ARTICLES

OBSERVATIONS ON NEW MAGNETIC MAP FROM THE COMMISSION FOR THE GEOLOGICAL MAP OF THE WORLD

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Abstract: Magnetic data over the oceans indicate very large areas of subsided, extended continental crust. They have well-defined borders with subaerial continents and mid-oceanic areas bearing marked magnetic lineations. The latter ("C-Series magnetic chrons") are conventionally seen as a basaltic record of oceanic spreading and magnetic polar reversals. For this paper they comprise continent severely extended during Earth expansion. They form just half of the submarine areas. Larger numbers of lineations in the southern Pacific and Atlantic and progressively less in the northern oceans indicate northward-propagating extension. Pre-extension "Pangaea" was global. Magnetic lineations are also present along continental margins, where drilling and seismic data indicate rifting, extension, seaward-dipping wedges and serpentinized mantle. "Oceanic" areas currently attributed to the 40 Ma Cretaceous magnetic "quiet period" are continental. They did not experience the severe extension of strongly lineated areas. All "oceanic plateaux", "intra-oceanic" volcanic arcs and linear island chains lie on areas of continental crust. There is no "andesite problem", since volcanic arcs lie above silicic crust. Similarly, there are no "subduction factories" of continental crust below arcs. There is a succession from intra-continental - continental margin Triassic/Jurassic-early Cretaceous extension through non- or partly extended (?middle Eocene), subsided submarine crust to strongly lineated crust, highly extended ($\beta \geq 5$) in the ?late Cretaceous-Cenozoic, and the currently active, high standing mid-oceanic ridges. Large areas of extended continent below sea level will offer significant opportunities for hydrocarbon exploration. Territorial disputes are likely.

Keywords*: magnetic anomaly, continent, superchron, andesite, factory, expansion.*

Introduction

Conventional perception is that the Earth carries continental crust, oceanic (basaltic) crust and marginal, loosely discussed and poorly sampled/quantified, stretched continental crust in between. Global maps generally present the world as blue – below sea - and continent, cut off at or near the coastline. Anything blue is "oceanic" and devoid of continental crust: "The ocean basins provide a unique opportunity to investigate magmatic processes and mantle composition"- since -"The absence of continental crust as a potential contaminant provides an untarnished sample of the deep Earth" (Saunders and Norry, 1989). "Magmatic arcs in oceanic basins are presumed to lie on oceanic crust and to be important for geochemical studies of basalts because contamination by continental material cannot have occurred" (Leat and Larter, 2003). Oceanic plateaux and volcanic chains are products of plumes or hotspots and wedges of seaward-dipping reflections (SDRs) are volcanic.

Directly at odds with convention are numerous retrieved samples of continental crust in "oceanic" areas (e.g., Storetvedt, 2003; Vasiliev and Yano, 2007; Yano et al., 2009). DSDP drilling found continental rocks below 3950 metres water at Site 547 (DSDP Shipboard Scientific Party, 2007). Continental sources to the west supplied upper Palaeozoic - lower Mesozoic sedimentary rocks in the Andes and Grenvillian continental basement, the Arequipa Massif, is present off the Peruvian coast (Nur and Ben-Avraham, 1983). Oil companies are finding major resources along rifted and subsided continental margins in increasingly deeper water. Latest generation rigs are rated to 4,000m water depth.

The Carte Géologique du Monde (Bouysse, 2009) is a great improvement in portrayal of world geology. It shows onshore geology, continental shelves, major sub-sea fractures and ridges and perceived magnetic seafloor age (but see below).

Magnetic map indicates lots of submarine continental crust.

The Korhonen et al. (2007) Magnetic Anomaly Map of the World compiles magnetic anomaly data (near-surface and satellite data along with modelled oceanic data – see map for details of techniques used), which the authors attribute to metamorphic and igneous rocks in the crust and upper mantle and their redox state. The map, introduced by Purucker (2007), shows strong variation from magnetic highs to lows over N America, northern Eurasia, India and central/western Australia. I shall refer to this as NCMS (Northern Continental Magnetic Signature). NE and NS trends are common. Many of these correspond to ancient crustal provinces (compare **Fig. 1** with the map of N America basement (Wilco, 2008).

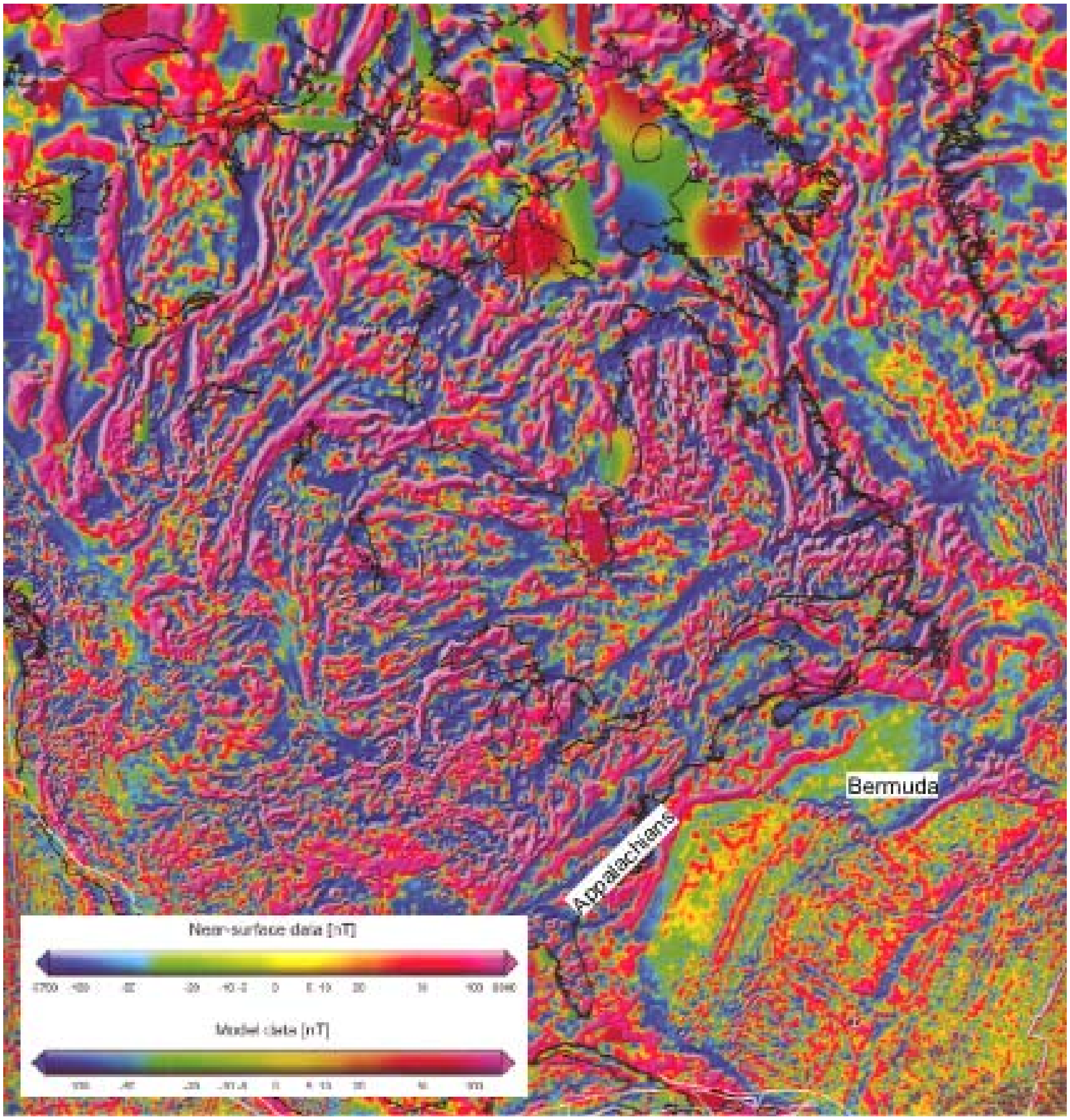

Fig. 1. Magnetic anomalies of North America. After Korhonen et al. (2007).

A different magnetic character appears over the southern continents – South America, Europe – Africa, India and SE Asia, except for southern central Australia (**Fig. 2**). I will refer to this as SCMS (Southern Continental Magnetic Signature). A similar pattern appears to be present over higher latitudes. Amplitudes are more muted and I suspect this is due to crustal extension and thickness of sedimentary cover. There is a strong boundary, for example, between the NCMS of the Precambrian Fennoscandinavian Shield and the SCMS of Europe SW of the Tornquist Line. EW trends are common in northern S America and N Africa.

Importantly, the SCMS extends from subaerial continent well out into "oceanic" areas and indicates large areas of subsided continent. There are large extensions of Africa westwards into the Atlantic and eastwards into the Indian Ocean. The large, continental, Madagascar Island is an important subaerial sample of this crust. Here, the Bemolanga and Tsimiroro fields contain 29 billion barrels of oil reserves. Continent extends from the Bay of Bengal almost as far as Australia. There is a large area of continent in the centre of the Indian Ocean.

The western half of the Pacific (**Fig. 2**) carries the same character, except for the magnetically lineated areas (M-series) of upper Jurassic – lower Cretaceous crust east of the Mariana arc, separating the Shatsky and Hess Rises, the Mid-Pacific Mountains and Ontong Java (continental roots). An area of SCMS extends northwards from east of N Zealand to the Hawaiian Islands whence it turns NW and follows the island chain.

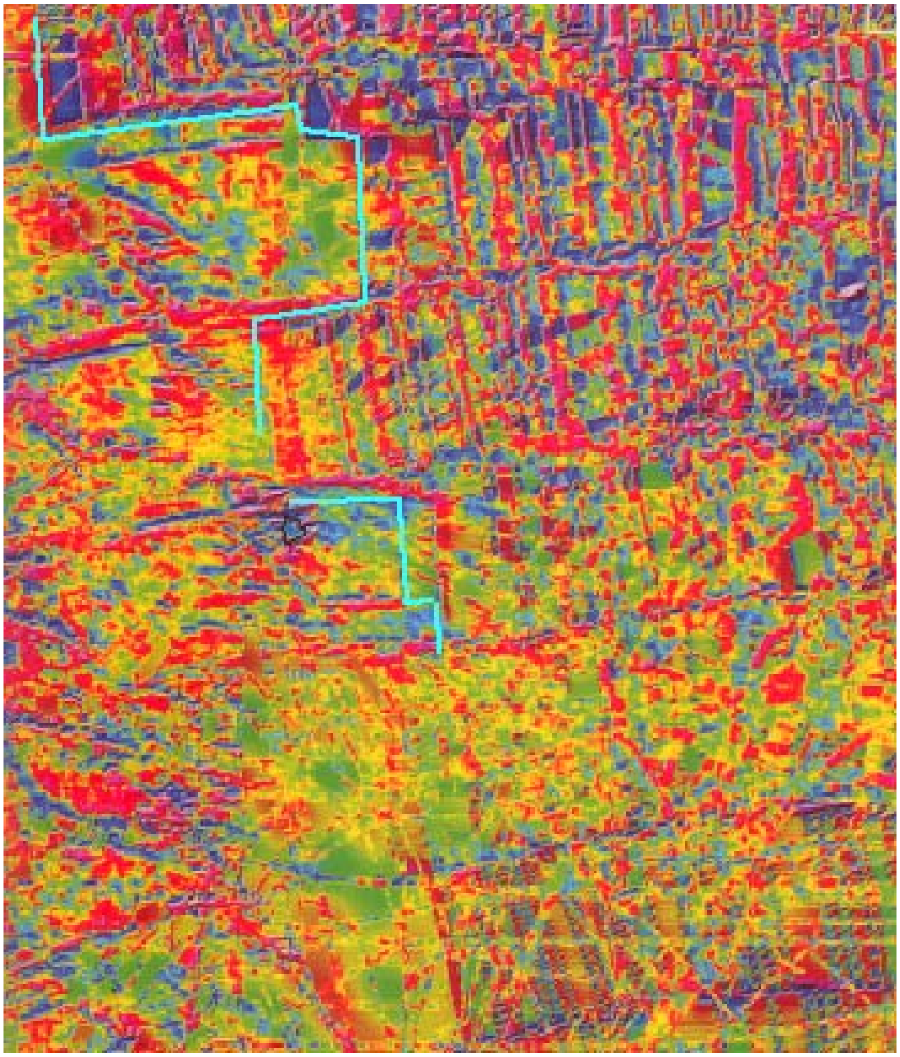

Fig. 2. Magnetic anomaly map, western Pacific. After Korhonen et al. (2007). The blue lines marking the eastern edge of SCMS crust correspond to the limit of the Cretaceous Quiet Zone shown by Atwater et al. (1993, fig. 1).

Pacific SCMS extends over the area ascribed to the North Pacific Cretaceous Quiet Zone (Atwater et al., 1993). Convention sees this as "oceanic" crust formed when magnetic polarity changes stopped for a period of 40 million years (the Cretaceous magnetic Long Normal or "Superchron"). Instead, it is an area of subsided continent - the "Quiet Zone" is a lack of record rather than absence of magnetic reversal. Comparison of the Bouysse (2009) and Korhonen et al. (2007) maps shows that all submarine areas shown as Cretaceous oceanic crust are continental.

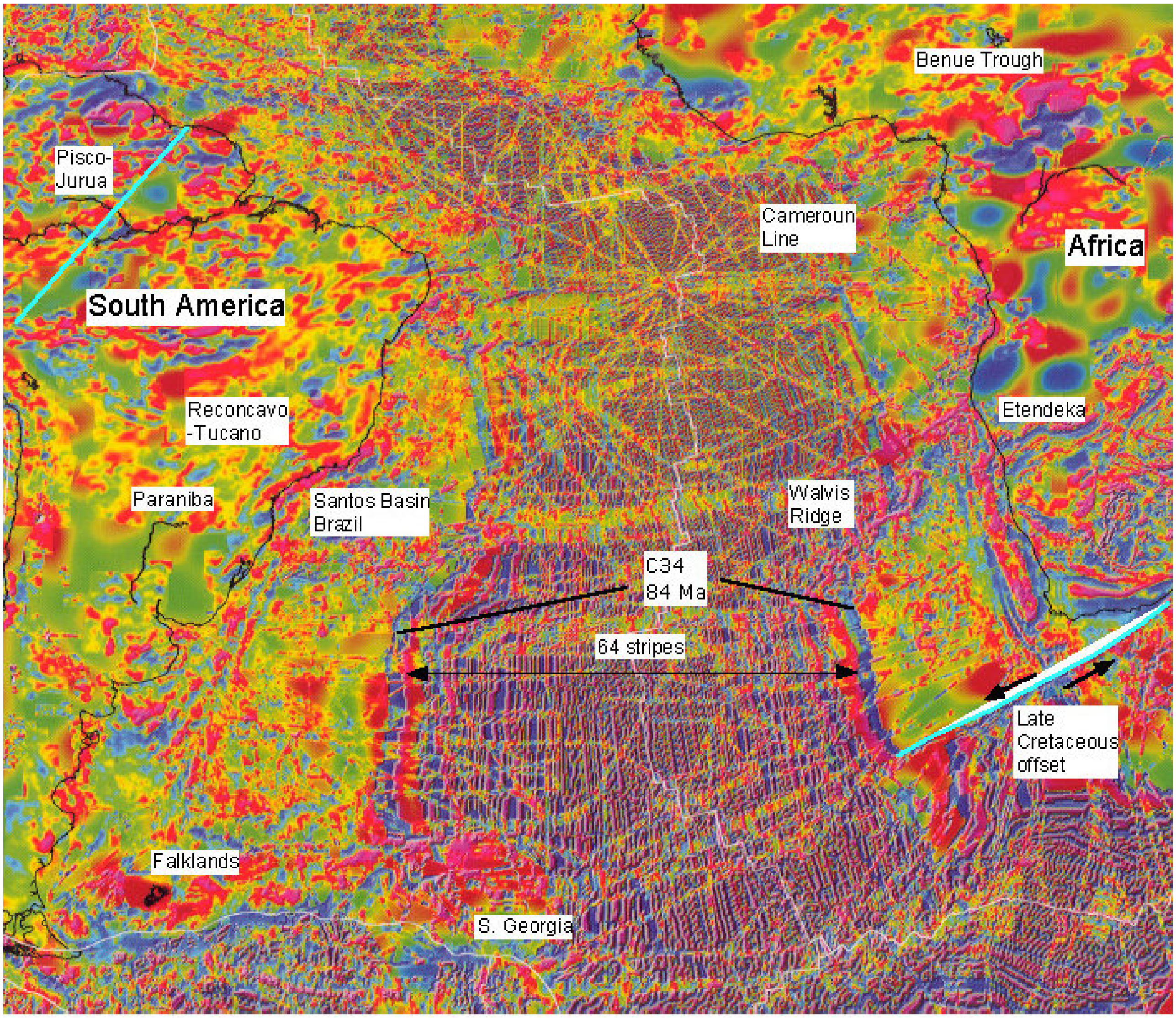

Fig. 3. Magnetic anomaly map, South Atlantic. After Korhonen et al. (2007). Compare with **Fig. 1**. Note that there are around 32 magnetic lineations symmetrically distributed on each side of the Mid-Atlantic Ridge in the south, where the C-series magnetic chrons were modelled (Cande and Kent, 1992).

The SCMS crust extends subaerial S. America by about 50% eastwards into the S Atlantic (**Fig. 3**). Shallow water, lower Cretaceous, lacustrine carbonates in the offshore Brazilian Tupi Field now at 6 – 7 km below sea level in 2,200 metres of water show that continental crust has subsided significantly in the area. Further south continental crust occurs on the N Scotia Ridge from the Falkland Islands to South Georgia. N America also extends eastwards, into the Central Atlantic. The outboard boundary of the SCMS is very clear in both areas.

High frequency magnetic lineations

Convention relates that sea-floor spreading records the periodic (average: 700,000 years) reversal of Earth's magnetic field. The Korhonen et al. (2007) Magnetic Anomaly Map clearly shows distinct areas of subsea crust characterized by high frequency magnetic lineations (for example, the central part of **Fig. 3**). They occur as generally north-trending zones 90 degrees apart, in the east Pacific, Atlantic, Indian and west Pacific and arise from a generally E-W belt encircling Antarctica. I refer to them as SSMS (Strongly Striped Magnetic Signature).

The Carte Géologique du Monde (Bouysse, 2009) indicates that these everywhere are the Campanian - Recent magnetic C-series, beginning at Chron 33 (84 Ma). I observe that there are around 60 (157 Ma Kimm) lineations each side of the mid-ocean ridge in the southern Pacific and some 33 west of the ridge in the north. This makes me wonder what the 33 magnetic C-Series chrons of the Geologic Time Scale 2008 (International Commission on Stratigraphy) mean.

The C-Series of 33 Chrons was derived from a synthetic South Atlantic magnetic anomaly model with added details from Pacific and Indian Ocean magnetic profiles (Cande and Kent, 1992; Ogg 1995). Curry (1985) wrote, "The anomaly sequence generally accepted as standard is based on a single track across the South Atlantic and its representativeness of at least the greater part of the Cenozoic has never been seriously challenged." Curry (1985) noted that apparently very accurate time scales (see, for example, the Geologic Time Scale 2008, International Commission on Stratigraphy) assumed sea-floor spreading at a constant rate. Variation of spacing from track to track did not support this. For Curry (1985) the role of patterns of magnetic reversals in the construction of time-scales needed re-evaluation.

There are around 32 lineations each side of the ridge in the southern S. Atlantic (**Fig. 2**), 23 at Brazilian latitudes (60 Ma Paleocene), just 12 (30 Ma Oligocene) in the Central Atlantic and only 10 (26 Ma Oligocene) south of Iceland. These systems of SSMC clearly are northward propagating and the age of the C-Series portrayed by the Bouyssee (2009) map seems questionable. My interpretation is that SSMS crust records Earth expansion advancing from the south. Expansion could involve volume change of peridotite to basalt and/or serpentinization.

"Dimmed" SCMS extends across parts of the SSMS in the Central Atlantic and eastern Pacific to the mid-ocean ridges. This is consistent with continental rocks recovered from the Mid-Atlantic Ridge. It suggests that SSMS is severely extended continental crust. Studies in the South China Sea indicate a stretching factor of $\beta \geq 5$ for such areas (Hu et al., 2009). **Figure 4** illustrates a S America – Africa reconstruction after removal of such stretching. It strongly challenges conventional Pangean reconstructions such as the famous computer-assisted map of Bullard et al. (1965). On a pre-extended (?Early Jurassic) Earth, "Pangaea" would have been global, rather than an unrealistic, asymmetric mass.

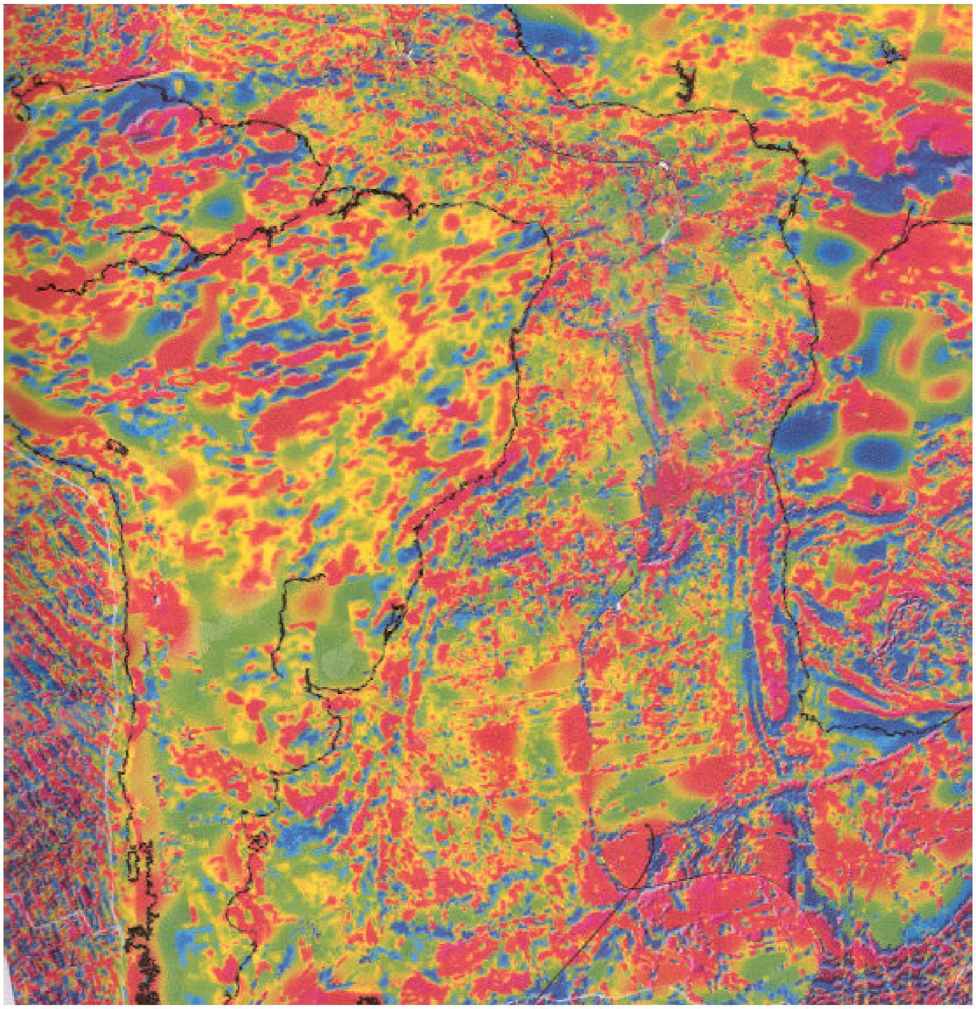

Fig. 4. Pre-expansion reconstruction of S America-Africa. Data from **Figure 3**. Compare with classic Pangean reconstructions such as that by Bullard et al., 1965, based upon continental margin bathymetry.

What do we know about inboard magnetic lineations?

In both N and S America, inboard, coast-parallel magnetic lineations record early rifting/extension (**Figs. 1 & 3**). Perhaps the best-known area is eastern N America. Triassic extensional reactivation of the onshore Palaeozoic Appalachian system accommodated red beds and sills. In the Jurassic activity jumped offshore. Here, seismic and drilling record rift deposits followed unconformably by wedges of Jurassic sediments, salt, Jurassic-Cretaceous carbonates and upper Cretaceous – Neogene clastics (summarized by James, 2009, fig. 6). Symmetric magnetic lineations, identified as chrons 33 and 34, occur *within* extended continental crust (tilted-block architecture) on the facing margins of southern Australian and Antarctica (Whittaker et al., 2008). Sibuet et al. (2007) suggested that magnetic lineations *within* transitional crust of the Newfoundland Basin and the Iberia abyssal plain reflect serpentinized mantle.

In summary, strong magnetic lineations in SCMS crust indicate local severe extension.

Lineations within offshore SCMS crust

East of N America a magnetic lineation (red lines, **Fig. 1**) runs coast-parallel to the volcanic edifice of Bermuda, built of Middle Eocene lava flows and intrusive rocks (Vogt et al., 2007). Here refraction velocities above the Moho have intermediate continental values (Officer et al., 1952). A parallel

(?equivalent) feature joins the Madeira and Canary Islands in the SCMS area off NW Africa. A similar, strong anomaly runs sub-parallel to the coast of S America towards the North Falkland Trough.

Karner (2008) discussed ocean-continent transition. Zones may be 100's km wide and contain organized magnetic anomalies. Many passive margins carry exhumed continental mantle rocks, lack magmas and top-basement detachments and show an "extension discrepancy" with rapid thinning of continental crust without obvious faulting. Refraction data from West Africa and northwest Australia indicate that passive margin subsidence requires thinning of continental crust from 30-40 km to ~10 km. Similar thicknesses characterize crust in Middle America (James, 2009, fig. 5). Early depositional environments seem to be characterized by shallow water, evidenced by Tithonian carbonates of the Iberian margin now at abyssal depths (c.f. Aptian lacustrine carbonates 7 km bsl offshore Brazil).

Brown et al. (2009) discussed seismic data from Nova-Scotia, Morocco, Brazil and West Africa margins. Unusual deep water structures, earlier seen as structural relief on magnetically-quiet oceanic crust, are highly rotated fault blocks with growth geometries. They could be continental or oceanic, syn- or post-rift, but internal geometries and presence below an assumed breakup unconformity suggest that basement is not oceanic. Sediments below salt in deep waters are not rotated by synrift faults. Depocenters lie above a deep seismic reflector which could record Moho or lower crust detachments. Some evidence indicates attenuated, serpentinized mantle in these areas.

In summary, lineations within offshore SCMS crust probably reflect severe continental crust extension. The remainder of offshore SCMS is likely to be more like onshore continental crust (e.g., Madagascar).

Seaward Dipping Wedges?

Seaward dipping wedges (SDRs) typify extended continental crust (Hinz, 1983; Rosendahl et al., 1992). They are common in the North and South Atlantic (Jackson et al., 2000). They could consist of shallow marine to subaerial volcanic layers (Hinz, 1983), volcanic layers on ocean crust (Mutter et al. 1982) or sediments in half grabens with continent-ward dipping listric faults (Bally, *pers. comm.*, 2008).

Offshore Norway a wedge, 230 x 60 km, includes basalts, drilled during DSDP Leg 38 (Hinz, 1983). Similar wedges are present off south Greenland and the Rockall plateau, on the SW African margin and on the Abutment Plateau/Walvis Ridge, in the Argo Abyssal Plain off NE Australia, in areas of the Baltimore Canyon Trough and Georges Bank off the eastern United States, off Kathiawar Peninsula/India, on the continental margin, Weddell Sea, Antarctica and on the Abutment Plateau/Walvis Ridge. Seismic data offshore Argentina-Uruguay show progressively distal, seaward dipping wedges below Aptian – Recent sediments (Franke et al., 2010).

South Atlantic deep-water regions contain SDRs more than 100 km wide, as much as 7 km thick, and thousands of kilometres long (Jackson et al., 2000). A pre-Aptian salt sedimentary package is characterized by a belt of proximal syn-rift tilted blocks overlain by an extremely thick sag basin in more distal areas (Mohriak et al., 2008).

In summary, SDRs characterize at least part of SCMS crust. Some include volcanic products, others just sediments.

Plateaux, arcs and chains

All "oceanic plateaux" (Kerguelen, Ontong Java, Manihiki, Kikurangi, Shatsky, Caribbean, Exmouth, Agulhas, Mascarene, Naturaliste, Vöring) and most "oceanic islands" lie on SCMS. Only in the Pacific, the Tuamotu Island chain and Easter Island – Sala y Gomez Ridge extend to the mid-ocean ridge. In the Atlantic, the Azores Plateau trends NW across the Mid-Atlantic Ridge. Continental rocks have been retrieved here (summarized by Yano et al., 2009). Evidence for presence of continental crust exists at Seychelles/Mascarene, Faeroes, Rockall Bank, Jan Mayan - Iceland, Kerguelen, Ontong Java, the Parcel Islands, the Agulhas Plateau, Cape Verde and the Cameroon Line (Charvis et al., 1997; Frey et al., 2002; Gregoire et al., 1994; Ingle et al., 2002; Ishikawa et al., 2007; Laughton et al., 1970; Ramsay et al., 1986; Weis et al., 2001).

Oceanic plateaux

Nur and Ben-Avraham (1983) summarized that oceanic plateaux are anomalous rises above the sea floor that are not parts of known continents, active volcanic arcs or active spreading ridges However, many have crustal thicknesses of 20 to 40 km and many have an upper crustal velocity of 6.0-6.3km/sec, typical of granitic rocks in continental crust. Statement that continental crust is not involved is not justified.

It is amazing that many "oceanic" plateaux are seen to be one big igneous pile when they are not comprehensively drilled. Drilling, dredging and submersible sampling have tested only the uppermost components of the 20 km thick "Caribbean Plateau" and its faulted (rifted–intruded?) margins. The bulk of the plateau remains uncalibrated, yet it is widely thought to be oceanic crust, formed in the Pacific in the Jurassic, thickened by Cretaceous basalt outpouring (e.g., Kerr and Hastie, 2006). In fact, Caribbean data (tectonic trends, crustal thicknesses, seismic architecture, silicic chemistry) indicate that its geology extrapolates that known from seismic and drilling along the extended eastern seaboard of N America. The Caribbean evolved in the Jurassic/Cretaceous between the separating Americas (James, 2009). There is much continental crust present.

Basin-dipping reflector sequences are common beneath the eastern flank of the southern/western Kerguelen Plateau (Coffin et al., 1997; Symonds et al. 1997). Grab samples suggest that the southern Plateau contains continental crust. Mafic granulite xenoliths, normally found only in continents, occur on Kerguelen Island (Ramsay et al. 1986). Continental rocks, particularly garnet-biotite gneiss, occur at Site 1137, Elan Bank, (Ingle et al., 2002). A quartz-garnet clinopyroxenite xenolith from the island of Malaita on the Ontong Java Plateau indicates Neoproterozoic lower crust with an age of 0.5-1 Ga within the Pacific mantle (Ishikawa et al, 2007).

Amundsen et al. (2002) and Paquette et al. (2006) found zircons from old continental crust below Iceland and Mauritius (southern extensions of the Jan Mayen and Mascarene micro-continents).

In summary, "oceanic" plateaux are founded upon continental material of SCMS crust.

"Intra-oceanic" island arcs, the "Andesite Problem" and "subduction factories"

Leat and Larter (2003) wrote that magmatic arcs in oceanic basins are presumed to lie on oceanic crust and to be important for geochemical studies of basalts *because contamination by continental material cannot have occurred*. All they should say is that the arcs occur in a marine setting. Their presumption results in the interpretation that abundant silicic rocks and mid-crustal layers with continental seismic velocities in "intra-oceanic" volcanic arcs represent "continentalization" - the so-called "subduction factory" (Tatsumi and Kosigo, 2003).

According to Tatsumi and Kosigo (2003) the major products of the subduction factory are magmas, solidified products and continental crust. They write: "Formation of andesitic crust is one of the greatest dilemmas facing those who are interested in the origin of continental crust, because basaltic magmas dominate the magmatism on the modern Earth." "Geochemical characteristics of bulk andesitic continental crust ... are broadly identical to those of current subduction zone lavas; this has led several researchers to speculate that continental crust was created at convergent plate margins (e.g., Keleman 1995; Taylor and McLennon, 1995)." Tatsumi and Kosigo (2003) proposed a complex model of continental crust formation via magma mixing involving present arc basalt magma, present arc mantle, present amphibolite, ancient amphibolite, ancient arc basalt and felsic magma. Involvement of original continental crust is a far simpler explanation.

Over 80% of volcanoes produce andesitic lava and clastics (Gill, 1981). Continental crust is andesitic in composition (Taylor and McLennan, 1985; Rudnick and Fountain, 1995). Chemical and seismic indications of continental rocks below the arcs (and below some backarc basins) reflect continental fragments.

In summary, the "andesite problem" and "subduction factories" do not exist.

Sea-floor ridges

Many of the “hotspot tracks” in the western Pacific trend NW. Those in the eastern Pacific (Cocos and Nazca) and eastern Atlantic (Walvis and Cameroon Volcanic Line) trend NE. They parallel major lineaments within continents. For example, in the eastern Pacific the Cocos Ridge parallels Palaeozoic sutures along eastern N America and the Nazca Ridge continues the S American, trans-continental Pisco-Jurua fault (**Fig. 3**) (Szatsmari, 1983).

There has to be a fundamental reason why major trans-continental fault systems extend ocean-ward. Walvis Ridge DSDP Site 525A encountered basalts with continental crust signature (Class and le Roex, 2006). They are indistinguishable from basalts of the Etendeka flood basalt province and similar to basalts of Alto Paraniba. Cameroon Line “oceanic sector” lavas exhibit continental signature (Rankenburg et al., 2004). The authors proposed that this results from continent-derived sediments or by rafted crustal blocks that became trapped in the oceanic lithosphere during continental breakup in the Mesozoic. Whatever, continental crust is involved.

Continental material has been dredged, drilled or reported as outcrops from a number of ocean islands and submarine ridges, suggesting that many are underlain by continental fragments (Amundsen et al., 2002).

In summary, sea-floor ridges are extensions in SCMS (continental) crust of onshore tectonic lineaments.

When did submarine SCMS crust assume its character?

Hallam (1977) dated the opening of the S. Atlantic seaway as Late Toarcian or Early Aalenian and there must have been an earlier connection to explain the presence of European type Sinemurian and Pliensbachian faunas in Argentina (Ager, 1986). Dykes formed in the late Jurassic and flood basalts of Africa (Etendeka) and Brazil (Alto Paraniba) formed at 145 Ma (late Tithonian) and 127.5 Ma (Hauterivian, Franke et al., 2010). Basalt extrusion also occurred in the Benue Trough at 147±7 Ma (late Tithonian, Fairhead, 1988). The Paraná flood basalt formed at 134.7 Ma (Thiede and Vasconcelos, 2010). Swarms of NE faults cut pre-rift sediments and basement, now as deep as 9 km, in the Reconcavo - Tucano rift of Brazil (Milani et al., 1988). Continental flood basalts in the offshore Santos Basin formed at around 138 Ma (McKee and Asmus, 1983). Further south dyke swarms in the Falklands formed at 190 Ma (end Lias), 178 Ma (Bajocian - middle Jurassic) and 121 Ma (Barremian/Aptian) (Stone et al., 2008). Eleven wells offshore southern S America found restricted marine Cretaceous or Jurassic rift deposits above Palaeozoic rocks (Geological Map of South America, Schobbenhaus and Bellizia, 2001).

Brachiopod and belemnite fossils and conglomerates document marine opening and tectonic activity along east Africa in the Jurassic (Toarcian) (Ager, 1986). The Mozambique Channel formed in the Bathonians. In the western Pacific crust with M-Series magnetic lineations formed between the Bathonian and Barremian (165 – 125 Ma). Australia rifted from Antarctica in the Jurassic and Late Jurassic rifting occurred on the NW Shelf (Whittaker et al., 2008).

In summary, in the Central and S Atlantic, Indian and Pacific areas, extension began in the Jurassic. I suggest this records the beginning of the sequence: continent - continental margin extension – partly extended, subsided SCMS – SSMS crust. Inboard, coast-parallel magnetic lineations mark the beginning of this sequence.

When did submarine SCMS crust subside to present depths?

It will be important to know when subsidence of SCMS crust occurred. Some possible clues follow. Shallow water Middle Eocene now lies below deep water limestones in several parts of the Caribbean (James, 2009). Old world mammals crossed from Africa to Madagascar up to the Middle Eocene (McCall, 1997). Rapid subsidence of middle Eocene carbonates occurred in the Great Australian Bight at 43 Ma (Li et al., 2003). Lower Eocene reef carbonates lie at around 1500 m depth on guyots of the Marshall Islands (Schlager et al., 1987). Rapid subsidence of the Tuamotu Ridge occurred in the late Middle Eocene (Burkle and Saito, 1966).

In summary, SCMS crust may have foundered as recently as Middle Eocene.

Conclusions

1) Continental crust forms up to 50% of submarine crust. It is locally extended crust, with SDRs and serpentinized mantle (local magnetic lineations).
2) Crust with magnetic stripes of the C-series forms the other 50% of submarine crust. This likely is extremely extended ($\beta \geq 5$) continental crust (continental material is sampled at mid-oceanic ridges), with much serpentinized mantle (many magnetic lineations).
3) C-series crust is distributed in a circum-Antarctic ring and four, N-S systems, rising from the ring systematically at 90-degree intervals.
4) The C-series includes up to 60 stripes in the south Pacific, many more than the 33 Chrons modelled in the South Atlantic.
5) The C-series of the N-S systems narrows with diminishing numbers of magnetic lineaments from south to north. This indicates northward-propagating expansion.
6) There is no Cretaceous magnetic Superchron. “Oceanic” crust attributed to this is continental. There was no severe extension (serpentinization) to record magnetic flips between 120 – 84 Ma
7) All “oceanic” plateaux have continental foundations.
8) All “oceanic” islands have continental foundations – there are no “intra-oceanic” islands in the sense of their existing on basaltic crust.
9) There is no “andesite problem” or “subduction factory” genesis of continental crust. Island arc volcanoes lie above original continental crust.
10) There are no “hotspot tracks”. Island chains follow intracontinental lineaments, commonly NE or NW.
11) Pre-extension “Pangea” was global.
12) The great submarine extensions of continents will provide opportunities for mineral exploration and probably will be the subject of territorial debate.

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