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Editorial

100 years of research on the West African Craton

The West African Craton extends across 14 countries in western Africa, and consists of two Archean nuclei in the north-western and south-western parts of the craton juxtaposed against an array of Paleoproterozoic domains made up of greenstone belts, sedimentary basins, regions of extensive granitoid-TTG plutons and large shear zones, which are overlain by Neoproterozoic and younger sedimentary basins. The borders of the WAC are largely defined by a combination of surface geology and gravity signatures (Burke and Whiteman, 1973; Roussel and Lesquer, 1991; Ennih and Liegeois, 2008a, b).

The earliest surviving geology maps from Africa, or any continent, date back to a map of a sandstone quarry, gold mine and settlement at Bir Umm Fawakhir, Egypt (Scribe-of-the-Tomb Amennakhte, son of Ipuy, 1160 BC; Harrell and Brown, 1992) and show the local distribution of mines, mineralised occurrences and transport routes, which find an echo in the of the Kéniéba region of Senegal some thirty centuries later (Vincent and Delmare, 2015). Although earlier small scale geological maps exist for West Africa (e.g. Lenz, 1882), it was the undertaking prior to 1920 of systematic 1:M geological mapping by Henry Hubert, a French Government official working in French West Africa (and a founding member of the Commission for the Geological map of the World) that culminated in the 1934 publication of the 1:6 M regional map that first shows a recognisable pattern of the distribution of cratonic rocks and overlying basins that carries through to today's maps, including the work described in this special volume on the Tectonics, Metallogeny of the West African Craton (Fig. 1; Hubert, 1934). The same year, the Gold Coast Geological Survey published a map of southern Ghana at 1:500,000 scale that is even more precise, for this smaller region, and locates many of the gold deposits which have since been exploited (Junner, 1934). The involvement of Henry Hubert also involved his support for the creation of a colonial research organisation which was founded in 1942 as the "Service de Recherches Scientifiques Coloniales" and which was a precursor to the Institut de Recherche pour le Développement, one of the key partners in the West African Exploration Initiative, a public–private-partnership that has supported the research described in many of the papers in this volume.

From the early maps of Hubert, through systematic mapping campaigns by colonial and postcolonial geological surveys and museums, (notably the Bureau de Recherches Géologiques et Minières, the British Geological Survey and the Bundesandstalt für Geowissenschaffen und Rohstoffe: the French, British and German surveys respectively; and geophysical acquisition programs led by the precursor to the Institut de Recherche pour le Développement) to today's data acquisition, supported by transnational organisations including UNESCO, the Commission for the Geological map of the World, the World Bank and the European Union, we have seen a diverse range of country-level and regional research and data integration programs (Fig. 2). In 1991, the IGCP 233 "The West African Orogens and Circum-Atlantic Correlatives" produced a volume that presented the state of our knowledge on many aspects of the geology and metallogenesis of the WAC at the time (Dallmeyer and Lécorché, 1991; editors). More recently, in 2003–2007, the IGCP 485 "The boundaries of the West African craton" focused on the peculiar events occurring at craton margins (metacratonic areas), favoured intra-Africa mobility of African geologists and produced a volume (Ennih and Liégeois, 2008a, b; editors) of >500 pages and 25 papers demonstrating the interest in the geology and metallogeny of the WAC boundaries.

Immediately following the independence of the first African colonies, the Economic Commission for Africa commissioned a report by Frank Dixey (then President of the Association of African Geological Surveys) entitled "Geology, Applied Geology (Mineral Resources) and Geophysics in Africa", as part of a wider review of the natural resources of the African continent (UNESCO, 1963). This report highlighted a series of challenges facing the African geological surveys and the minerals industry that was actively exploring on the continent. The African Mining Vision, released in 2009, (together with the AMV Action Plan, 2012 and the Country Mining Vision, 2014) are a logical continuation of this earlier work. The AMV recognises the need for collaboration between the various stakeholders in the African minerals sector in its action plan (African Union Commission 2011) and states that critical success factors include the development of mutually beneficial partnerships between the state, the private sector, civil society, local communities and other stakeholders, as well as a comprehensive knowledge of its mineral endowment.

Eleven of the thirteen articles in this volume were funded directly or indirectly by the AMIRA International West African Exploration Initiative (WAXI). WAXI is an ongoing public–private-partnership that provides graduate and professional training as a result of direct industry and partner government financial support. Since its inception in 2006 the WAXI program has undertaken research activities via a long-standing partnership between West African and international academic partners, West African geological surveys and local training centres such as Teng Tuuma Geoservices (TTG) in Burkina Faso.

The thirteen articles in this special issue fall into three main classes and cover many parts of the West African Craton (Fig. 3), as follows.

Local or craton-scale geological studies.

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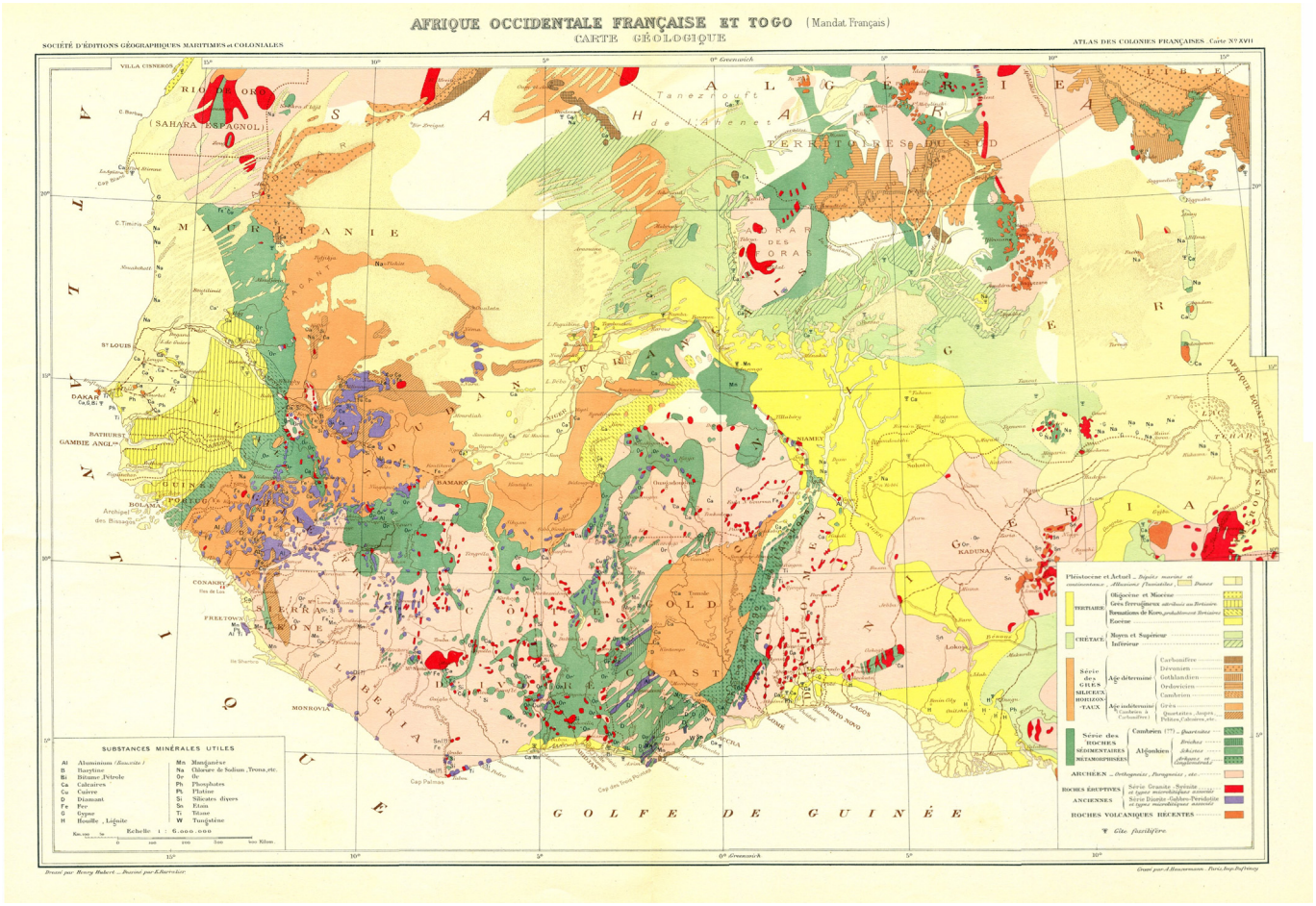

Fig. 1. Geological map of French West Africa and Togo by Hubert, 1934. 1:6 M Scale. This map is based on a compilation of 1:1 M scale map sheets produced over the preceding 20 years.

- Baratoux et al., 2015- A new litho-structural framework for the Gaoua region, Burkina Faso, a region that hosts the copper mineralization in Gongondy, Dienemera and Mt Biri copper deposits, based on the integration of high-resolution geophysical data and field mapping. Overprinting relationships suggest that copper mineralization is associated with the first deformation event, characterized by E–W trending structures related to N–S shortening.

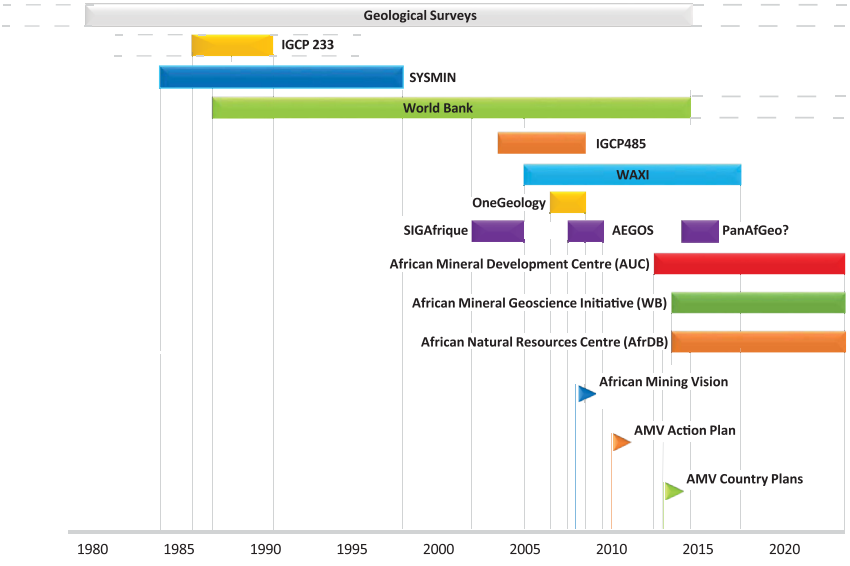

Fig. 2. Geoscience data acquisition and integration initiatives in West Africa and Africa since 1980. The release dates of the three documents related to the African Mining Vision published by the African Union are also noted (African Union, 2009, 2012; AMDC, 2014).

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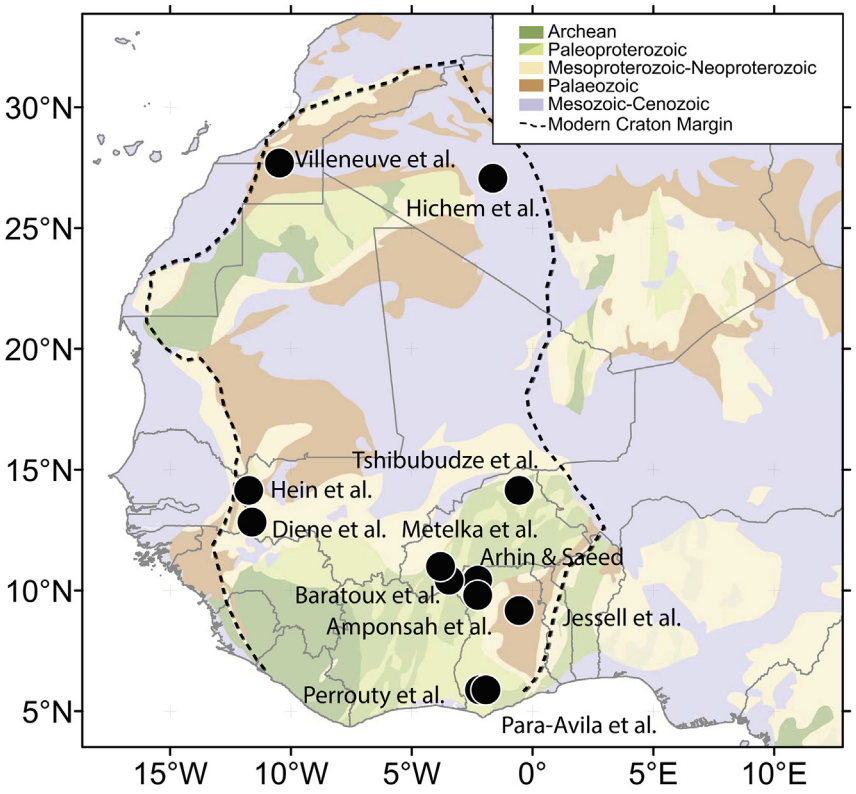

Fig. 3. Map of the West African Craton with location of studies in this special issue. The dashed line shows the approximate modern margin of the West African Craton (Jessell et al., 2015a). The Jessell et al. paper on mafic dykes extends across the whole craton. Geological map of West Africa showing the ages of the major terranes, modified from the Geological Survey of Canada 1:35M map of the world (Chorlton, 2007). *Reference for Chorlton:* Chorlton, L.B., 2007. Generalized Geology of the World: Bedrock Domains and MajorFaults in GIS Format; Geological Survey of Canada, Open File 5529, 1 CD-ROM.

- Diene et al., 2015- Review of gold mineralisation styles associated with the Senegal-Mali Shear zone in the context of ground geochemical and airborne geophysical data sets. The concentration of synvolcanic felsic rocks, fault, and Au mineralisation within the SMSZ suggest that it represents a synvolcanic structure or a series of structures which acted as conduits for magmatic and hydrothermal fluids and were reactivated during the subsequent deformation events.
- Hichem et al., 2015- 3D aeromagnetic and gravity data inversion used to define major lineaments in the WAC of SW Algeria. The presence of the major faults throughout the continental crust described in this work is an important argument to highlight that the domains located on both sides of the suture zone between the WAC and the mobile zone remained active since the Pan-African.
- Jessell et al., 2015c- Craton-scale mapping of mafic dyke swarms based on a combination of interpretation airborne magnetic datasets and previously mapped dykes. There are up to 5 different dyke orientations found locally in many parts of the craton, and we this work demonstrates that there is a long and complex history of mafic magmatism across the craton, with as an upper limit up to 26 distinct dyke swarms mapped based on their orientation and location.
- Tshibubudze et al., 2015- Tectonic and magmatic evolution of the Oudalan-Gorouol belt, Burkina Faso, based on field mapping and analytical studies of magmatic units. These studies have defined the presence of a gneiss basement termed the Lilengo gneiss complex, with recognition of an angular unconformity that defines the basal contact of the Birimian Supergroup.
- Villeneuve et al., 2015- Tectonic analysis of the Souttoufide belt, Morocco, and its relationship to the adjacent Mauritanides and Anti-Atlas belts. The Souttoufide belt is a polyorogenic belt located at the margin of the WAC, including both Pan-African and Variscan orogens similarly to the adjacent Anti-Atlas and Mauritanides belts but with major peculiarities giving to the Souttoufides a great importance for the correlations between the Appalachian and the West African belts.

Ore deposit descriptions.

- Amponsah et al., 2015- A structural, geochemical and metallogenic analysis of the Julie gold deposit, NW Ghana. The Julie deposit is a rare case of granitoid (TTG)-hosted mineralization.
- Hein et al., 2015- Post-emplacement evolution of the Yatela gold deposit, western Mali. The combined mineralogical, textural and petrographic study of residuum samples, together with whole rock and detrital zircon geochronology have established a process of formation beginning in the Palaeoproterozoic followed by deposition of these recycled sedimentary units between 1114 Ma and ca 700–750 Ma.
- Perrouty et al., 2015- A structural and metallogenic analysis of the Wassa gold deposit, SW Ghana. From its early timing and its associated mineral assemblage, this style of mineralization constitutes a reasonable candidate for the source of the Tarkwa placer gold.

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- Parra-Avila et al., 2015- Constraints on the timing of mineralisation of the Wassa gold deposit, SW Ghana. The new age on the Wassa deposit is consistent with the possibility of an early gold mineralizing vent during the Eoeburnean phase at ca. 2191–2158 Ma.

Regolith studies.

- Arhin and Saeed, 2015- Coupled geochemical and regolith mapping of units in complex regolith terrains of savannah regions of NW Ghana. This study identified four broad regolith classes using the major oxides and concludes that mineral exploration companies use weight proportions of K/Al and Mg/Al ratios to characterise different regolith types to support the field identification of the different regolith materials in complex regolith terrains.
- Jessell et al., 2015b- Interpretation of regional geophysical datasets to identify a major paleochannel incising Voltaian Sediments in central Ghana. The integration of magnetic, radiometric and EM data sets define a 230 km long, 2 km wide main channel, with 20 km wavelength and 10 km amplitude meanders. Published geomorphological studies suggest that the modern drainage pattern has been in place for at least 11 Ma, and probably at least 45 Ma.
- Metelka et al., 2015- Spectral library of lithologies and their weathered equivalents from SW Burkina Faso. The variation in spectral signatures implies that discrimination between the sampled materials based on hyperspectral data analysis should be possible. The newly acquired spectral library provides primary information for the analysis of remote sensing data in West Africa.

The articles cover 12 countries, with the 59 authors coming from 12 countries including 22 authors from Africa.

This special issue is a companion to three other special issues consisting of research on the West African Craton (Precambrian Research, Economic Geology & Ore Geology Reviews), and together hopefully form the impetus for a renewed interest in the geology of this fascinating region that has been the subject of intense exploration by the minerals industry over the last 10 years.

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