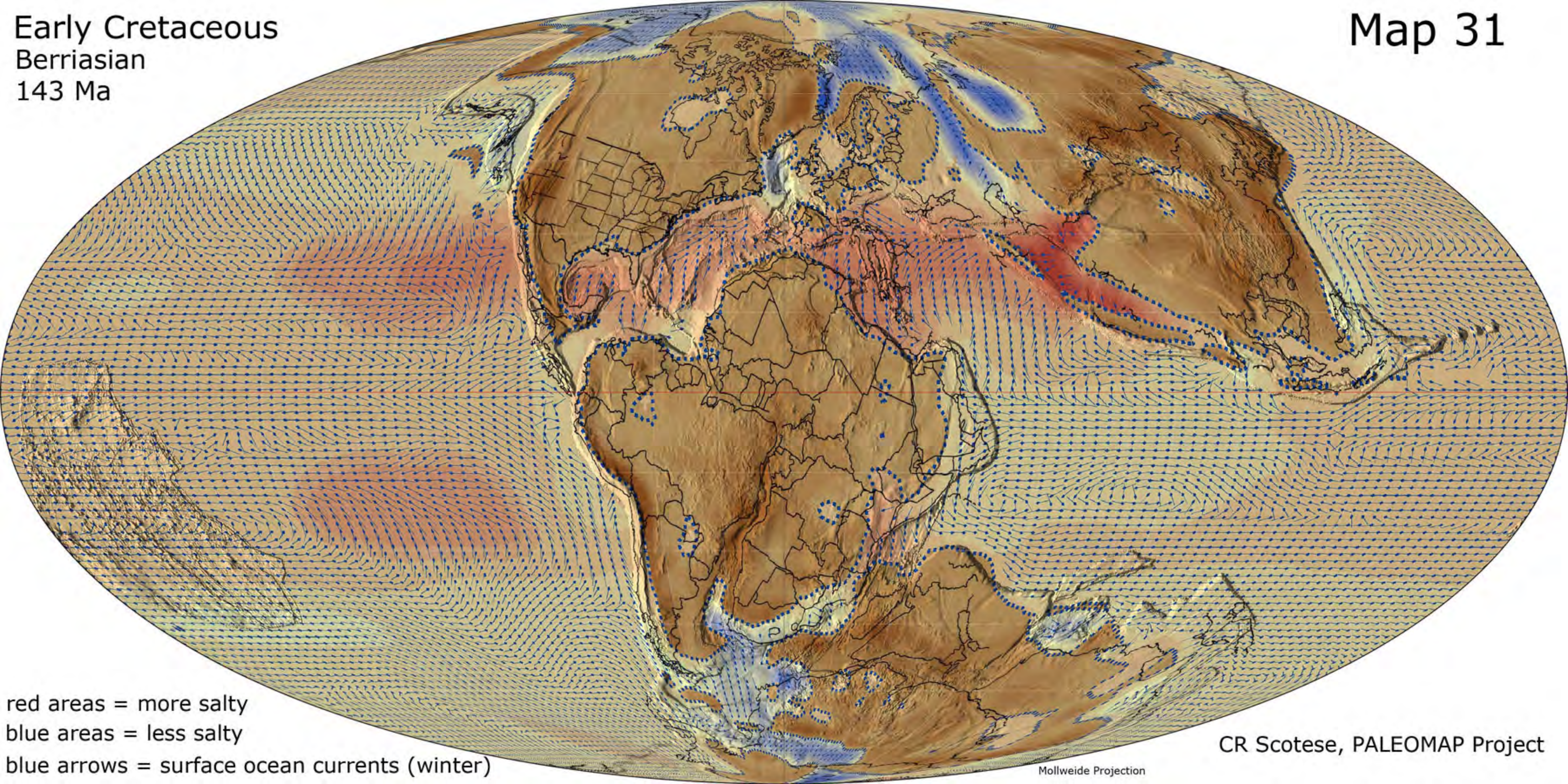
red areas = more salty
blue areas = less salty
blue arrows = surface ocean currents (winter)

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Mollweide Projection

Early Cretaceous
Berriasian
143 Ma

Map 31



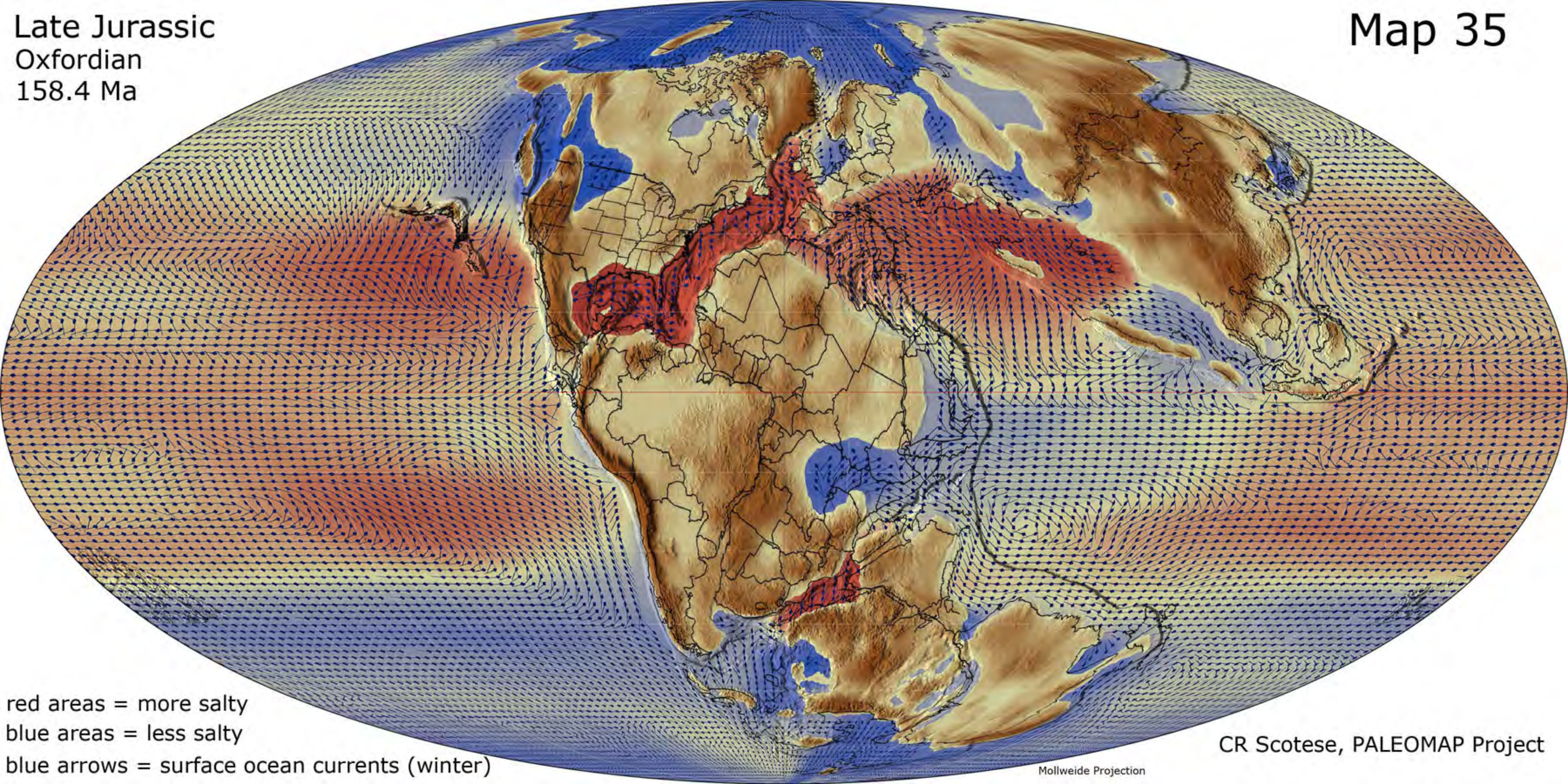
red areas = more salty
blue areas = less salty
blue arrows = surface ocean currents (winter)

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Mollweide Projection

Late Jurassic
Oxfordian
158.4 Ma

Map 35



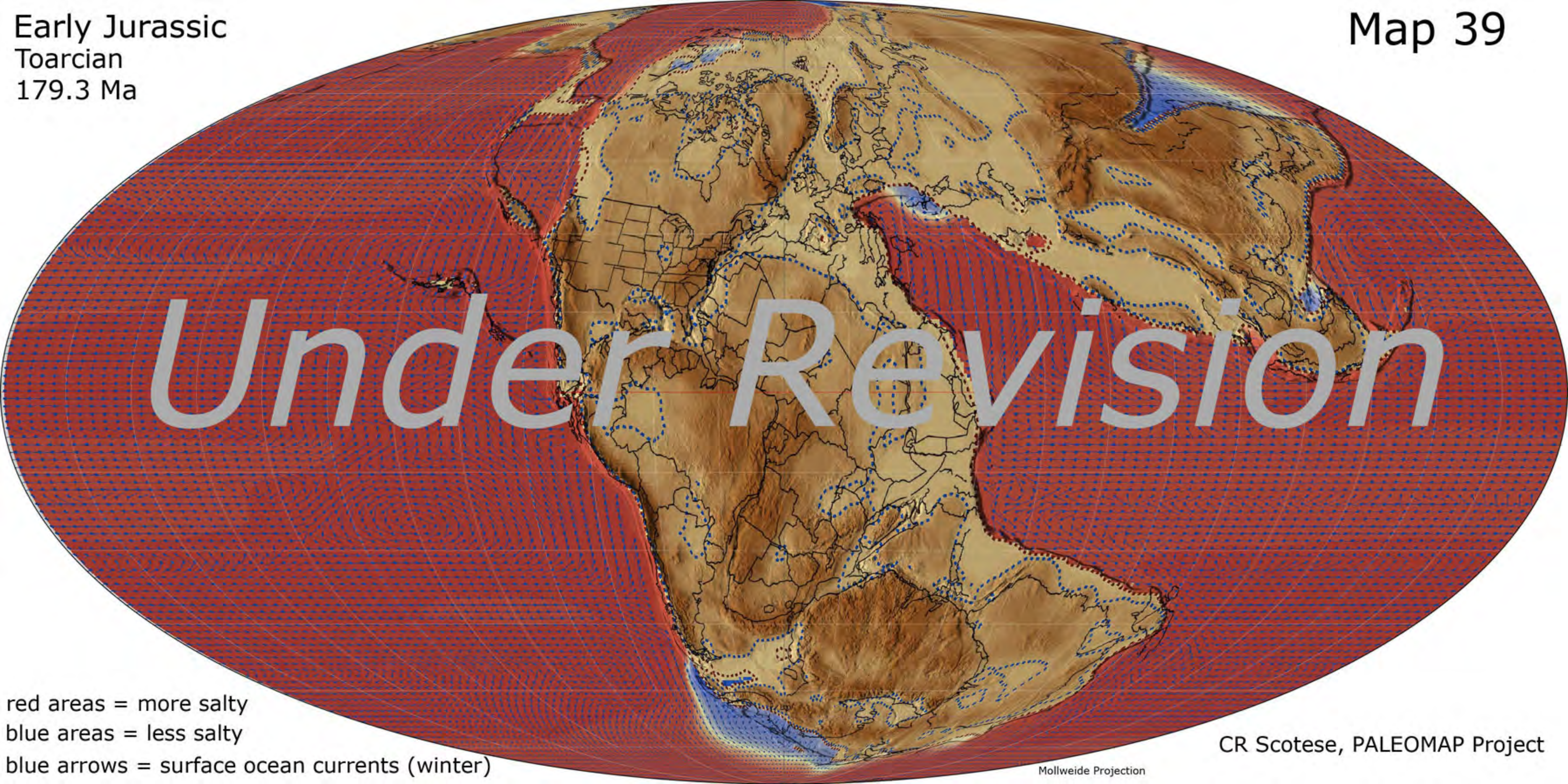
red areas = more salty
blue areas = less salty
blue arrows = surface ocean currents (winter)

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Mollweide Projection

Early Jurassic
Toarcian
179.3 Ma

Map 39



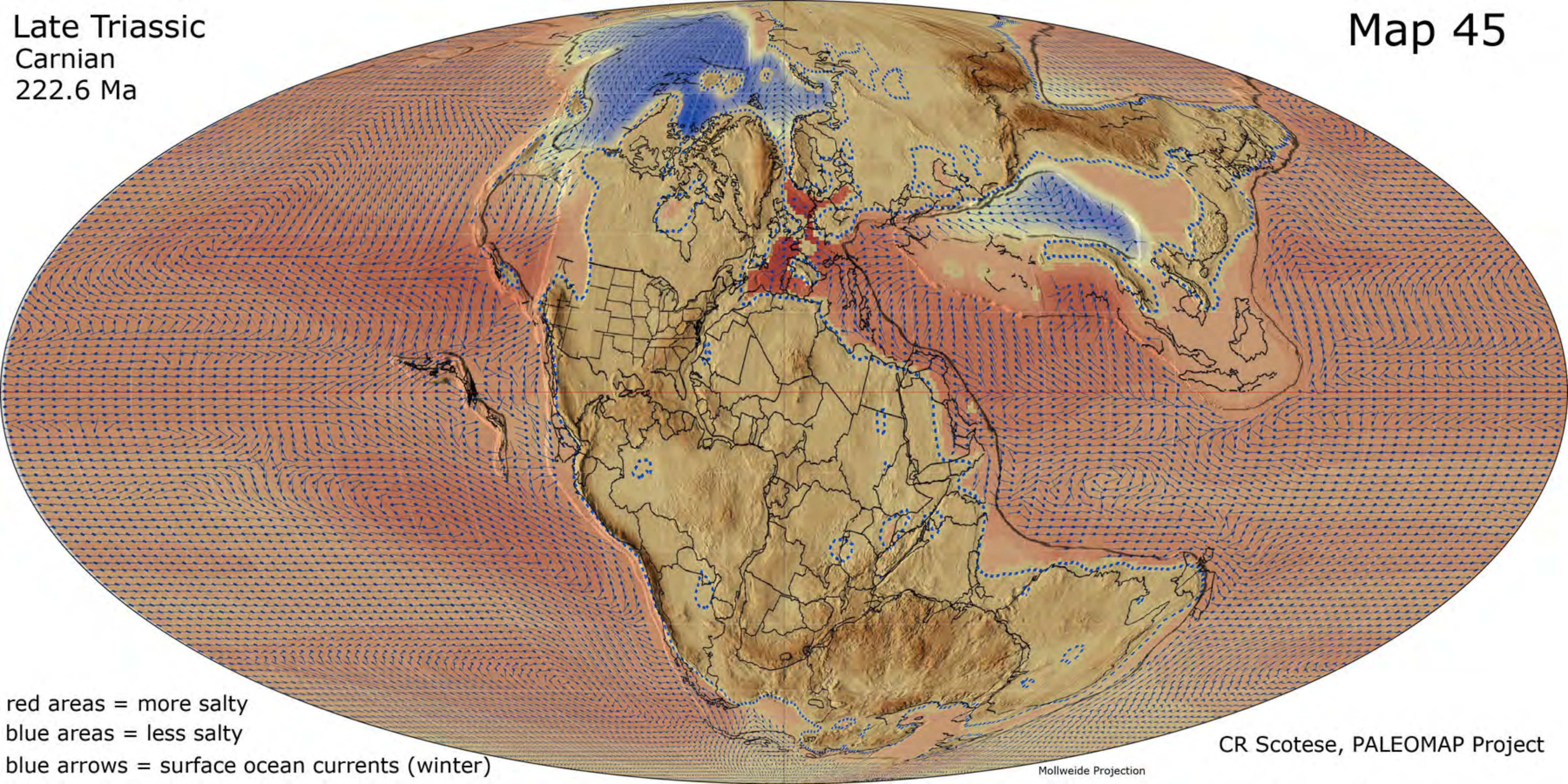
red areas = more salty
blue areas = less salty
blue arrows = surface ocean currents (winter)

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Mollweide Projection

Late Triassic
Carnian
222.6 Ma

Map 45



red areas = more salty
blue areas = less salty
blue arrows = surface ocean currents (winter)

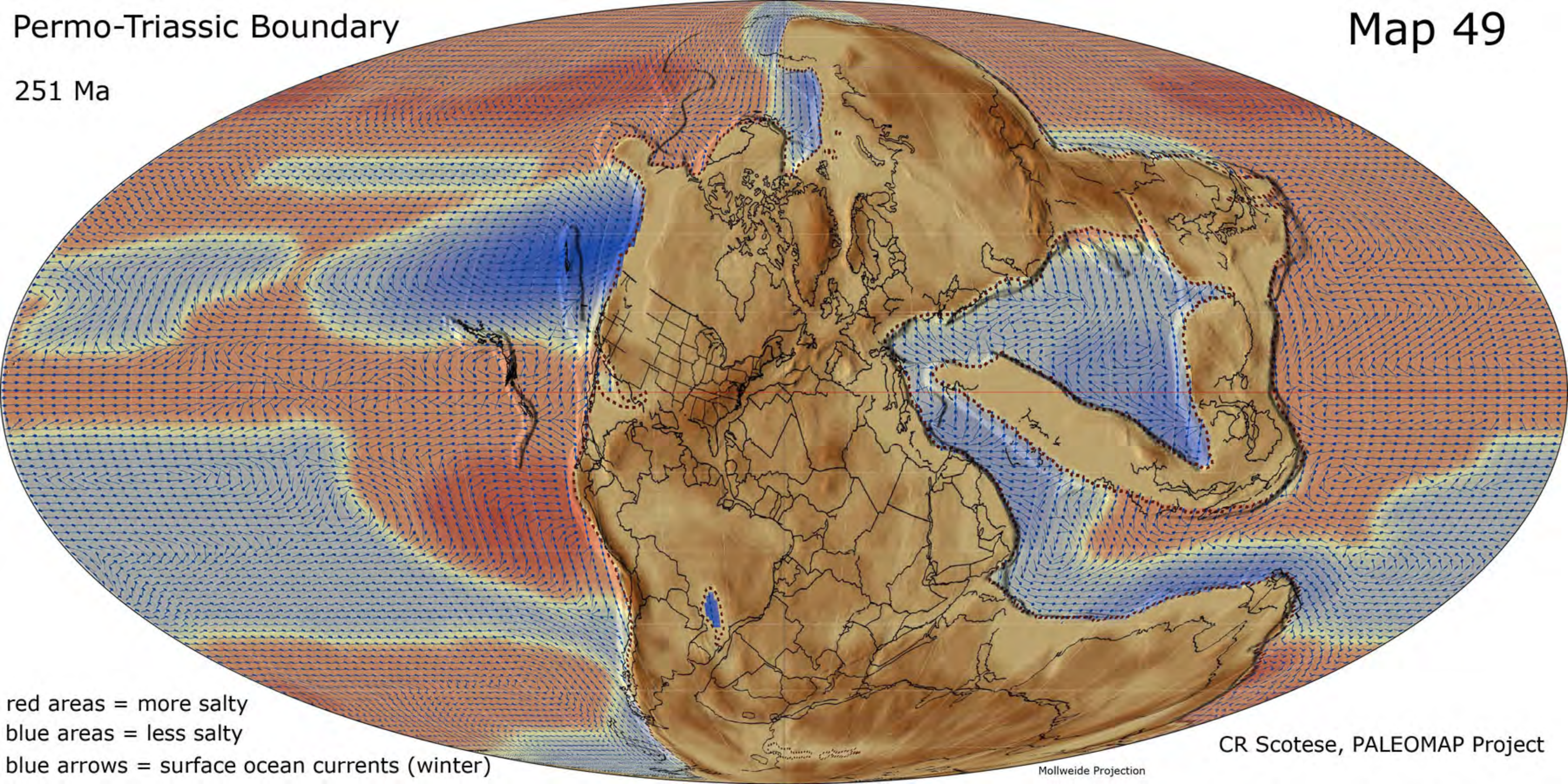
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Mollweide Projection

Permo-Triassic Boundary

Map 49

251 Ma



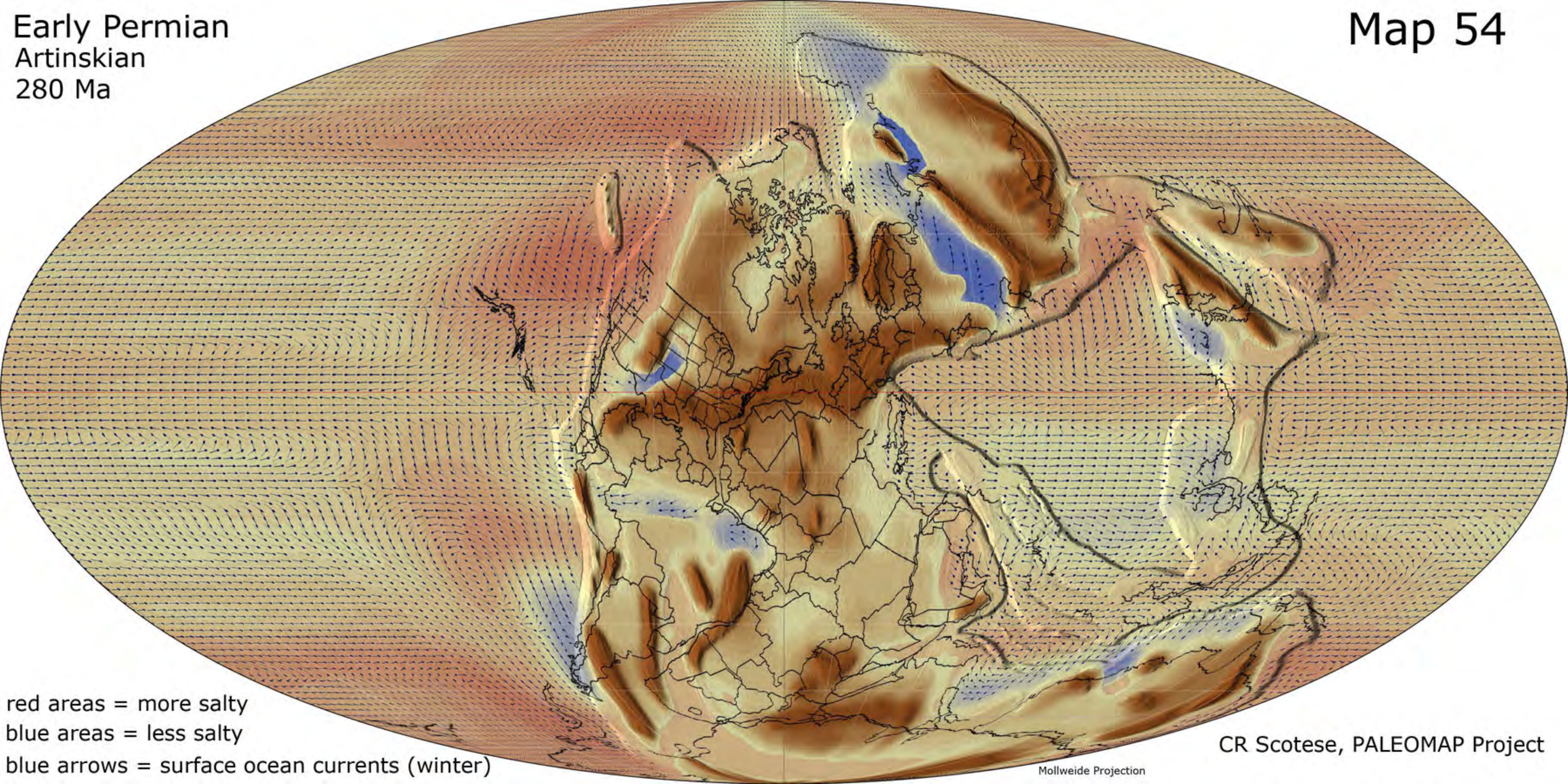
red areas = more salty
blue areas = less salty
blue arrows = surface ocean currents (winter)

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Mollweide Projection

Early Permian
Artinskian
280 Ma

Map 54



red areas = more salty
blue areas = less salty
blue arrows = surface ocean currents (winter)

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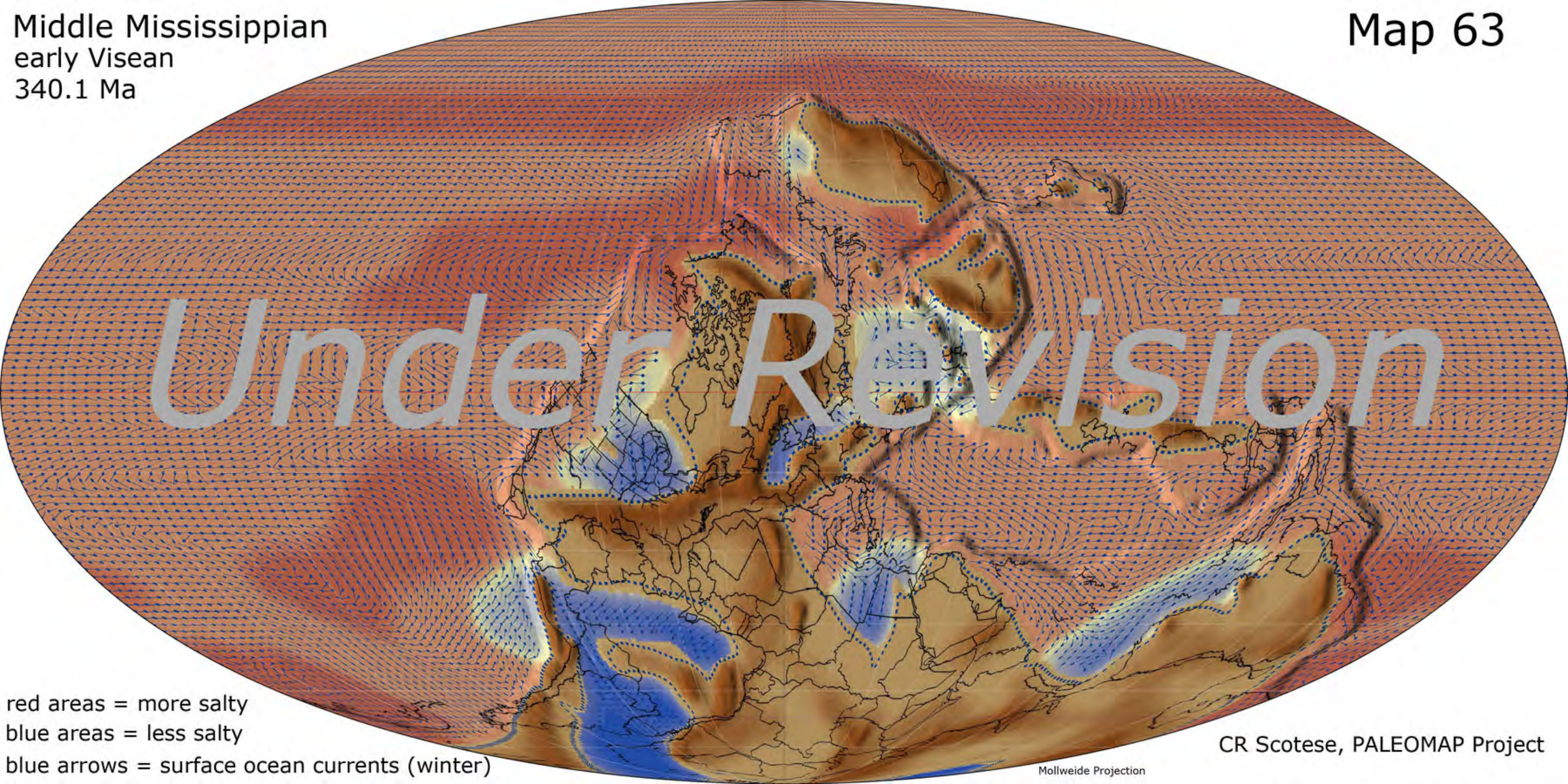
Mollweide Projection

Under Revision

red areas = more salty
blue areas = less salty
blue arrows = surface ocean currents (winter)

Middle Mississippian
early Visean
340.1 Ma

Map 63



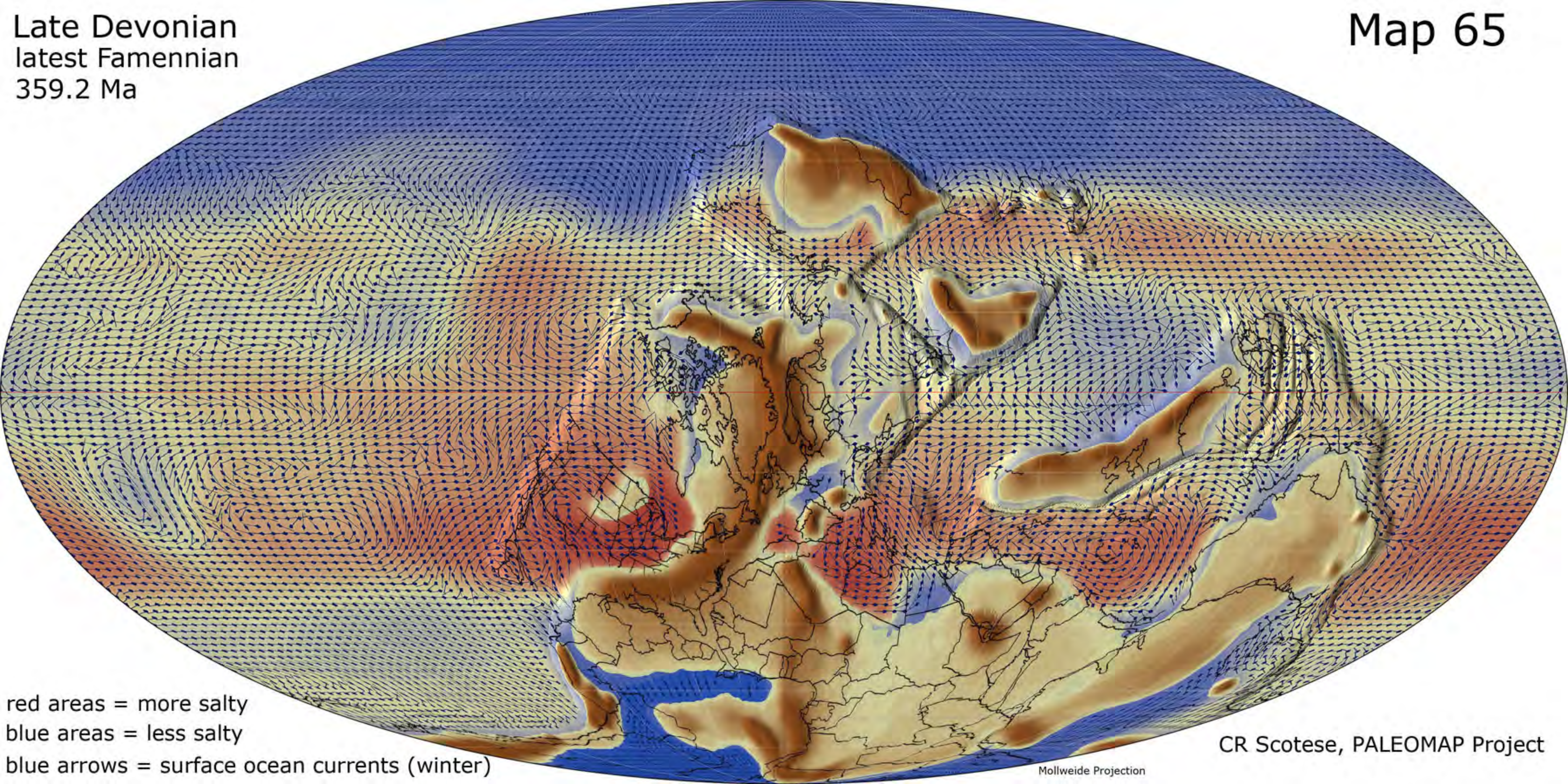
red areas = more salty
blue areas = less salty
blue arrows = surface ocean currents (winter)

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Mollweide Projection

Late Devonian
latest Famennian
359.2 Ma

Map 65



red areas = more salty
blue areas = less salty
blue arrows = surface ocean currents (winter)

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Mollweide Projection

Early Devonian
Emsian
402.3 Ma

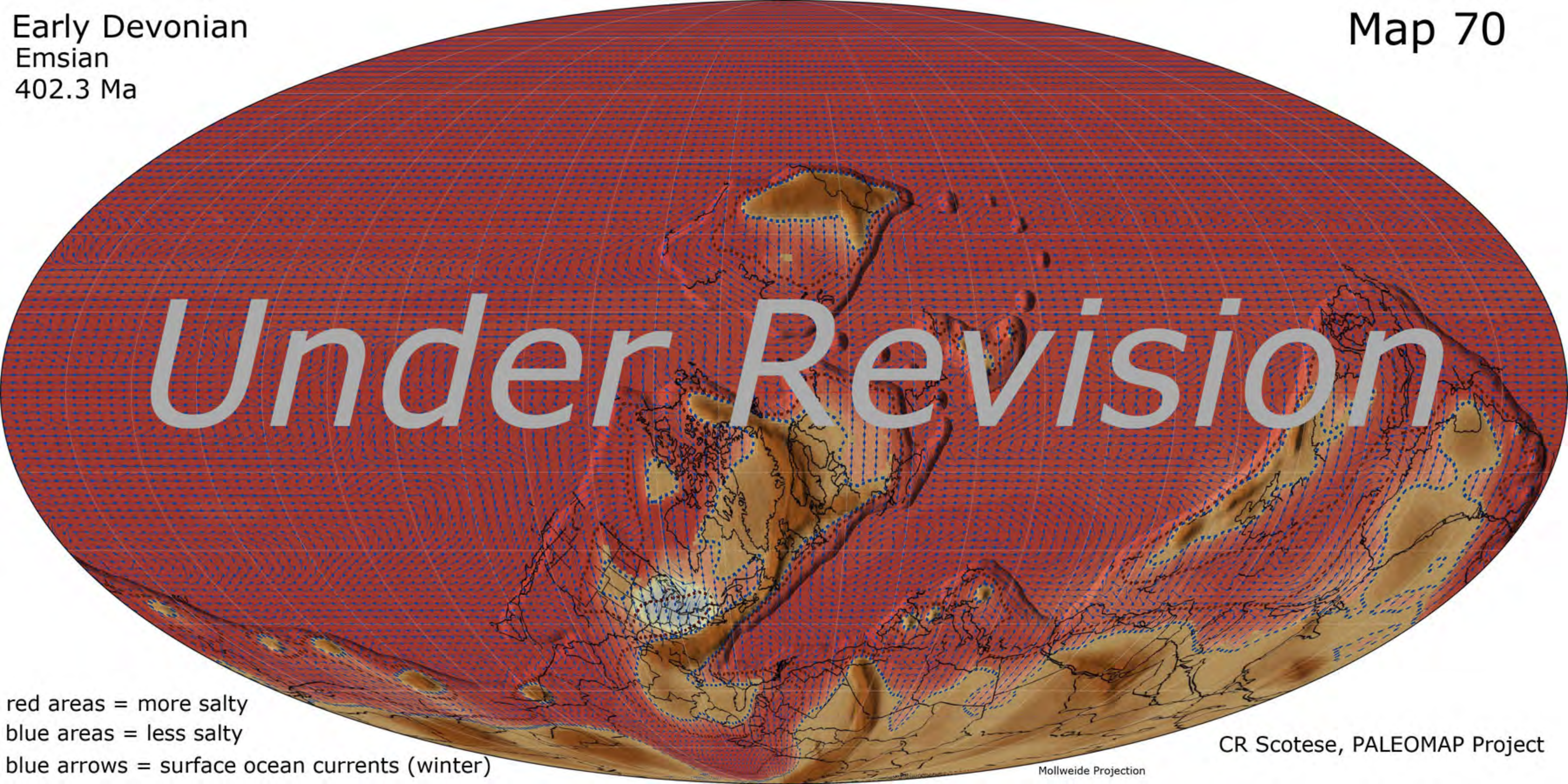
Map 70

Under Revision

red areas = more salty
blue areas = less salty
blue arrows = surface ocean currents (winter)

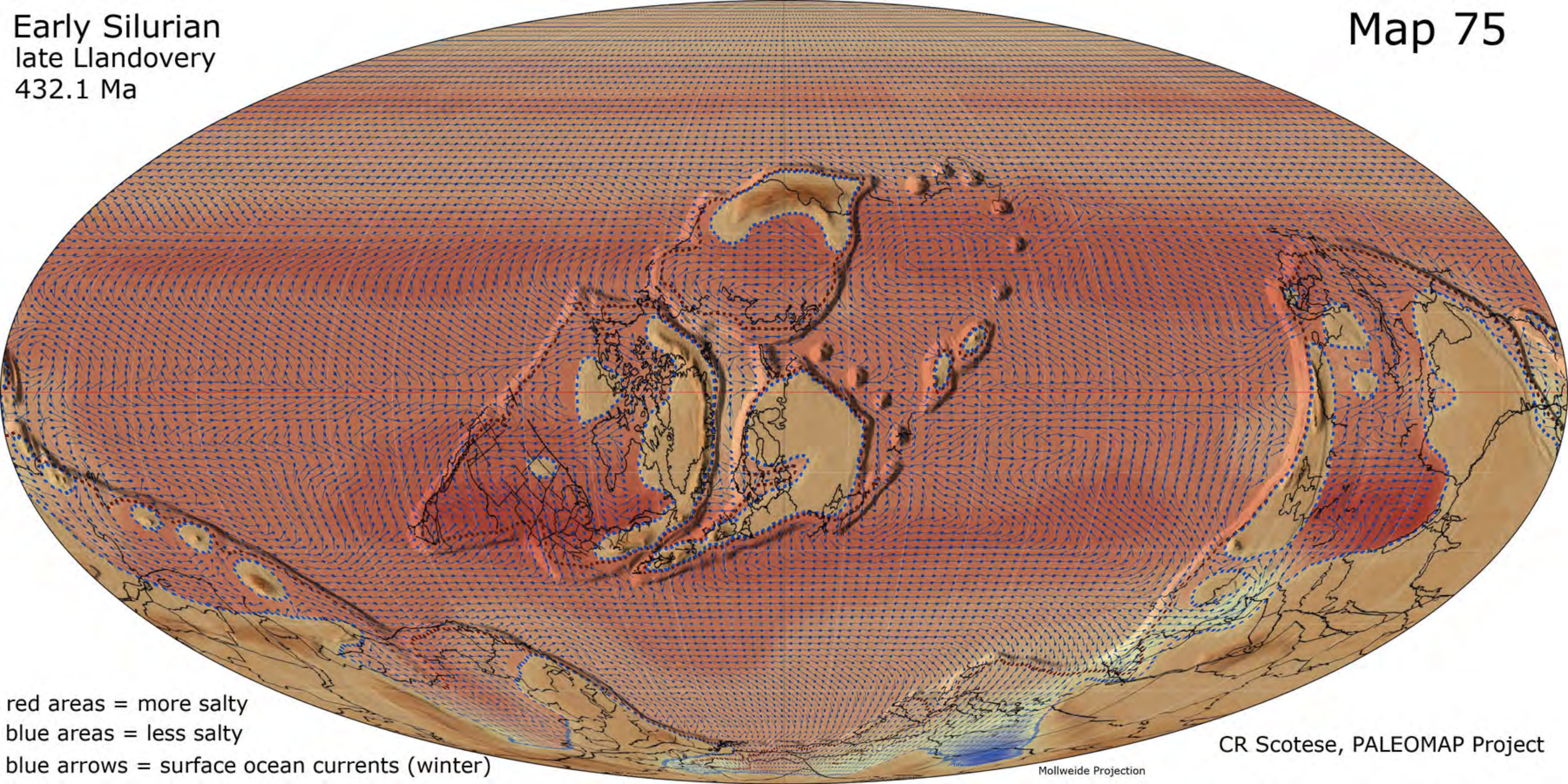
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Mollweide Projection



Early Silurian
late Llandovery
432.1 Ma

Map 75



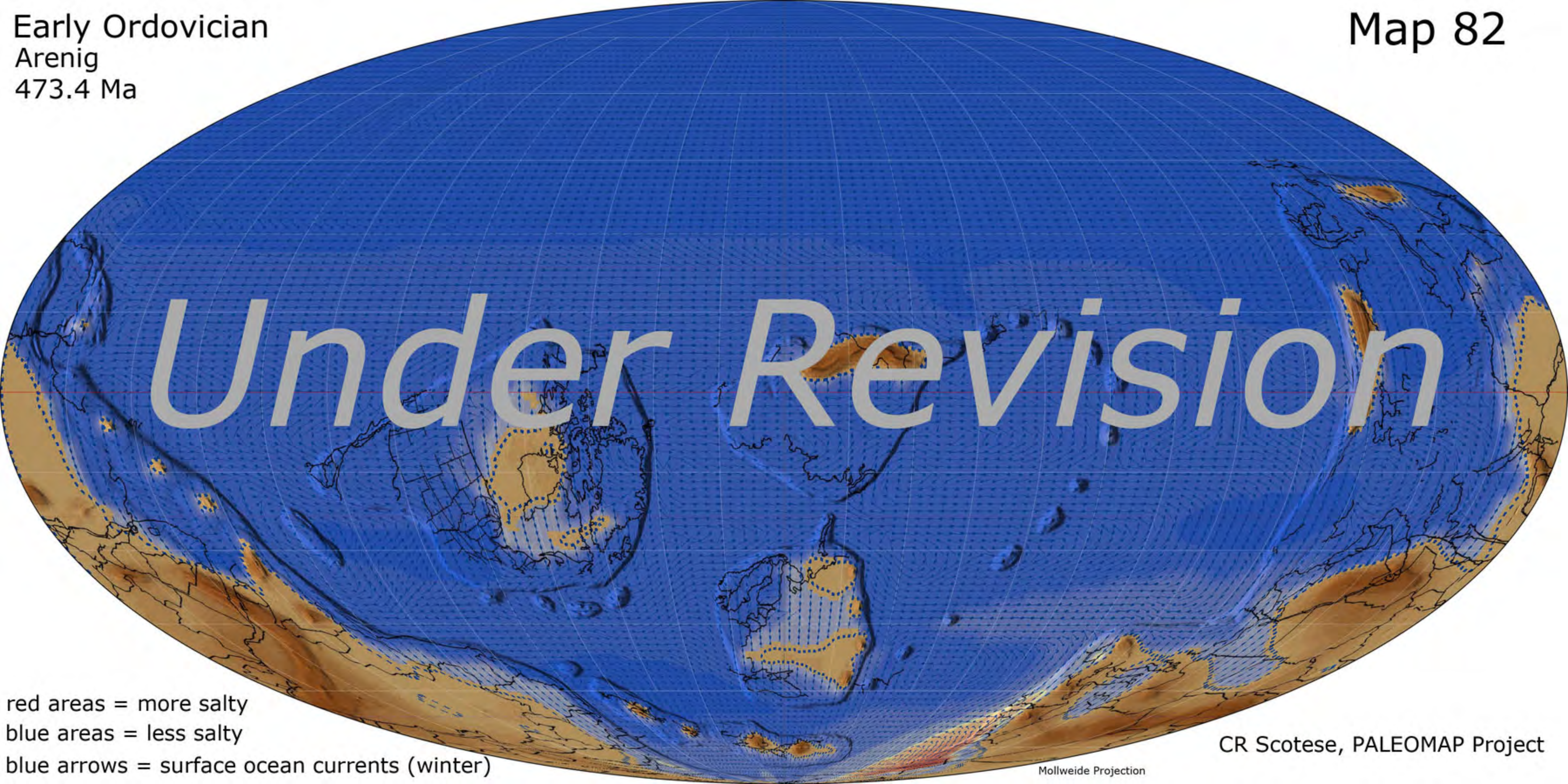
red areas = more salty
blue areas = less salty
blue arrows = surface ocean currents (winter)

Mollweide Projection

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Early Ordovician
Arenig
473.4 Ma

Map 82



red areas = more salty
blue areas = less salty
blue arrows = surface ocean currents (winter)

CR Scotese, PALEOMAP Project

Mollweide Projection

Under Revision

red areas = more salty
blue areas = less salty
blue arrows = surface ocean currents (winter)