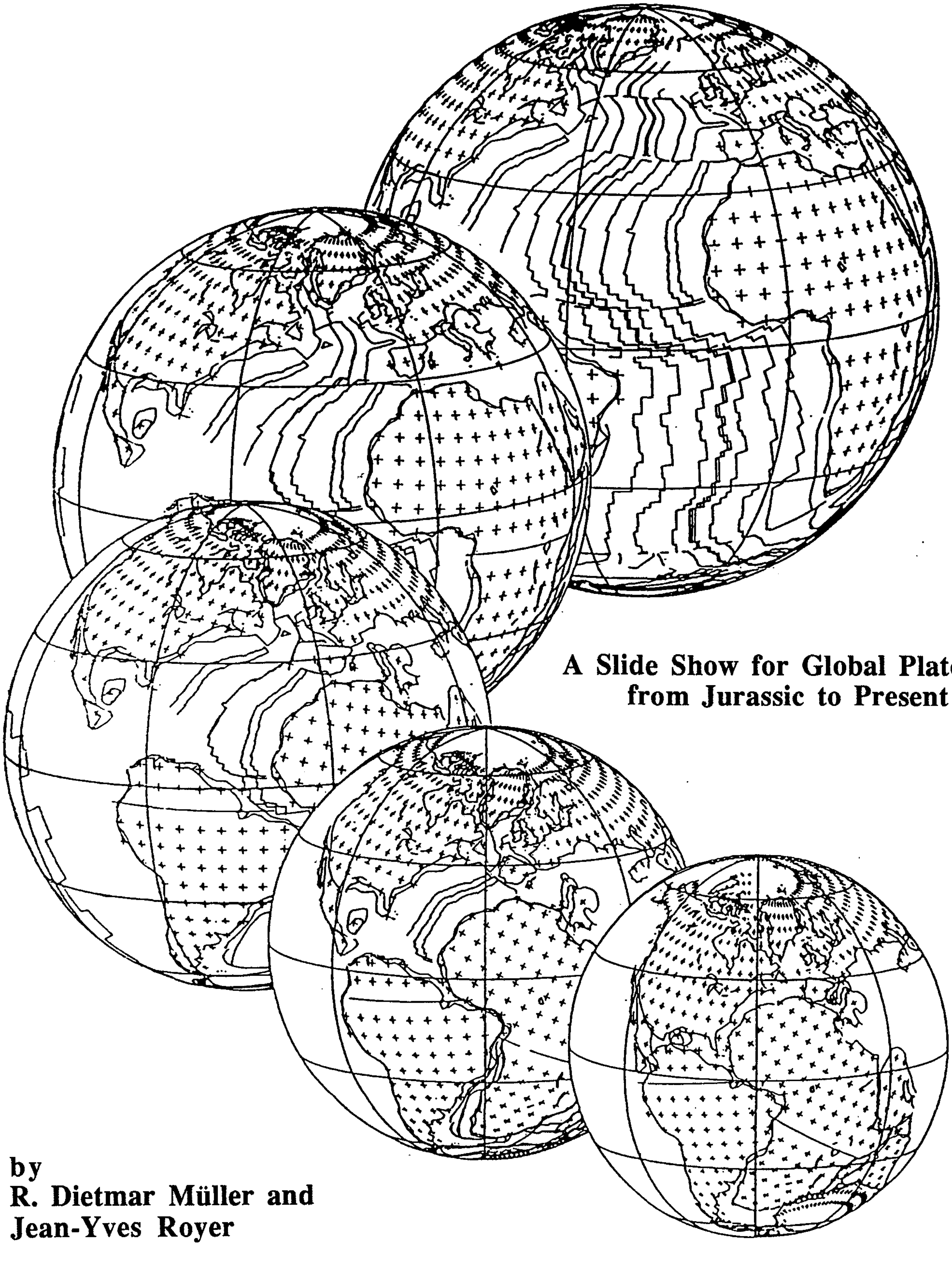
PALEOCEANOGRAPHIC MAPPING PROJECT
PROGRESS REPORT No. 54 - 0389



A Slide Show for Global Plate Motions from Jurassic to Present Day

by
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A SLIDE SHOW FOR GLOBAL PLATE MOTIONS FROM THE JURASSIC TO PRESENT DAY

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Abstract

A global model for Mesozoic and Cenozoic plate motions has been developed by the Paleoceanographic Mapping Project (POMP) during the last four years. It is based on a digital tectonic database that includes modern plate boundaries, marine magnetic anomaly data, fracture zone lineations, bathymetric data, Seasat and Geosat altimetry data, mapped ocean-continent boundaries and continental tectonic data. We used this global model to produce a set of 22 slides that display global and regional plate reconstructions, which illustrate the global plate tectonic development of the ocean basins from the breakup of Pangea in the Middle Jurassic to present day.

Our reconstructions for the eastern Indian Ocean are consistent with the known seafloor spreading history of the Australian-Antarctic Basin and the Wharton Basin since the Late Cretaceous. In particular, they resolve the problem of overlap between the Kerguelen Plateau and Broken Ridge. An internally consistent plate model for the entire South Pacific region has been developed using a combination of satellite altimetry, magnetic anomaly and bathymetry data. Our closure of the South Atlantic that takes into account intracontinental deformation in Africa and South America does not assume any of the substantial gaps or overlaps that are inherent in rigid plate models. Reconstructions for the North Atlantic region are based on a new compilation of magnetic and fracture zone data.

Data — slides 2-7

Slides No. 2-7 show our global database of magnetic anomaly pics and lineations as well as fracture zones, compiled by the Paleoceanographic Mapping Project (POMP, slide No. 1). The magnetic anomaly data in the North Atlantic (slide 2) are compiled from Srivastava and Tapscott (1986), Srivastava et al. (1988) and unpublished data from K. Klitgord (pers. comm.). In the South Atlantic (slide 3), the magnetic anomaly picks are taken from Cande et al. (1988) and the fracture zones are based on interpretations of Geosat altimetry data (Nürnberg et al., 1987). The magnetic anomaly picks in the western Indian Ocean (slide 4) are based on Royer et al. (1988), and the magnetic picks in the eastern Indian Ocean (slide 5) are from Royer and Sandwell (1989). The fracture zones in the Indian Ocean (slide 4, 5) have been mapped using a combination of Geosat altimetry and magnetic anomaly data (Royer et al. 1989). The magnetic lineations in the Pacific Ocean (slides 6, 7) were compiled by Mayes et al. (1989) and Renkin and Sclater (1988). The fracture zones in the South Pacific (slide 6) have been identified using Geosat altimetry data and magnetic lineations (Mayes et al., 1989). All plates and geographic names mentioned in the text are shown on Fig. 1.

Plate Reconstructions

Global plate reconstructions were plotted on Molleweide projections. Regional reconstructions were either plotted on Mercator projections or on transverse Mercator projections (North Atlantic). Plates that move separately from each other are color-coded. Light blue areas on regional reconstructions outline bathymetric contours of submarine volcanic ridges and plateaus on oceanic crust. For reconstructions from the Early Cretaceous (120 Ma) to present day the plates were oriented according to a hot spot reference frame from Morgan (1981) . The orientations of plates in reconstructions prior to 120 Ma are based on the paleomagnetic reference frame from Ziegler et al. (1983).

The Breakup of Pangea — slide 8

Slide 8 displays the configuration of Pangea in the Middle-Jurassic before it started to break up by seafloor-spreading in the Central Atlantic. The separation between Africa and North America resulted in the formation of Laurentia in the northern Hemisphere and Gondwana in the southern Hemisphere.

The Breakup of Gondwana — slide 9

At about 160 Ma, separation of Gondwana into East and West Gondwana started with seafloor spreading in the Somali Basin (north of Madagascar) and in the Mozambique Basin (south of Madagascar). This resulted in strike-slip along the Davie Ridge and along the Antarctic and Mozambique margins. At about 130 Ma, rifting propagated northward into the South Atlantic (slide 10).

The breakup of West Gondwana — slide 10

We have used a new model for the early breakup history of West Gondwana (between Africa and South America) including intraplate deformation (Nürnberg et al., 1987). The fit of North Africa to northern South America is constrained by the fit of the strike-slip margin of the New Guinea Plateau (Africa) with the Demarara Rise (South America) and by equatorial fracture zones identified from Geosat altimetry data. The fit of South Africa relative to southern South America is constrained by the well mapped Falkland-Agulhas fracture zones and transform margins. It is not possible to find a fit reconstruction using two rigid plates that satisfies both constraints. The intraplate deformation zones included in our model are:

1. The Benue/Gongola/Niger rift system in North Africa, a sinistral wrench fault/rift zone.
2. An intraplate deformation zone in South America that stretches from the Parana/Chacos Basins to the Andean Cochabamba/Santa Cruz Bend (slide 10, border between blue and red area on South America).
3. The Salado and Colorado Basins in South America that show E-W structural trends with faulting starting in the Upper Jurassic.

Our model assumes that during the first rift phase in the Upper Jurassic/Lower Cretaceous the rift propagated northward, while forming western branches in the Salado, Colorado and Parana/Chacos basins (slide 10).

Breakup of Laurentia — slide 11

Slide 11 displays the beginning breakup of Laurentia, when opening between Iberia and Newfoundland started in the Lower Cretaceous as a consequence of continuing seafloor spreading in the Central Atlantic. Subsequently the rift propagated northward between Labrador and Greenland. The subsidence history on the northern Labrador shelf started as early as about 130 m.y. ago (chron M10). The extensional tectonic regime at that time initiated rift basins north of Newfoundland from the Rockall Trough to the western margin of Norway.

The breakup of West Gondwana and the continuing disintegration of East Gondwana in the Upper Cretaceous — slides 12, 13

The breakup of East Gondwana started in the Late Cretaceous at about 127-118 Ma (chrons M5-M0), when seafloor spreading started between India and Antarctica/Australia (slide 12). At approximately the same time, spreading stopped in the Somali Basin and

Madagascar became rigidly attached to Africa. This plate scenario included strike-slip between Madagascar and India as well as between southern India and Antarctica.

At the same time, between chrons M4 and M0 (126-118 Ma), rifting propagated northward into the South Atlantic into the Benue Trough/Niger Rift (slide 13). It caused rifting and strike-slip between North and South Africa. South America was now acting as one rigid plate.

<u>The continuing segmentation of Laurentia, East and West Gondwana in the Late Cretaceous/Cenozoic</u> — slides 14-22

Chron 34 (84 Ma) — slide 14, 15

In the upper Cretaceous rifting and seafloor spreading propagated into the equatorial Atlantic between North Africa and South America (slide 14). Both Africa and South America now acted as rigid plates. A plate reorganization in the Cretaceous Quiet Zone, before chron 34, caused Antarctica and Australia to split apart and India to move away from Madagascar by seafloor spreading in the Mascarene Basin (slide 15). At the same time seafloor spreading propagated into the Labrador Sea in the North Atlantic, separating Greenland from North America.

Chron 28 (65 Ma) — slide 16

Near the Cretaceous Tertiary boundary, seafloor spreading ceased in the Mascarene Basin and jumped north to the Seychelles to create the Eastern Somali Basin and the Arabian Sea along the Carlsberg Ridge. During this time, the Deccan Traps were emplaced in western India (slide 16).

Chron 24 (56 Ma) — slide 17

At chron 24 in the Lower Tertiary, seafloor spreading started in the North Atlantic between Greenland and Eurasia and in the Eurasian Basin (Arctic). This event constituted the last step for the disintegration of Laurentia.

Chron 18 (42 Ma) — slide 18

At chron 18 seafloor spreading in the Wharton Basin between Australia and India ceased. At the same time spreading between Australia and Antarctica speeded up as Kerguelen Plateau and Broken Ridge rifted apart. Shortly before this time, at chron 20, Greater India started colliding with Asia.

In the southwestern Pacific east of Australia, the Late Paleocene opening of the New Caledonia Basin caused the Norfolk Ridge to rift apart from the Lord Howe Rise. The New Hebrides, Lau Ridge and Colville-Tonga-Kermadec ridges were formed as continuous island arcs in the Late Cretaceous.

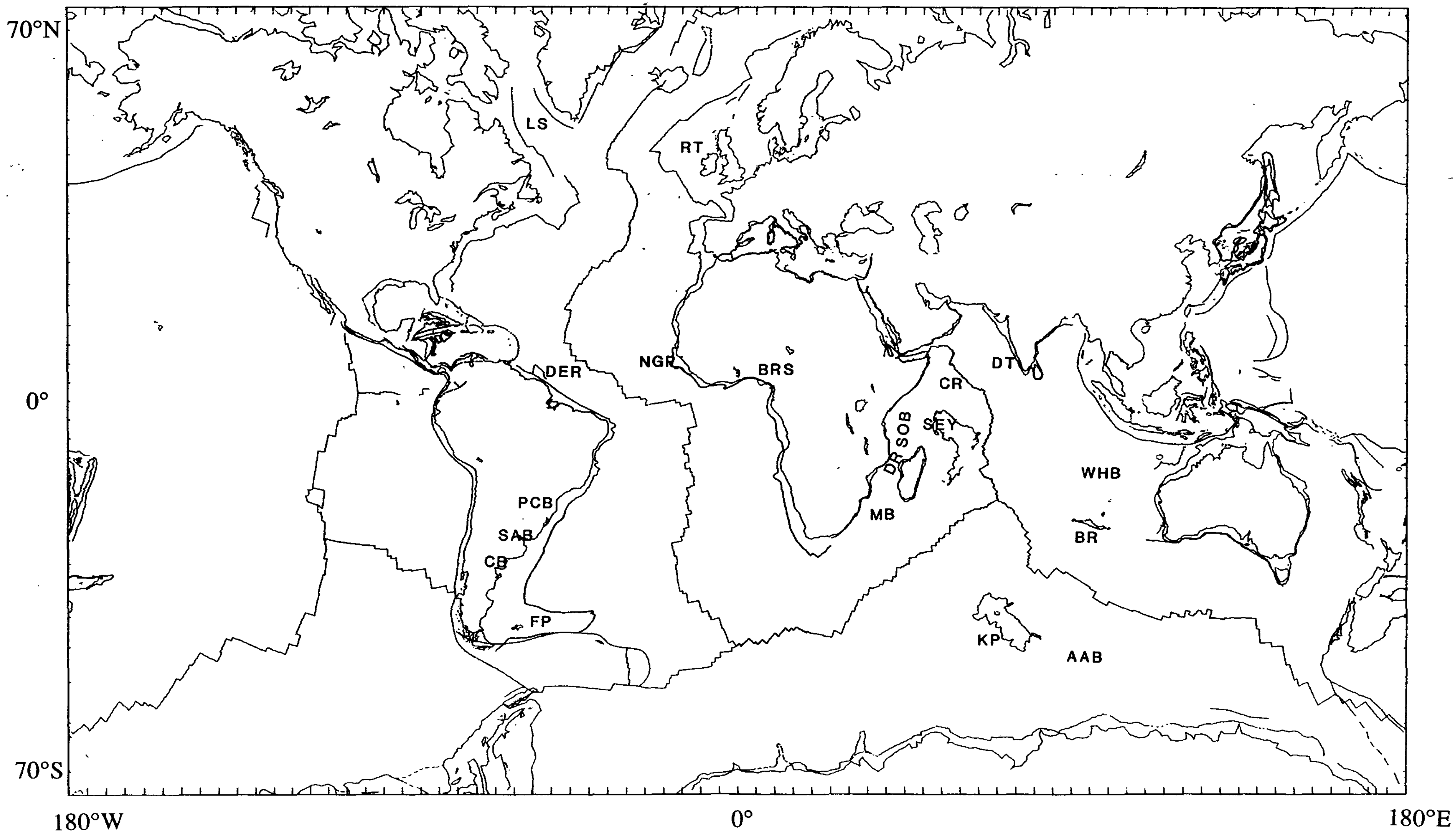
Chron 13 (36 Ma) — slides 19-21

At chron 13 the seaway between Tasmania and Antarctica opened (slide 19, 20), initiating circum-antarctic circulation. Prior to chron 13, seafloor spreading in the Labrador Sea had ceased (slide 21). Thus Greenland became part of the North American plate.

Present Day — slide 22

This slide shows the present day configuration of all major spreading ridges and plates.

Figure 1. Geographic names mentioned in text. AAB = Australia-Antarctic Basin; KP = Kerguelen Plateau; BR = Broken Ridge; SOB = Somali Basin; MB = Mozambique Basin; DR = Davie Ridge; NGP = New Guinea Plateau; DER = Demarara Rise; FP = Falkland Plateau; BRS = Benue Rift System; CB = Colorado Basin; SAB = Salado Basin; PCB = Parana-Chacos Basins; RT = Rockall Trough; LS = Labrador Sea; SEY = Seychelles; CR = Carlsberg Ridge; DT = Deccan Traps; WHB = Wharton Basin.


70°N
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LS
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BRS
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CR
SEY
SOB
DR
MB
WHB
BR
KP
AAB
PCB
SAB
CB
FP

Figure 1

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P.O.M.P.

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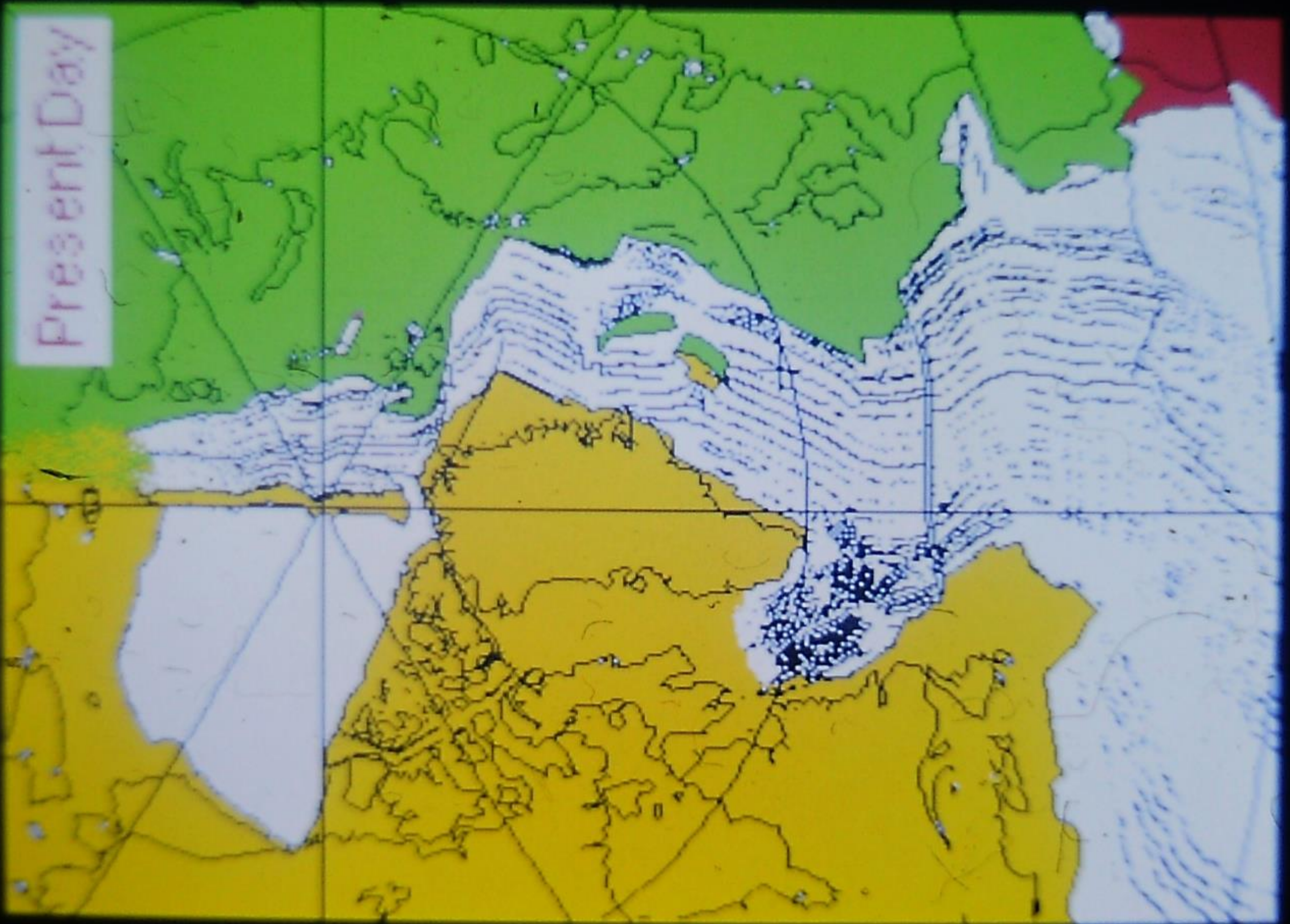
Present Day


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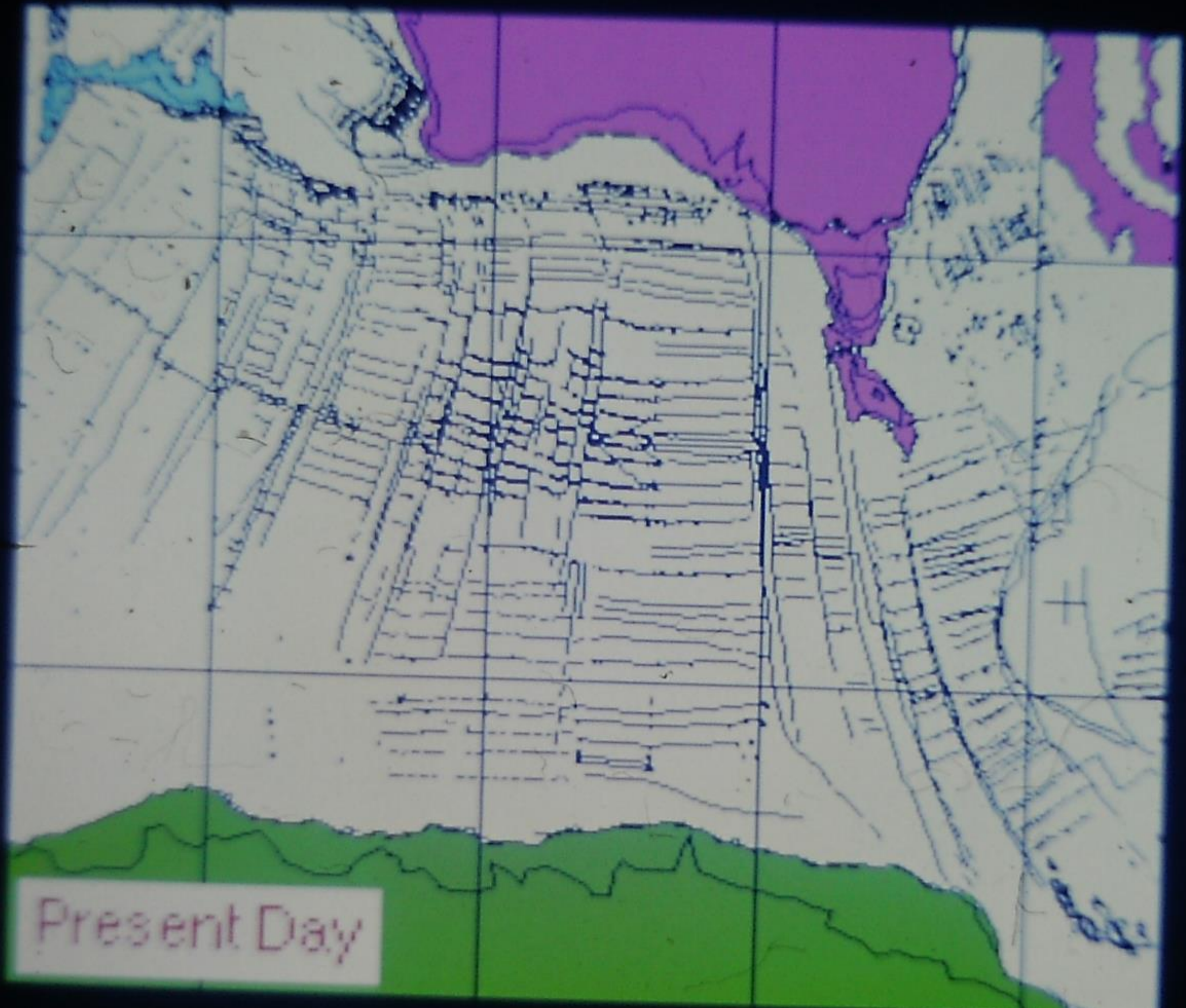
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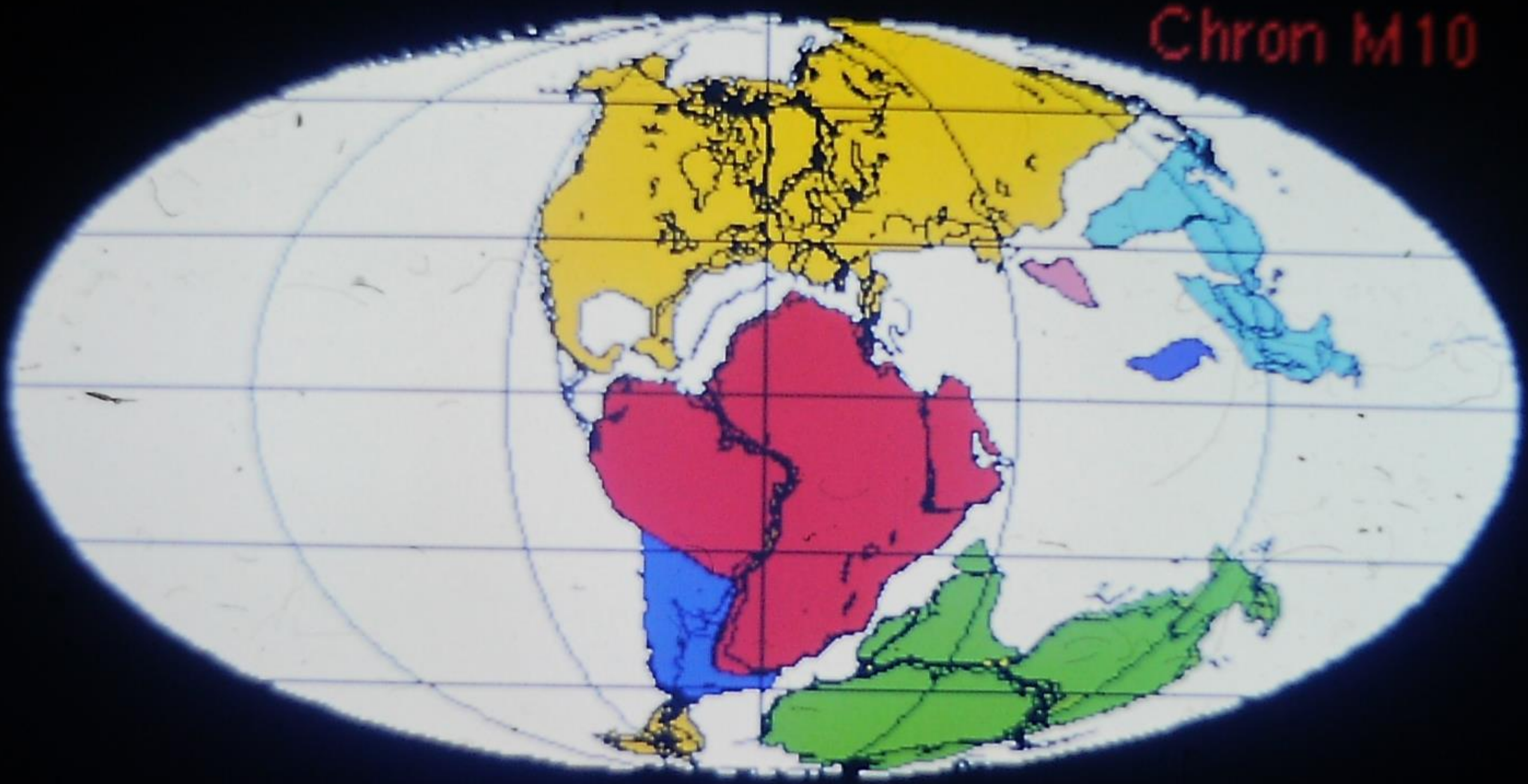
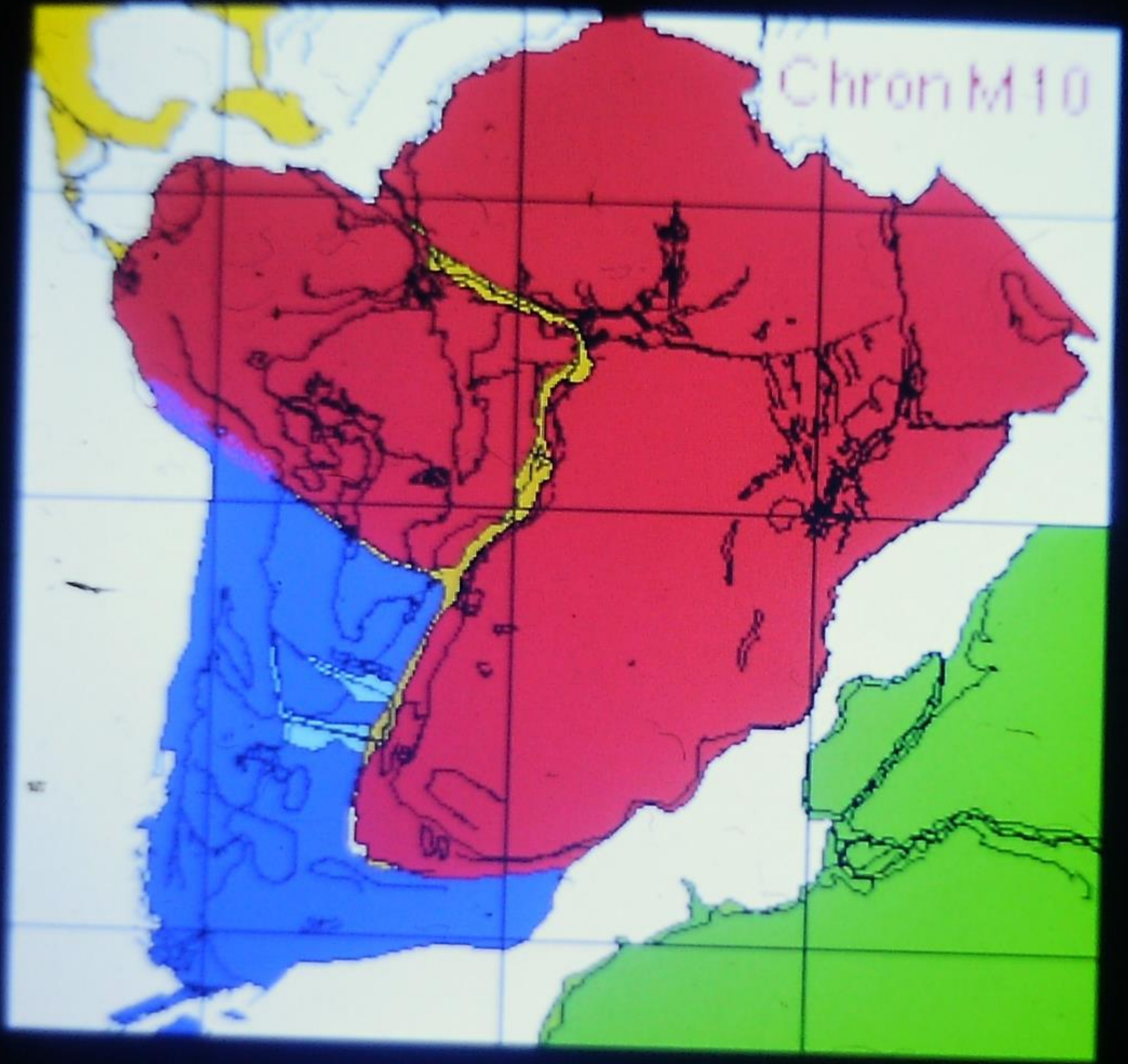
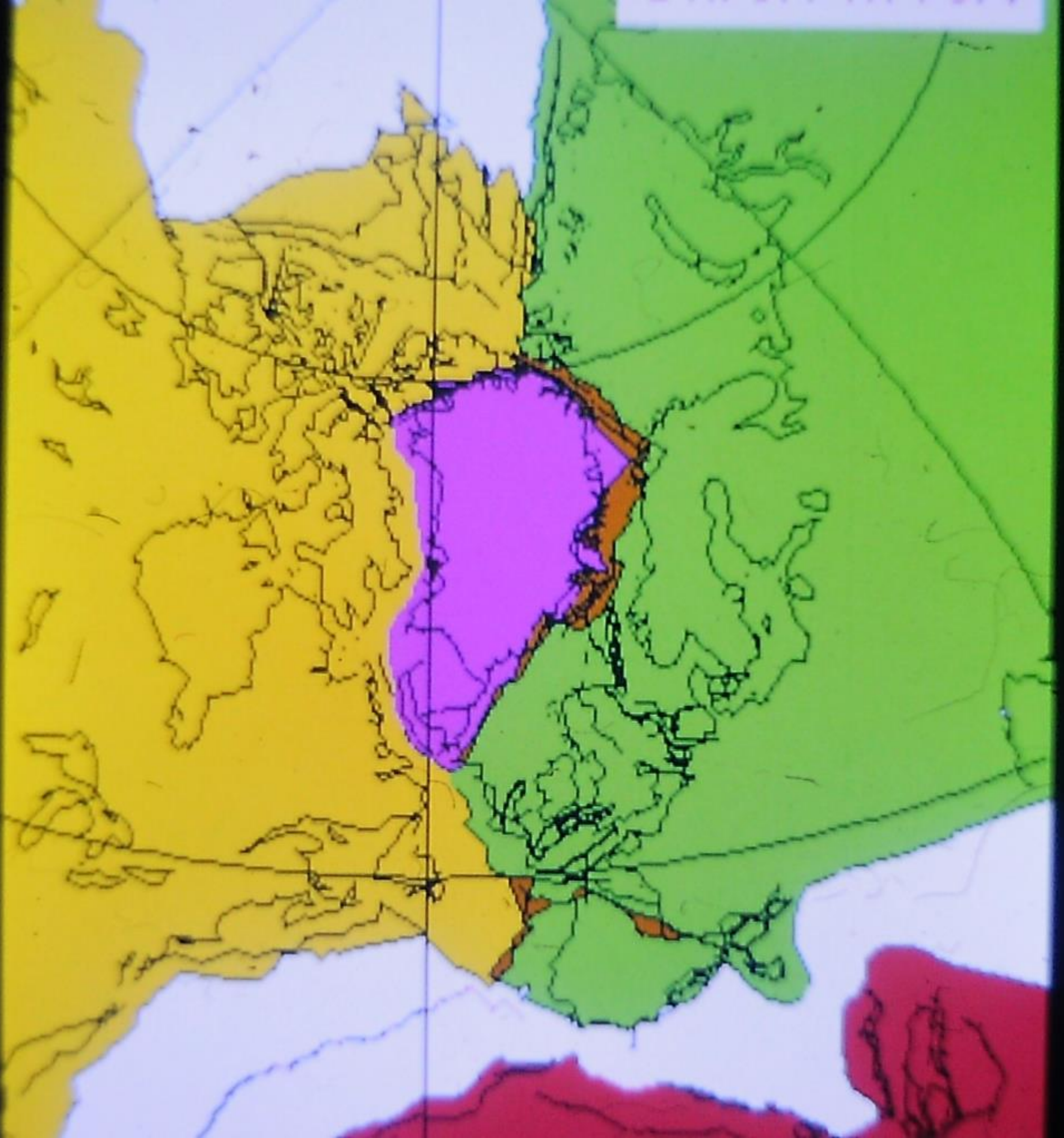
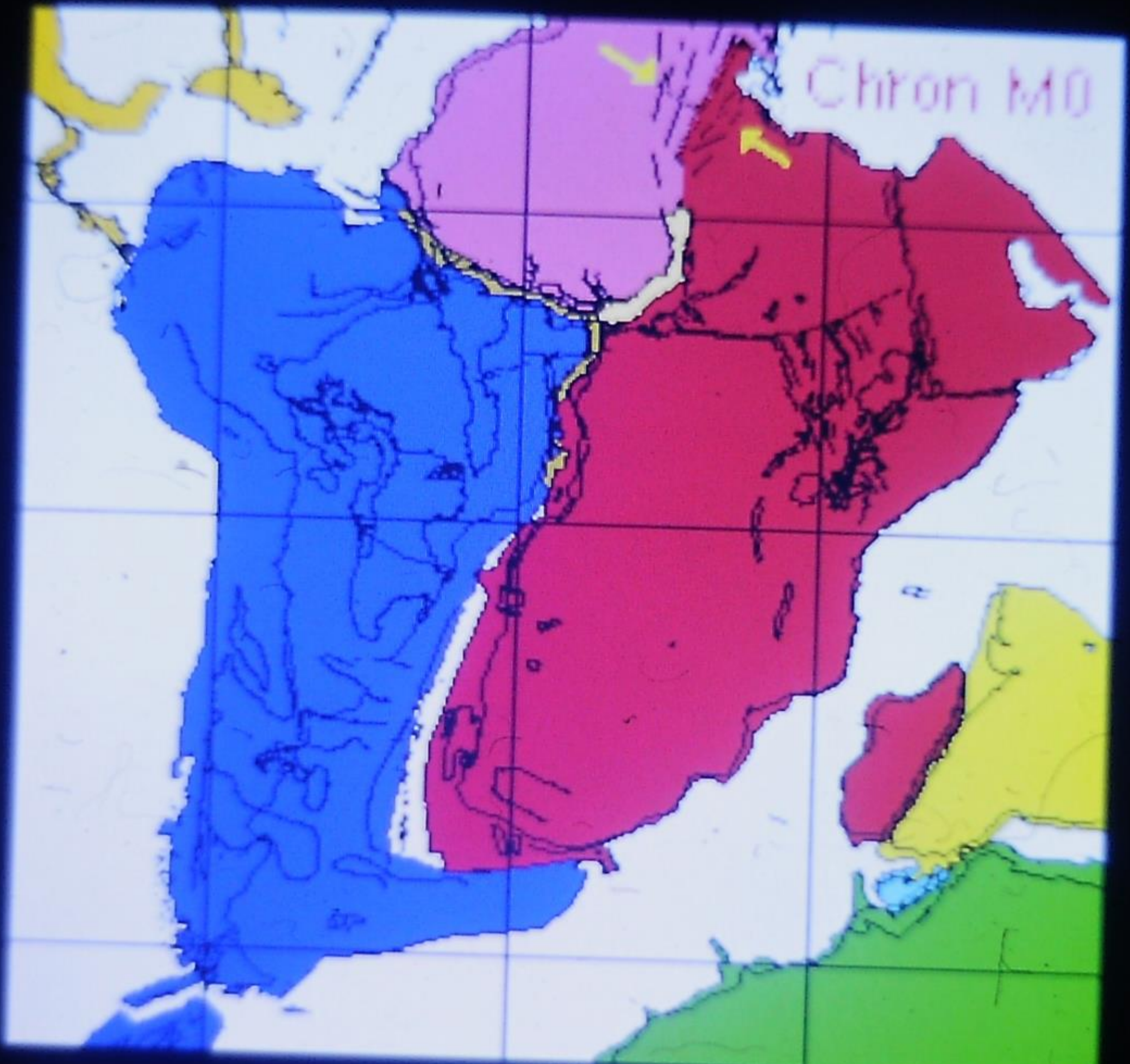
175 Ma

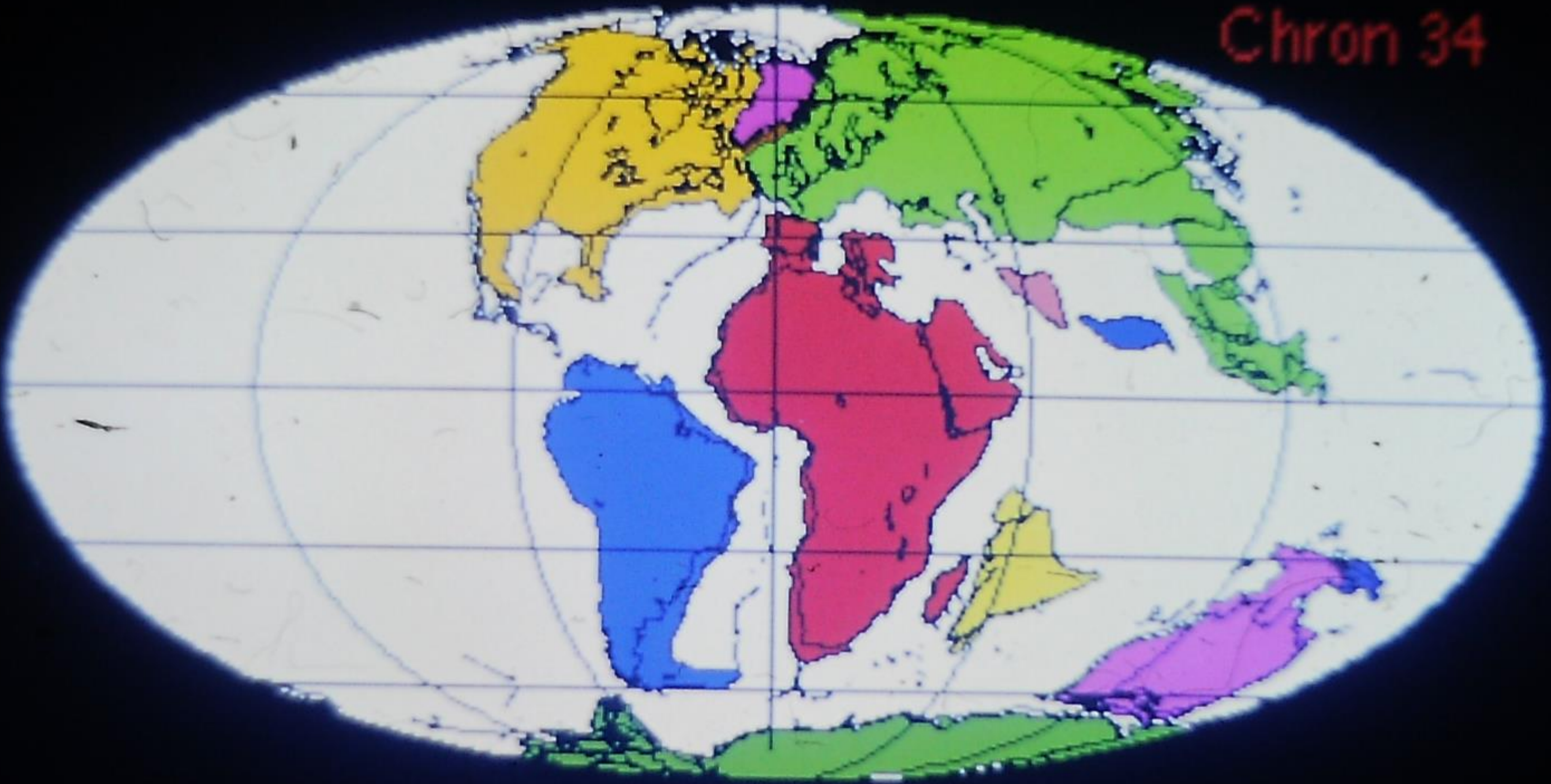

Chron M10

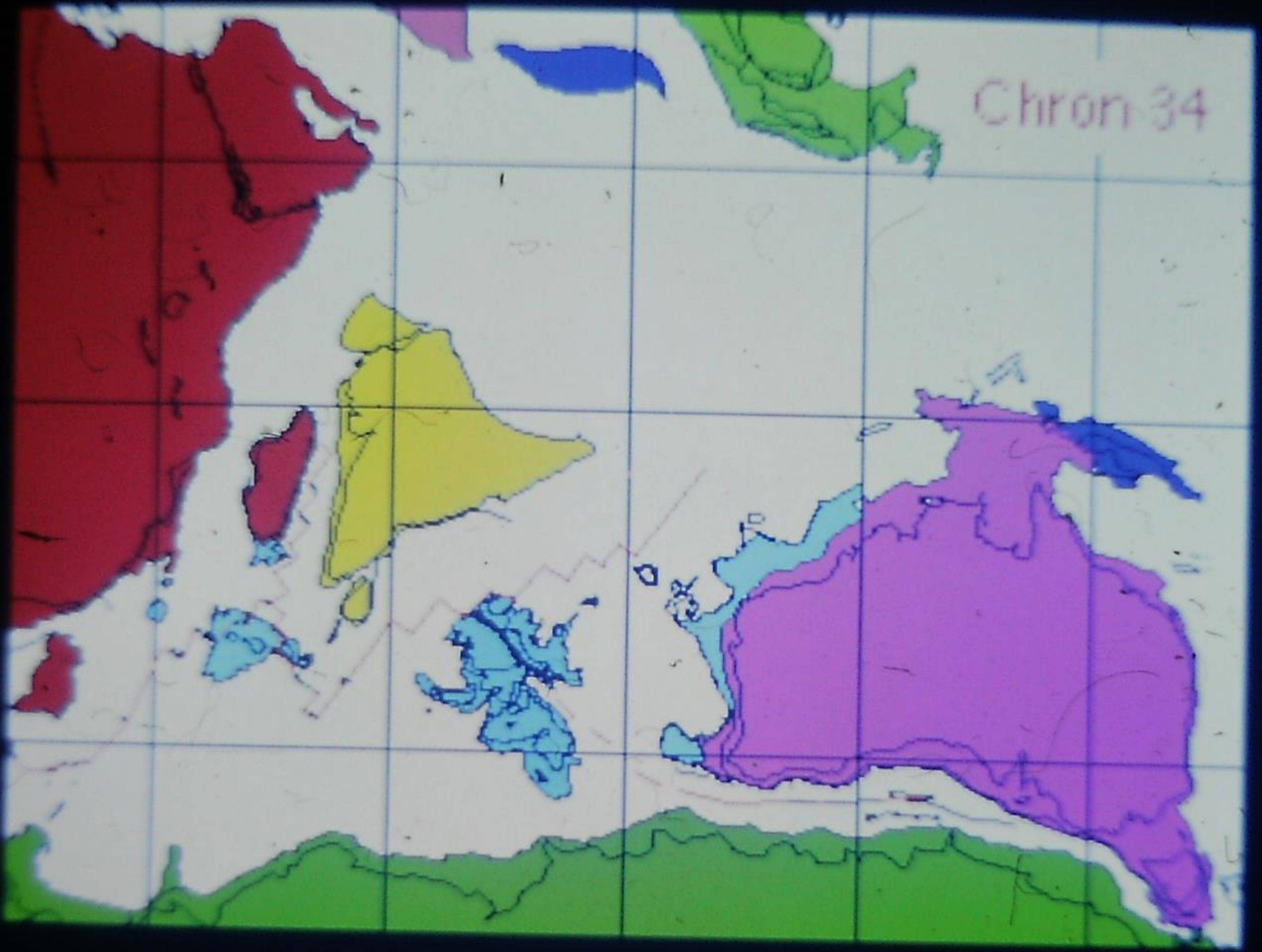

Chron M10



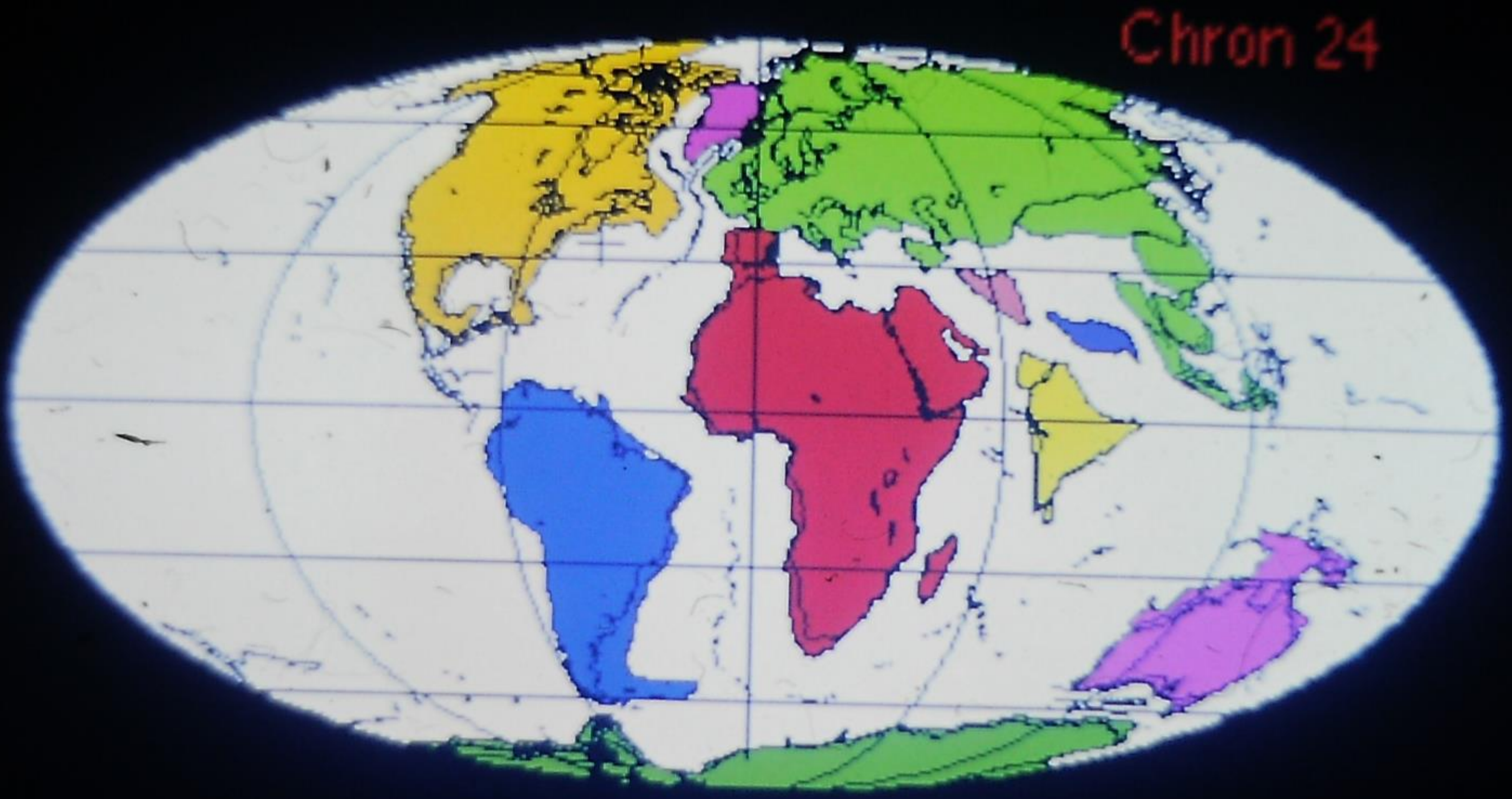

Chron M0

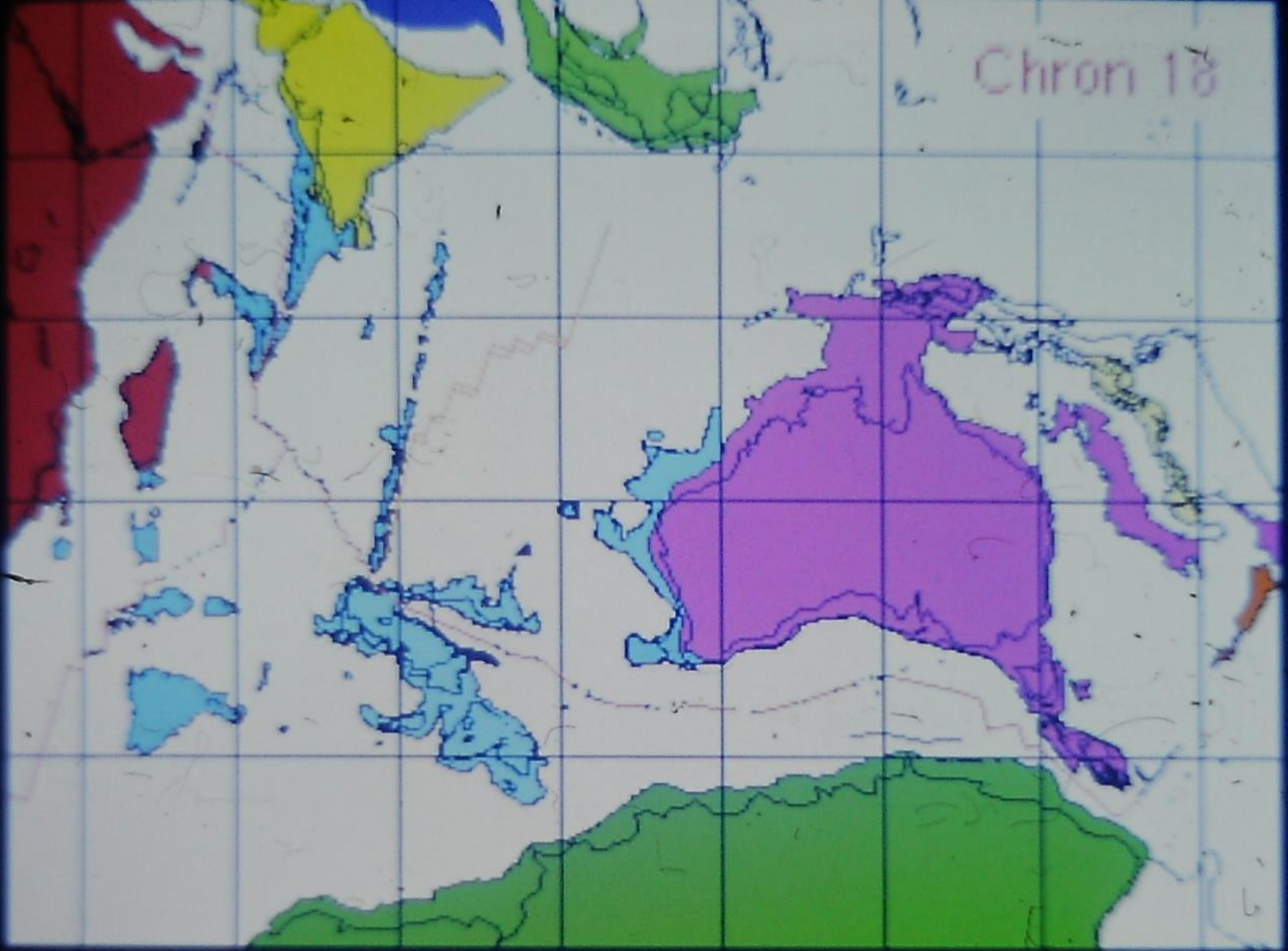

Chron M0


Chron 34

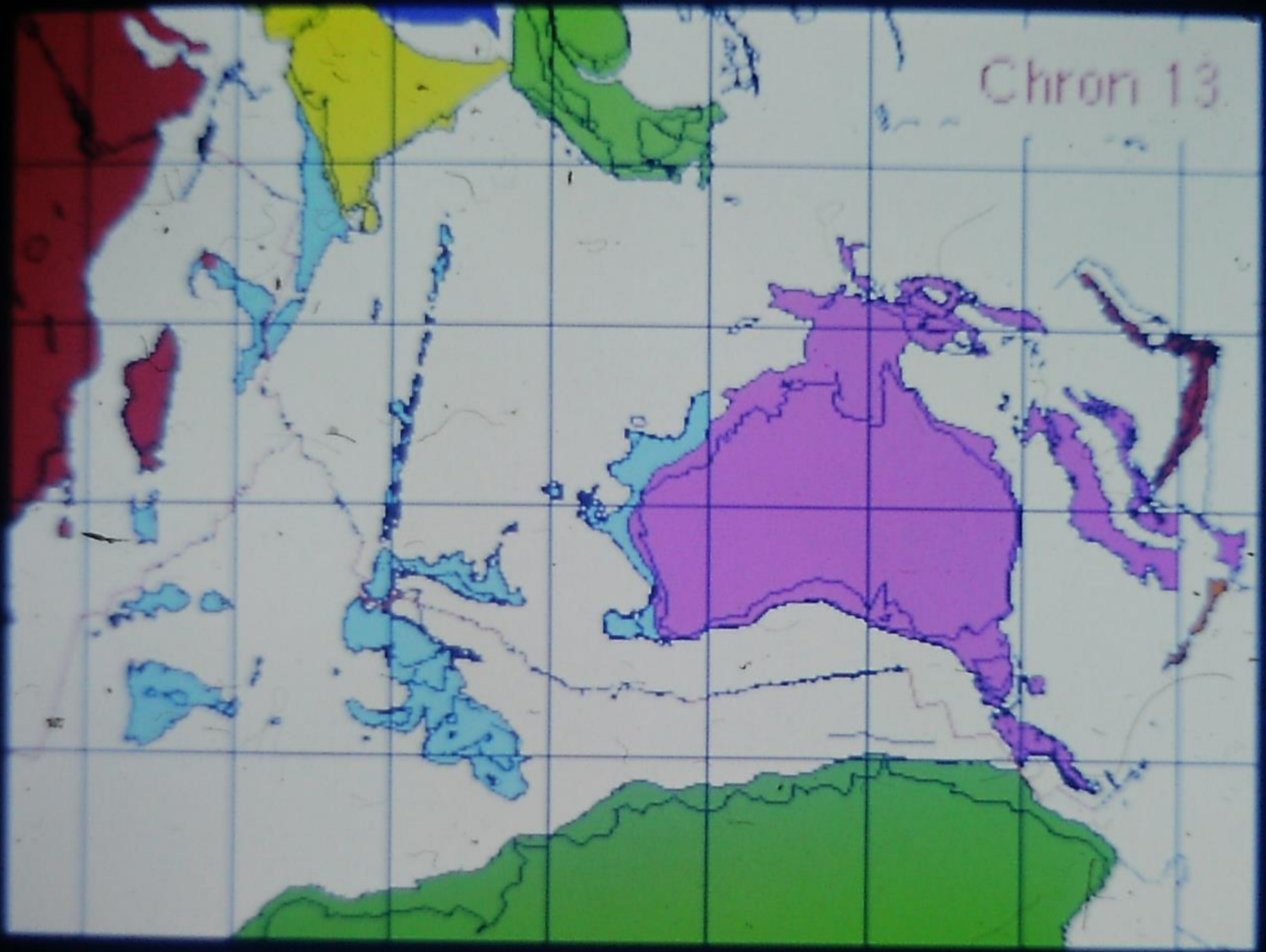

Chron 34


Chron 28


Chron 24


Chron 18


Chron 13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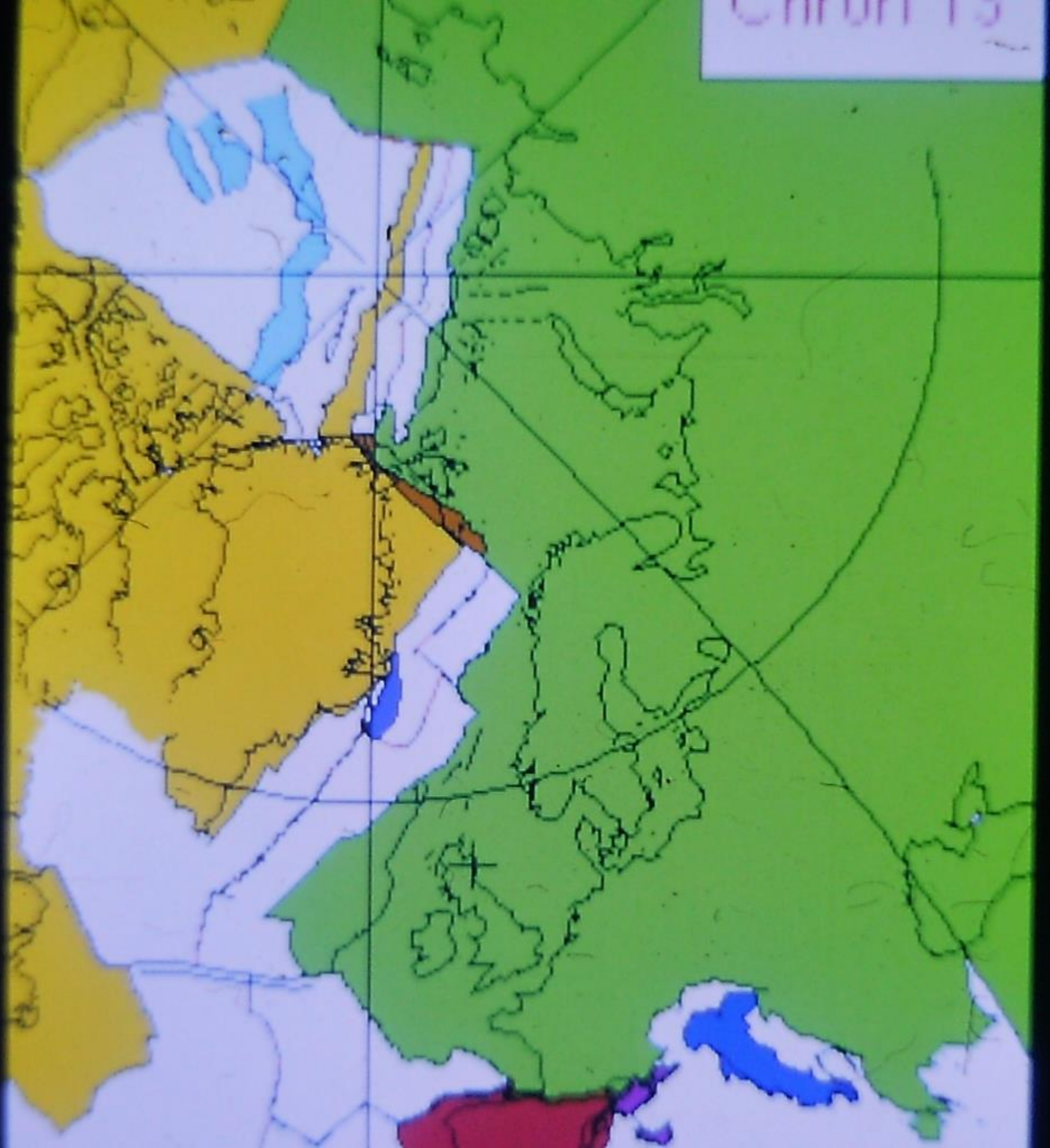

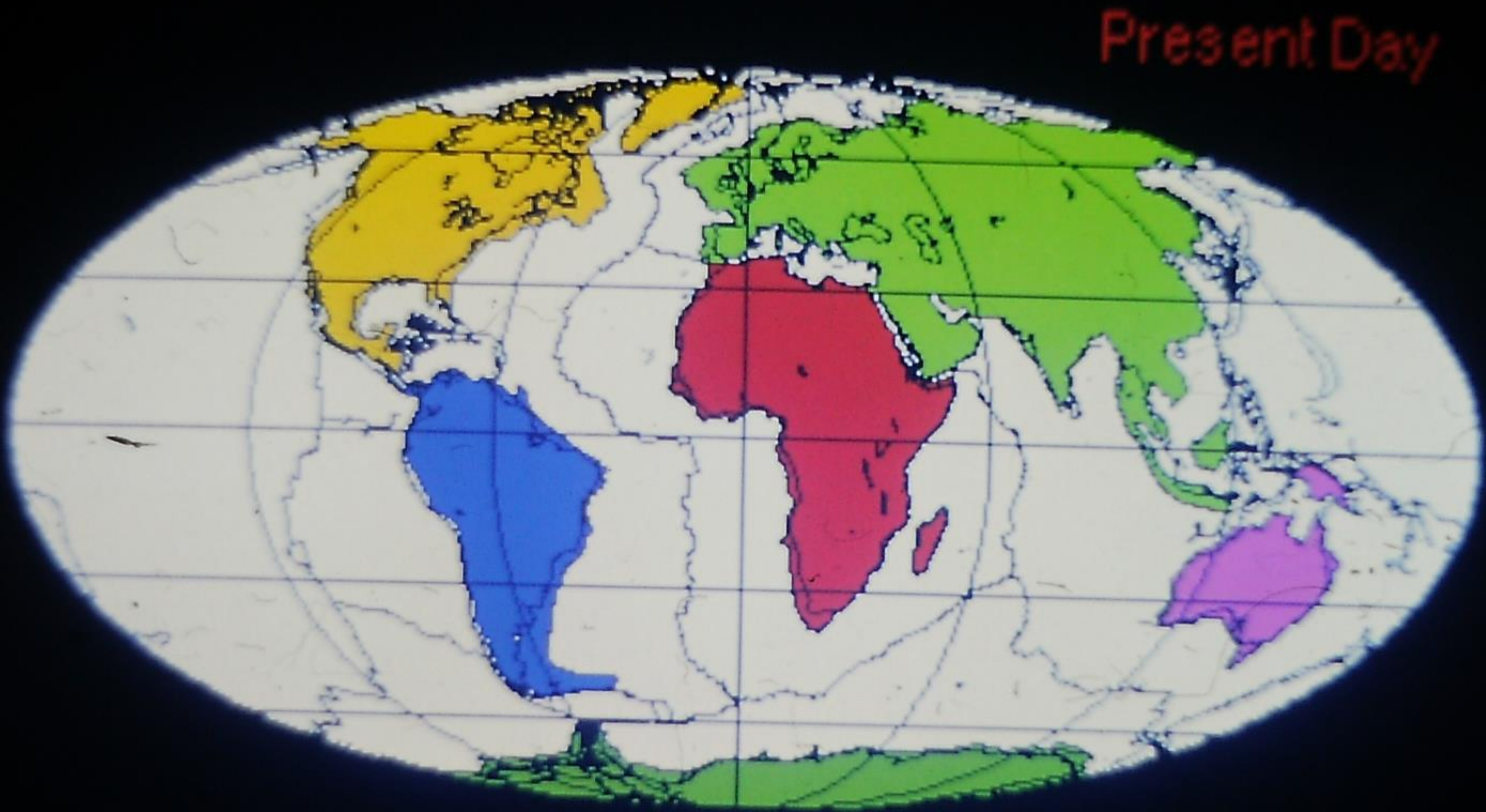
Present Day