

GEOLOGICAL MODEL PROJECT SUMMARY



International Seabed Authority
Geological Model Project

Sensitization Seminar, United Nations New York
February 16, 2012

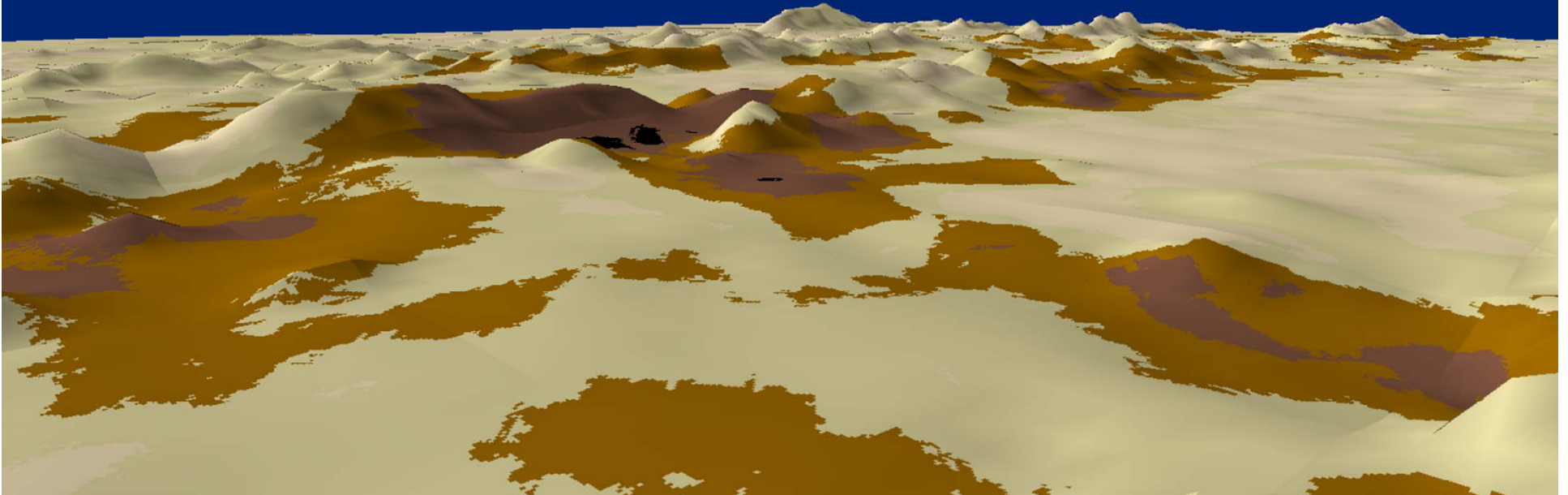


GEOLOGICAL MODEL ITEMS FOR DISCUSSION

- **OVERVIEW**
- **RESOURCE DATA & ASSESSMENT**
- **GEOLOGICAL MODEL SUMMARY
OF RESULTS**
- **EARLY APPLICATION OF PROJECT
RESULTS TO NORI/TOML
CONTRACT AREAS**

PROJECT OVERVIEW

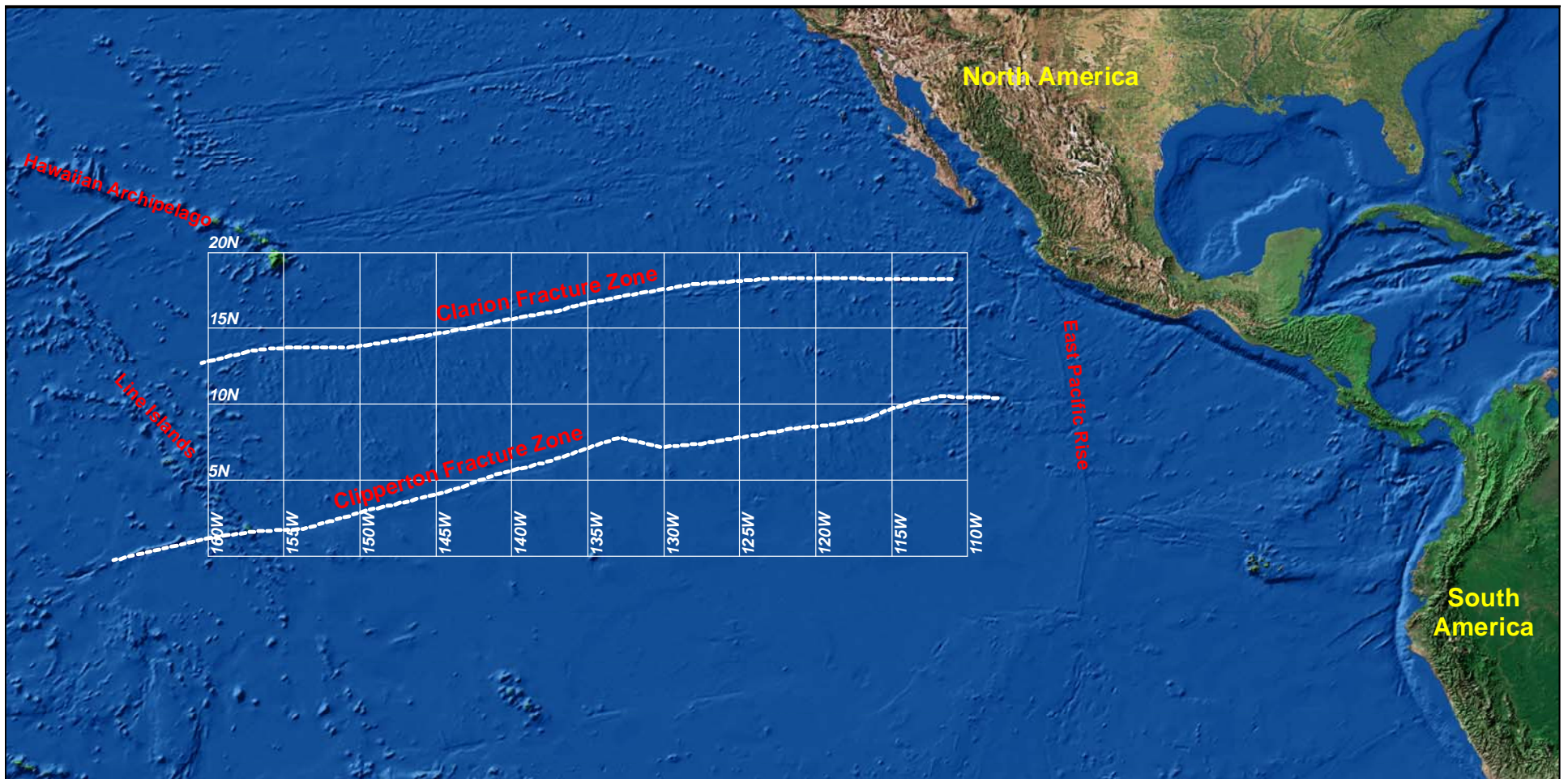
- OBJECTIVES
- TEAM
- MILESTONES
- PRODUCTS



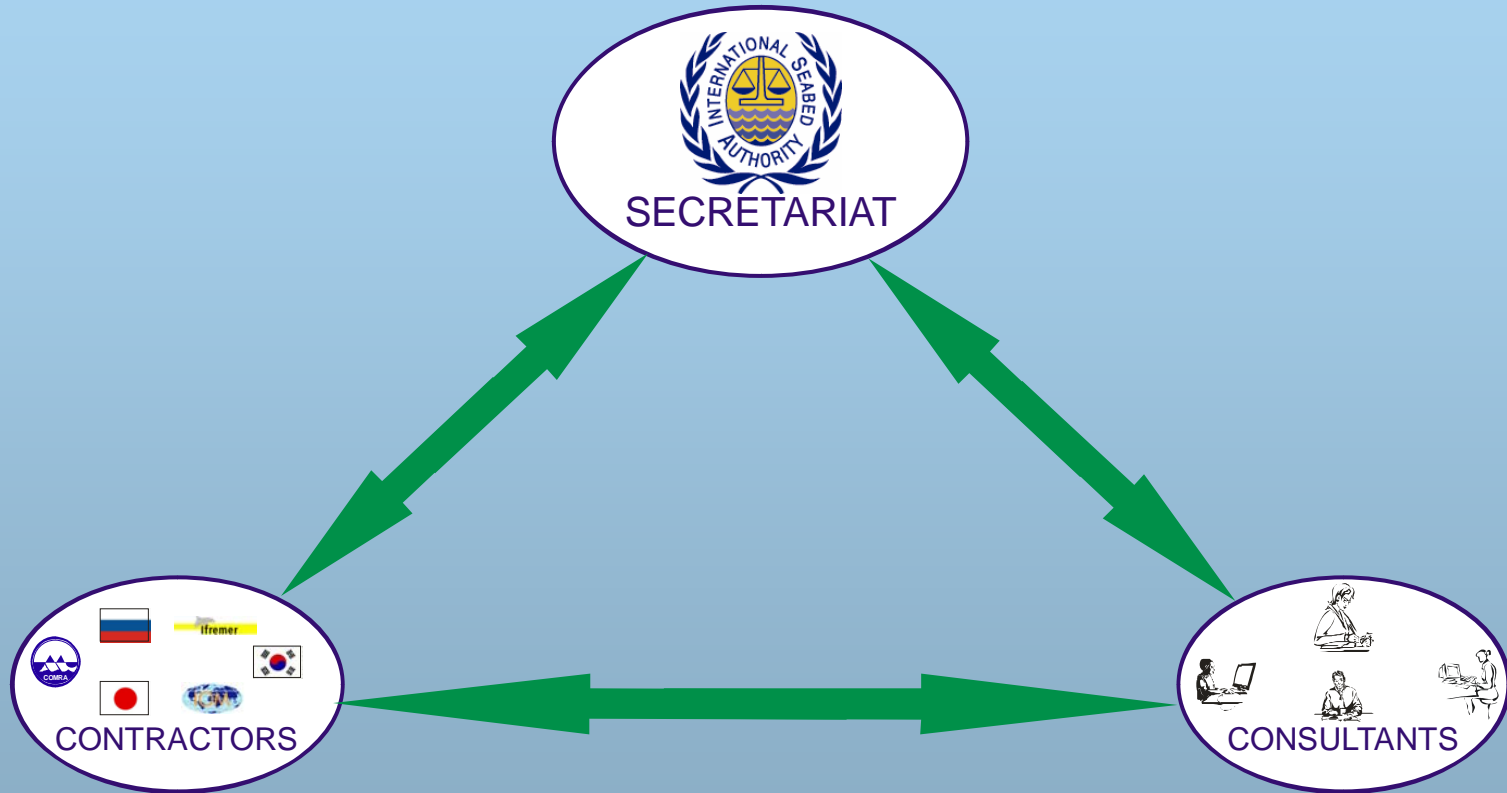
ISA PROJECT OBJECTIVES

- 1. IMPROVE CLARION-CLIPPERTON
ZONE (CCZ) RESOURCE
ASSESSMENT**
- 2. INTEGRATE AVAILABLE
RESOURCE AND RELATED
ENVIRONMENTAL DATA**
- 3. PROVIDE USEFUL GUIDELINES
FOR PROSPECTING AND
EXPLORATION**

CLARION-CLIPPERTON ZONE 110° – 160° W; 0° – 20° N



PROJECT TEAM



PROJECT MILESTONES

MILESTONE

COMPLETION DATE

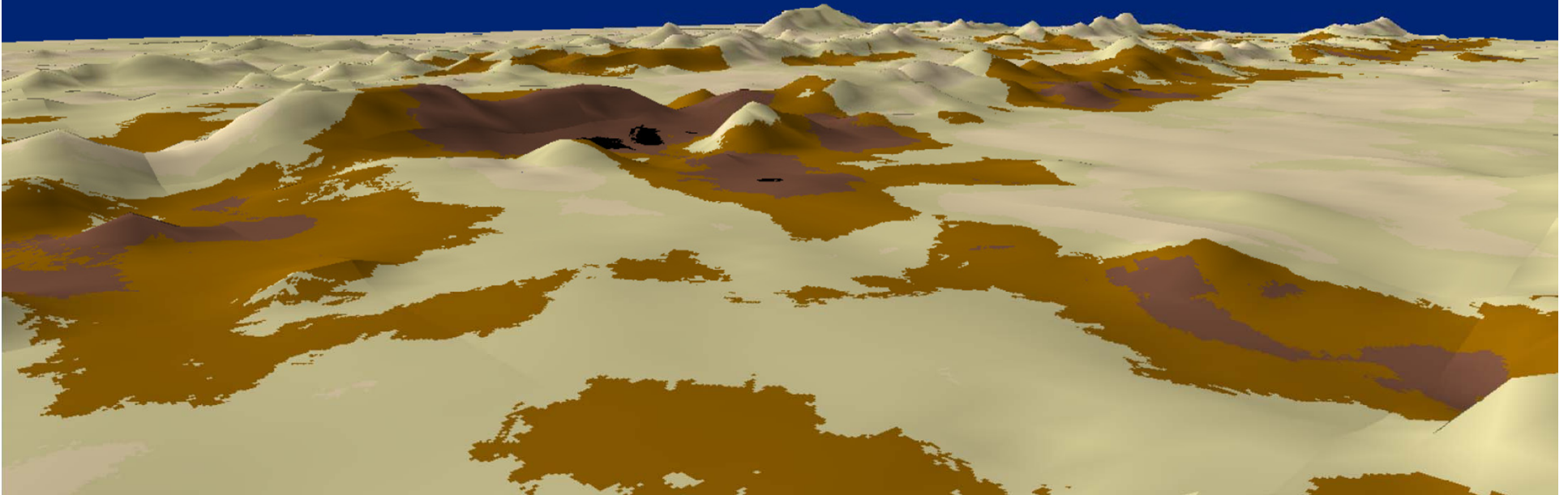
- | | |
|------------------------|----------------|
| 1. PRELIMINARY REPORTS | 2006 - 2007 |
| 2. MID-COURSE MTG. | NOVEMBER 2007 |
| 3. REPORTS ASSEMBLED | FEBRUARY 2009 |
| 4. FINAL REVIEW | SEPTEMBER 2009 |
| 5. FINAL WORKSHOP | NOVEMBER 2009 |
| 6. PUBLISHED BY ISA | MARCH 2010 |

DELIVERED PRODUCTS

- ***RESOURCE DATA &
ASSESSMENT***
- ***GEOLOGICAL &
ENVIRONMENTAL DATA
ASSEMBLY***
- ***GEOLOGICAL MODEL***
- ***PROSPECTOR'S GUIDE***

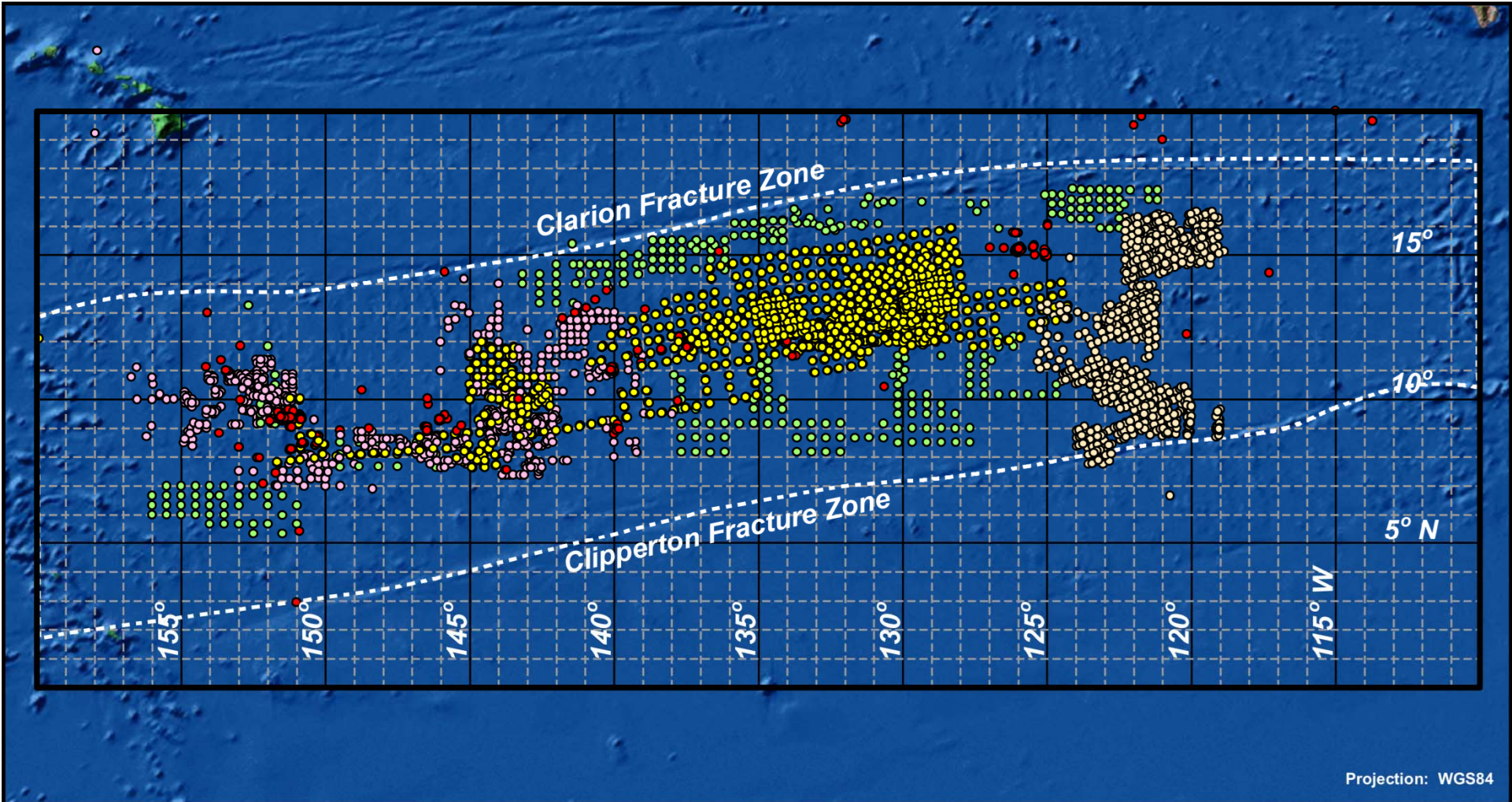
RESOURCE DATA & ASSESSMENT

- SOURCES
- SPATIAL DISTRIBUTIONS
- ASSESSMENT SUMMARY



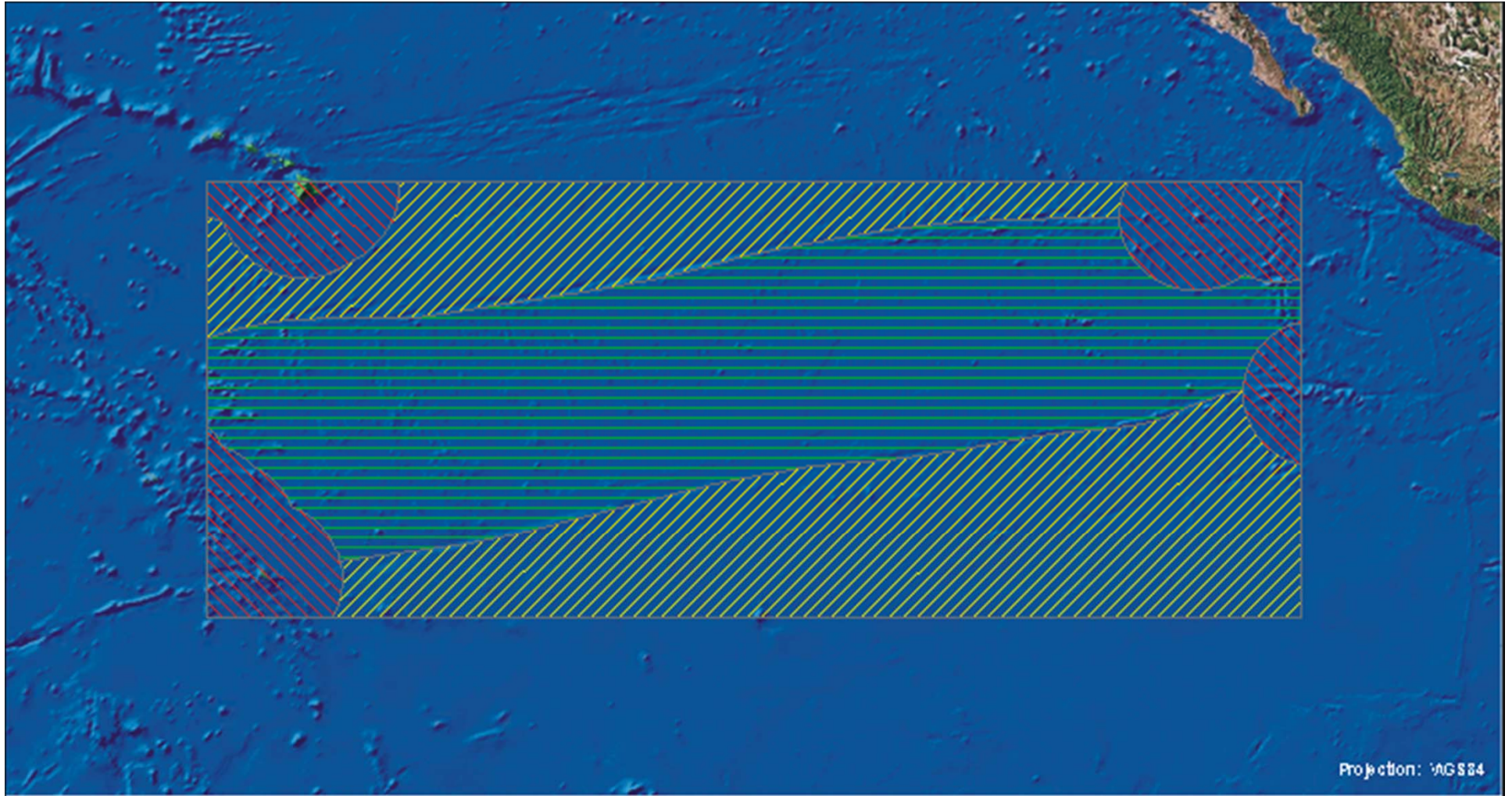
RESOURCE DATA




<i>Data Source</i>	<i>CDR</i>	<i>KOREA</i>	<i>OMCO</i>	<i>COMRA</i>	<i>IOM</i>	<i>Totals After Screening</i>
<i># Stations: Abundance</i>	253	329	7,738	52,473	790	61,583
<i># Stations: Manganese</i>	879	258	5,875	716	664	8,392
<i>#Stations: Cobalt</i>	711	258	5,900	716	664	8,249
<i>#Stations: Nickel</i>	799	258	5,923	716	664	8,360
<i># Stations: Copper</i>	882	258	5,924	714	664	8,442



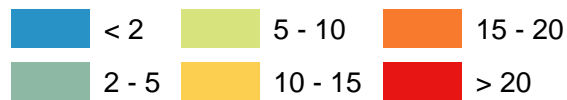
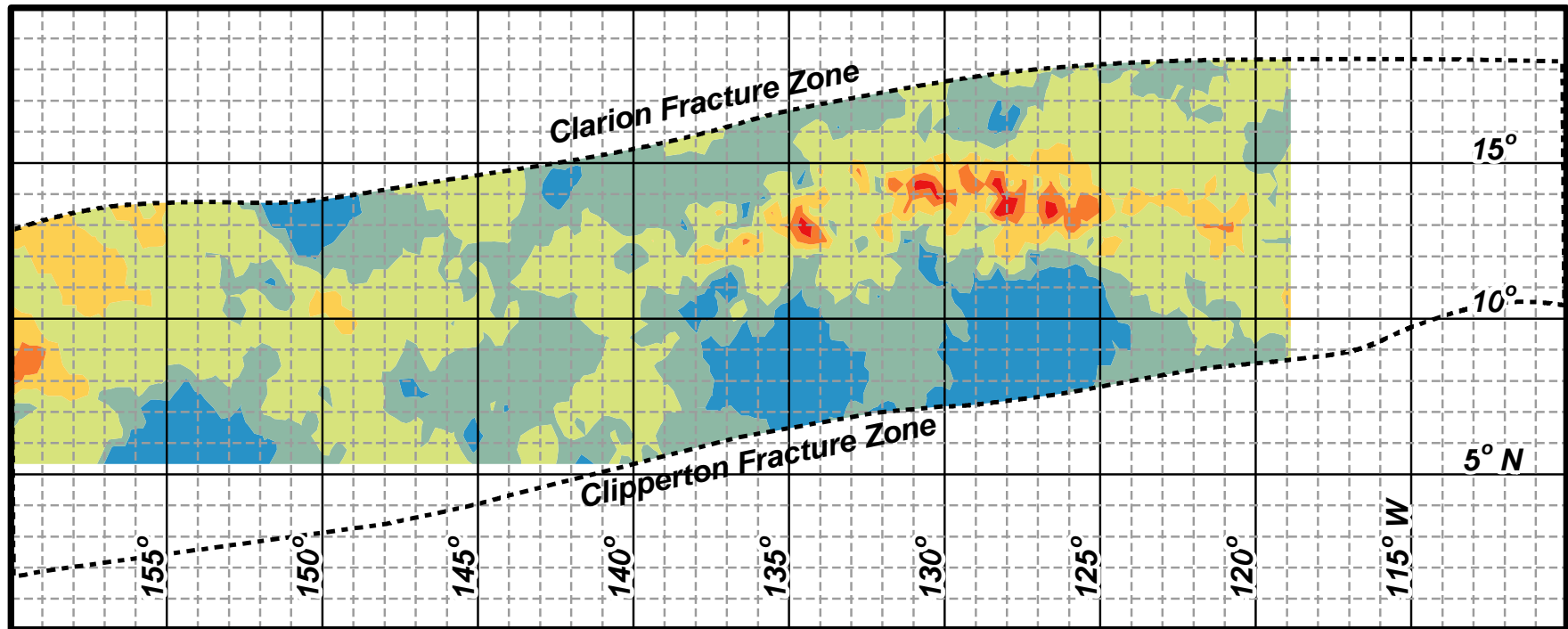
Source of Data		
● CDR	○ IOM	● OMCO
● COMRA	● KORDI	

CCZ AREA BREAKDOWN

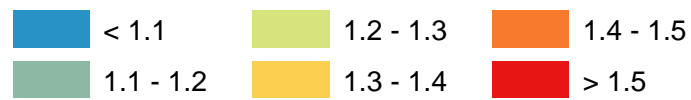
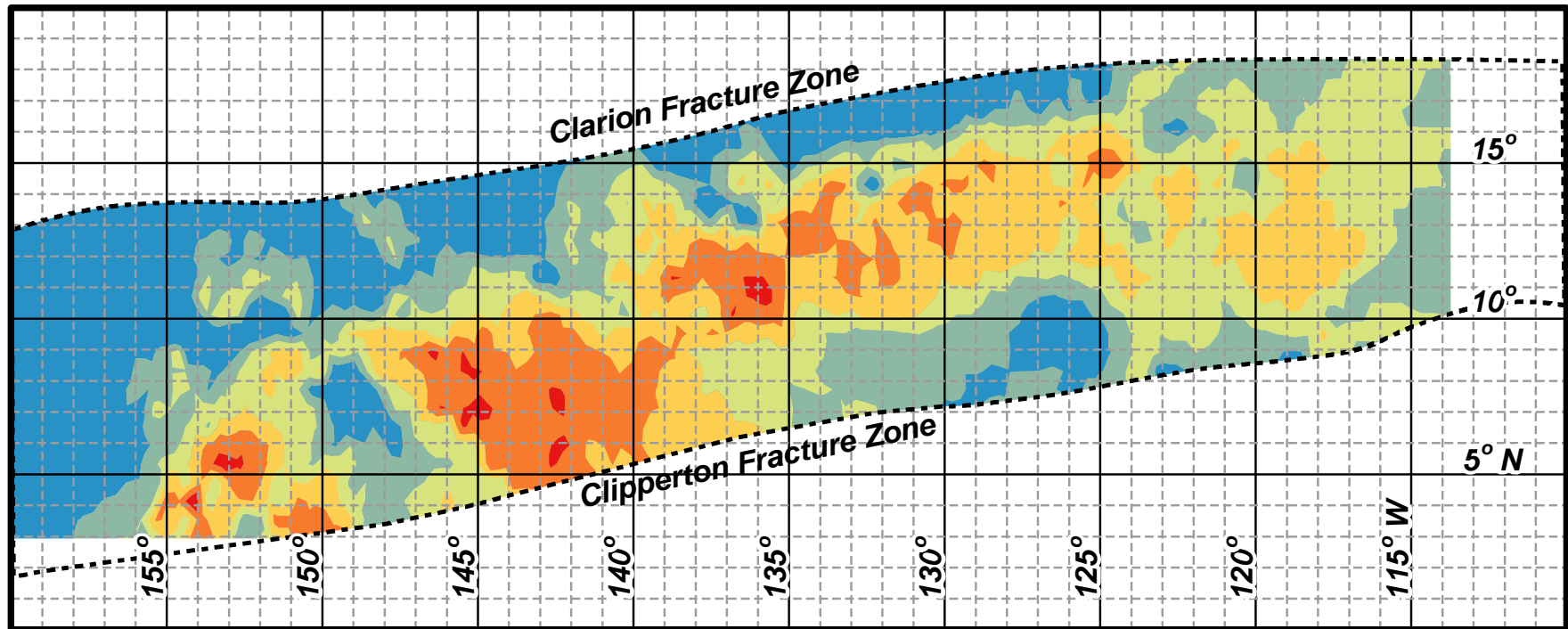


-  Between Fracture Zones & in Area (5.19 M km²)
-  In Nation State Exclusive Economic Zones (1.39 M km²)
-  In Area but not Between Fracture Zones (5.52 M km²)

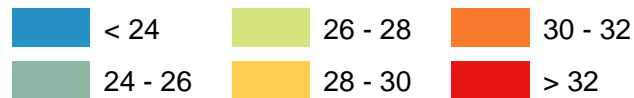
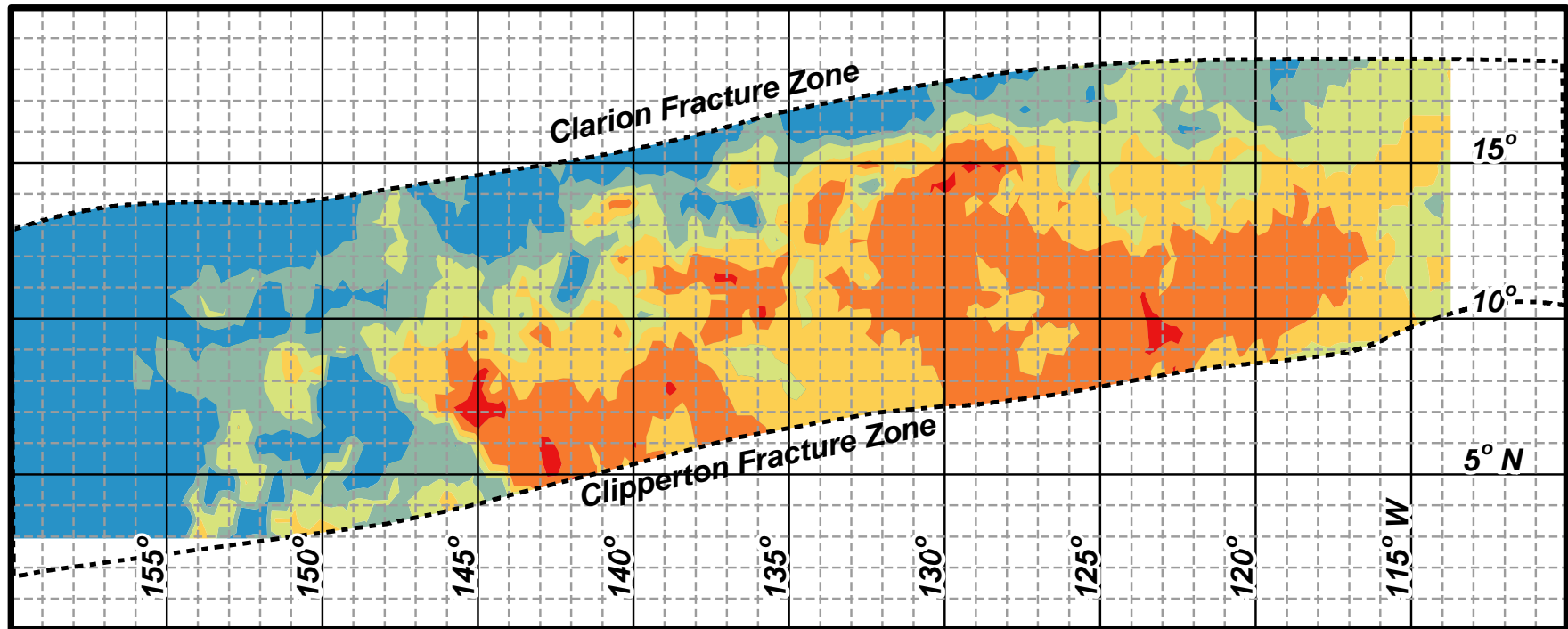
Nodule Abundance (kg/m²)



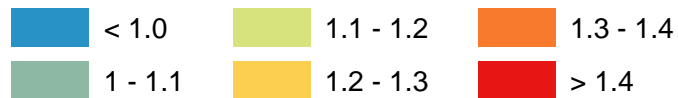
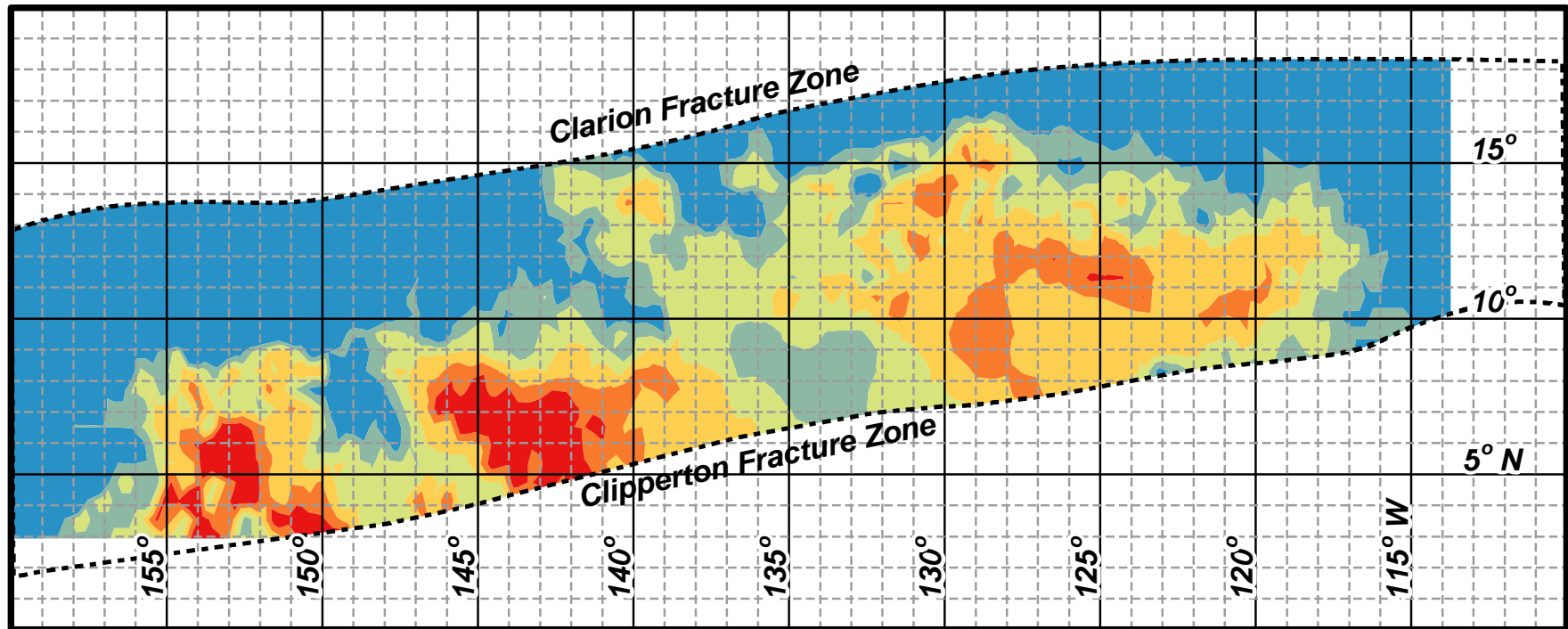
Nickel (Dry Wt. %)



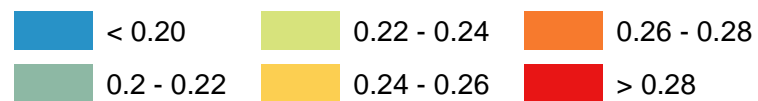
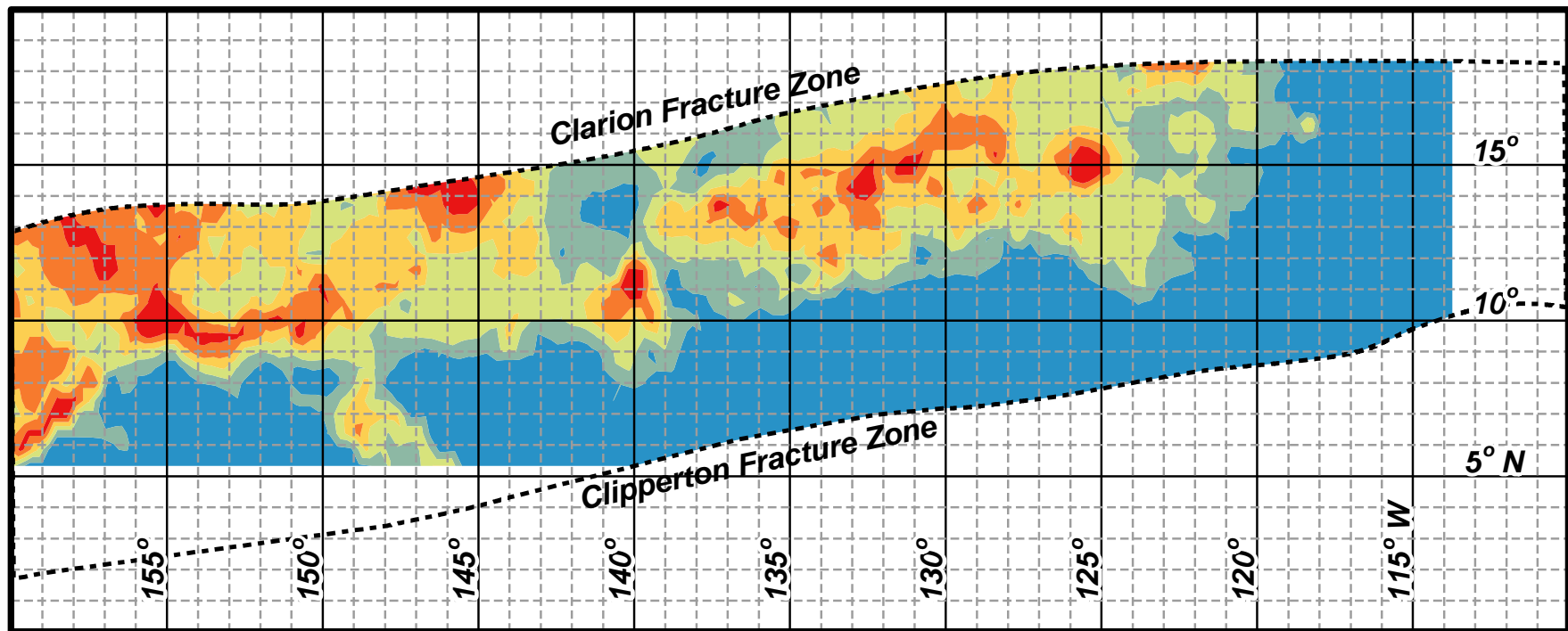
Manganese (Dry Wt. %)



Copper (Dry Wt. %)



Cobalt (Dry Wt. %)

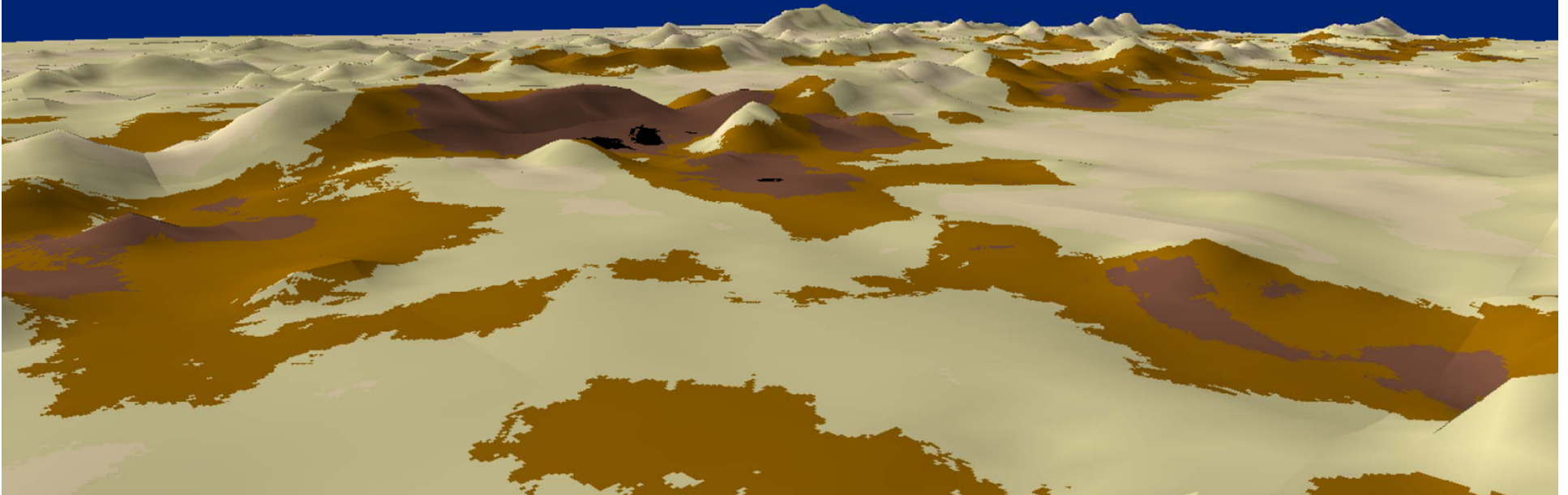


RESOURCE ASSESSMENT SUMMARY

Source	Included Area (km ² X 10 ⁶)	Inferred Resource (metric tons X 10 ⁶)				
		Nodules	Mn	Co	Ni	Cu
KORDI (low estimate)	3.83	21,100	5,950	46.4	270	234
KORDI (high estimate)	4.19	30,700	8,657	67.5	393	341
Ordinary Kriging	4.85	27,100	7,300	58.0	340	290
Annual World Production	-	-	31 (2006)	0.07 (2009)	1.4 (2007)	16 (2010)
Source; ISA Technical Study #6						

GEOLOGICAL MODEL

- BIOGEOCHEMICAL APPROACH
- SDSS APPROACH



MODEL GOAL: USE PROXY DATA TO PREDICT RESOURCE DATA

PROXY DATA

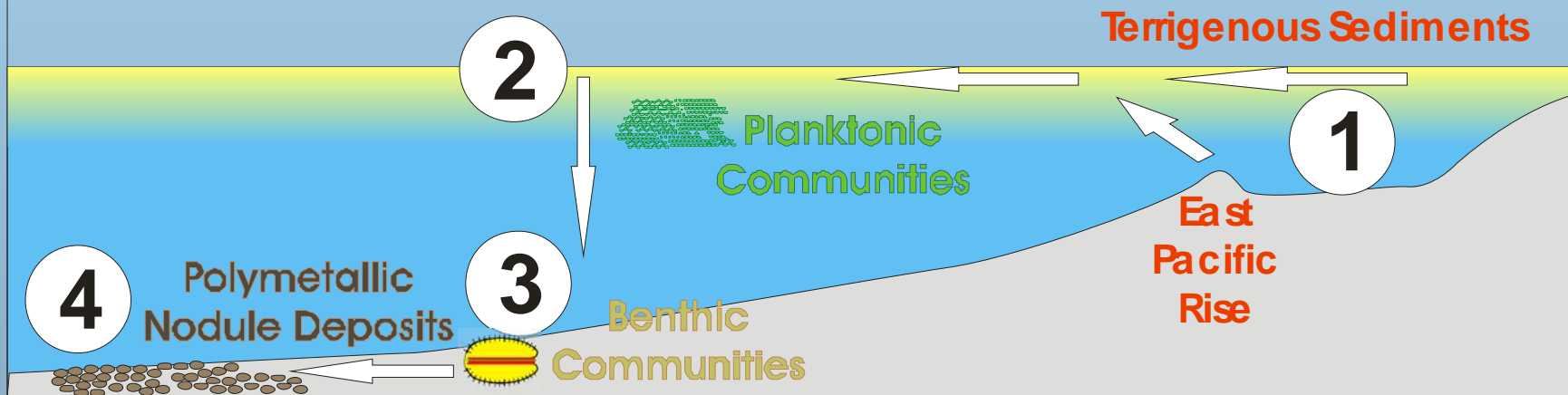
- ***BATHYMETRY***
- ***TECTONIC/VOLCANIC
DATA***
- ***SEDIMENT DATA***
- ***NODULE MORPHOLOGY***
- ***WATER COLUMN DATA***
- ***BIOLOGICAL DATA***

RESOURCE DATA

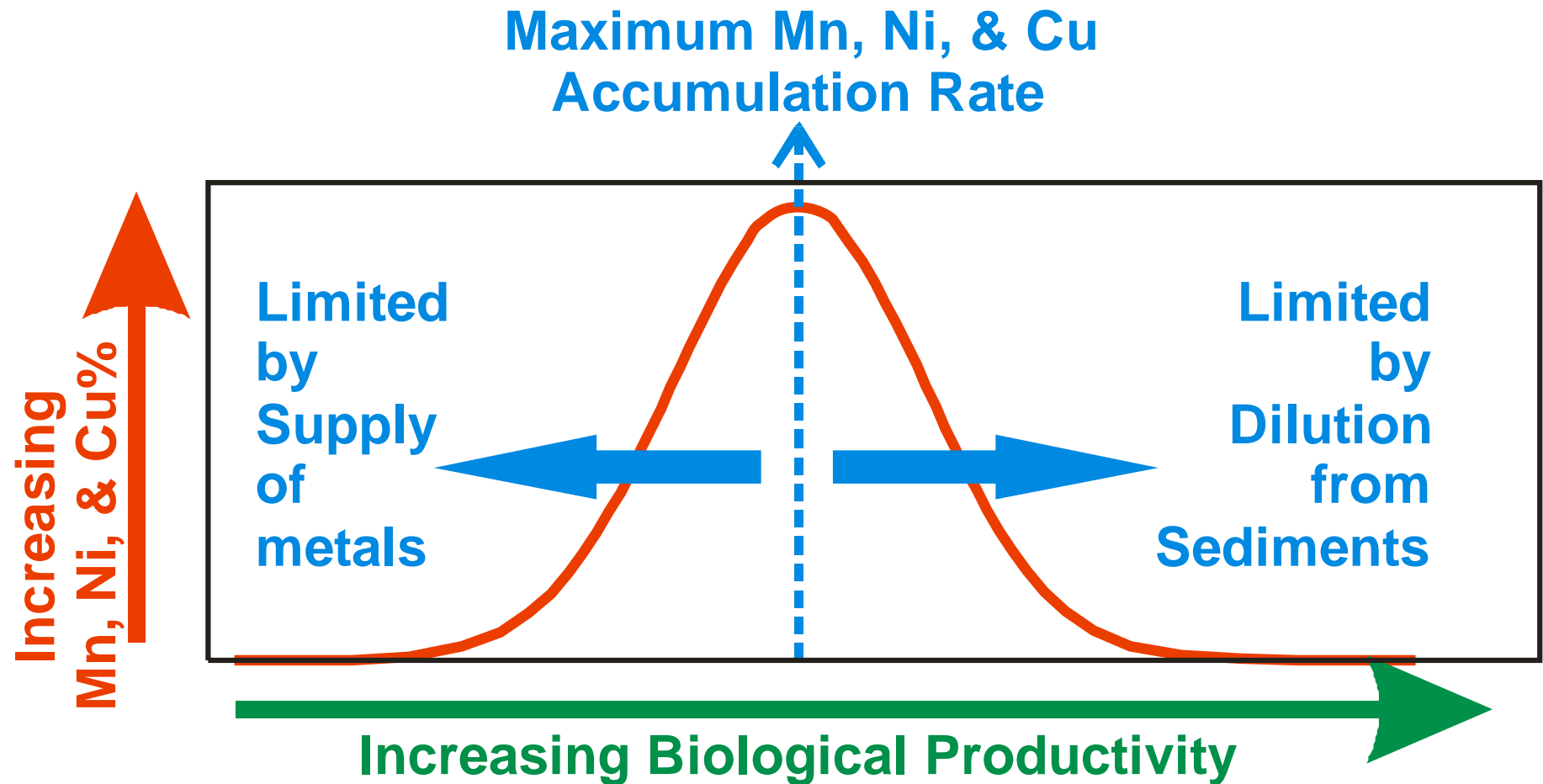
- ***ABUNDANCE***
- ***MANGANESE***
- ***NICKEL***
- ***COPPER***
- ***COBALT***

BIOGEOCHEMICAL MODEL GENERAL HYPOTHESIS

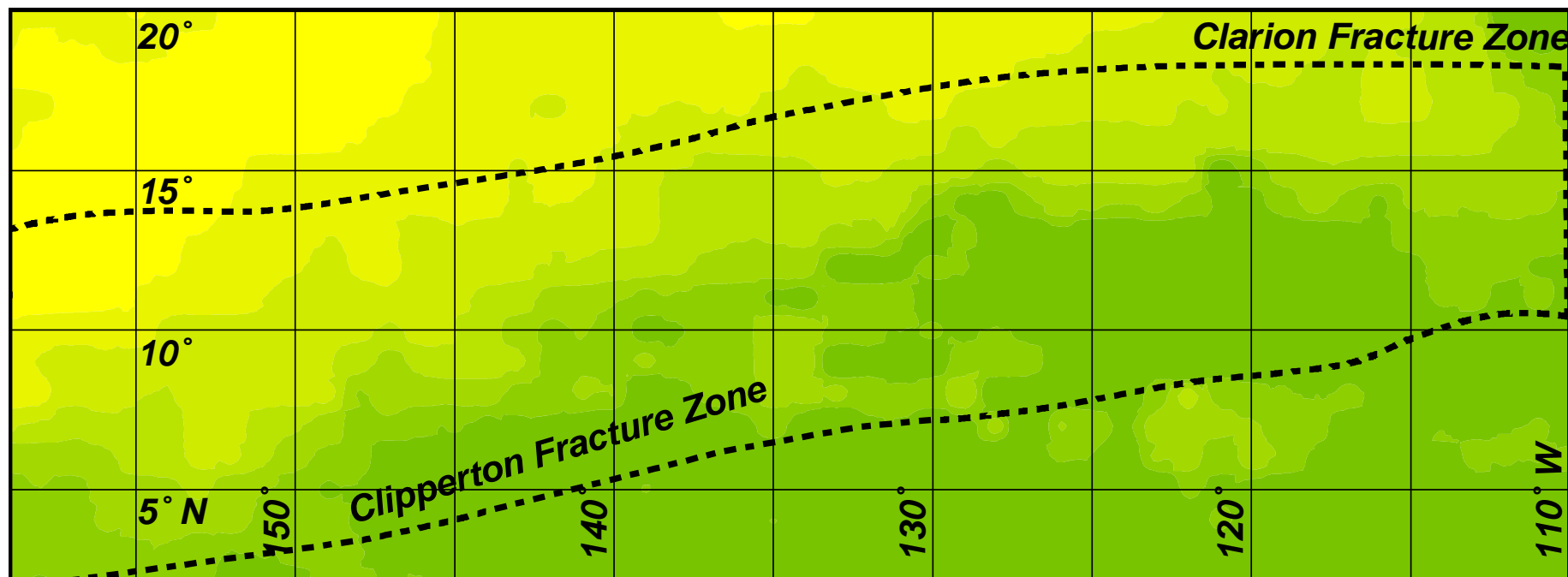
1. Sources of metals: Land and East Pacific Rise, carried in suspended sediments
2. Sediments consumed by zooplankton & converted to larger pellets that sink
3. Fecal pellets metabolized by benthic fauna, releasing reduced metals
4. Reduced metals scavanged by Mn oxide surfaces



BIOGEOCHEMICAL MODEL: PREDICTED EFFECT ON DEPOSITS



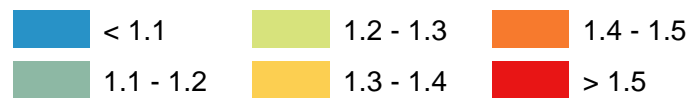
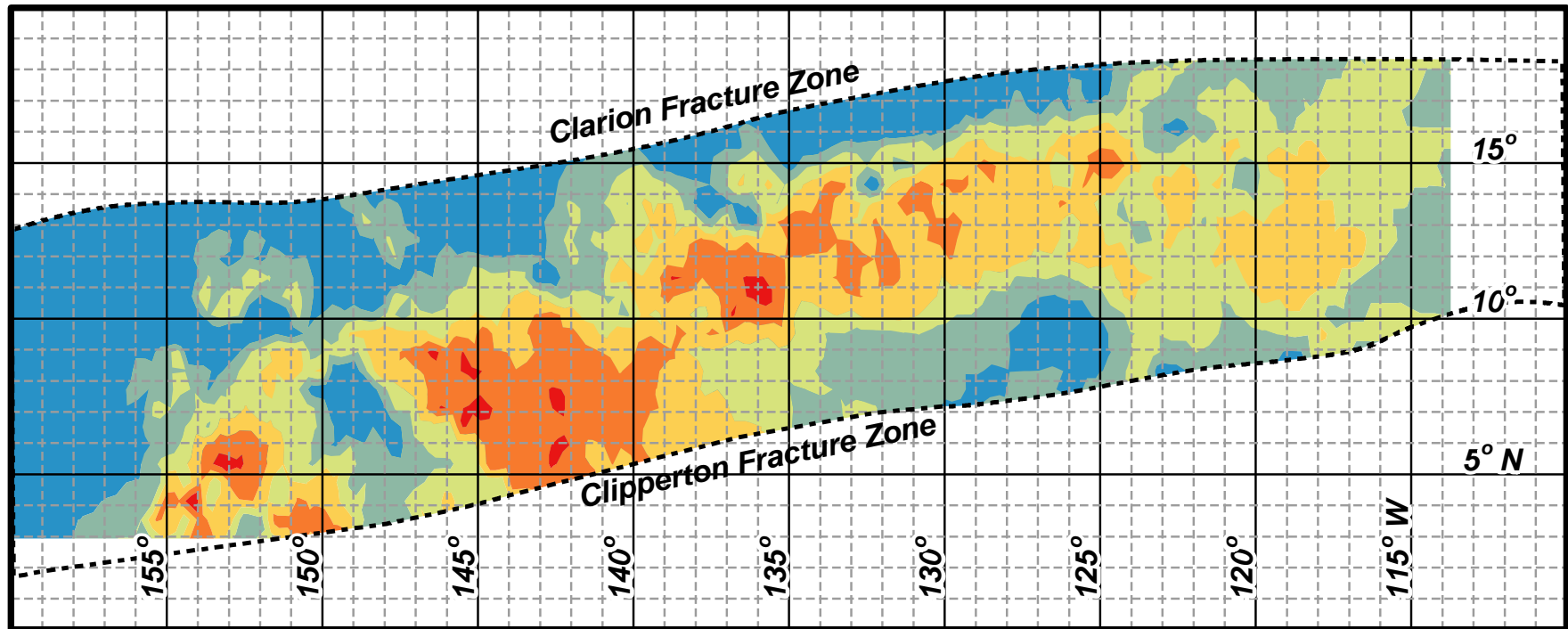
Surface Water Chlorophyll



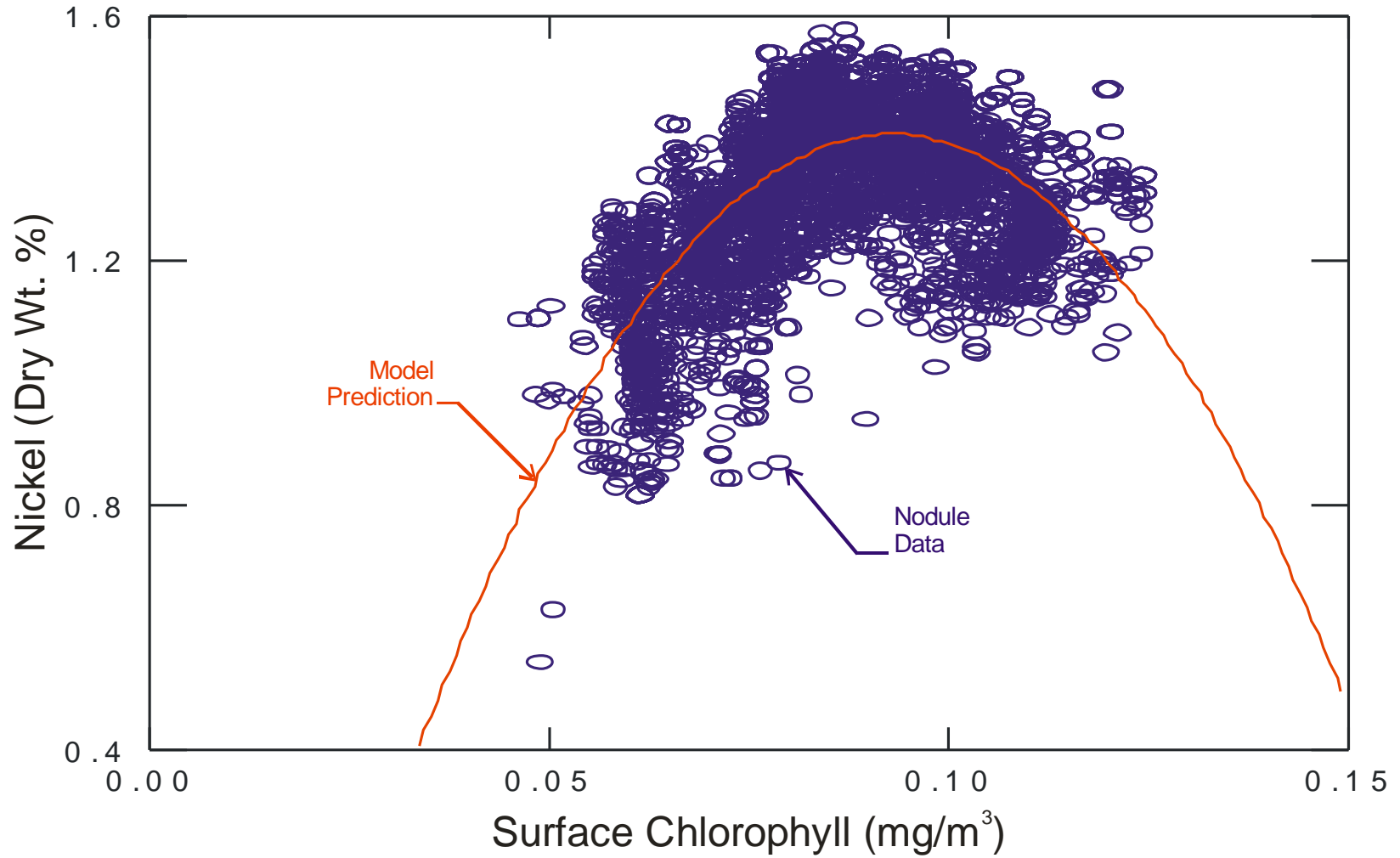
Surface Water
Chlorophyll (mg/m^3)



Nickel (Dry Wt. %)



***MODEL FIT WITH
CHLOROPHYLL DATA
($R^2 = 0.44$)***



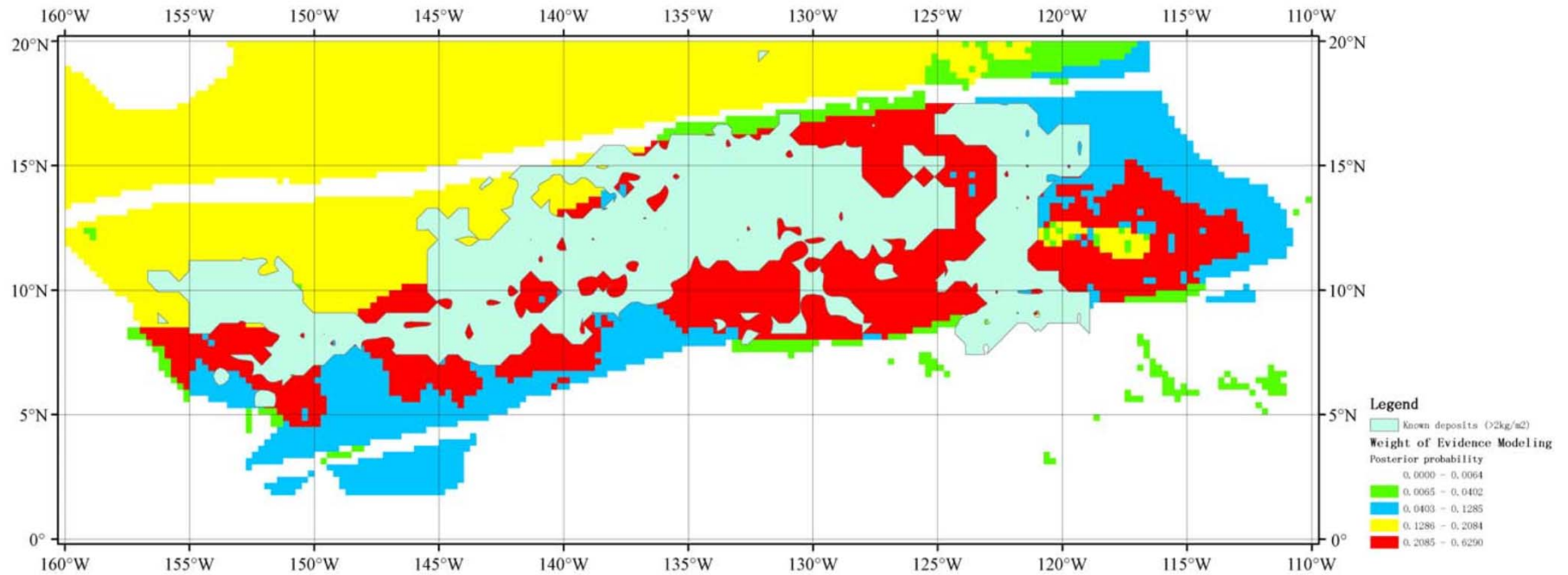
BIOGEOCHEMICAL MODEL PRIMARY RESULTS

- ABUNDANCE NOT PREDICTED**
- MODEL ACCOUNTS FOR ~50% OF Mn, Ni, & Cu CONTENT VARIABILITY**

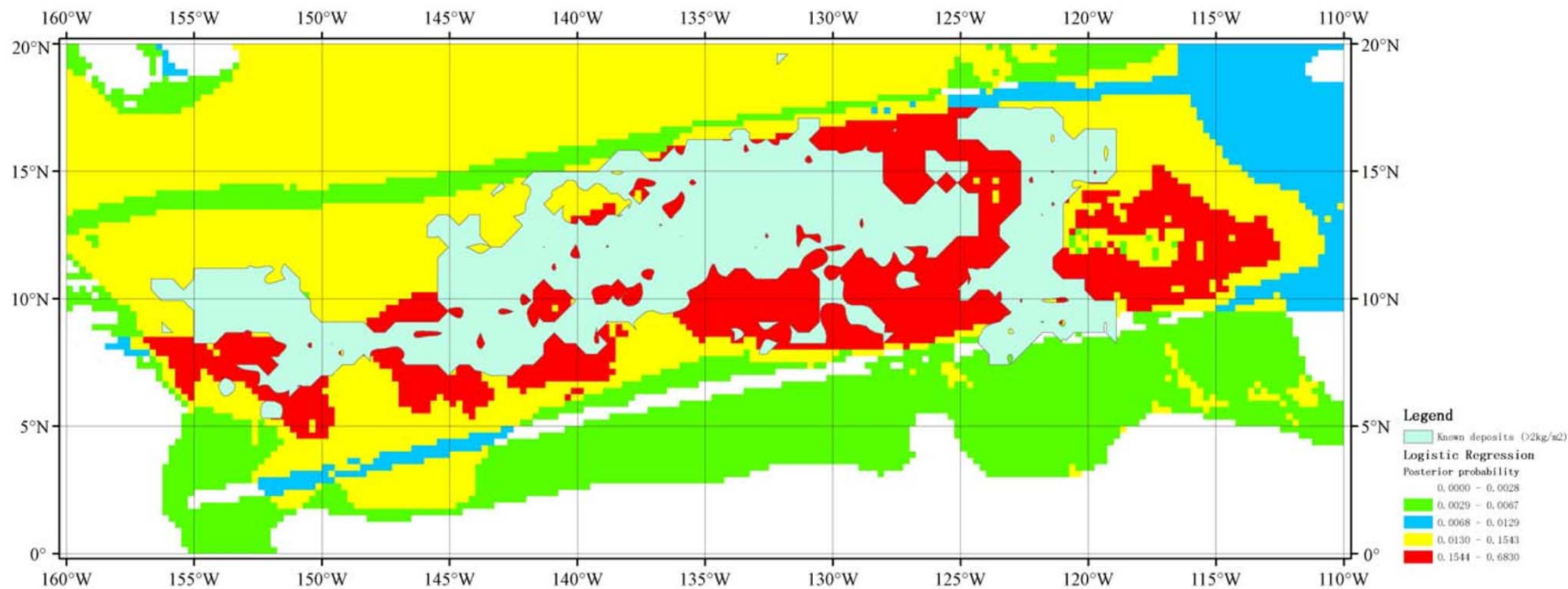
SPATIAL DECISION SUPPORT SYSTEM MODELING (SDSS)

- USED WITH STANDARD MINING
EXPLORATION METHODS**
- EMPLOYS OBJECTIVE ALGORITHMS
WITH POTENTIAL PROXY
VARIABLES**
- PREDICTS OPTIMAL EXPLORATION
TARGETS**

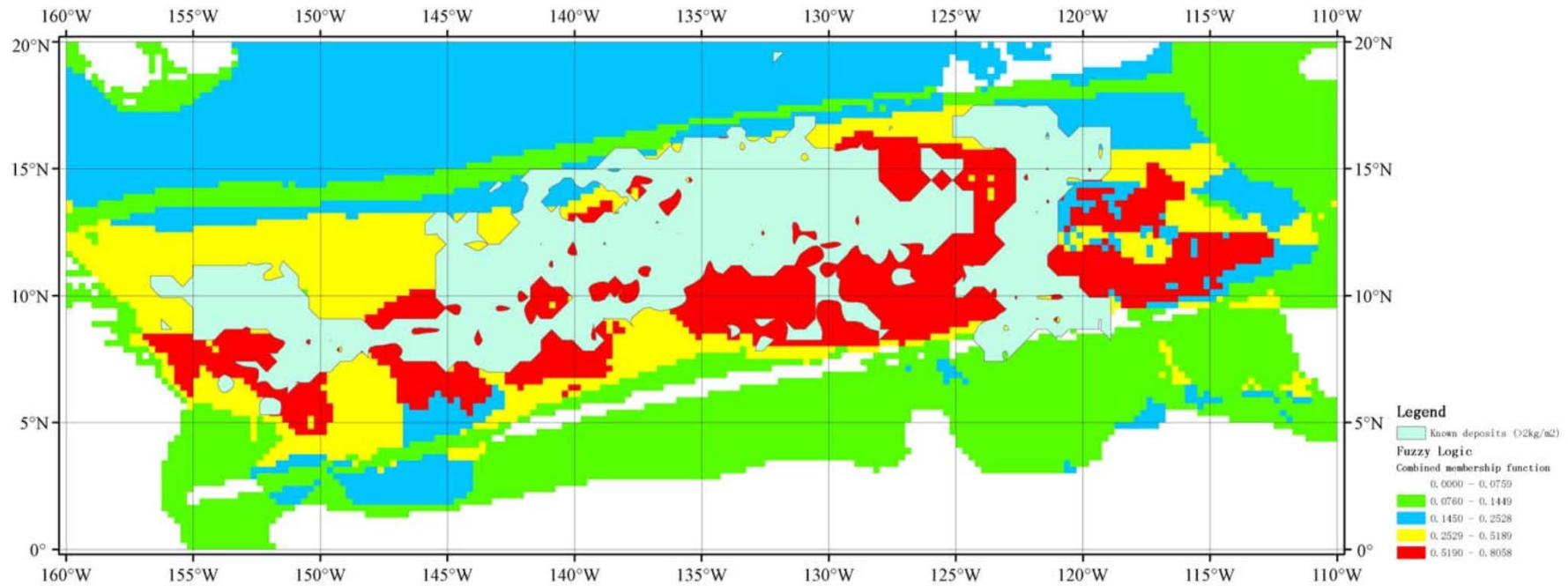
WEIGHTS OF EVIDENCE



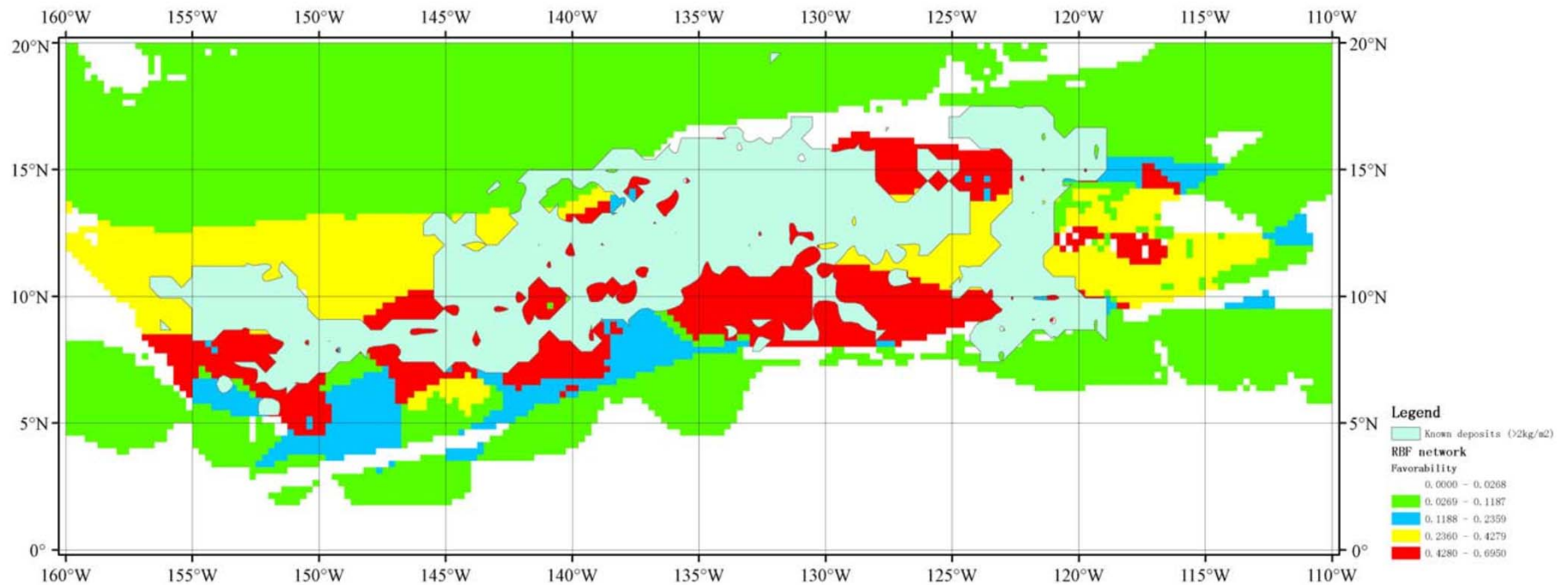
LOGISTIC REGRESSION



FUZZY LOGIC



NEURAL NETWORK MODELING

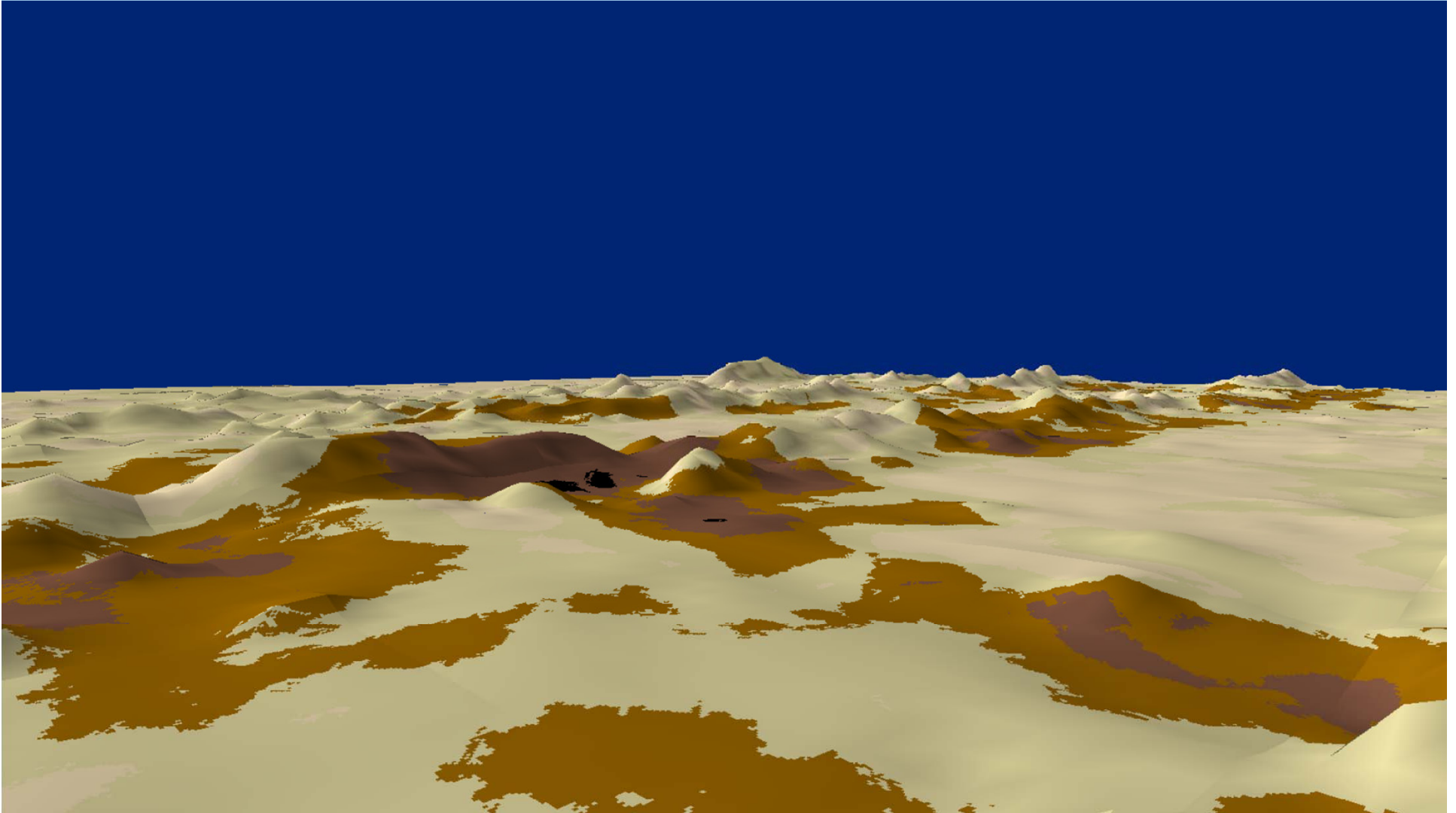


SDSS MODELING PRIMARY RESULTS

OPTIMAL EXPLORATION TARGETS:

- Between explored areas
- To the south of explored areas

RECENT USE OF MODEL

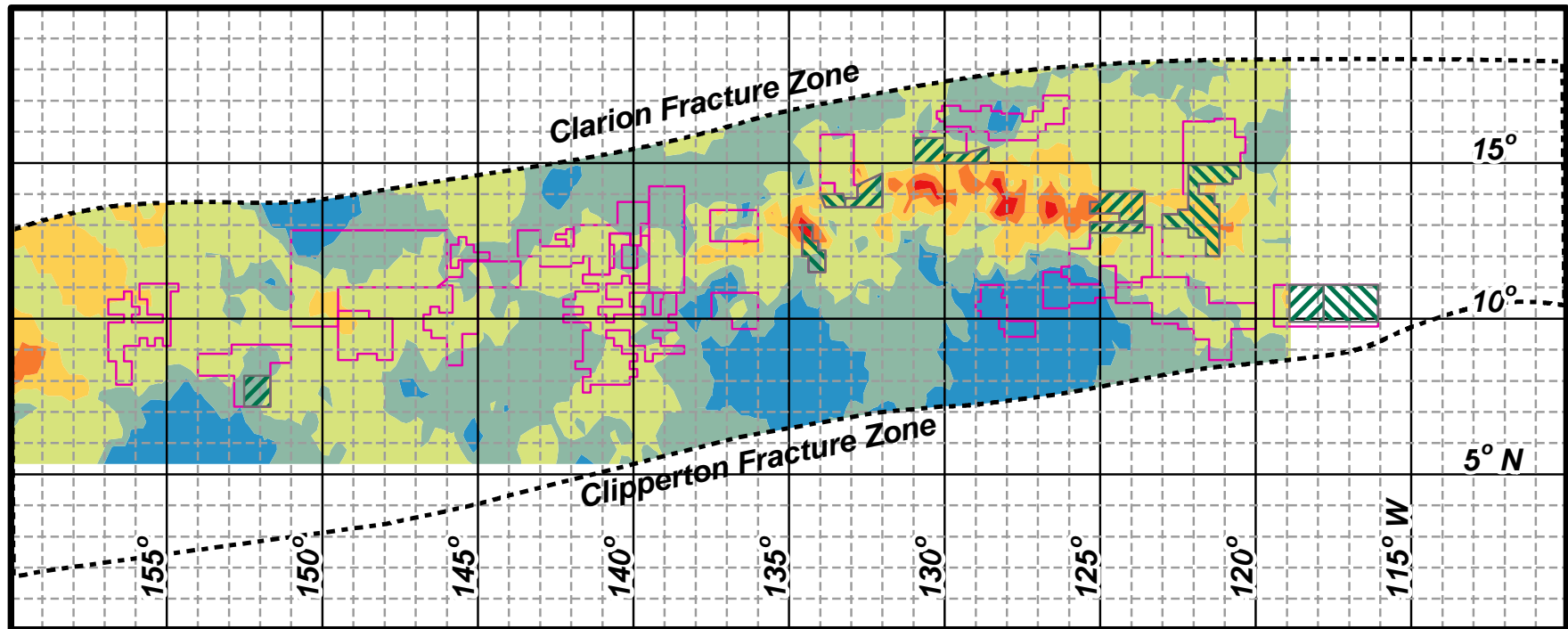





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NAURU & TONGA EXPLORATION AREAS



-  Reserved Areas
-  TOML Exploration Area
-  NORI Exploration Area

Nodule Abundance (kg/m²)

 < 2	 5 - 10	 15 - 20
 2 - 5	 10 - 15	 > 20

GEOLOGICAL MODEL SUMMARY OF RESULTS

- **ORGANIZED & INTERPRETED
AVAILABLE INFORMATION ON CCZ**
- **PROVIDED RESOURCE
ASSESSMENT & SUPPORT FOR
GEOLOGICAL THEORIES**
- **PREDICTED AREAS FOR FUTURE
EXPLORATION**
- **TO DATE RESULTS HELPED TO
DEFINE NORI & TOML CONTRACT
AREAS**