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Editorial

Editorial: Special Volume of the 24th Colloquium of African Geology

1. Introduction

The Geological Society of Africa (GSAf), since its establishment 40 years ago, remains the most inspiring Society in Africa. Its colloquia attracted experts from universities, Geological Survey Organizations, mining companies, and various other Earth Scientists from the continent and beyond.

This Special Volume is a result of the 24th Colloquium of African Geology (CAG24) organized under the auspices of the Ethiopian Geosciences and Mineral Engineering Association (EGMEA) in partnership with the Addis Ababa University, Ministry of Mines and the Geological Survey of Ethiopia, from 8 to 14 January 2013, in Addis Ababa, Ethiopia. The Colloquium held under the theme *"40 years of GSAf (1973–2013): Earth Sciences Solutions to African Development Challenges"* has been a forum of fruitful deliberations leading to new provoking ideas, better understanding of African Geology as well as its resources in particular, and to numerous discussions on Earth Sciences related issues of worldwide significance.

The CAG24 has been attended by close to 500 participants from 60 countries representing 6 continents, among which about 300 were delegates from 30 different African countries. Three hundred twenty-five papers were presented in various sessions discussing themes involving: Craton Formation and Destruction, the Pan-African orogeny; Sedimentology, Stratigraphy and Palaeontology; the East African Rift System; Earth Resources (Mineral, Geothermal, Hydrocarbon, Groundwater) and Remote Sensing methods of Resources Exploration; Environmental Geology; Geoheritage and Geotourism; Earth Sciences Education; Geoscience Information; and Geophysical Methods.

In this Special Volume of the Journal, 36 manuscripts that have gone through rigorous review process are presented. They are organized in six sub-themes representing: Basement Geology and Geodynamics; Stratigraphy and Sedimentology; Energy Resources; Engineering Geology and Hydrogeology, Remote Sensing Application, Integration and Modelling; and Environmental Geology, Medical Geology and Geology for Society.

2. Basement Geology and Geodynamics

Africa is an outstanding continent for studying Precambrian basements, as they have largely escaped the Phanerozoic orogenies. The African outcrops allow a proper study of the major orogenic events, the later reactivations by younger orogenies as well as deciphering events occurring far from plate boundaries, during the Phanerozoic and during the Precambrian itself. This is the case of the Paleoproterozoic Francevillian basin in Cameroon (2.1–2 Ga) studied by **Thiéblemont et al.**, whose filling was accompanied by volcanism displaying an alkaline to calc-alkaline transition, reflecting an evolution from a diverging to a converging setting, echoing the Eburnean events occurring in Central Africa. **Mapani et al.** show that the Namibian Hohewarte metamorphic complex, accreted onto the Kalahari craton before the late Neoproterozoic Damaran orogeny, possesses a complex evolution that generated several major events at different times (1.76, 1.29, 1.17, 1.06 Ga) at the end of the Paleoproterozoic and of the Mesoproterozoic, each time with mostly the adjunction of juvenile material.

Nkoumbou et al. went through the Pan-African orogeny to decipher the pre-collisional history of the Yaoundé Series in Cameroon, a basin filled with both old and juvenile material during an extensional process to the north of the Congo craton, which led to rifting and limited oceanization. In Cameroon, the Pan-African orogeny is marked by large shear zones around the Congo craton, accompanied by magmatism. **Kouemo et al**. studied the kinematics of one of these shear zones using a detailed structural approach combined with Anisotropy of Magnetic Susceptibility (AMS) measurements, showing several reversals in the shearing, the sinistral movements being favorable for the intrusion of the Fomopea and Bandja plutons.

In Hoggar, Algerian Sahara, **Doukkari et al**. built metamorphic pseudosections for the remarkable Tighsi eclogites in the Aleksod-Egéré terrane that show a spectacular range of reaction textures. They allowed determining the clockwise high-pressure metamorphism that culminated at nearly 20 kbar and 700 °C before showing an isothermal decompression before the exhumation. More to the west, in Morocco, **Blein et al**. provide new U-Pb SHRIMP zircon ages for the Bou Azzer-El Graara dismembered ophiolite in the Anti-Atlas, the northern boundary of the West African craton. They interpret the successive age groups obtained (770–760, 755–695 and 660–640 Ma) as distinct orogenic periods followed by a continental volcanic arc between 630 and 580 Ma, before the deposition of the Ouarzazate Group and the Cambrian series including volcanic deposits. **Karaoui et al**. provide a comprehensive study of the huge volcano-sedimentary Ouarzazate Supergroup in the Bas Draâ inlier in the Moroccan Anti-Atlas, marking the post-collisional stage of the Pan-African orogeny. Sixteen terrestrial volcanosedimentary lithofacies reach a thickness of 2000 m. Although the series is mostly ignimbritic, they have distinguished volcanoes, calderas, dome complexes, fluvial systems fitting a global extensional system, precursor of the Cambrian extension and volcanism along the northern Gondwana margin. **Beyth et al**. show that the Eilat area, in southern Israël, is not simply the northern tip of the Arabian–Nubian Shield (ANS) but is an excellent representative of the ANS geological evolution as a whole, corresponding to the closure of the Mozambique ocean.

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Indeed, more than 400 million years, from 950 to 530 Ma, are recorded there: island arc formation and accretion, metamorphism, calc-alkaline dioritic to granitic intrusions at several stages, late alkaline granites around 600 Ma but also sediment depositions and the late intrusion of doleritic dykes at c. 530 Ma. Cambrian to Eocene sedimentation marked the stability of the area during the Phanerozoic.

Amenna et al. obtained a first paleomagnetic pole age-constrained by a fold test in the remote SE Algeria (In Ezzane, Murzuq basin). This allowed them to define an improved Moscovian (310 Ma) reference pole for Africa, a major constraint for paleocontinental reconstructions including Gondwana. **Henry et al**. used paleomagnetism for dating sedimentary formations loosely dated by other methods, including paleontology. They showed in SE Algeria (In Ezzane, Murzuq basin) that the Zarzaïtine Formation, considered to be Middle Triassic to early Jurassic in age, is actually Permian. This implies far-reaching consequences such as important diachronism of the deposition of this formation and significant differential vertical movements. **Abtout et al**. used gravimetry to decipher the structure of the basement below the Cheliff basin, one of the most seismically active regions in Algeria, where the strong El Asnam earthquake occurred in 1980. Their study allowed detecting elongated structures in 3D, giving rise, for the first time, to an underground structural map of the area.

Adhana studied the 500 km long E–W oriented (Gulf of Aden parallel) Yerer-Tullu Wellel volcano–tectonic lineament intercepting the Main Ethiopian rift. It displays a complete continental rift volcanic succession, from silica over-saturated basalt to rhyolite to the east to silica undersaturated basanite to phonolite in the west, passing through silica-saturated alkali basalt to trachyte. This transition is interpreted as a deepening of the mantle source partial melting towards the west, i.e. when going away from the main Ethiopian rift.

3. Stratigraphy and Sedimentology

Stratigraphy and Sedimentology of some Phanerozoic basins in western, central and eastern Africa, spanning from Palaeozoic (Permian) to Caenozoic (Oligocene), with a special emphasis on Cretaceous, are discussed. Two studies elaborate the depositional and climatic environments of the Permian in Ethiopia. **Bussert** used lithofacies associations from northern Ethiopia to determine the depositional environments during and after the Late Paleozoic Ice Age (LPIA) and shows that most of the sediments were deposited in subaquatic environments. **Enkurie** presents detailed description of microfloral assemblages from central Ethiopia, which provides an age constraint for the central Ethiopian Karoo. The study further argued that the change in the microfloral assemblage with time is a response to the change from a warm and cool temperate climate in Early Permian to progressively drier conditions during the Late Permian to Middle Triassic.

Cretaceous strata from Nigeria, Cameroon and Angola have been studied using different approaches: sedimentology/geochemistry, paleontology, and isotope stratigraphy and magnetostratigraphy, respectively. The sedimentology of the Cretaceous Calabar Flank in southeastern Nigeria studied by **Boboye** and **Okon** indicates varying depositional environments: fluvial setting for the Awi Formation, predominantly bioclastic (with high carbonate content) for the Mfamosing Formation, and quiet oxic and/or anoxic conditions for the Nkporo and Ekenkpon Formations. The organic geochemistry of the shales indicates a Type III kerogen, suggesting marginal mature to mature source rocks deposited in shallow continental to open marine setting. **Njoh** and **Petters** present and describe foraminiferal assemblages from the Late Turonian to Early Campanian Logbadjeck Formation in the northwestern Douala basin of Cameroon and showed their potential for dating sedimentary sequences in addition to their palaeobiogeographic applications. **Strganac et al**. present the first African stable carbon isotope record correlated to significant events in the global carbon cycle spanning the Late Cenomanian to Early Maastrichtian. This study of marine strata at the coast of southern Angola further integrated whole rock $^{40}Ar/^{39}Ar$ dating of intercalated basalt, in order to anchor the magnetostratigraphy and both invertebrate and vertebrate biostratigraphy.

Abbate et al. present reviewed and new data from intertrappean beds in Eritrea, Ethiopia, Sudan, Arabia, and Kenya, and showed that these continental intertrappean sedimentary beds (mostly encompassed between 29 and 27 Ma) mark quiescence during the dominant Trap volcanic activity. They also suggest the possible first occurrence of the genus Prodeinotherium in the African fossil record within these intertrappean beds.

4. Energy Resources

The geology, stratigraphy, geochemistry and potential of Energy Resources (shales and coal) from various parts of Africa and elsewhere are described and discussed. **Boboye** and **Nzegwu** analysed representative shale samples from exploratory wells to characterize and assess the potential capability of the Upper Cretaceous Shale units of the Bornu Basin in northeastern Nigeria. The results show that the Total Organic Content (TOC) of the shale units exceeds the threshold for petroleum generation and the dominance of marine organic matter with subordinate terrigenous input. They conclude that the potential is only fair to moderate for gaseous rather than liquid hydrocarbons. **Rotimi et al**. used well logs and seismic data to study the stratigraphy and reservoir quality of portions of the turbidites in Hems field (Bahai bay, China). They also explored a method to predict missing logs and clustering of electrofacies. They finally conclude that the reservoir quality of the Hems field is high especially if enhanced oil recovery methods are used.

Wolela carried out studies on the diagenesis of sandstones from the Blue Nile Basin (Ethiopia), as well as from the Ulster (UK) and Hartford (USA) Basins, and found out that source area geology, depositional environments, pore-water chemistry and circulation, tectonic setting and burial history controlled the diagenetic evolution. He concludes that secondary porosity predominates over primary porosity in all studied sandstones. **Vasconcelos et al**. studied the influence of oxidation of coal in its quality, especially its capacity for coke production, in the Chipanga Coal Seam, Moatize basin, Mozambique, a world class deposit for coking and thermal coal. They subjected representative samples to washability tests, and the Crucible Swelling index (CSI) of the Float 1.35 was determined. The study shows a direct relationship between the depth of the coal seam and its degree of oxidation, shown by the sudden decrease of the CSI when the coal seam approaches the surface. The sudden change of CSI, which generally occurs at a depth of ca. 10 m, led the authors to estimate the depth of the Limit of Oxidation (LOX) to 10 m.

5. Engineering Geology and Hydrogeology

Thorough understanding of geological systems is crucial to the evaluation of rock weathering and subsequent soil formation, to construction material selection and appraisal, as well as to land degradation and land sliding hazard assessment. These issues are discussed based on three case studies from Ethiopia. **Regassa et al**. present and discuss detailed geological and geochemical data from the geologically and topographically complex system of the Gilgel Gibe catchment in southwestern Ethiopia. They concluded that texture and structure of rocks play significant role in determining the degree of weathering, where lava flows have shown

less degree of weathering than their pyroclastic equivalents. **Engidasew** and **Barbieri** assess the general suitability of the Termaber basalt from central Ethiopia, as coarse aggregate for concrete mix and cut stone at industrial level. They integrated field geological investigation and a wide array of laboratory techniques to conclude that this widely distributed basalt unit in central Ethiopia has high economic potential as a construction material. **Raghuvanshi et al**. present a new expert evaluation technique for landslide hazard zonation (LHZ) with a case study in Wurgessa, northern Ethiopia. The new technique defined the anticipated adverse conditions in the study area, which in turn are satisfactorily validated with past landslide activities. Furthermore, the new technique could be applied for rapid landslide management during road construction projects.

Weitz and **Demlie** use a conceptual model to determine surface water and groundwater interaction in the Lake Sibayi catchment in the eastern part of South Africa. The hydrochemical and environmental isotope data revealed strong hydraulic connection between Lake Sibayi and the groundwater system, where the lake water balance correlates with observed lake level fluctuations. The study also attributed the recent lake level reduction to decreasing precipitation and rapidly increasing plantations, and emphasizes the dramatic negative effects on the neighbouring ecosystem and a potential seawater intrusion to the coastal aquifer.

6. Remote Sensing Application, Integration and Modelling

Various remotely sensed data (optical, microwave, hyperspectral including airborne geophysics) have been used to increase the efficiency of geologic mapping and mineral exploration campaigns. The integration of these various datasets with strategically planned field follow-ups in a GIS environment enables the extraction of subtle variations in geological features which otherwise is difficult from one dataset alone. Data integration provides enormous efficiency gains in geological mapping, mineral prospectivity modelling and modelling of geological processes. The value-added aspects of these techniques have been addressed. The application of high-resolution aeromagnetic data in mapping is discussed by **Anudu et al**. who studied the intra-sedimentary volcanic rocks and geological structures across the Cretaceous Middle Benue Trough in Nigeria, and by **Osinowo et al**. who reconstructed the basement topography of Siluko and environs in southwestern Nigeria. The integration part is covered by **Deroin et al**. who make use of radar data and field geological knowledge for mapping dome-and-basin patterns in the In Ouzzal Terrane of western Hoggar in Algeria, while **Herbert et al**. used interpretations derived from various remotely sensed data (optical, radar, aeromagnetic and radiometric datasets), validated in the field, as well as data Integration and Modelling for gold exploration in southwestern Uganda.

7. Environmental Geology, Medical Geology and Geology for Society

The realm of Environmental Geology is ever widening as new problems arise and new methodologies are developed. One of the major areas of emphasis is the impact of mining on all aspects of the environment, which becomes more important as the demand for mineral resources and fossil fuels is continuously rising. Moreover, the significance of geological materials and processes to human health is recognized as a major field of study. Earth systems are also linked to the on-going history of human development, and geological heritages should be at the core of sustainable development calling for concerted effort for geo-conservation. All these issues are addressed in this sub-theme. **Boboye** and **Abumere** conducted an integrated geochemical study on the Bida Basin of northwestern Nigeria in order to evaluate impacts of heavy metal concentration in water, soil, plants and to appraise the level of environmental damage. Their study found out strong correlation in metal concentrations in soil and plants, and high concentrations of Cr, V, Fe and Pb rendering water and soil unsuitable for drinking and farming, respectively. **Candeias et al**. studied the extent of an acid mine drainage from the Panasqueira Sn–W mine and its impacts on the Zêzere River in Central Portugal. The study showed that mining and beneficiation processes resulted in metal rich, strongly acidic mine wastes, while oxidation of sulphide tailings and flow from open impoundments are responsible for the mobilization and migration of metals from the mine wastes into the environment.

Kribek et al. evaluated the concentrations of some heavy metals (As, Cu, Co, Pb and Zn) in cassava growing on uncontaminated and contaminated soils of the Zambian Copper belt and their study clearly revealed that concentration of these metals in cassava is high in the neighbourhood of smelters. The study also showed cassava leaves to contain more metals than the tubers, and health hazards from consumption of cassava in the Copper belt to be moderate, but dietary health hazard could be higher when cassava leaves are not properly washed, as they are usually covered by metalliferrous dust. **Reis et al**. on the other hand assessed exposure and health risk posed by Al, Zn and Pb in outdoor dusts collected in recreational sites frequented by children at an industrial area in the western part of the Bassin Minier de Provence in France. The study revealed that Al occurs in very high concentrations mainly in non-bioaccessible forms, while Zn and Pb occur in low-average levels mainly in bioaccessible forms. The results also indicate that for Al and Zn, the outdoor dusts represent an acceptable risk to children's health while there is some health risk associated to environmental Pb.

Rocha and **da Silva** present a case study from Cape Verde, which shows the close link of geotourism and medical geology and the combined positive impact on enhancing rural development. The study assessed the potential of natural geological resources for both therapeutic purposes while serving at the same time as geotouristic sites.

De Mulder et al. assess the overall impact of the geosciences to the benefit of society. The study particularly addresses the issue of geoscience outreach as an important communication tool for geoscientists to approach political decision makers and the general public. The study uses the outreach programme of the International Year of Planet Earth (IYPE 2007–2009) as a case study to show the success of outreach programmes conducted at grassroots level.

8. Dedication

We dedicate this Special Volume to the successive leaders of the Geological Society of Africa, established in 1973, from the founders, Russell Black (Addis Ababa University, Ethiopia), and M.O. Oyawoye (Ibadan University, Nigeria), who was the first President of the GSAf, to Aberra Mogessie (Graz University, Austria), the current President, through the successive Presidents: C.A. Kogbe (Ife University, Nigeria), S. Muhongo (Dar Es Salam University, Tanzania), M. Abdelsalam (Texas University at Dallas, USA) and F. Toteu (Garoua Centre for Geological and Mining Research, Cameroon) [*cited affiliations at the time of their presidency*]. It is worth noting that the current President of the GSAf, Aberra Mogessie, was a student of Russell Black, some 40 years ago, in the Department of Geology of the Addis Ababa University. All the founders and Presidents have been major actors in the geological research in Africa and essential promoters in the dissemination of the information across country boundaries. They have played a very important role in the development and sustainable management of the continent's Earth

Resources and the improvement of the standards of earth science education and research in Africa. The current geological world in Africa would not be what it is without their dedication and contribution. We would like to warmly thank these eminent colleagues and scientists for their role and work as leaders of the Society.

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